

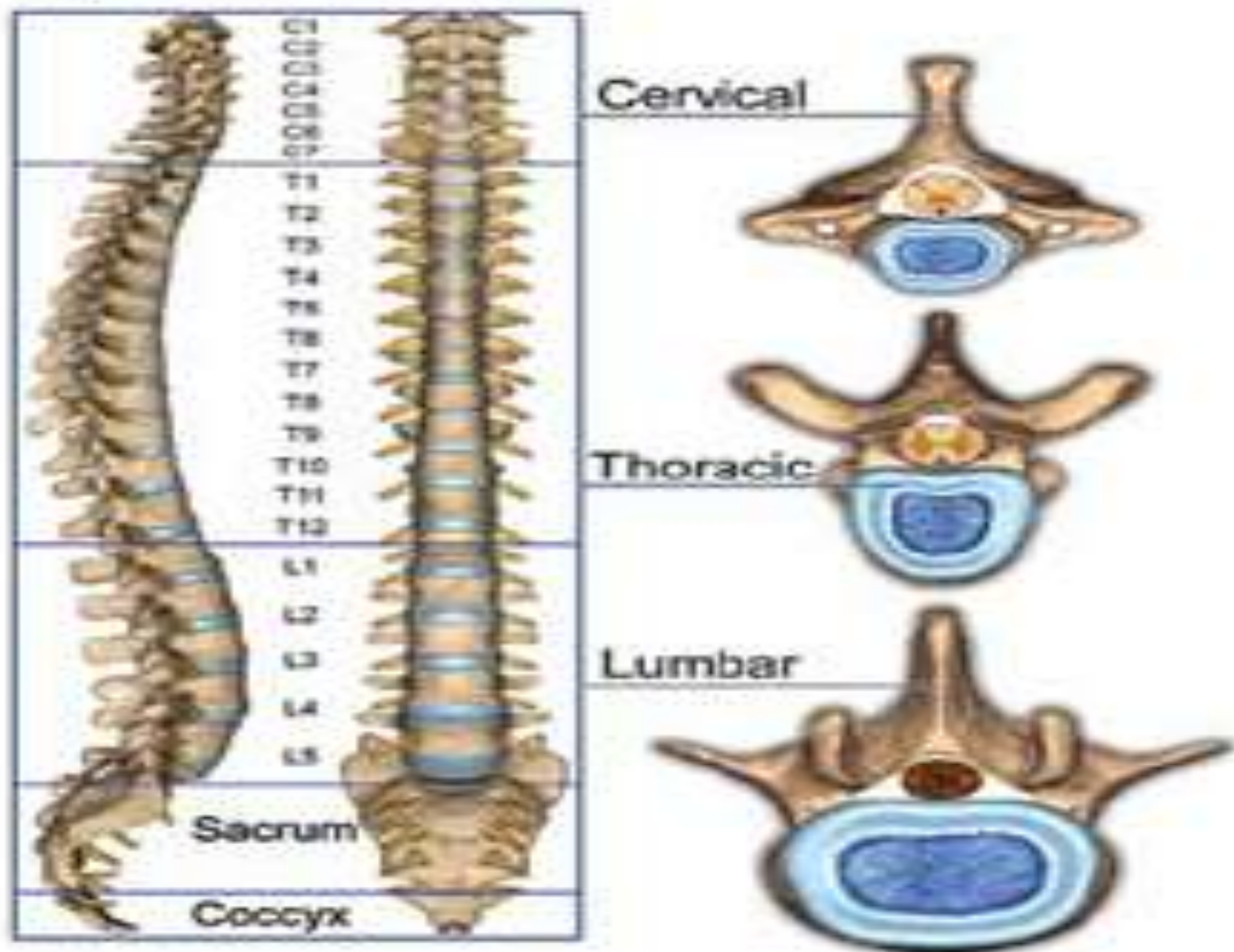


والدین کو پیار سے دیکھنا
بھی عبادت ہے۔

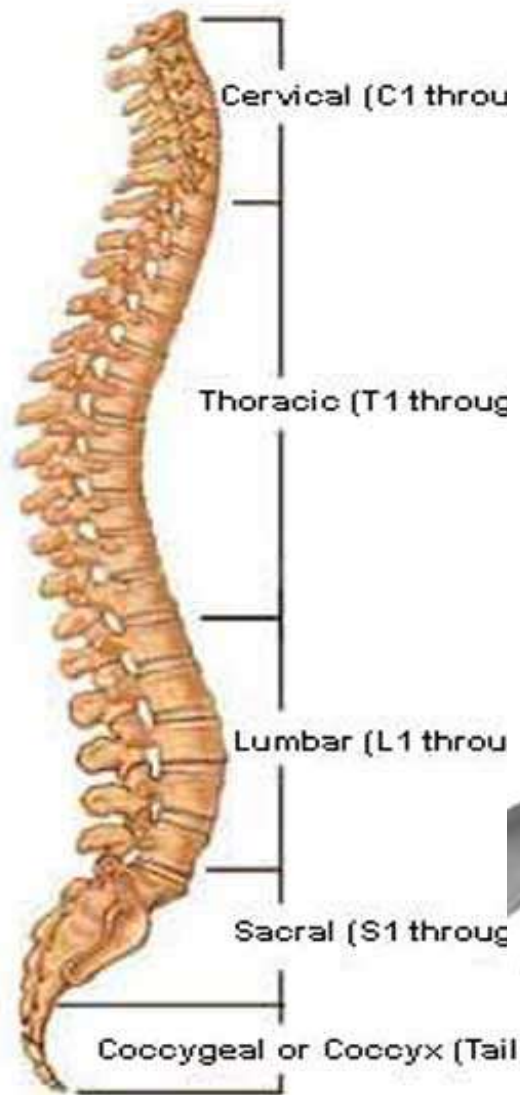
Biomechanics of Human Spine



Spine Anatomy

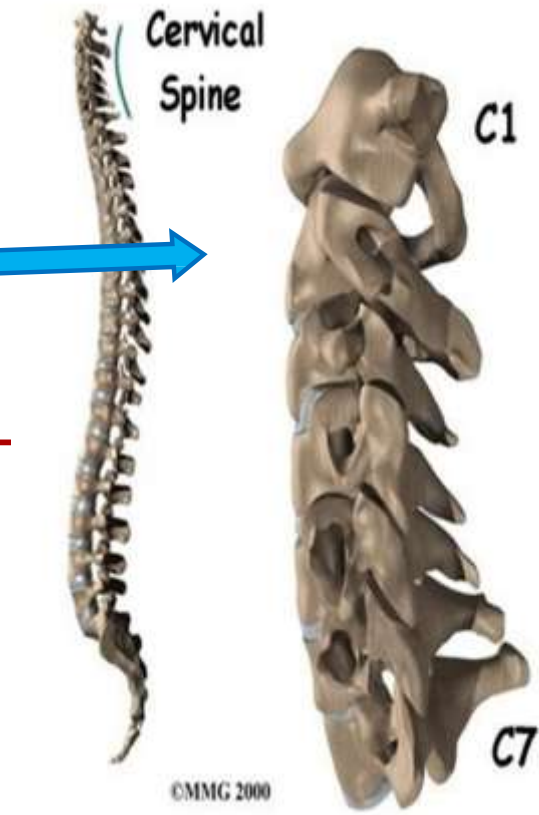
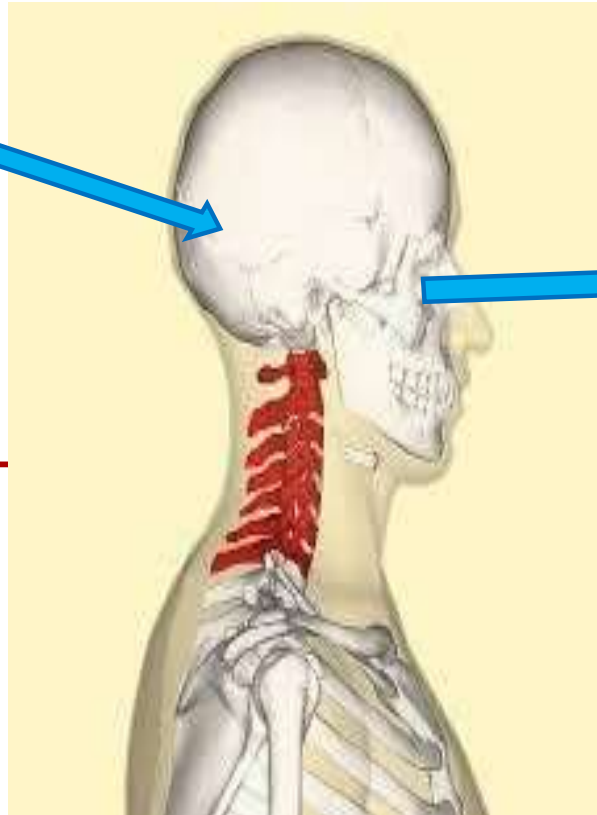


Lateral (Side) View of Normal Spinal Column



