

Anatomy of VERTEBRAL COLUMN



By
Hermizan Halihanafiah

VERTEBRAL COLUMN

- ▶ The vertebral column, also called the **spine, spinal column** or **backbone**.
- ▶ Composed of a series of bones called **vertebrae** (singular is vertebra).
- ▶ About 71 cm (28in): adult male.
- ▶ About 61 cm (24in): adult female.

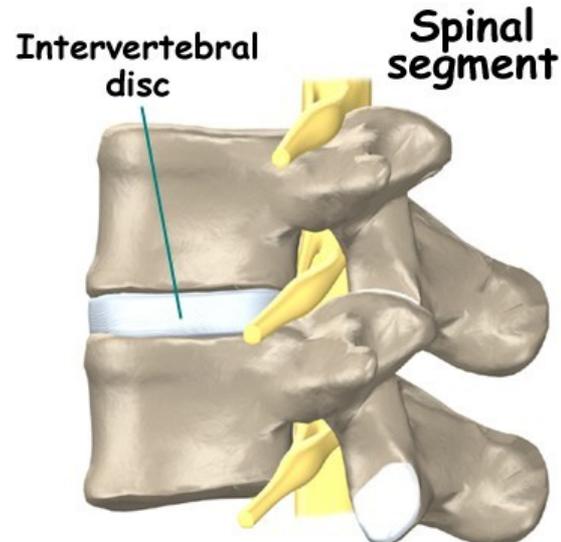
- ▶ Total number of vertebrae during **early development is 33.**
 - ▶ As a child grows, several vertebrae in the sacral and coccygeal regions fuse.
 - ▶ **Adults have 26 vertebrae.** *Sacrum and coccyx bones become fused.
- 

REGIONS OF THE VERTEBRAL COLUMN

- ▶ 7 cervical vertebrae (C1 - C7)
- ▶ 12 thoracic vertebrae (T1 –T12)
- ▶ 5 lumbar vertebrae (L1 – L5)
- ▶ 1 sacrum (5 fused)
- ▶ 1 coccyx (4 fused)

*The sacrum and coccyx do not have number.

- ▶ The cervical, thoracic and lumbar vertebrae → **movable**
- ▶ Sacrum and coccyx → **immovable**
- ▶ Between adjacent vertebrae from the second cervical vertebra to the sacrum are **intervertebral disc** (inter = between).





7 Cervical vertebrae

12 Thoracic vertebrae

5 Lumbar vertebrae

Sacrum

Coccyx

General Structure of Vertebrae

1. Cervical vertebrae (C1-C7)

- Formed framework of neck region
- Support skull
- Small in size
- Presense foramen in each transverse process

2. Thoracic vertebrae (T1-T12)

- Formed posterior part of thoracic cage
- Articulates with associated ribs

3. Lumbar Vertebrae (L1-L5)

- Formed skeletal support for posterior abdominal wall
- Characterized by large in size

4. Sacrum Vertebrae

- Fusion of 5 sacral bones
- Immovable (synostosis)
- Articulates with L5 at lumbosacral joint
- Articulates laterally with pelvic bone at sacroiliac joint.
- Formed posterior wall of lower abdominal and pelvic cavity

5. Coccyx

- Fusion of 4 coccyx bones
- Immovable (synostosis)
- Formed part of pelvic cavity

FUNCTIONS OF THE VERTEBRAL COLUMN

1. Supports the head.
2. Help maintain balance in the upright position.
3. Enclose and protect the spinal cord.
4. Permits movement (move forward, backward, sideways, and rotate).
5. Absorbs shocks during walking.
6. Serve as a point of attachment for the ribs, pelvic girdle and muscles of the back and upper limbs.

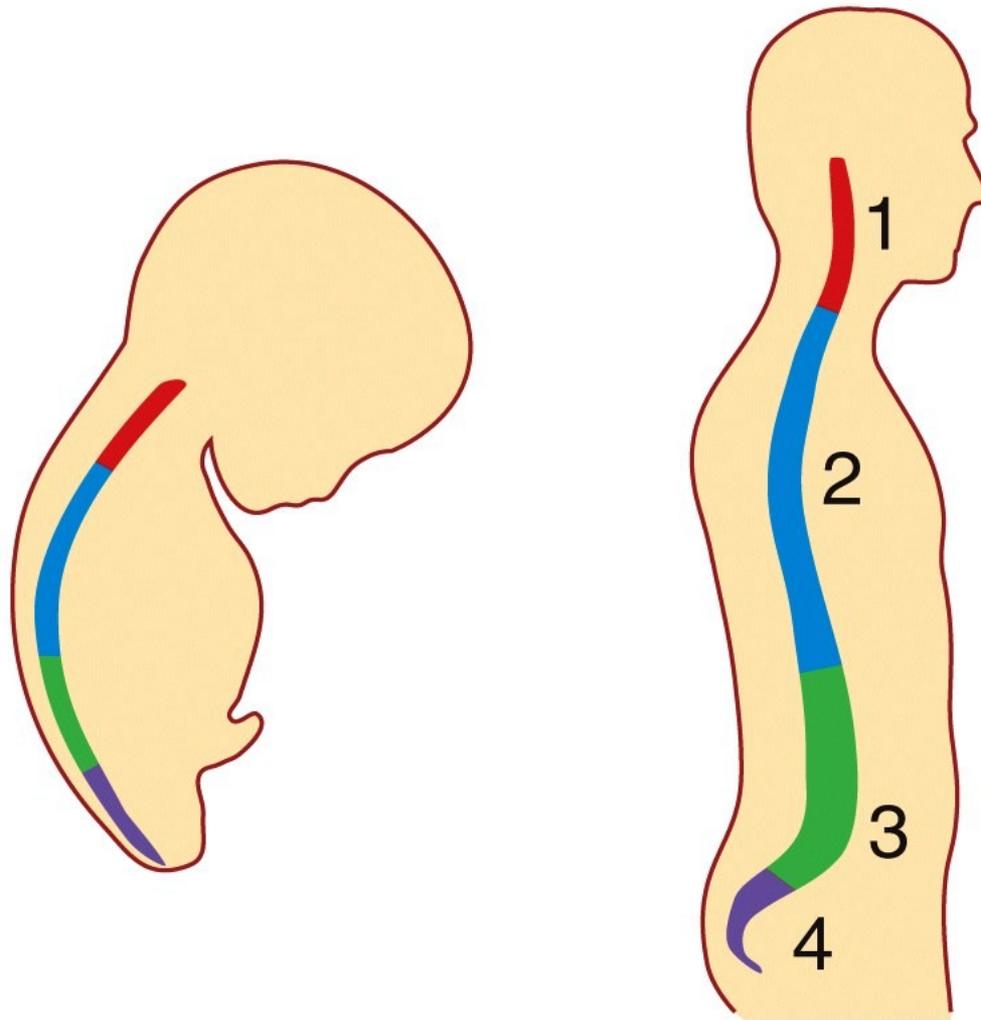
DEVELOPMENT OF THE VERTEBRAL CURVES

- In the **fetus**, there is a **single concave curve**.
- At **3 months** after birth when infant lifts head as it begins to crawl the **cervical curve develops**.
- When child sits up, stands and walks the **lumbar curve develops**.

- ▶ **In adult, it shows four slight bends called normal curve:**
 - ▢ **Cervical and lumbar curve are convex**
(bulging out)
 - ▢ **Thoracic and sacral curve are concave**
(cupping in)

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Single curve in fetus Four curves in adult

Fetal and adult curves

- The **thoracic and sacral curves** are called **primary curves** because they form first during fetal development.
- The **cervical and lumbar curves** are called **secondary curves** because they form later, several months after birth.
- All curve fully developed by age 10.
- However, secondary curves may be progressively lost in old age.

Differences newborn and adult spinal curvature

Newborn Spinal Curvature :

- ▶ C-shaped curve
- ▶ Known as Primary Curve
- ▶ Single curve

Adult Spinal Curvature:

- ▶ S-shaped vertebral column
- ▶ Four curve (cervical, thoracic, lumbar and sacral curve)
- ▶ Secondary curvatures develop after birth

**C-shaped
curve to
the right**



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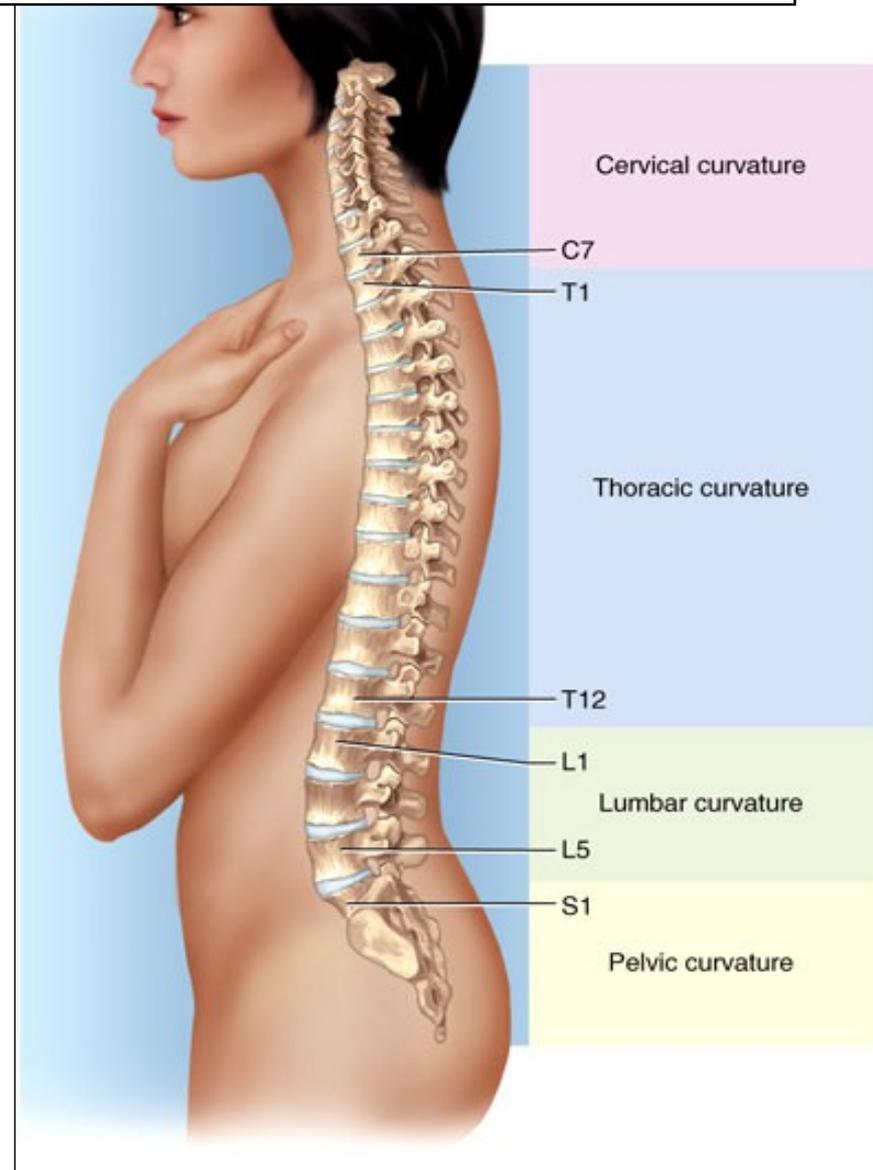
**S-shaped
curve**



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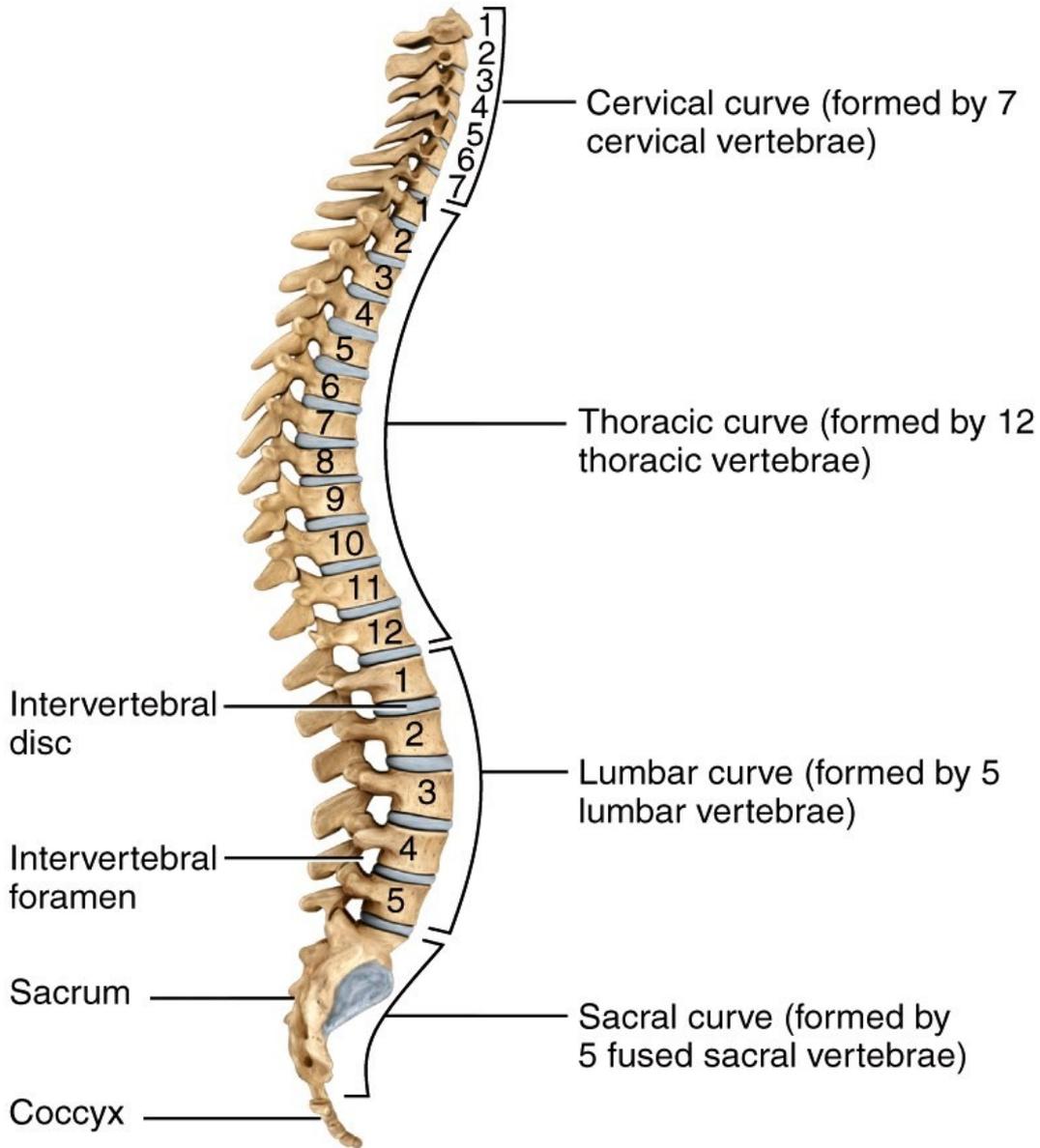
NORMAL CURVE OF THE VERTEBRAL COLUMN

- Consist of **four slight bends** (cervical, thoracic, lumbar, sacral)
- Cervical and lumbar curve are **convex** (bulging out).
- The thoracic and sacral curves are **concave** (cupping in).