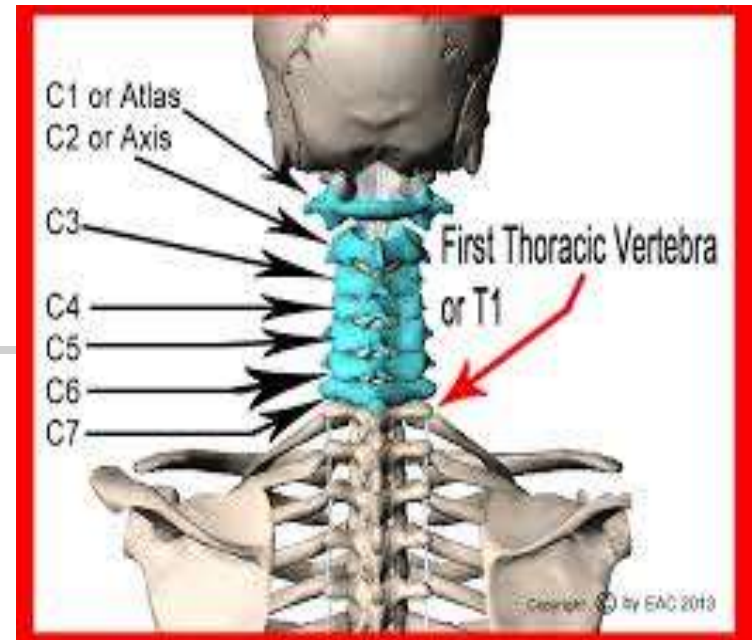
©MMG 2002

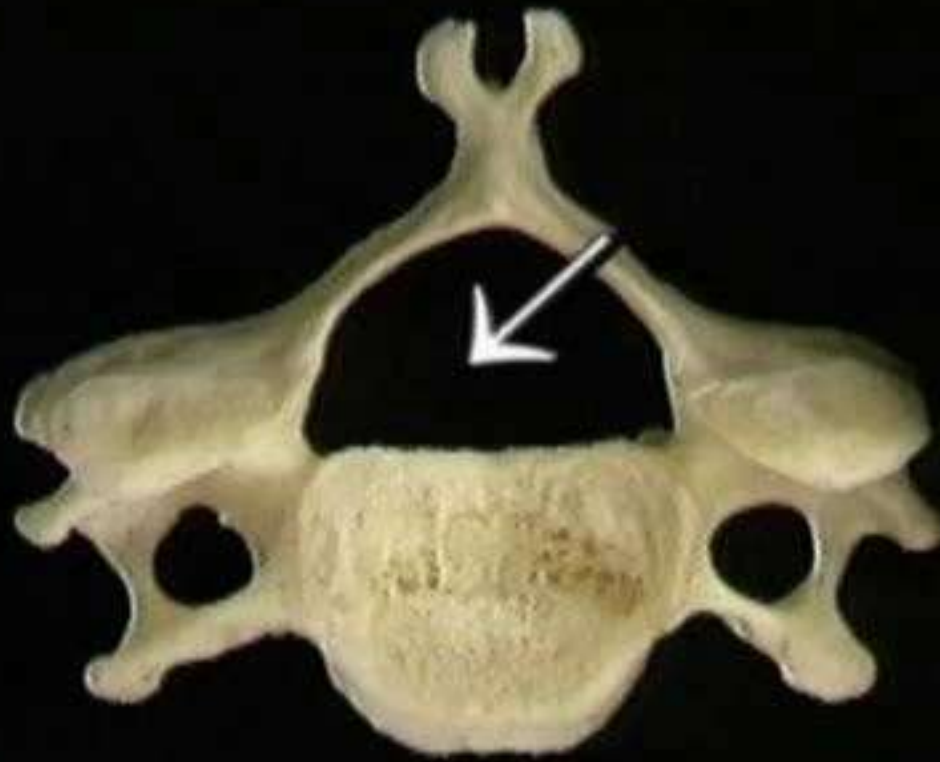
CERVIAL SPINE



Cervical Spine


- Seven vertebrae **C 1-7**
- More flexible
- Supports the head
- Wide range of motion
 - Rotation to left and right
 - Flexion extension
 - Up and down
- Peripheral nerves