POSTERIOR

ANTERIOR



Right lateral view showing four normal curves

FUNCTIONS OF THE NORMAL CURVE

- ▶ Increases its strength
- ▶ Help maintain balance in the upright position
- ▶ Absorb shocks during walking
- ▶ Help protect the vertebrae from fracture

ABNORMAL SPINAL CURVATURE

Scoliosis:

- ▶ lateral bending of the vertebral column, usually in the thoracic region.

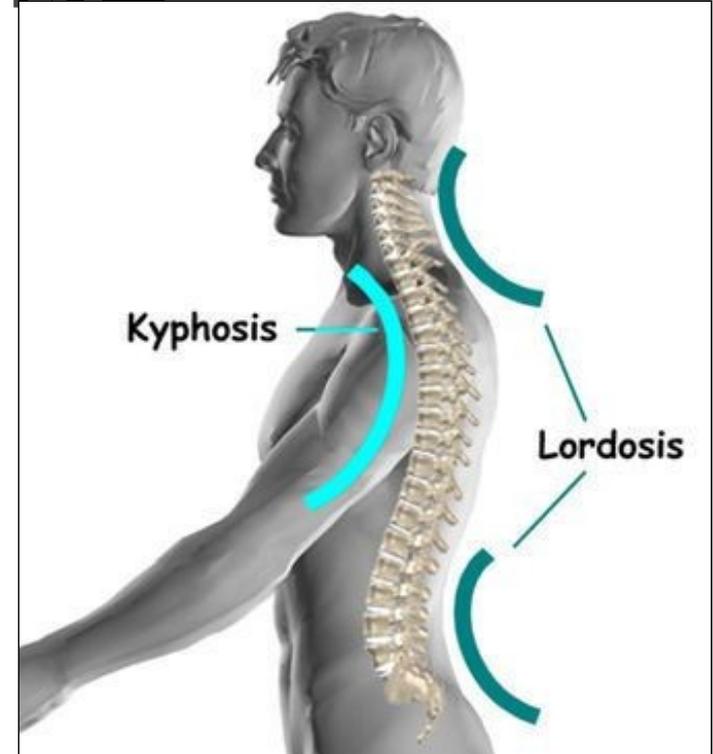
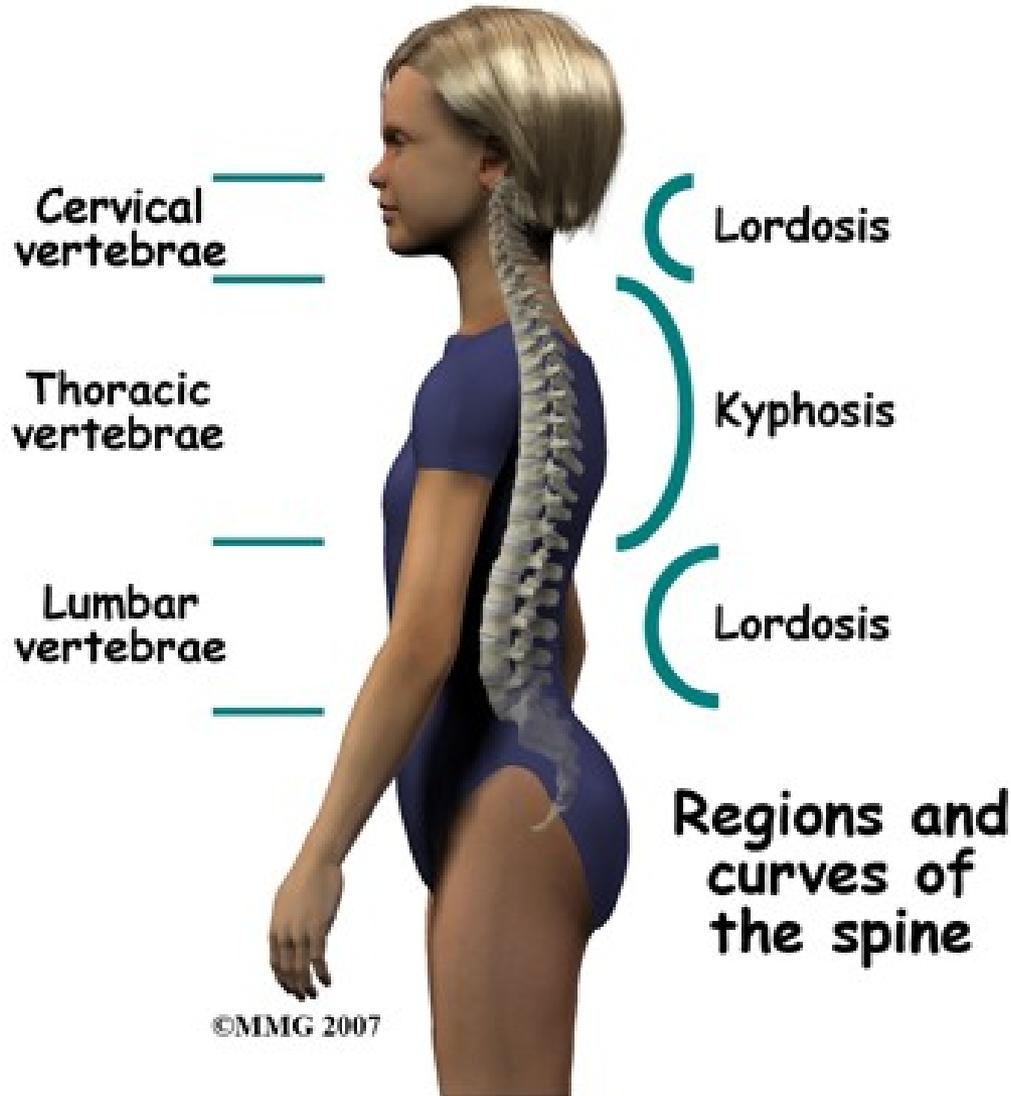
Kyphosis:

- ▶ Increase in the thoracic curve of the vertebral column.

Lordosis (Hollow back)

- ▶ Increase in the lumbar and cervical curve of the vertebral column.

ABNORMAL SPINAL CURVATURE



ABNORMAL SPINAL CURVATURE



(a) Scoliosis

(b) Kyphosis
("hunchback")

(c) Lordosis
("swayback")

Key

- Normal
- Pathological

Scoliosis

Scoliotic spine

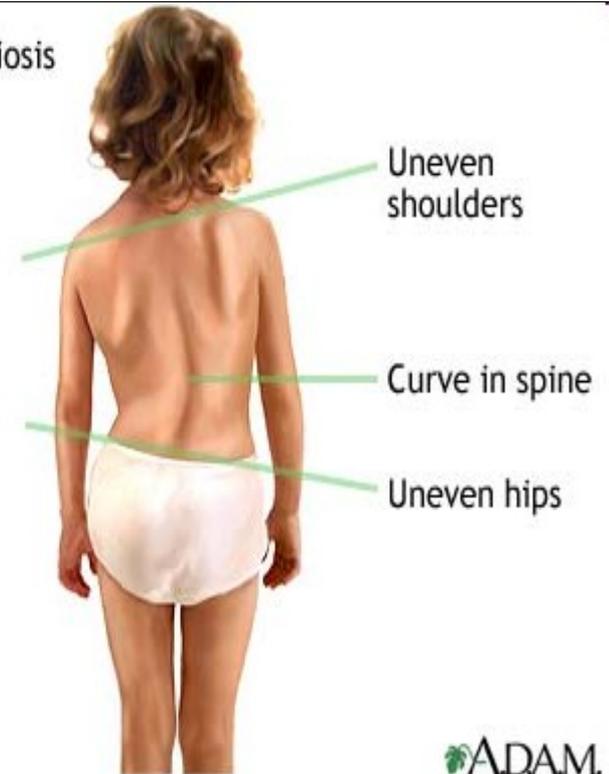


Normal spine



ADAM.

Signs of scoliosis



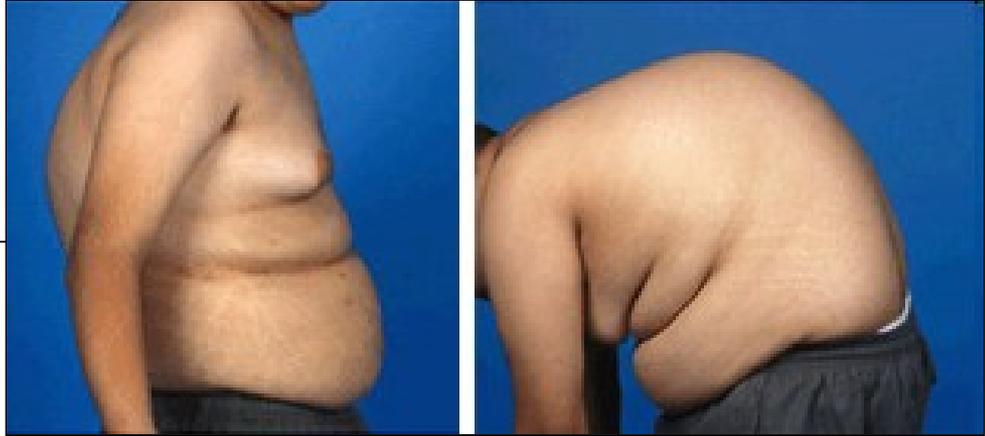
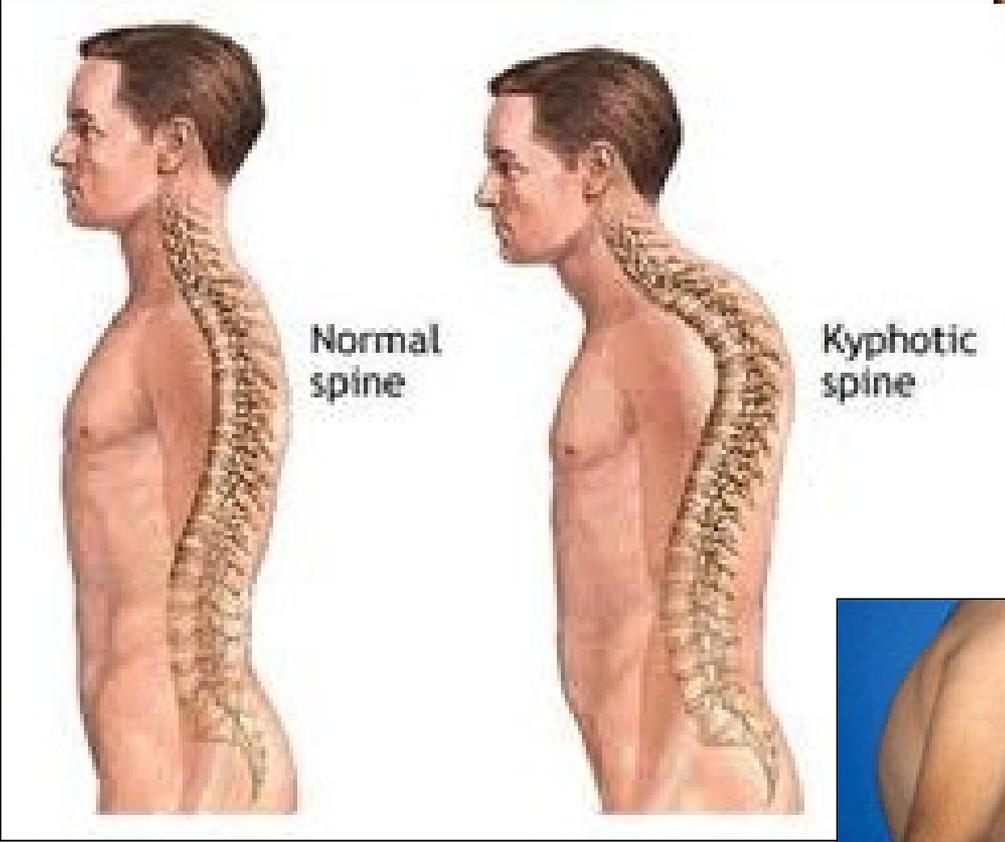
Uneven shoulders

Curve in spine

Uneven hips

ADAM.

Kyphosis



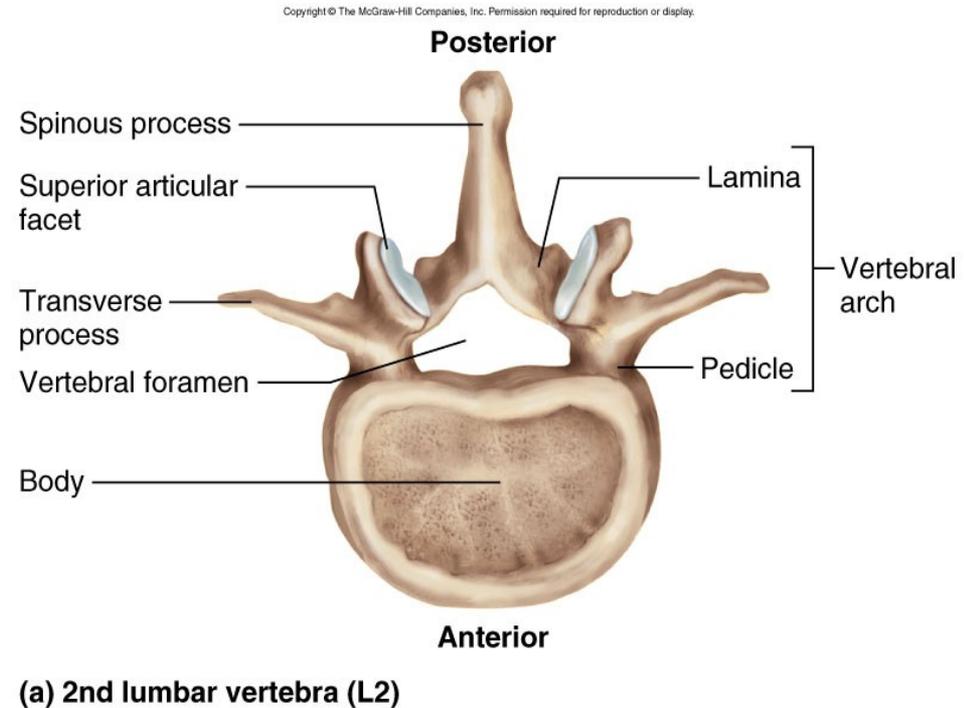
PARTS OF A TYPICAL VERTEBRAE

Typical vertebrae consists of:

- **A body**
- **A vertebral arch (pedicles and lamina)**
- **Seven processes:** two transverse processes, one spinous process, four articular processes

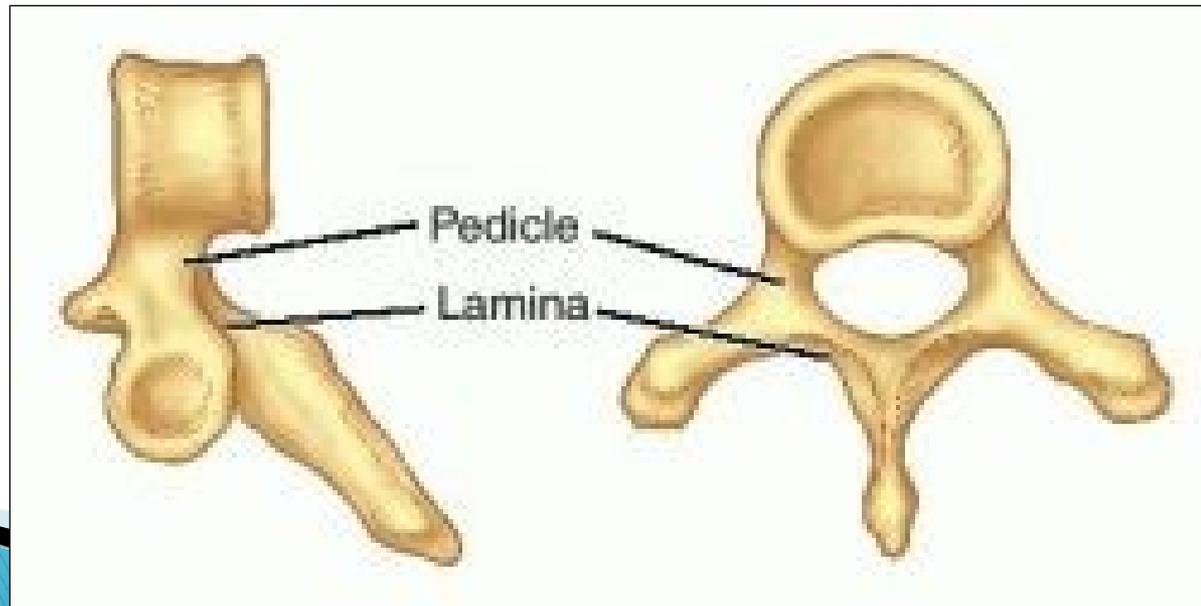
BODY OF VERTEBRAE

- ▶ Largest part of vertebra, thick.
- ▶ **Disc-shaped anterior portion**
- ▶ **Weight bearing** portion – size increases inferiorly
- ▶ Its **inferior and superior surfaces** are roughened and give attachment to the **intervertebral disc**.
- ▶ **Anterior and lateral surfaces** contain **nutrient foramina** – pathway for **blood vessels**.



VERTEBRAL ARCH

- ▶ Extend backwards from the body of the vertebra.
- ▶ Consists of a pair of **pedicles** and a pair of **laminae**.
- ▶ The pedicle project backward from the body to unite with the laminae.



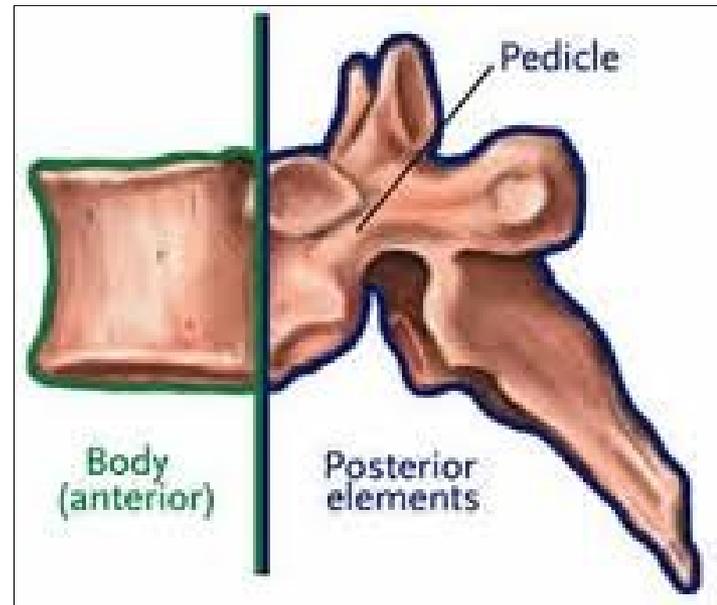
VERTEBRAL ARCH

Pedicle:

- ▶ two short, thick processes, which project backward.
- ▶ the concavities above and below the pedicles are named the **vertebral notches** –formed **IV foramina**

Laminae:

- ▶ two broad & flat plates directed backward and medialward from the pedicles.
- ▶ the **laminae** end in a single sharp, slender projection called a **spinous process**.



PROCESSES OF THE VERTEBRAE

7 processes arise from the vertebral arch:

- ▶ **TWO TRANSVERSE PROCESS**
- ▶ **ONE SPINOUS PROCESS**
- ▶ **FOUR ARTICULAR**

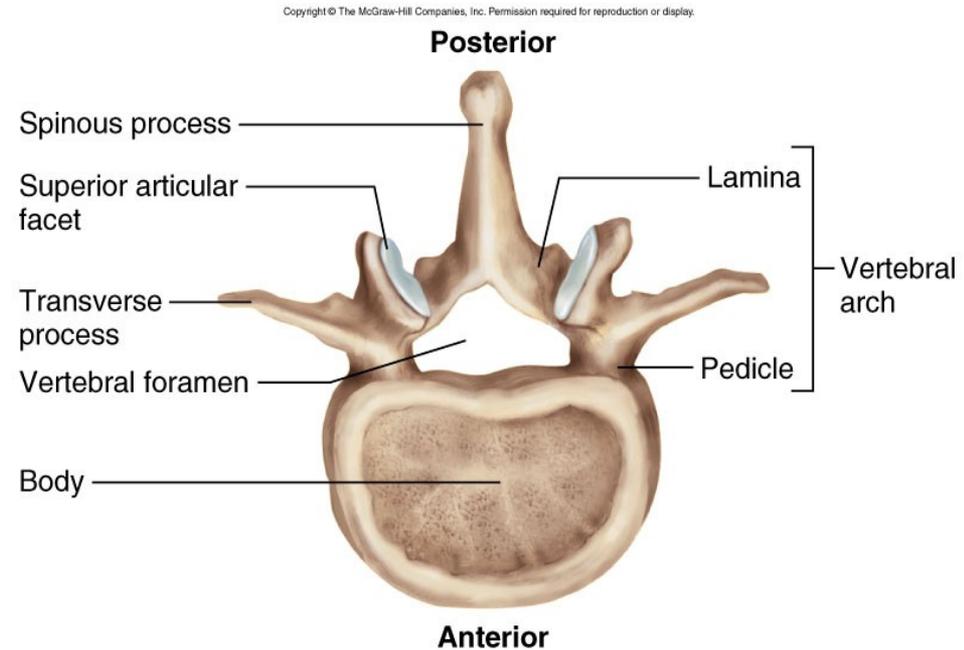
PROCESSES OF THE VERTEBRAE

TRANSVERSE PROCESS:

- ▶ Extends posterolaterally for the junction between pedicle and laminae on each side (left and right)

ONE SPINOUS PROCESS:

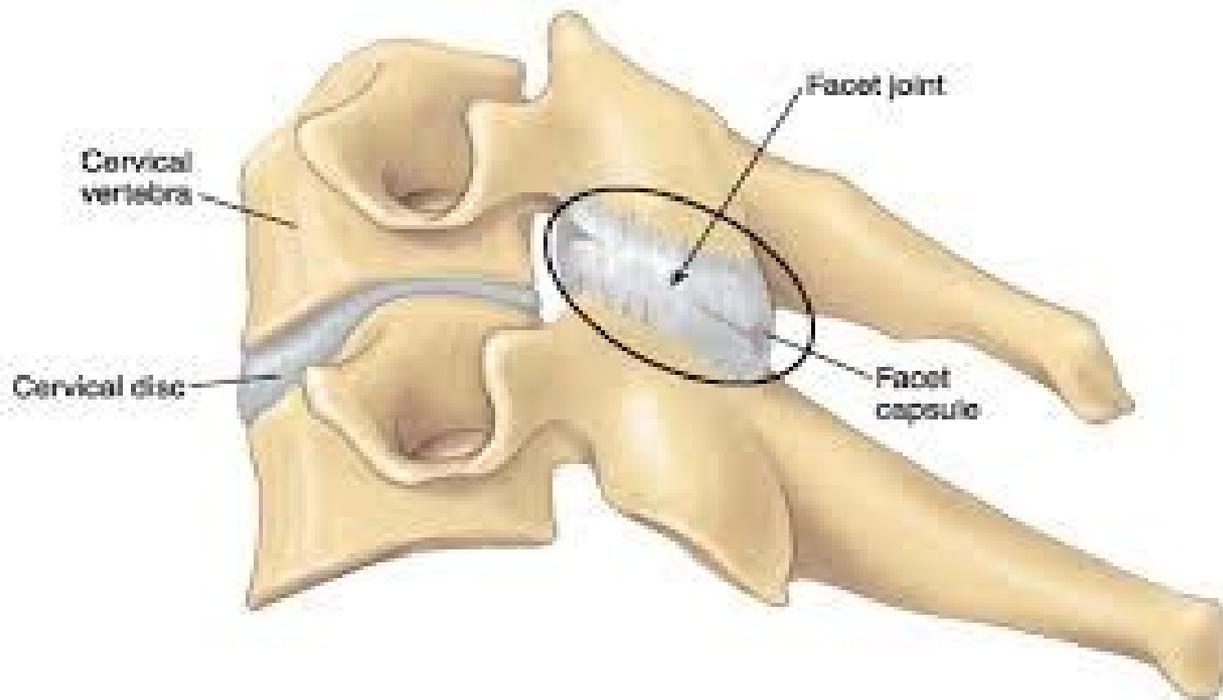
- ▶ A single spinous process projects posteriorly from the junction of the laminae.
- ▶ These 3 processes serve as points of attachment for muscles.



(a) 2nd lumbar vertebra (L2)

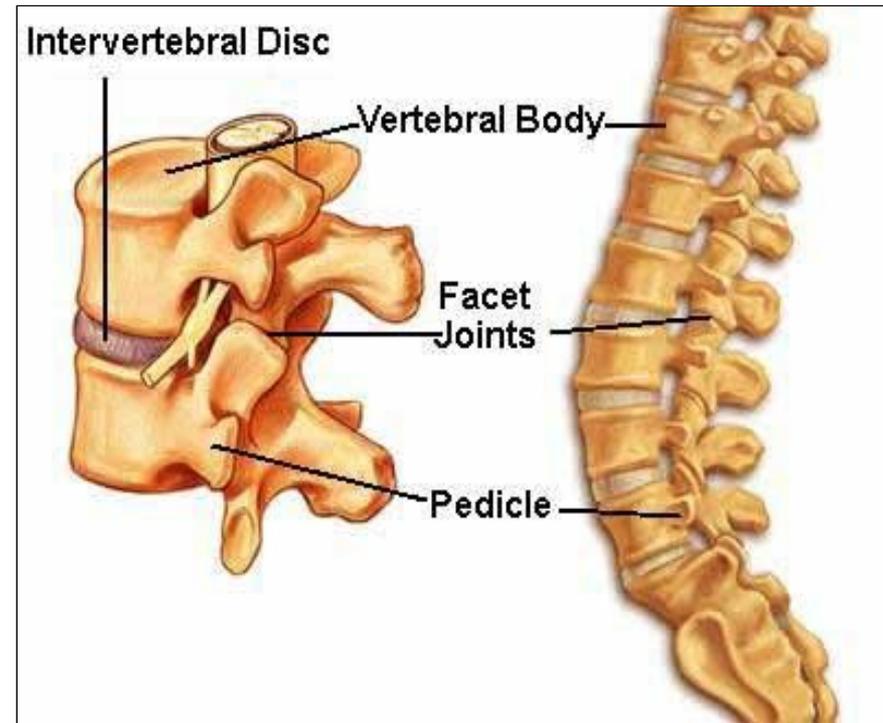
ARTICULAR PROCESSES (*Zygapophysies*):

- ▶ At the junction between pedicles and lamina meet, also projecting superior and inferior articular process.
- ▶ At the end of these processes – concave surface (facet)
- ▶ IAP of vertebrae above articulates with SAP of vertebrae below – zygapophysial joints (Facet Joints).