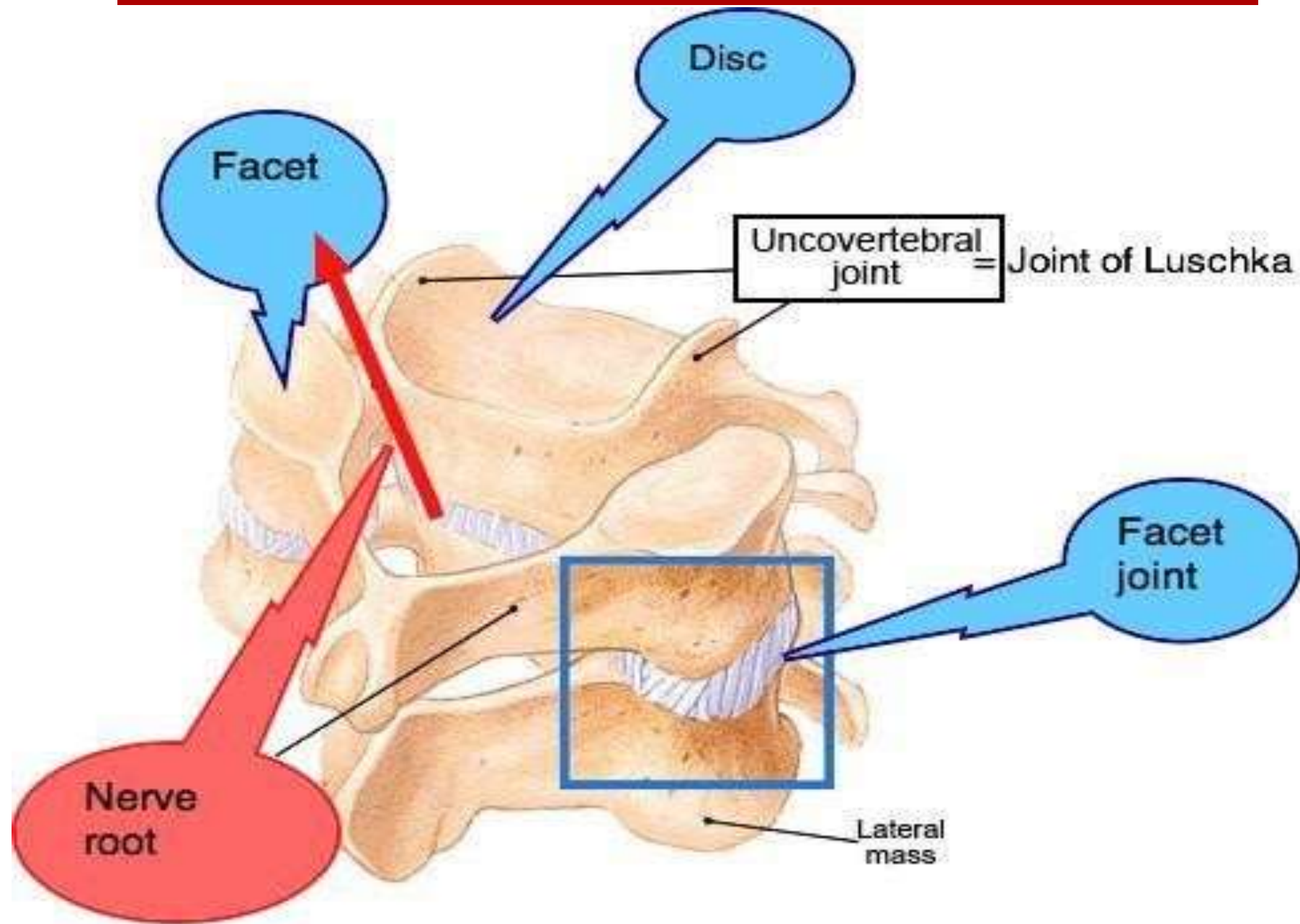


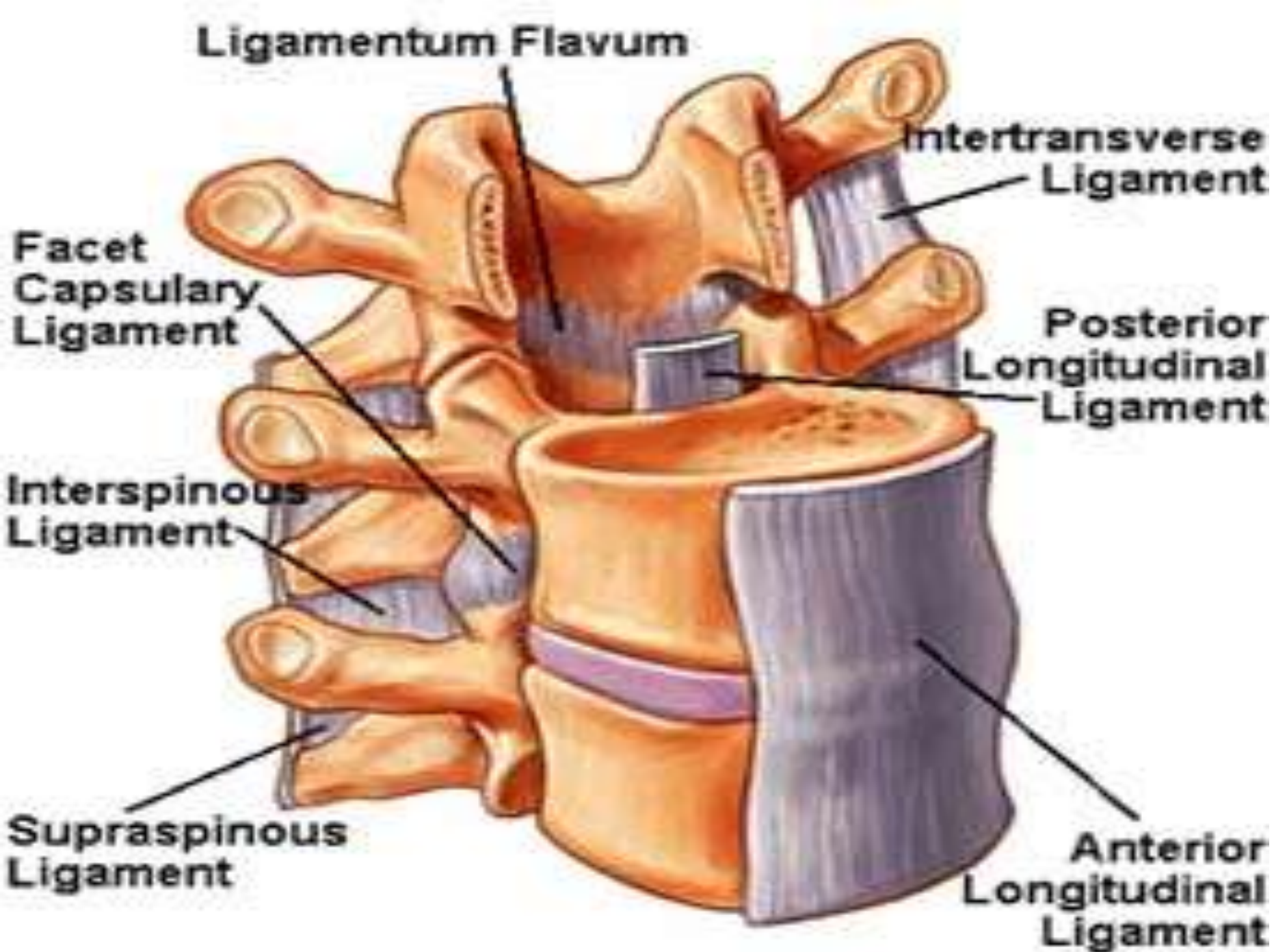
The cervical vertebrae are identified by foramina transversaria
.....vertebral artery