INTERVERTEBRAL DISCS

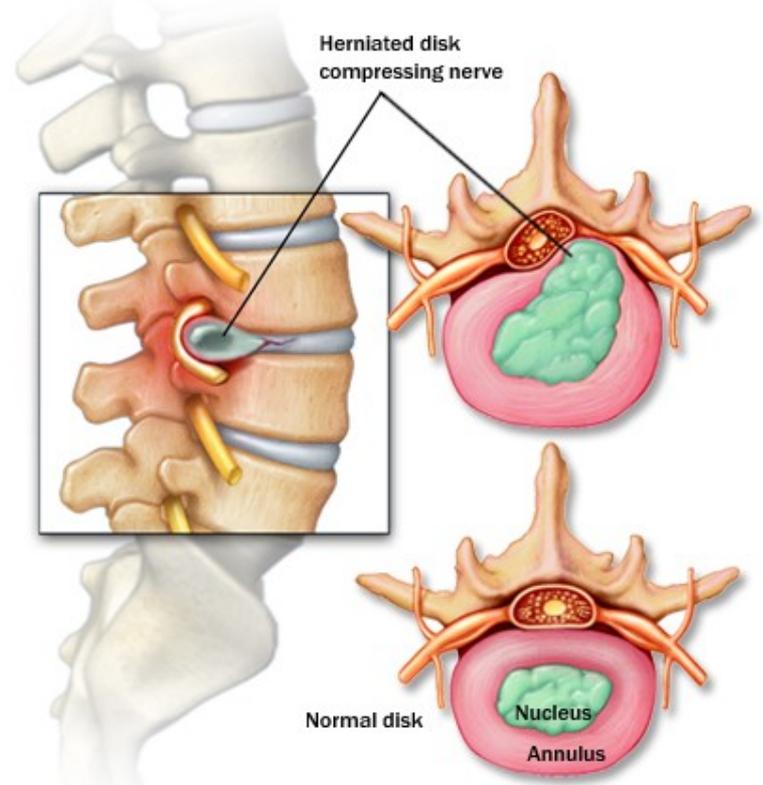
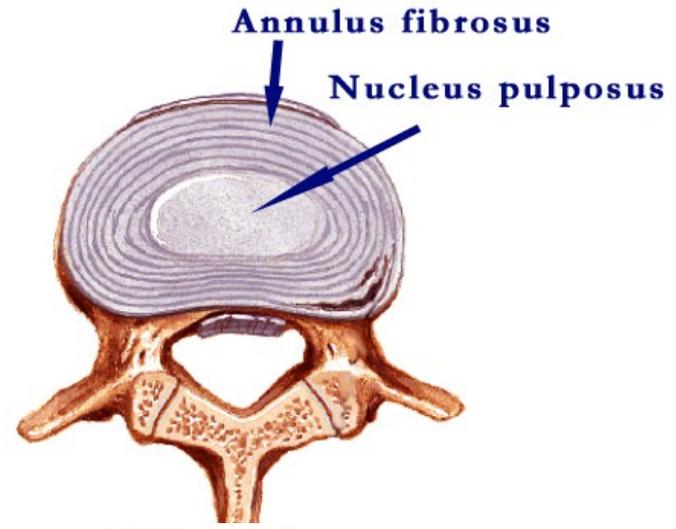
- ▶ Between the bodies of the adjacent **vertebrae C2 to the sacrum**.
- ▶ Each disc forms a cartilaginous joint to allow slight movement of the vertebrae, and acts as a ligament to hold the vertebrae together.



Each vertebral discs consist of:

- ▶ an outer fibrous ring consisting of fibrocartilage called **annulus fibrosus** (annulus = ringlike).
- ▶ Inner soft, pulpy, highly elastic substance called the **nucleus pulposus** (pulposus = pulplike), which acts as a shock absorber, absorbing the impact of the body's daily activities and keeping the two vertebrae separated

- ▶ Nucleus pulposus hardens and less elastic with age.
- ▶ Narrowing of discs and compression of the vertebrae results in a decrease in the height with age.
- ▶ A tear can occur within the annulus fibrosus (ring) and cause the nucleus pulposus may track into the vertebral canal or intervertebral foramen to impinge on neural structures – herniation IV discs. (prolapsed/slipped disc)



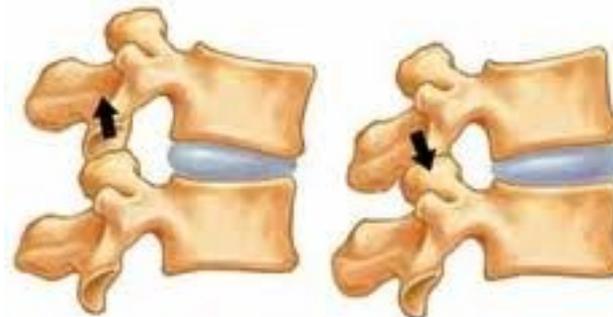
Functions of the intervertebral discs

1. Binds the vertebrae and forms a strong joint
2. Permits various movements of the vertebral column
3. Absorbs vertical shock and avoid friction during intervertebral joints movements.

Normal Disc

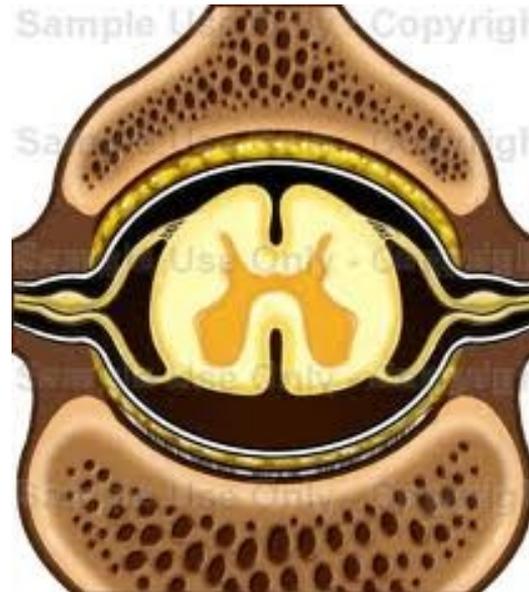
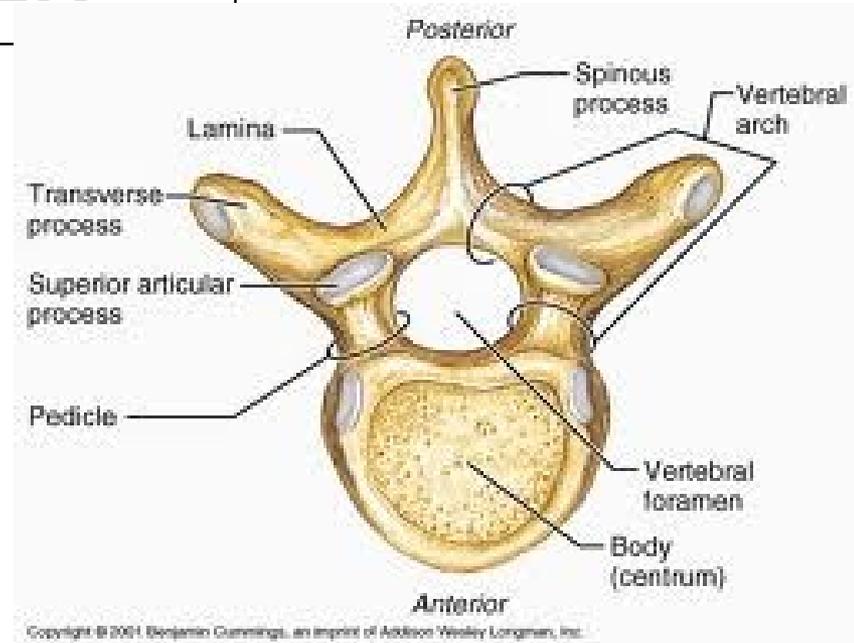


**Lateral (Side) View:
Working Facet Joints**



VERTEBRAL FORAMEN

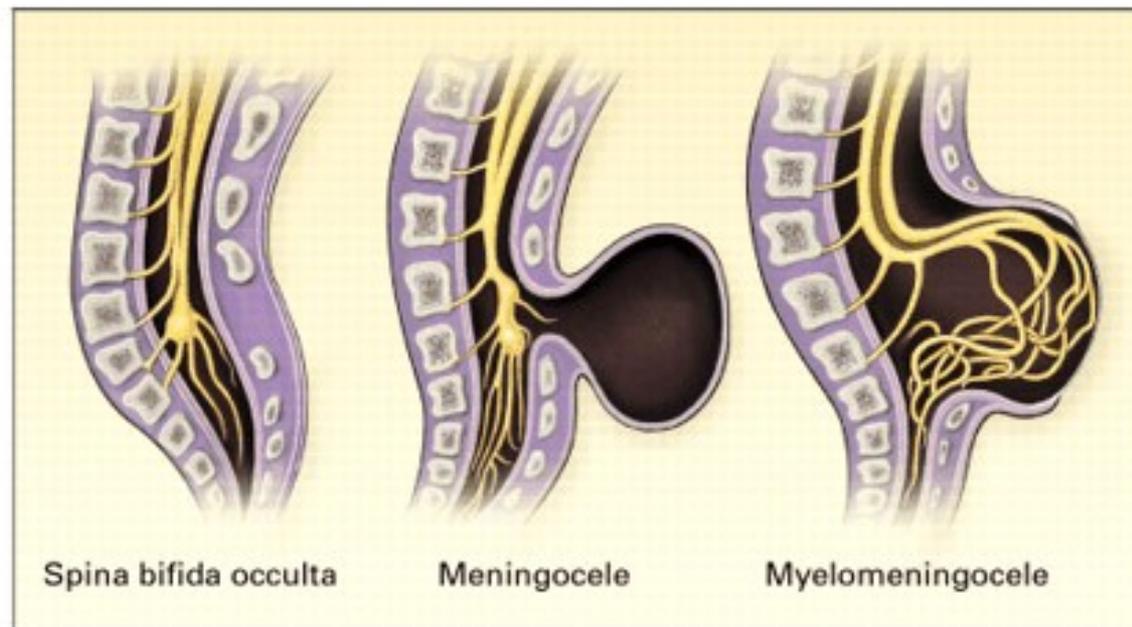
- ▶ Vertebral foramen contains : spinal cord and its roots, spinal meninges, ASA and PSA, Venous Plexus, fat
- ▶ The vertebral foramina of all vertebrae form the vertebral (spinal) canal.



Abnormalities of the Vertebral canal

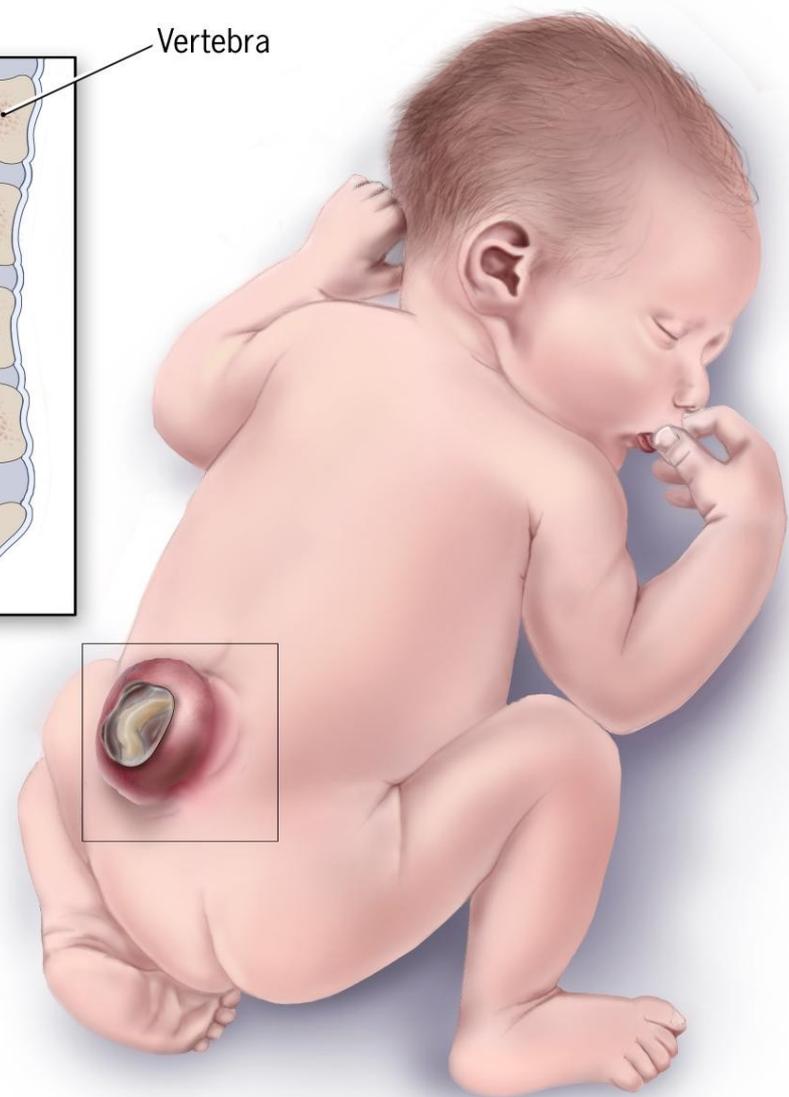
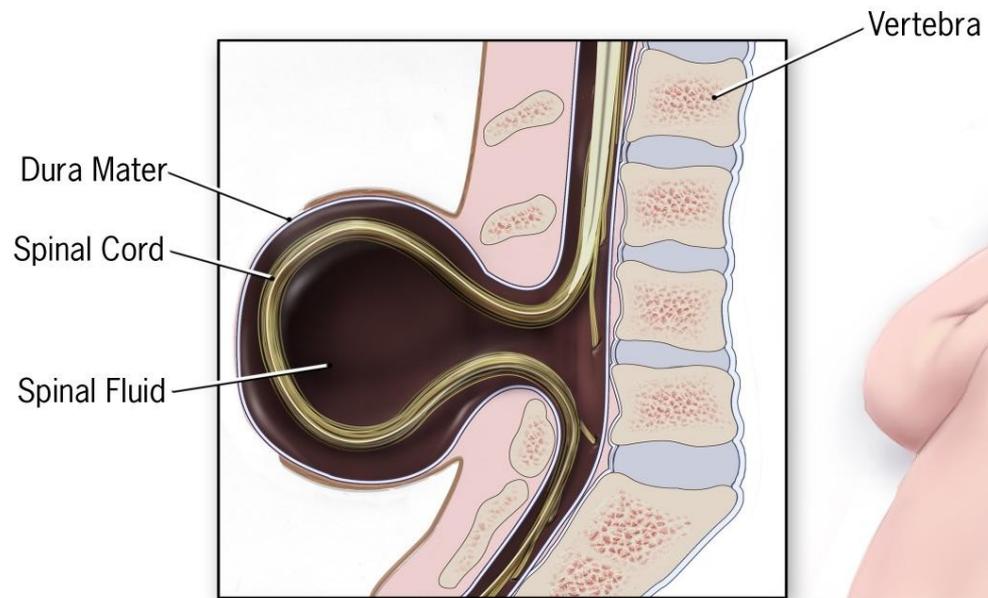
Spina bifida (congenital)