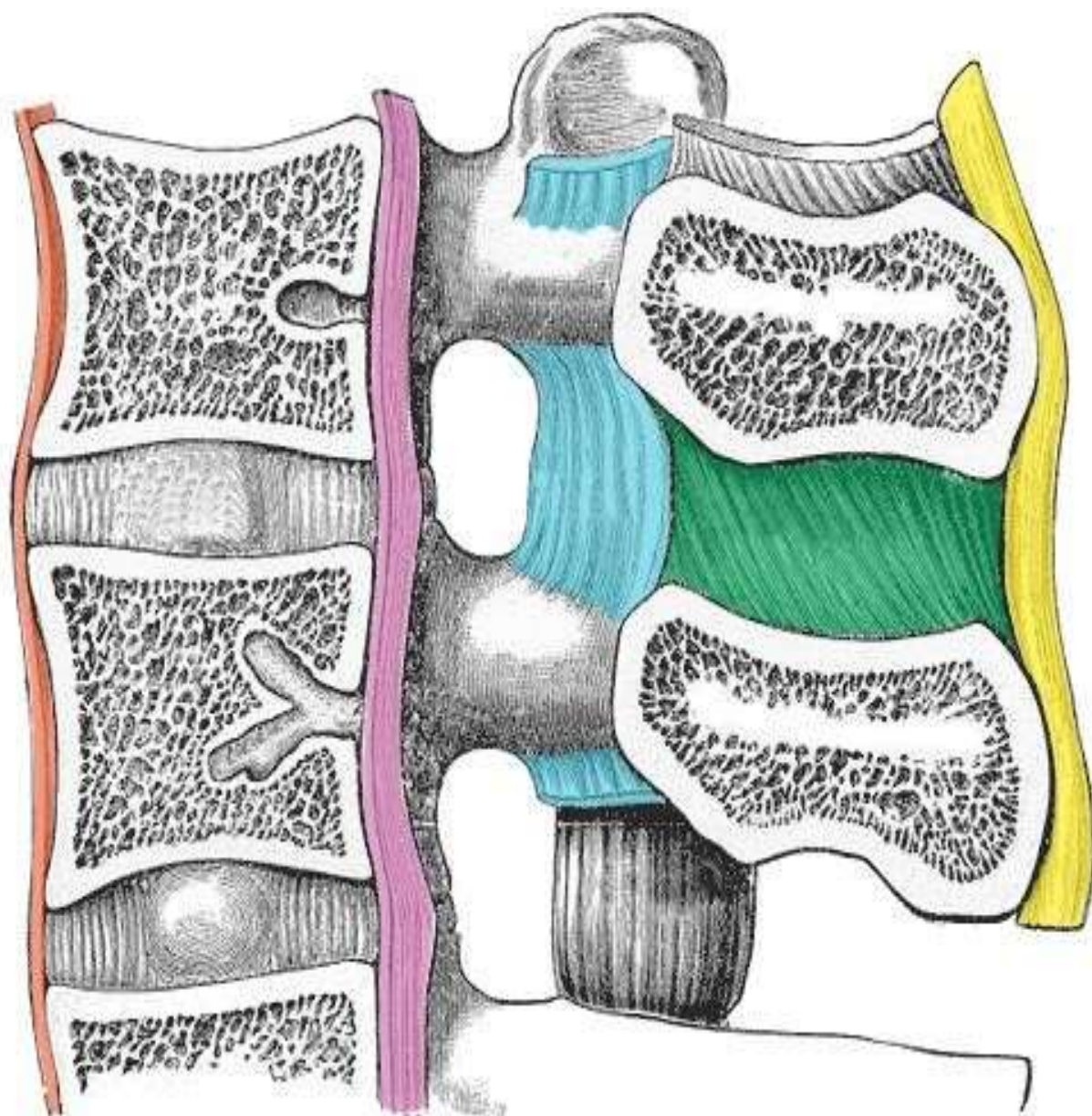







- 
- From C3 to T1 there is a total of 10 saddle- shaped , diarthrodial articulation between the unciniate (lateral) process of adjacent body known as uncovertebral joints.
 - They also facilitate the mobility of lower cervical spine.
-