- ▶ Two sides of vertebral arch fail to fuse during development, resulting in an open vertebral canal (cleft)
- ▶ Absence of spinous process
- ▶ Usually in lumbosacral region
- ▶ Protrusion of spinal meninges (out pouch) and may contain CSF – meningocele
- ▶ Protrusion of |



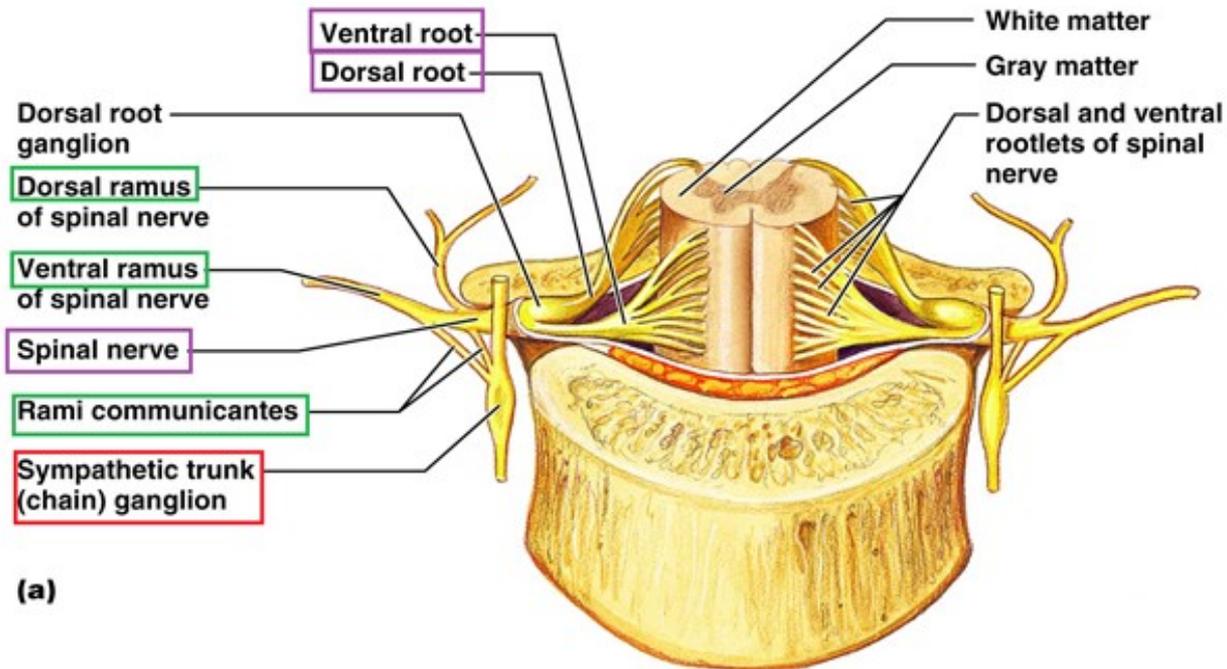
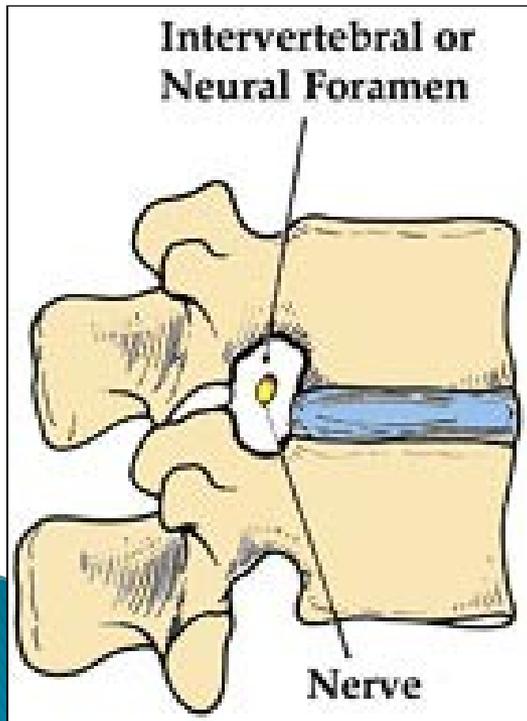
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Spina Bifida (Open Defect)



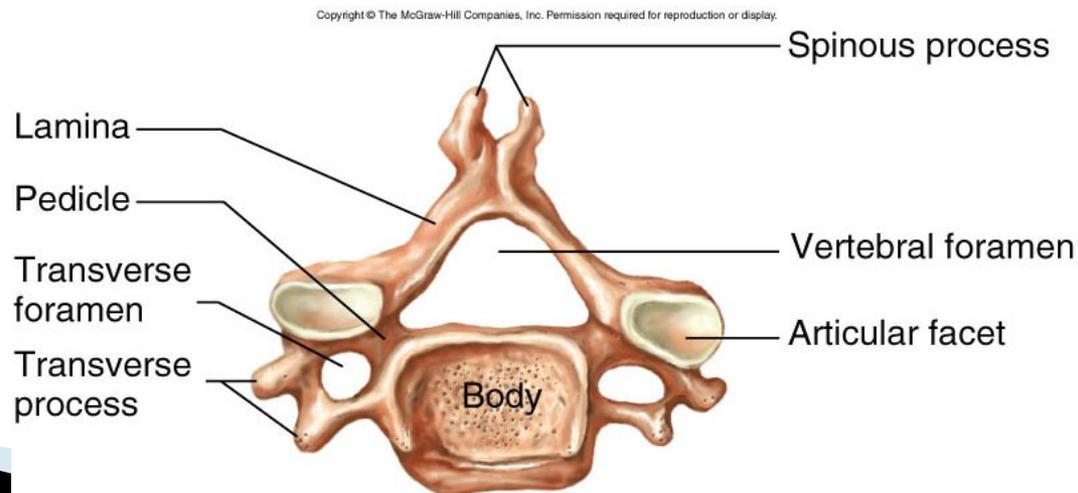
INTERVERTEBRAL FORAMEN

- ▶ Between every pair of vertebrae are two apertures, the **intervertebral foramen (formed by inferior and superior vertebral notches)**.
- ▶ Also called **neural foramen**.
- ▶ **Passageway for nerve roots**.



Cervical Vertebrae

- ▶ C1-C7 (formed framework of the neck)
- ▶ C1, C2 and C7 – atypical (looks weird!!!)
- ▶ C3-C6 – have similarities – typical
 - Smaller bodies, short
 - Larger vertebral arch – hence larger vertebral foramen (cervical enlargement)
 - Transverse process consist transverse foramina @ foramen transversarium (vertebral artery)
 - Spinous process short and bifid

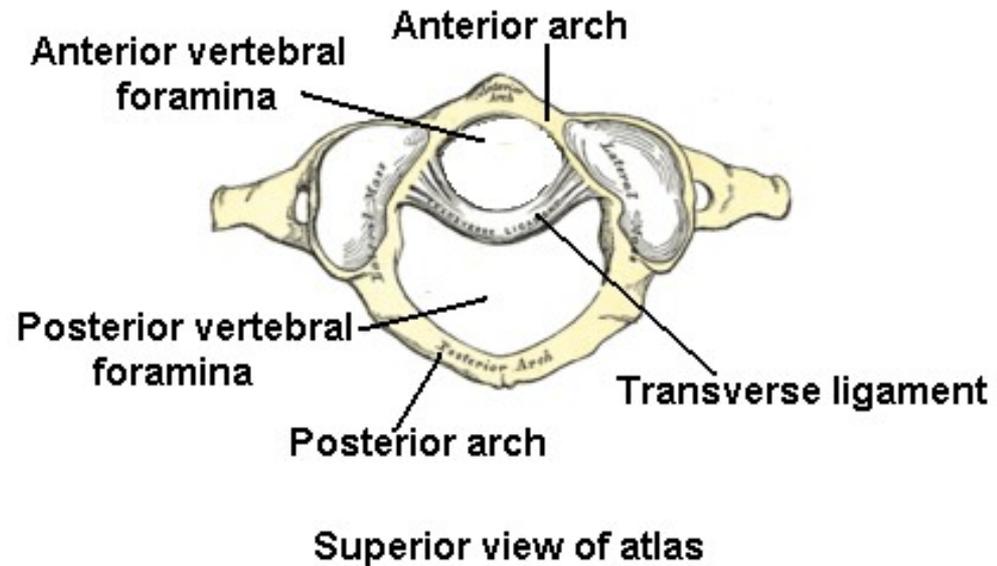


(c)

Cervical vertebra, superior view

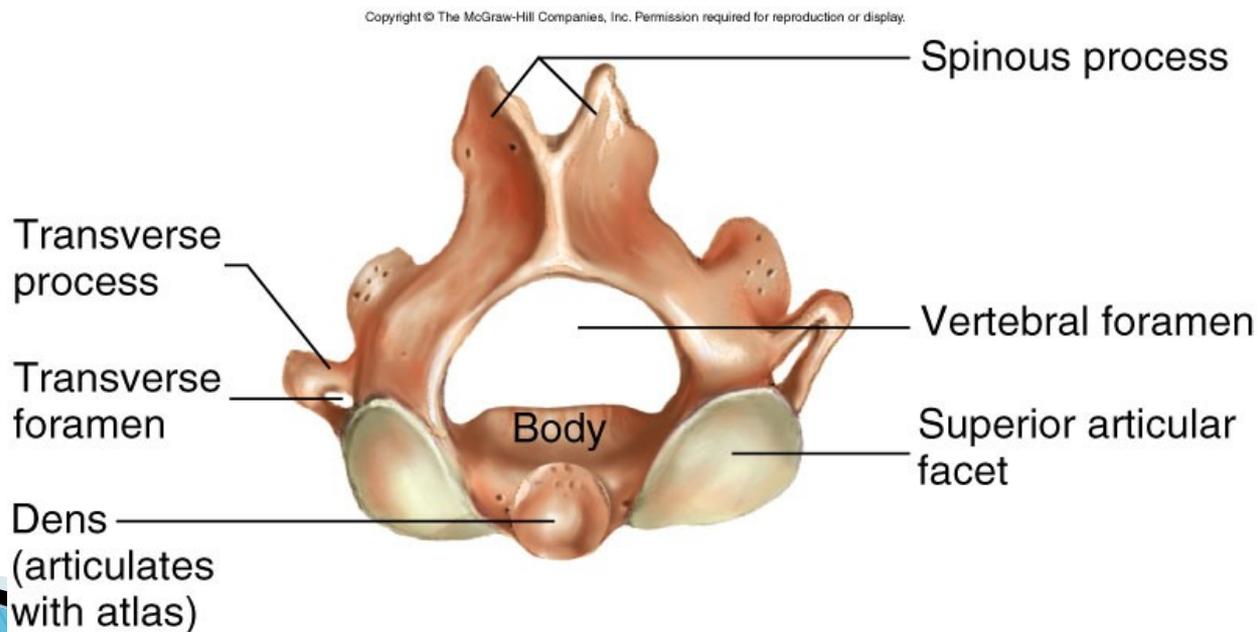
C1 – Atlas

- ▶ Ring shaped
- ▶ Lack of body (fused with body of C2)
- ▶ Composed by lateral masses interconnected by an anterior and posterior arch
- ▶ Each lateral masses consist SAFacet which articulates with occipital condyle – AOJ
- ▶ Also consist IAF which articulates with SAF of C2 – AAJ (C1/C2)
- ▶ anterior arch of C1 articulates with dens of C2 – support via transverse ligament



C2 (Axis)

- ▶ Structure similar with typical cervical vertebrae but
- ▶ Have peg like processes called dens or odontoid process
- ▶ Dens projecting upwards from body of C2 toward vertebral foramen of C1 which articulates with anterior arch of C1 (AAJ).

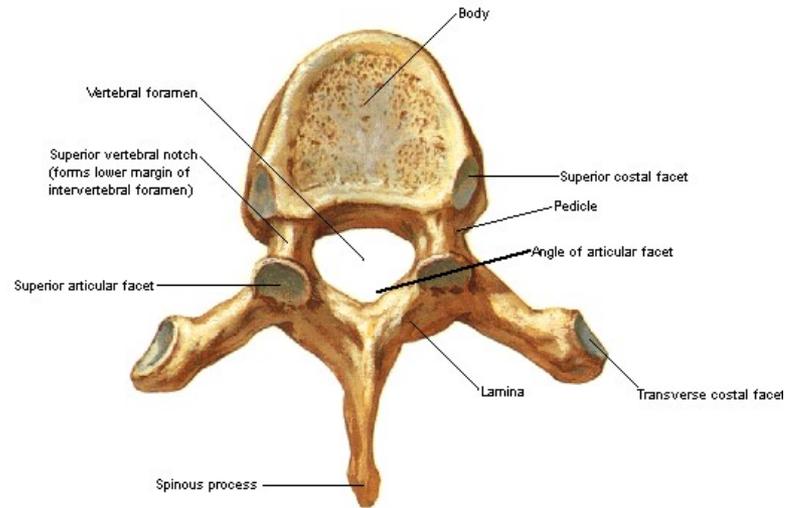


(b) **Axis (second cervical vertebra), superior view**

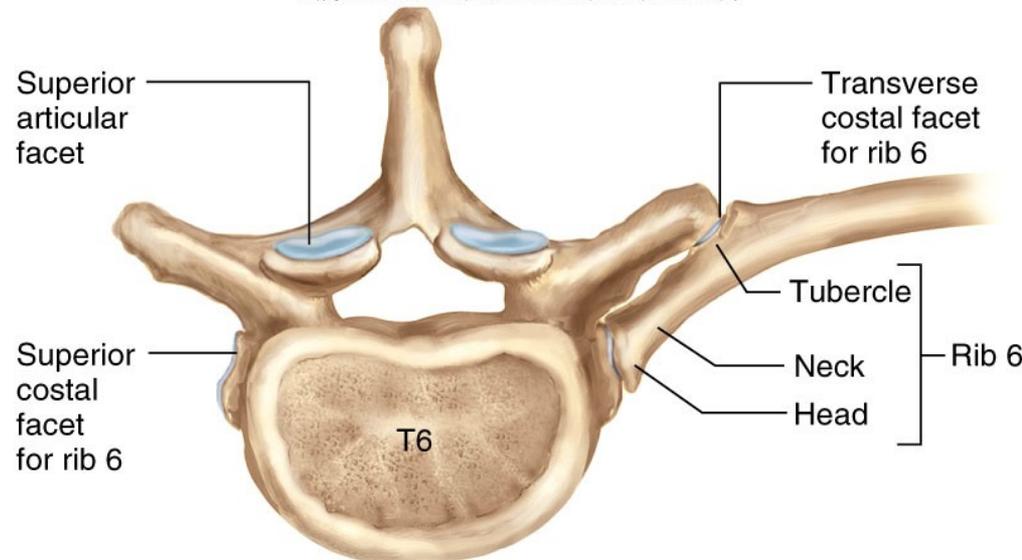
Thoracic Vertebrae (T1-T12)

Thoracic Vertebrae [T6]
Superior View

- ▶ Typical thoracic vertebrae
 - Fairly large size of body
 - Long spinous process and pointed and angled downward
 - Vertebral foramen generally circular
 - Transverse process projecting posterolaterally.
 - Have 3 pairs of facets – attachment for the ribs (2 pairs of demifacets at the body and 1 pair of facet at the transverse process).



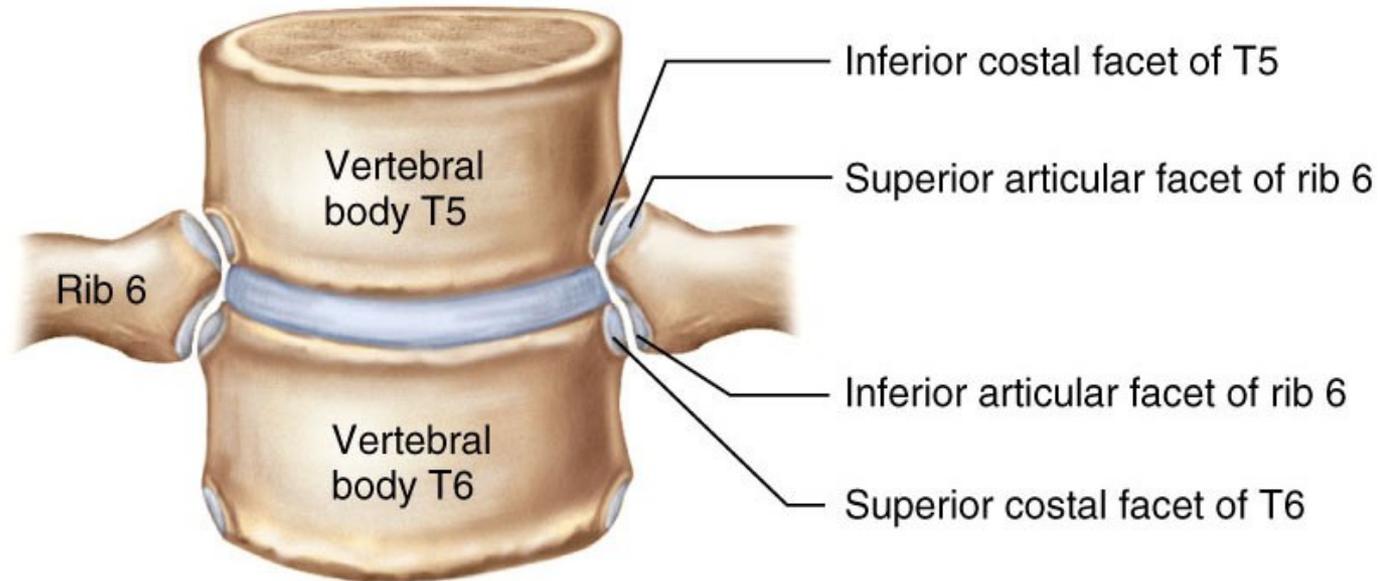
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(b) Superior view

- ▶ T1 has a superior facet and inferior demifacets for head of ribs.
- ▶ T2-T8 have superior and inferior demifacets for head of ribs.
- ▶ T9 has a superior demifacets
- ▶ T10-T12 have superior facet.
- ▶ Movements of the thoracic vertebrae are limited by thin intervertebral disc and by attachment of the ribs to the sternum (sternocostal jnt).

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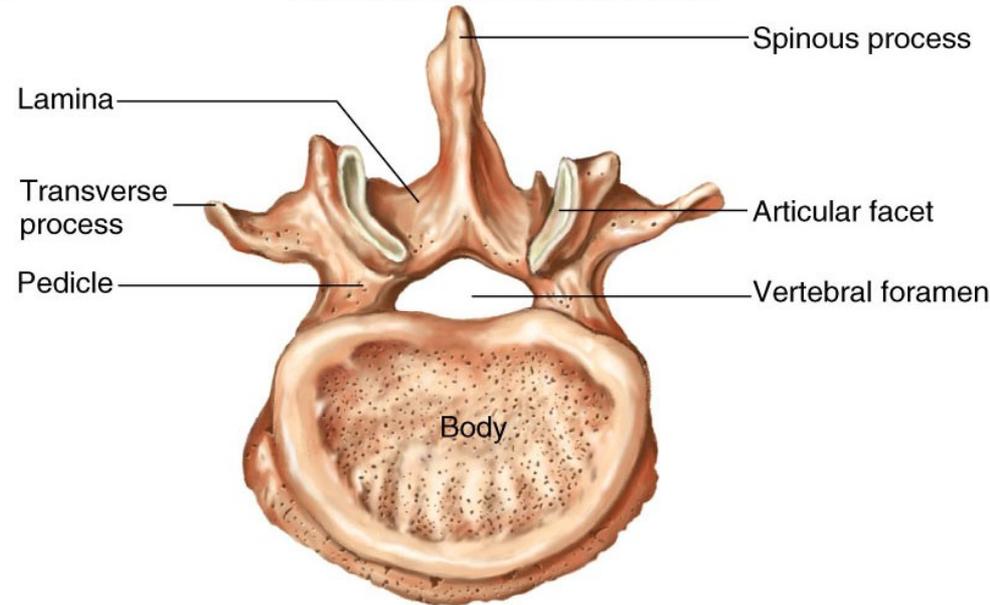


(a) Anterior view

Lumbar Vertebrae (L 1-L 5)

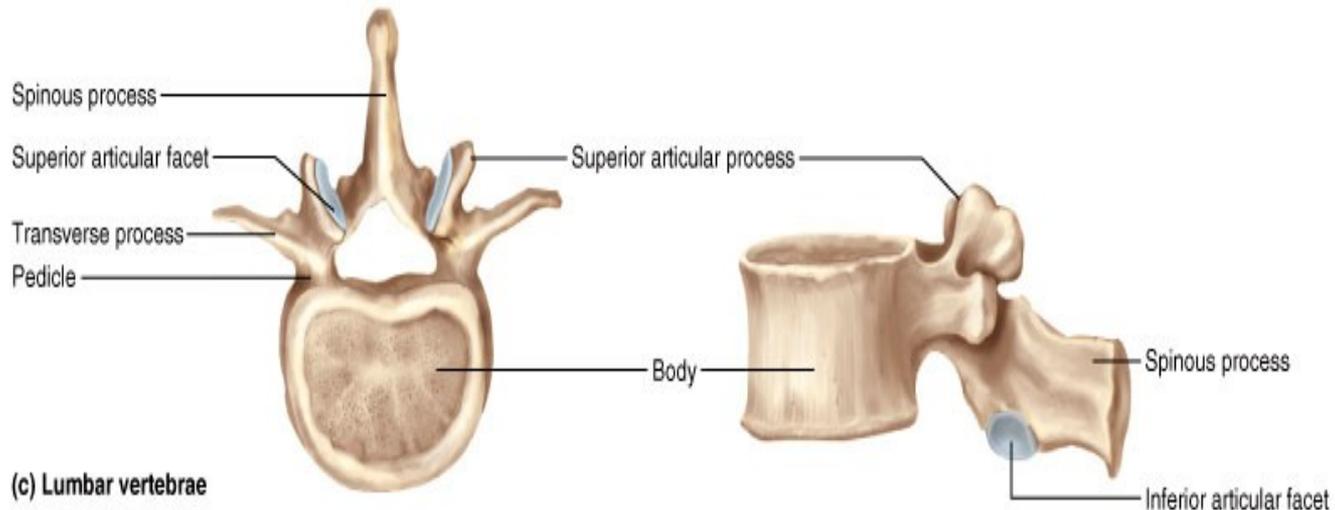
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- ▶ The largest and strongest – weight bearing
- ▶ Thickest body
- ▶ Spinous process is thickest and broad and project posteriorly – attachment for the large back muscles
- ▶ Superior articular process facing medially, inferior articular process facing laterally.



(e) Lumbar vertebra, superior view

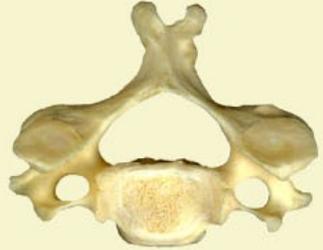
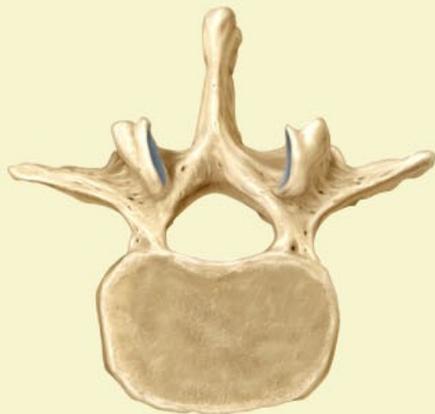
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(c) Lumbar vertebrae

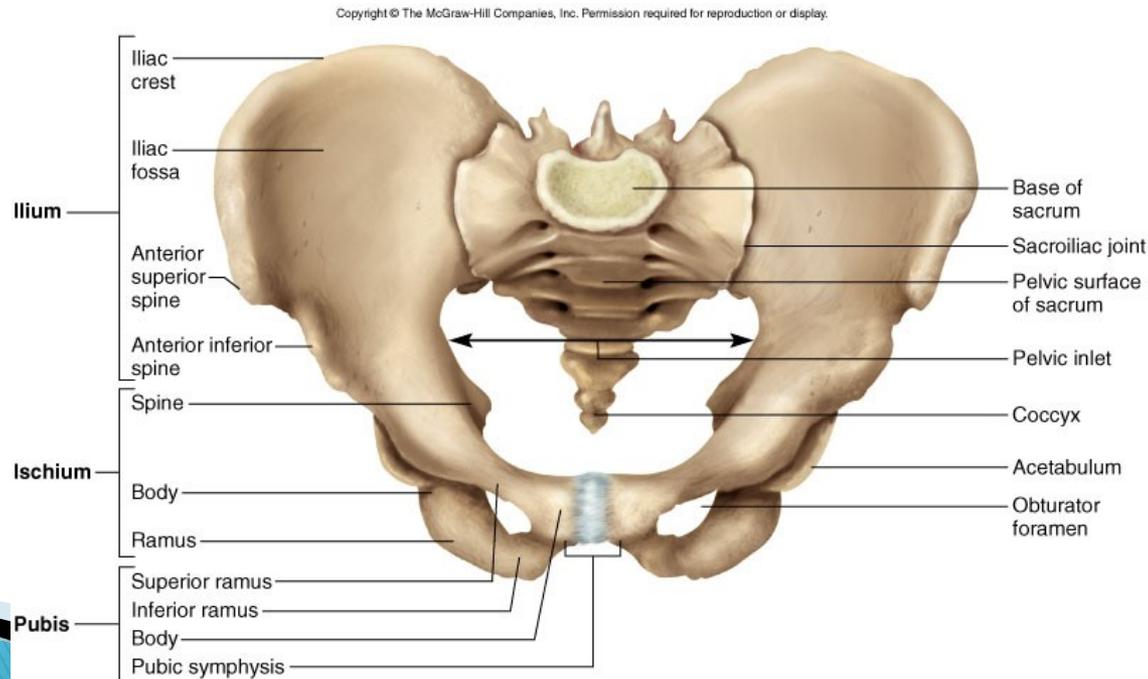
TABLE 7.4 

Comparison of Major Structural Features of Cervical, Thoracic, and Lumbar Vertebrae

CHARACTERISTIC	CERVICAL	THORACIC	LUMBAR
Overall structure			
Body	Small.	Larger.	Largest.
Foramina	One vertebral and two transverse.	One vertebral.	One vertebral.
Spinous processes	Slender and often bifid (C2–C6).	Long and fairly thick (most project inferiorly).	Short and blunt (project posteriorly rather than inferiorly).
Transverse processes	Small.	Fairly large.	Large and blunt.
Articular facets for ribs	Absent.	Present.	Absent.
Direction of articular facets			
Superior	Posterosuperior.	Posterolateral.	Medial.
Inferior	Anteroinferior.	Anteromedial.	Lateral.
Size of intervertebral discs	Thick relative to size of vertebral bodies.	Thin relative to size of vertebral bodies.	Massive.