Joint of Luschka



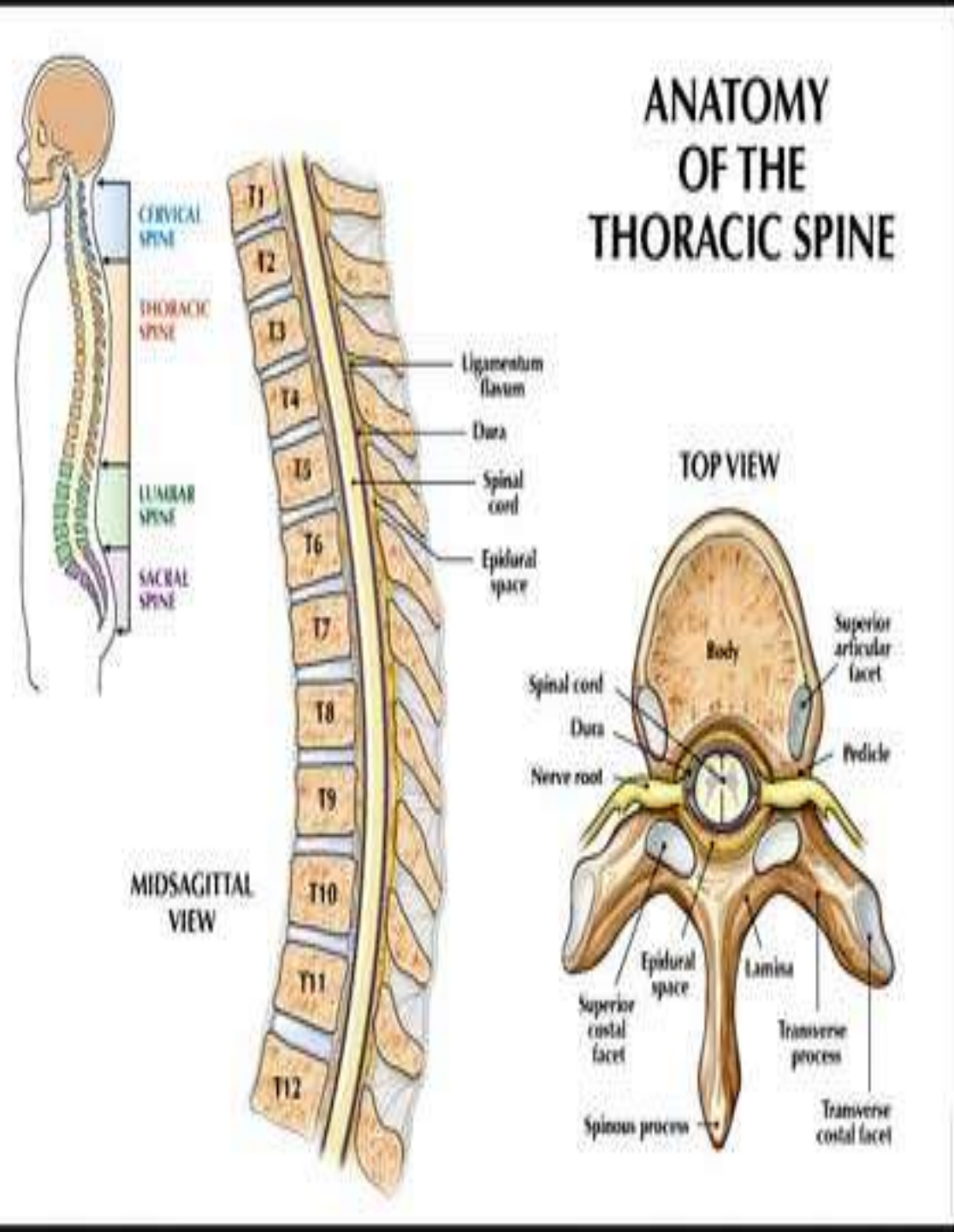


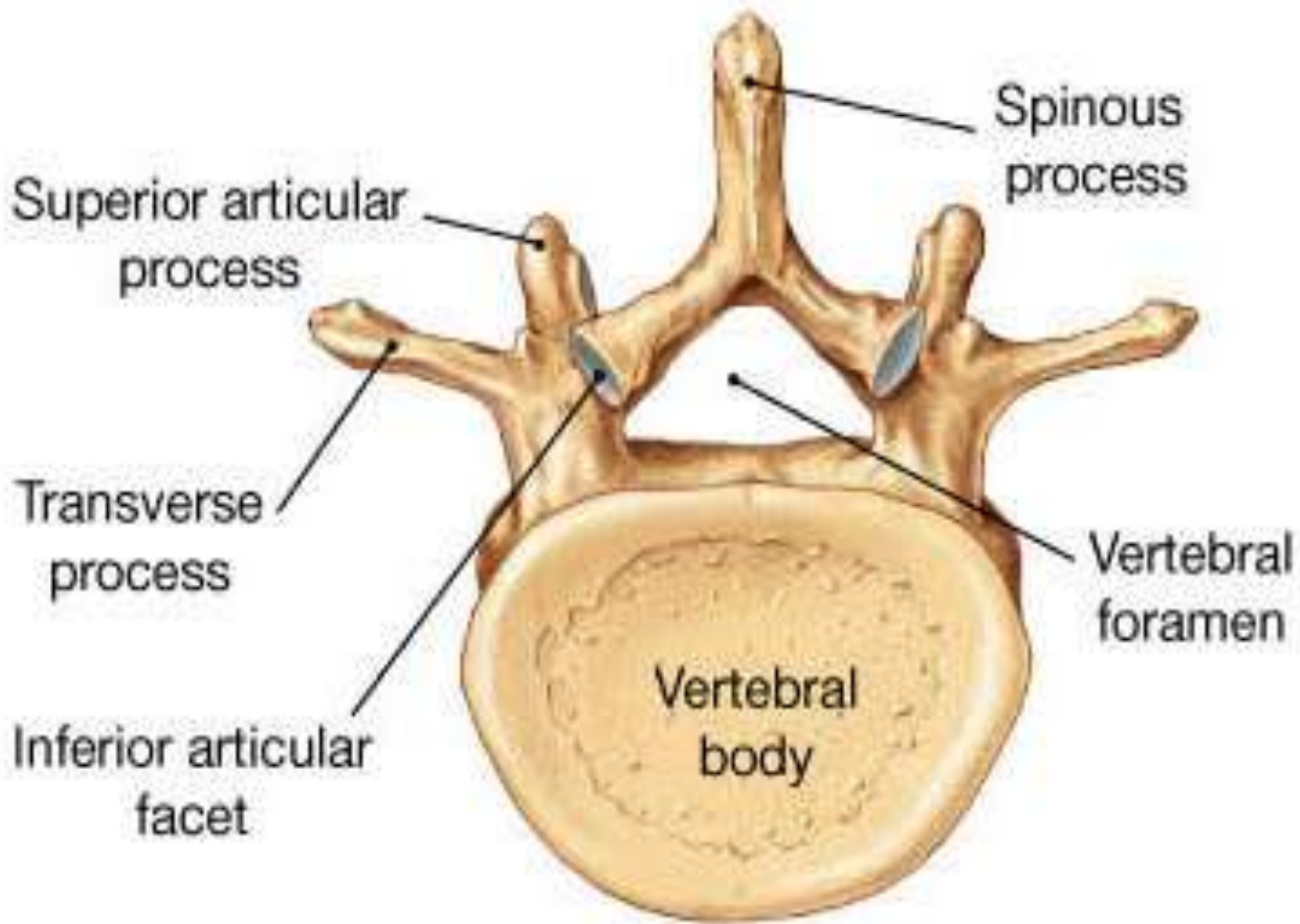


-  Anterior longit. ligament
-  Posterior longit. ligament
-  Ligamentum flavum
-  Interspinal ligament
-  Nuchal ligament

Thoracic S

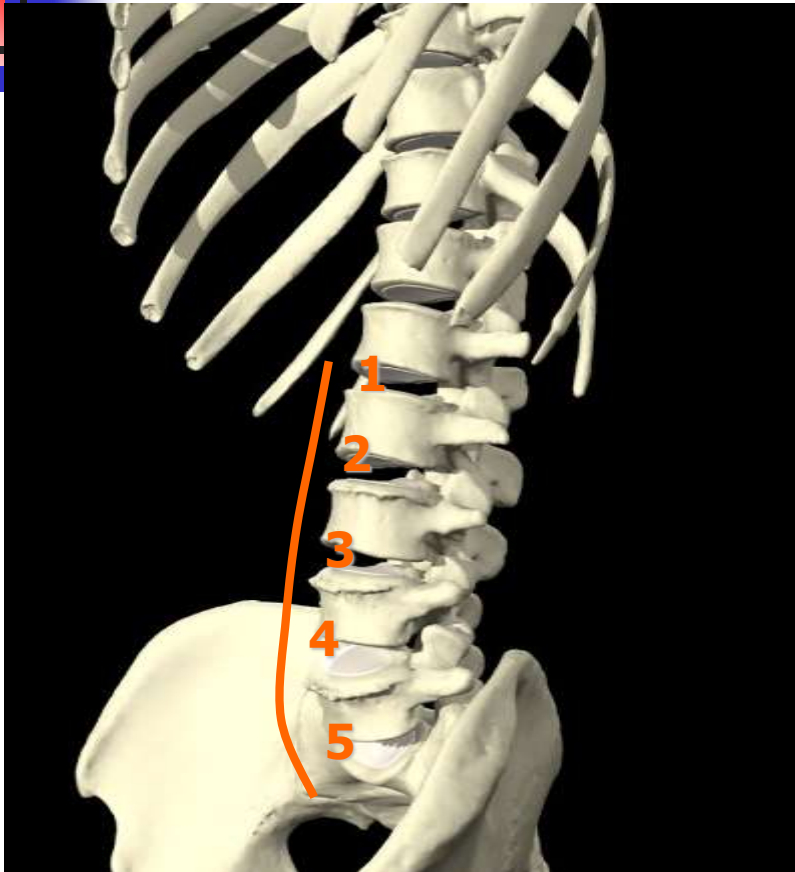
- Mid-back or dorsal region
- Twelve vertebrae
 - **T 1-12**
- Ribs attached to vertebrae
- Relatively immobile
- Peripheral nerves
 - Intercostal





(b) Inferior view

Lumbar Anatomy



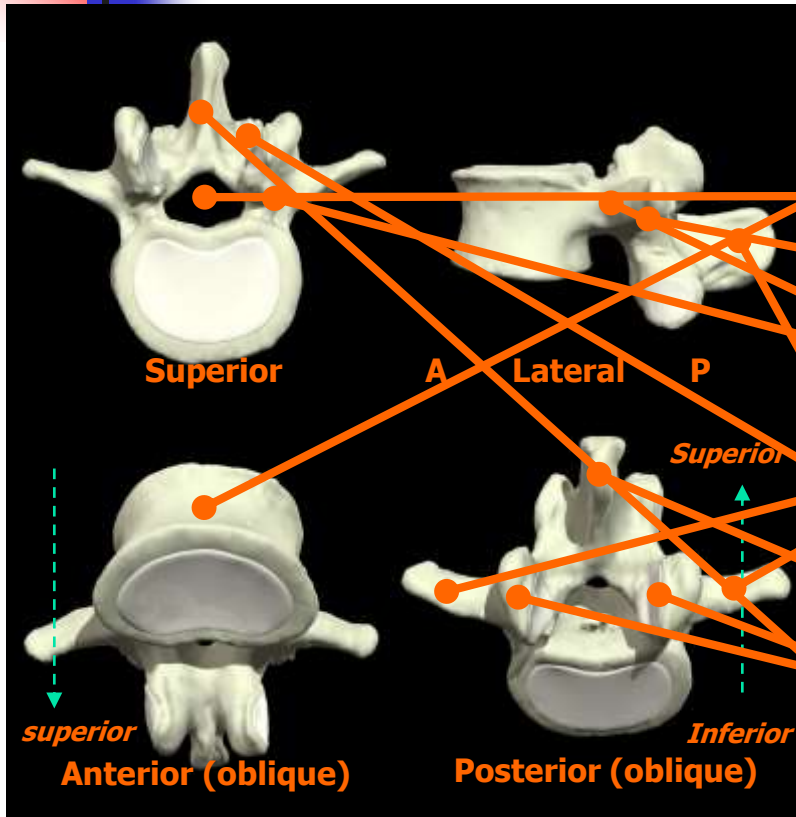
- 5 vertebrae L1-L5
- 5 intervertebral discs
- 5 pair of exiting nerve roots
- Lumbar lordosis L1-S1
 - The apex of lumbar lordosis L3-L4

Lumbar Spin

- Lower back
- Carries the weight of the upper body
 - Larger, broader
- Peripheral nerves



Lumbar Spine Anatomy



- Typical lumbar vertebra (L2)

- Body
- Vertebral foramen/canal
- Intervertebral foramen
- Pedicle
- Transverse process
- Lamina
- Spinous process
- Facet joints
- Pars interarticularis