Sacrum (S1-S5)

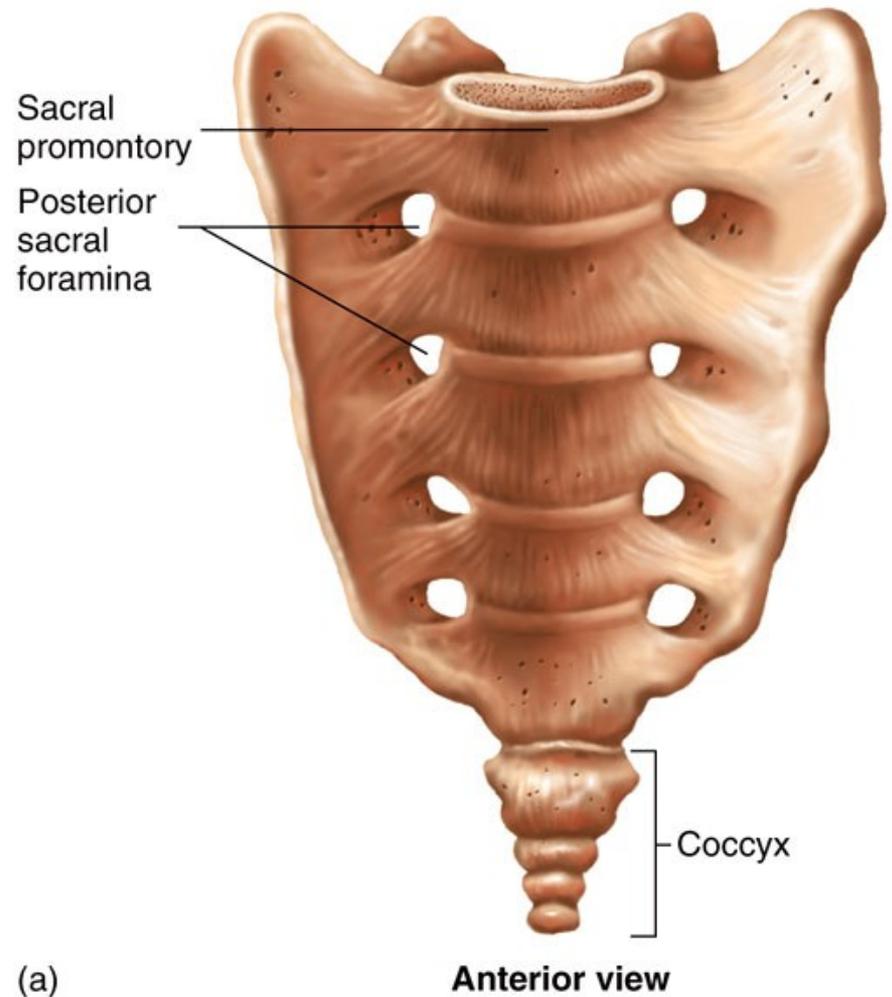
- ▶ Inverted triangular in-shaped
- ▶ Fusion of 5 sacral vertebrae – fusion started 16-18 y'old and completed at 30.
- ▶ Sacrum serve strong foundation for the pelvic girdle attachment (sacroiliac joint)
- ▶ Formed posterior wall of the lower abd cavity and pelvic cavity.
- ▶ At the superior (base), consist SAP which articulates with IAP of L5 – LSJ (L5/S1)



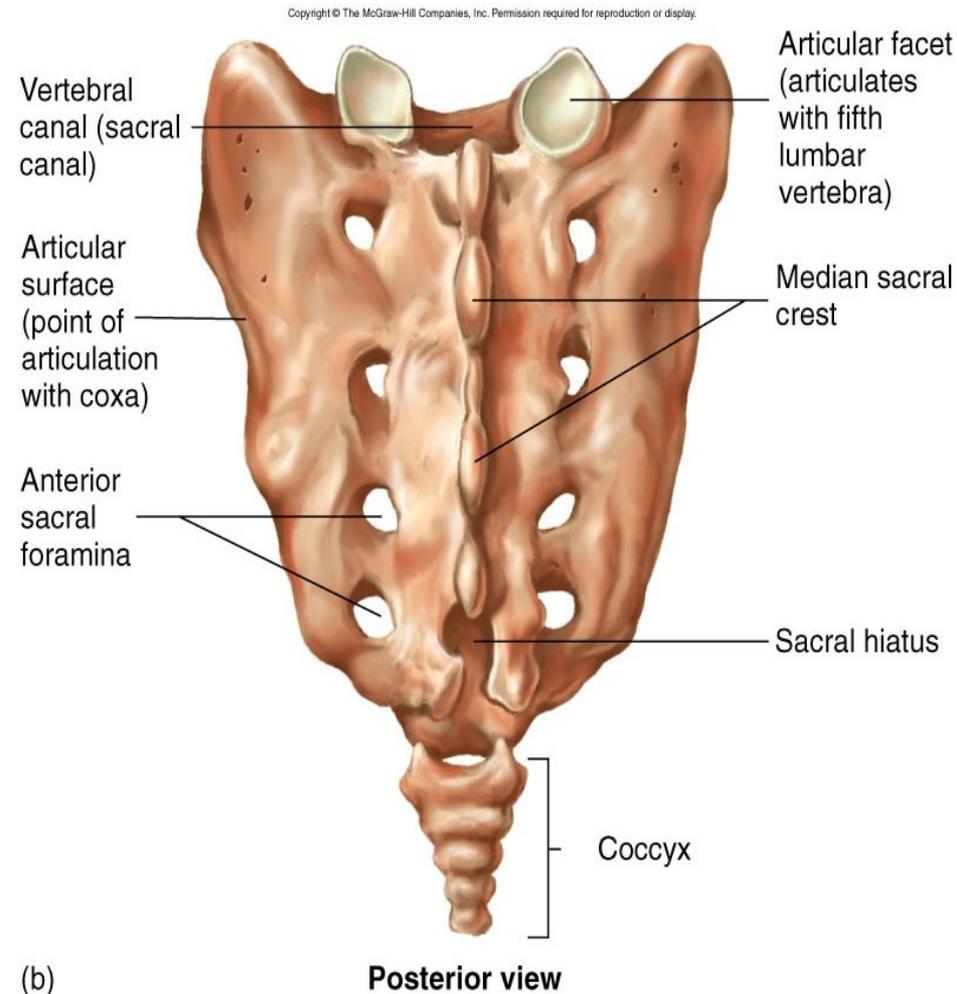
(a) Anterosuperior view

- ▶ anterior surface, consist transverse ridge, mark the joining of bodies
- ▶ Lateral surface – smooth surface called ala
- ▶ Anterior ridge of sacral body which projecting forward – promontory
- ▶ Consist 4 pairs of anterior sacral foramina – routes for anterior rami of sacral spinal nerve

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- ▶ At the posterior surface consist posterior sacral foramina – routes for posterior rami of sacral spinal nerves.
- ▶ Sacral canal- continuation of vertebral canal from L5 (routes for roots of sacral and coccygeal spinal nerves), and terminates as a opening called sacral hiatus (routes for S5 and co1 spinal nerve).
- ▶ On either side of the sacral hiatus, consist sacral cornua.
- ▶ Median sacral crest – fusion of spinous process
- ▶ Lateral sacral crest – fusion of transverse process



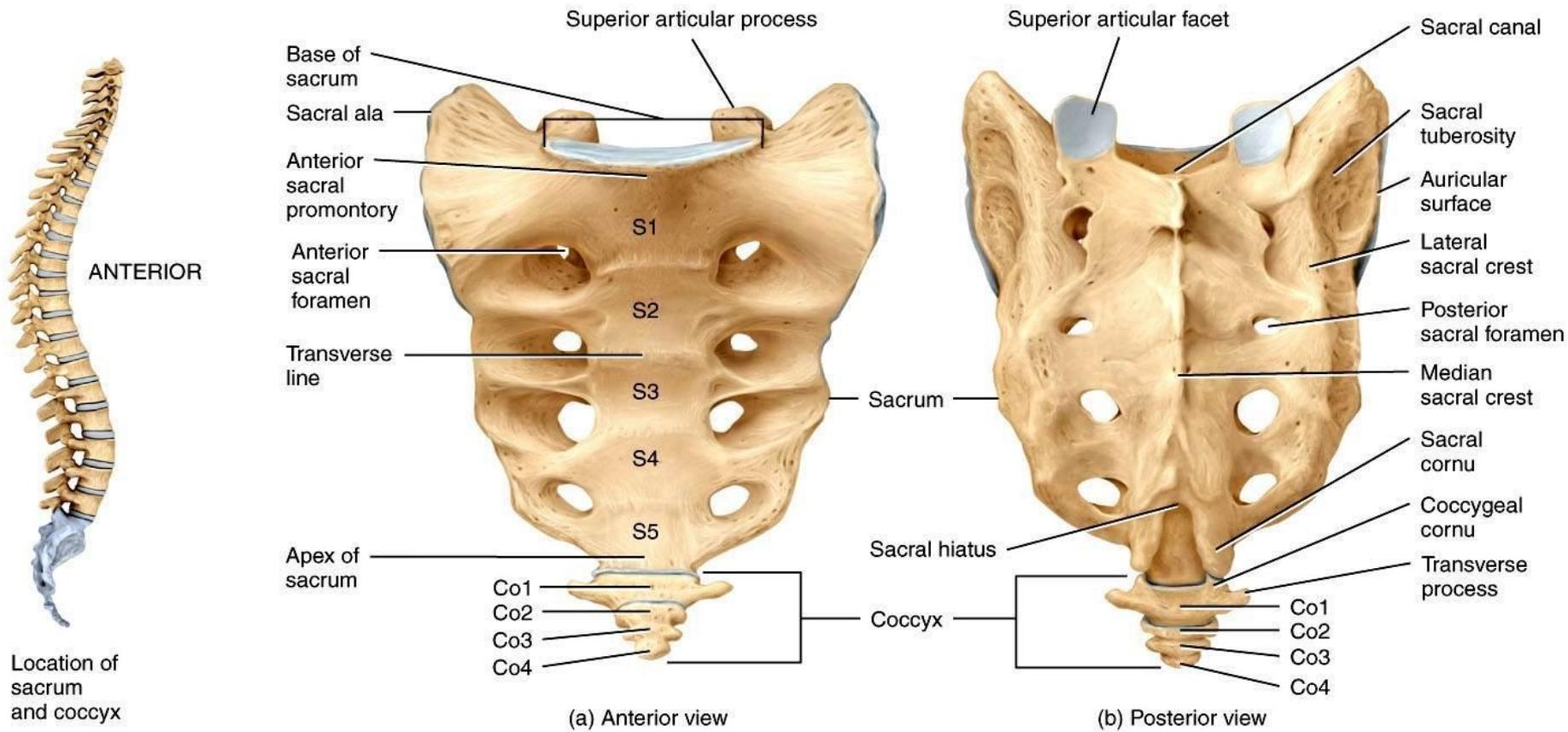


Figure 07.20ab Tortora - PHA 11/e
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Coccyx vertebrae (co1-co4)

- ▶ Inverted Triangular in shaped
- ▶ Fusion of 4 coccyx vertebrae
- ▶ Dorsal surface, 2 projection called coccygeal cornua – attachment for sacrococcygeal ligament and also attachment for pelvic floor muscles (levator ani)

FIG. 284.—The coccyx. Anterior aspect.