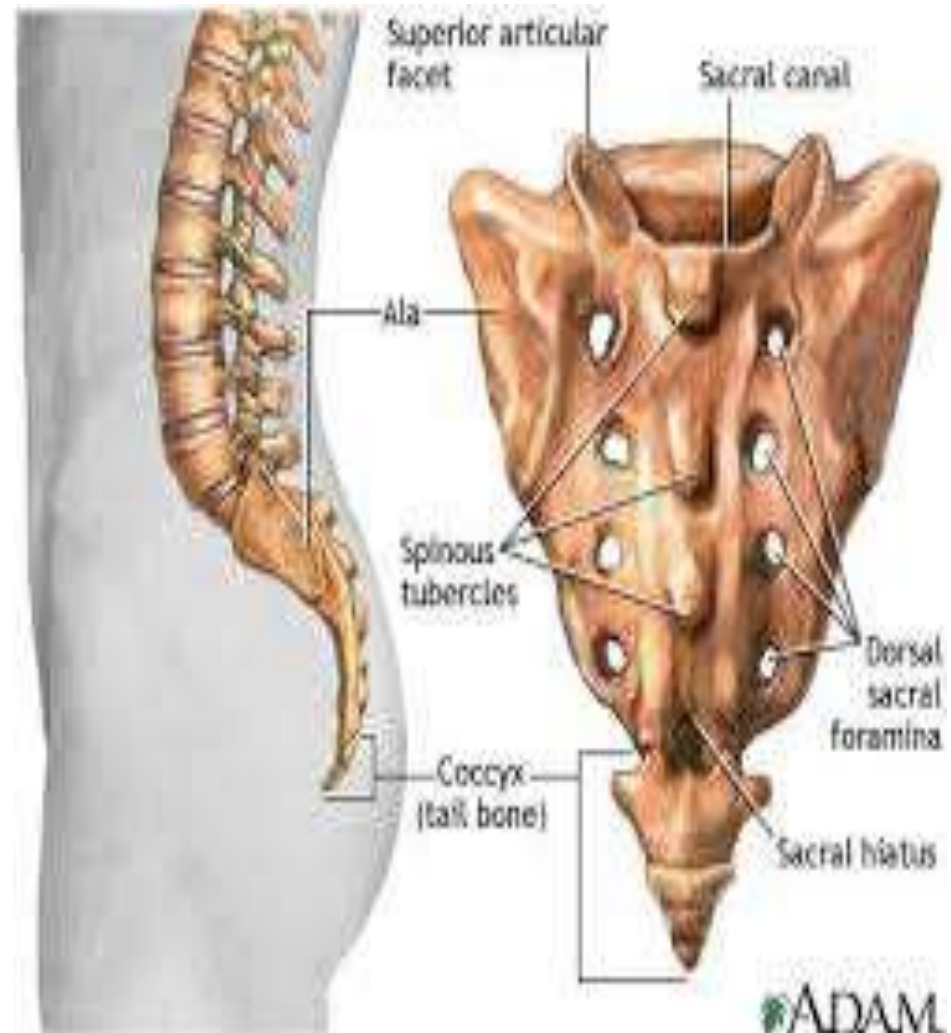
Sacral and Coccygeal region

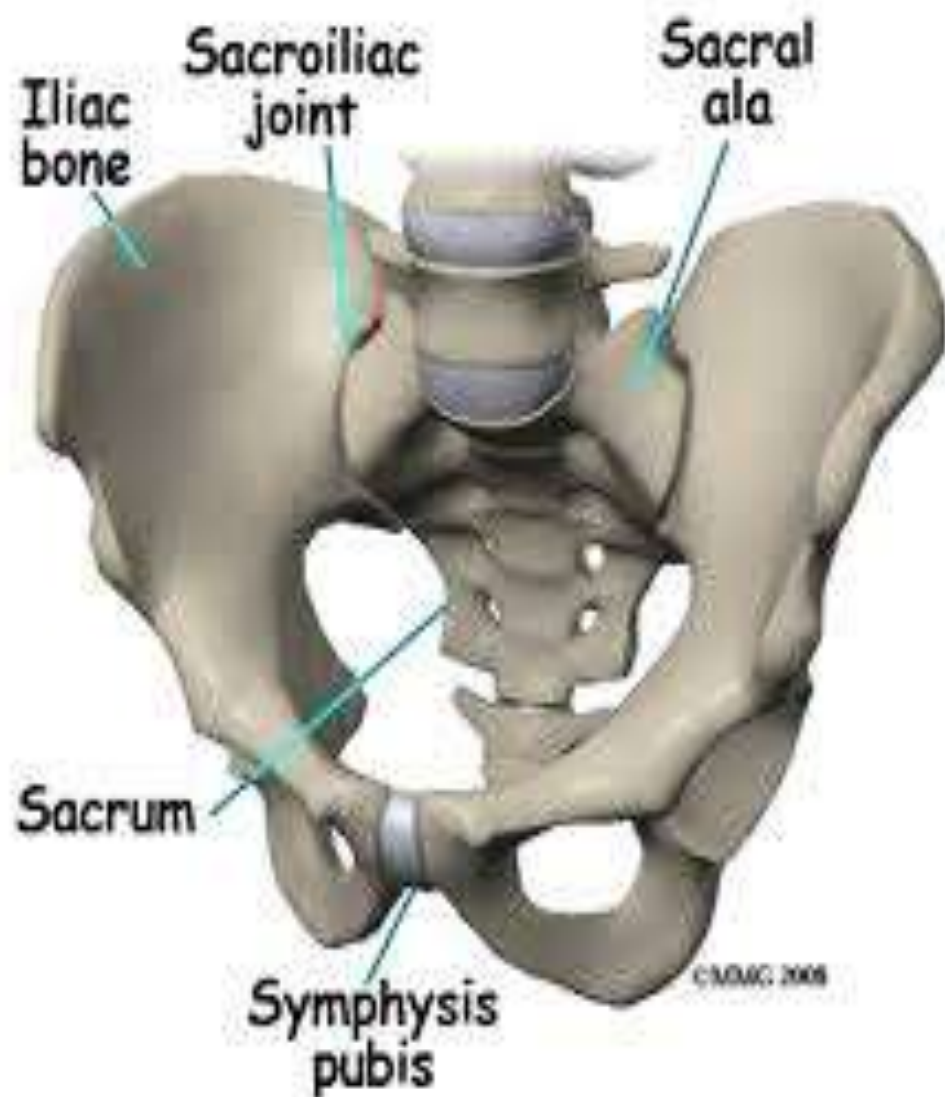
■ *Sacrum*

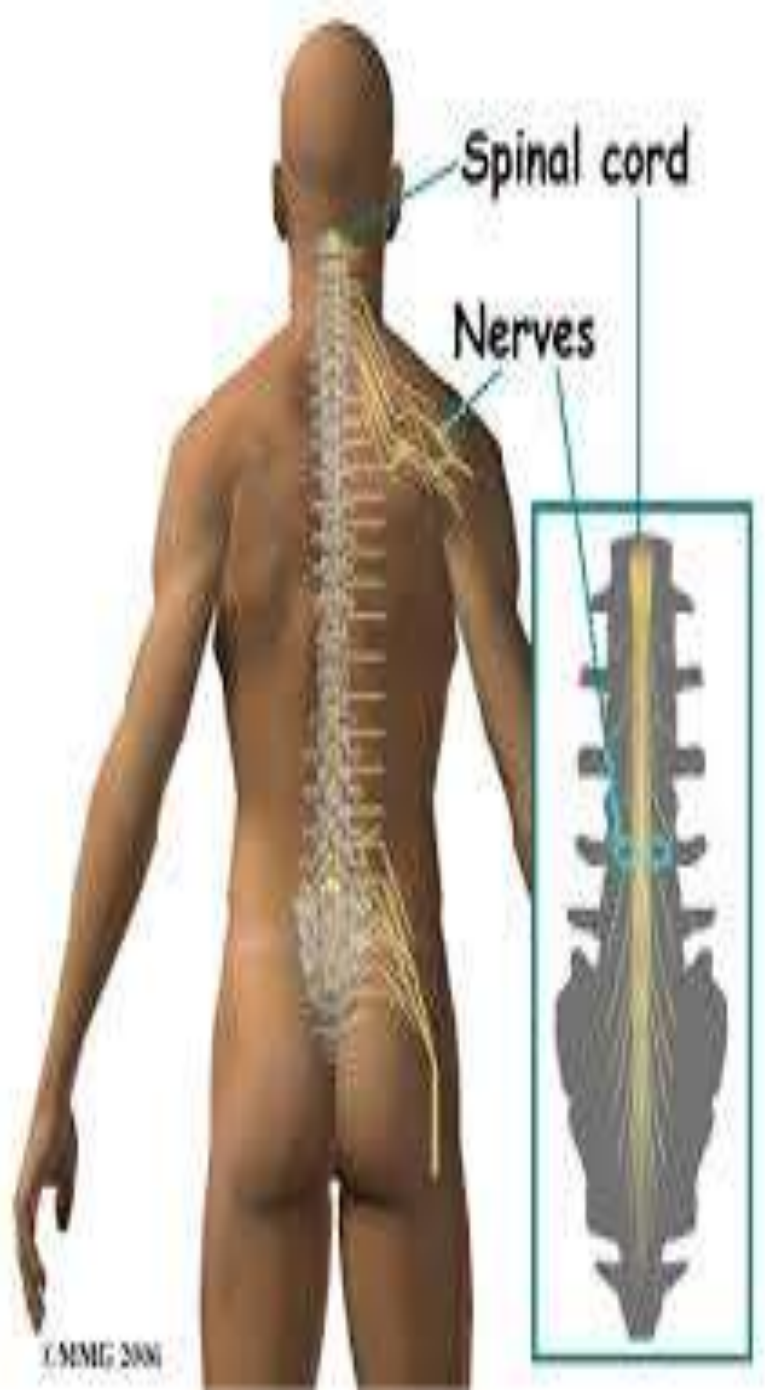