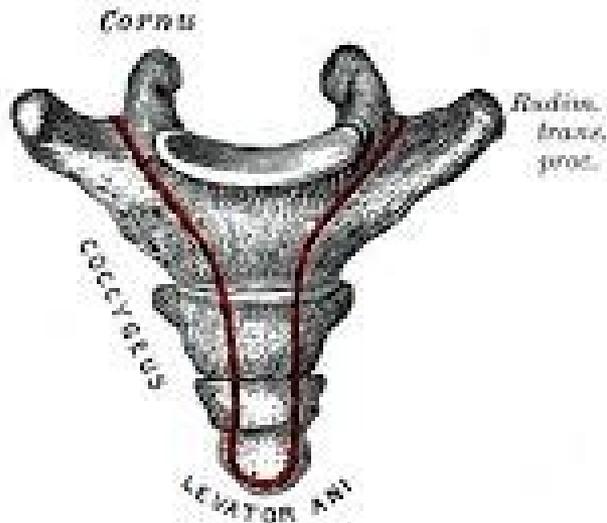
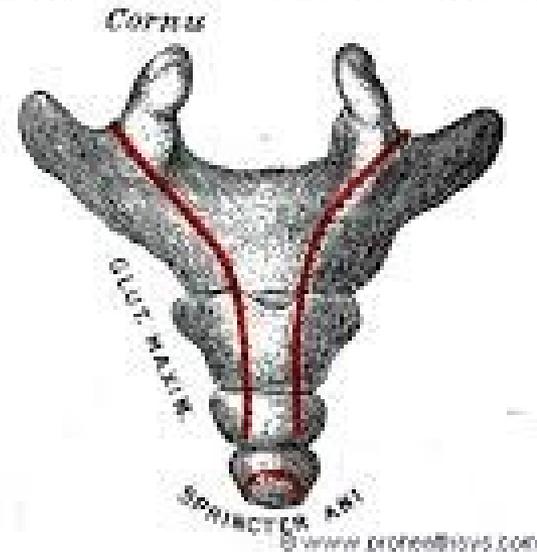
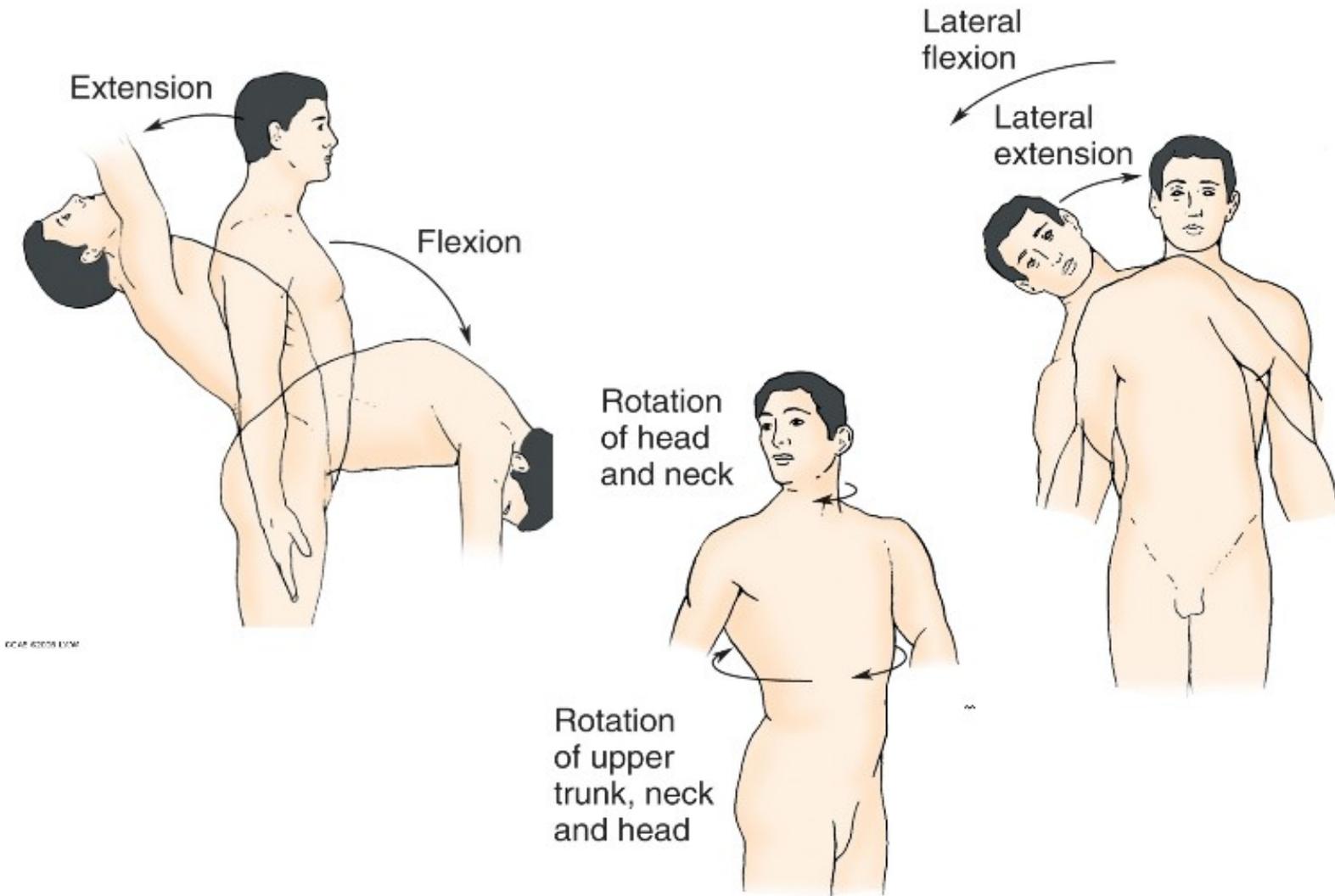


FIG. 285.—The coccyx. Posterior aspect.



Movements of the vertebral column

- ▶ Flexion (to bend)
- ▶ Extension (to stretch out)
- ▶ Hyperextension
- ▶ Lateral flexion
- ▶ Rotation – right and left rotate

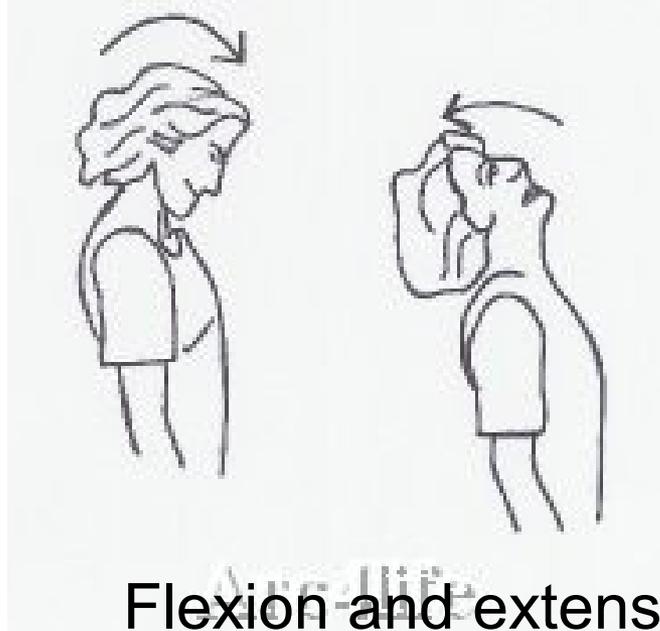


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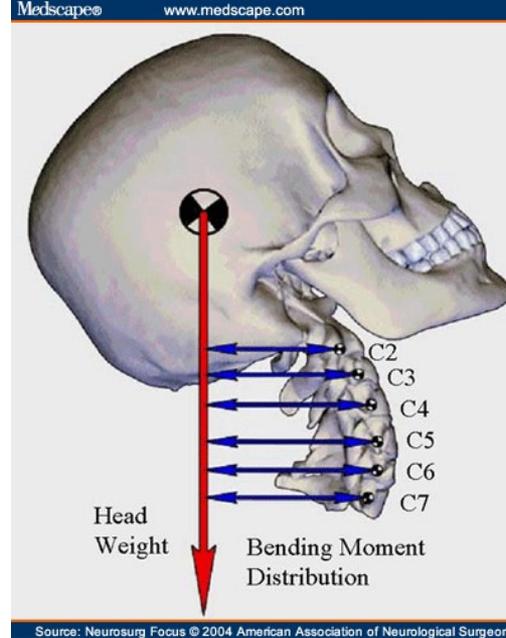
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Cervical Motion

- ▶ **Flexion:** C1 (atlas): allows for forward and backward motion of the head.
- ▶ **Extension:** Straightening the joint, moving the spine back
- ▶ **Lateral Flexion (Abduction):** moving the spine to the side (left or right); the neck moves toward the shoulder.
- ▶ **Rotation:** C2 (axis) for rotation making a "no" motion. Turning the spine to the side (right or left); the neck turns toward the shoulder.



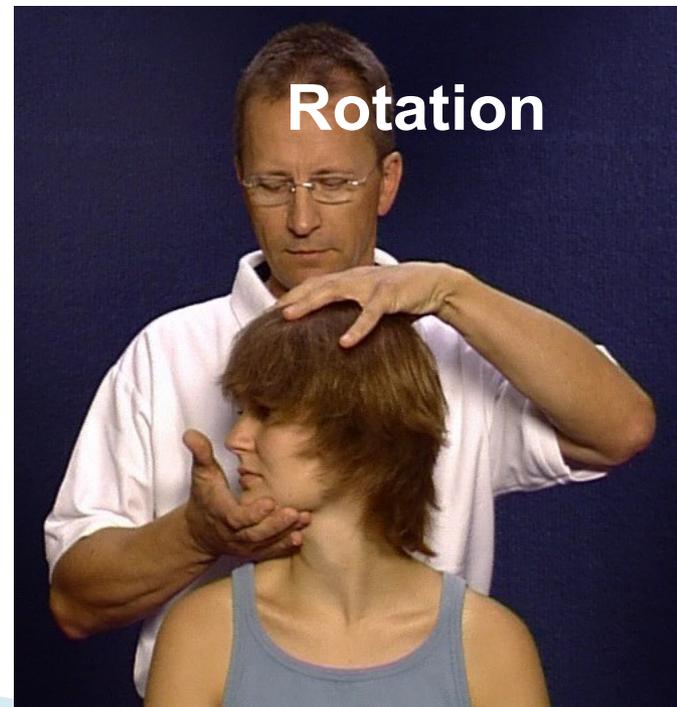
Flexion and extension



Source: Neurosurg Focus © 2004 American Association of Neurological Surgeons



Lateral flexion



Thoracic, Lumbar

- ▶ **Flexion:** moving the spine forward, the thorax moves toward the pelvis.
- ▶ **Extension / Hyperextension:** Straightening the joint by moving the spine back, the thorax moves away from the pelvis.
- ▶ **Lateral Flexion (Abduction):** moving the spine to the side (left or right), the thorax moves to the side toward the pelvis.
- ▶ **Rotation:** turning the spine to the side (right or left); the thorax rotates to one side.

The Spine

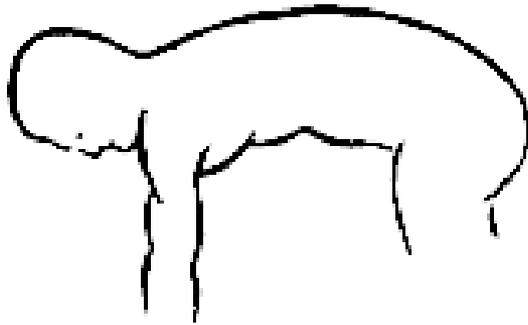


Fig. 5
Forward bending
(flexion)

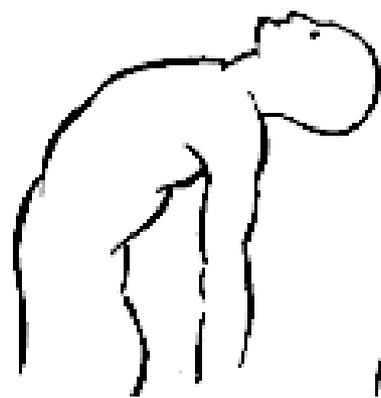


Fig. 6
Backward Bending
(extension)



Fig. 7
Lateral bending
right and left

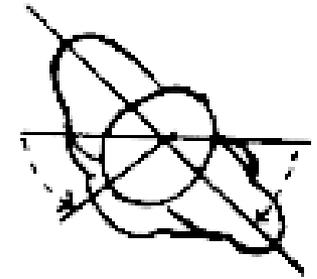


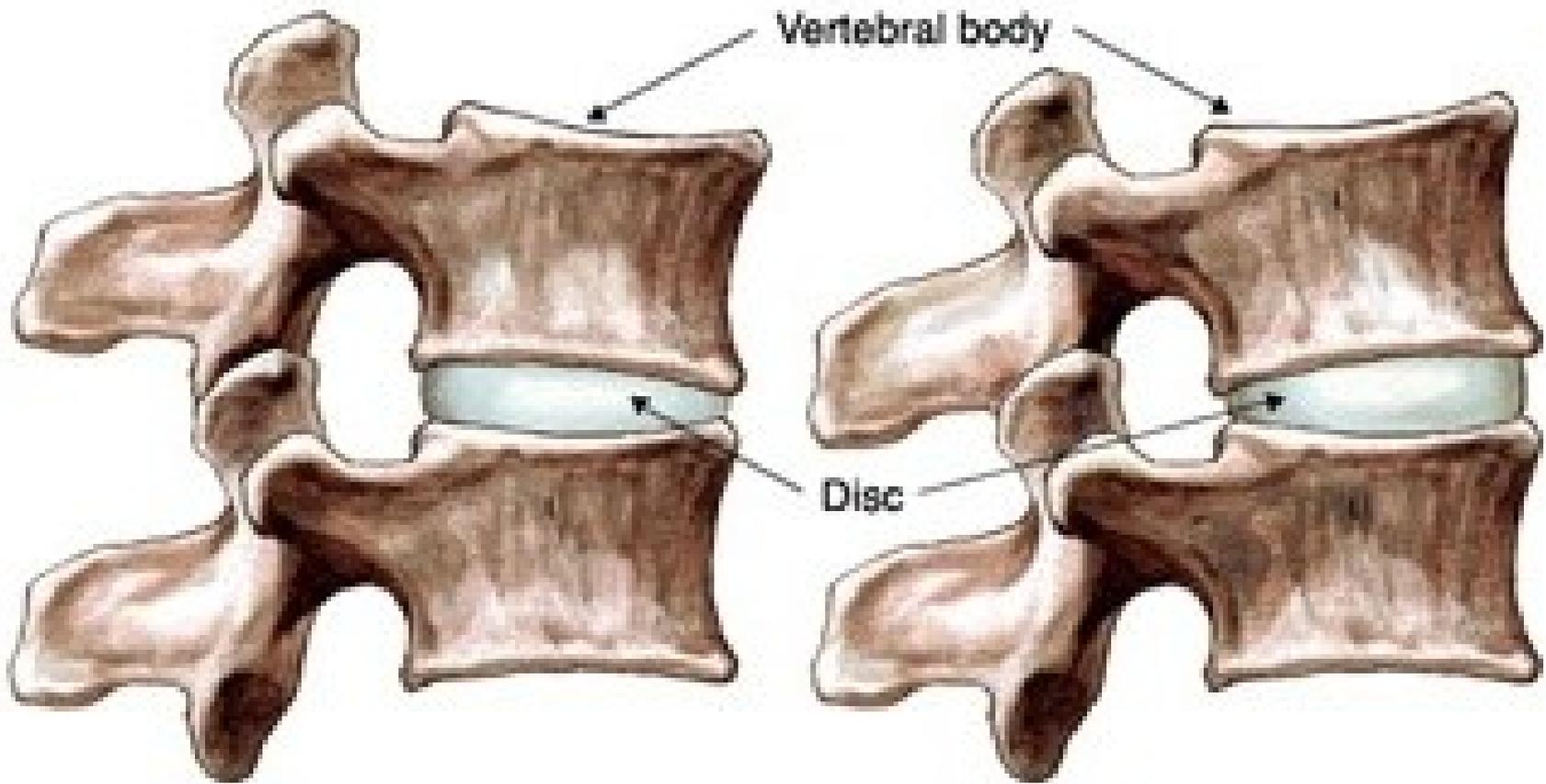
Fig. 8
Rotation,
right and left



Rotation



Lateral flexion



Flexion (Bending Forward)

Extension (Bending Backward)

- ▶ **Hyperextension** is a straightening movement that goes beyond the normal, healthy boundaries of the joint