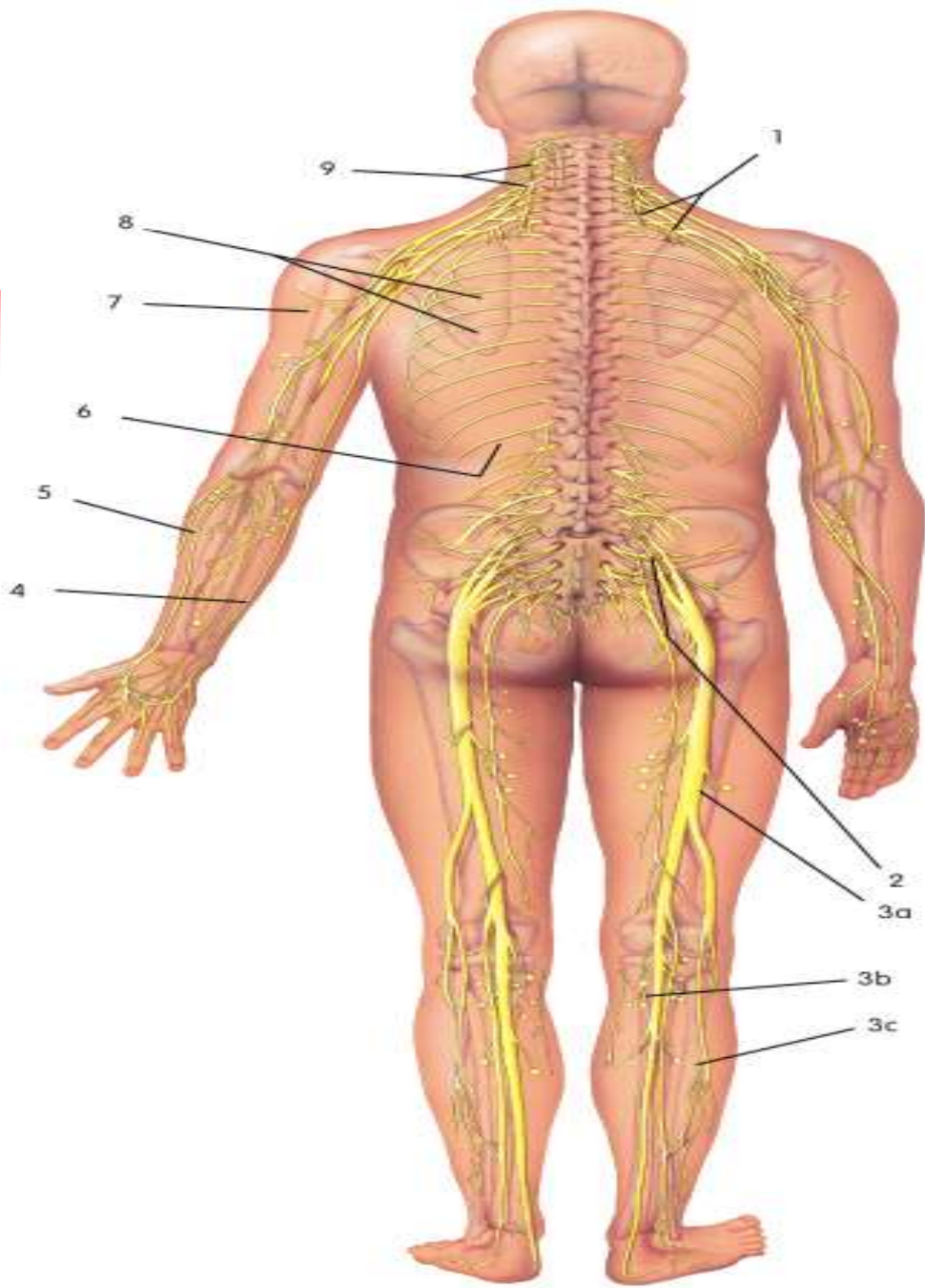
- Triangular structure
- Base of the spine
- Connects spine to pelvis
- Nerves to pelvic organs

■ *Coccyx*

- Few small bones
- Remnant of tail



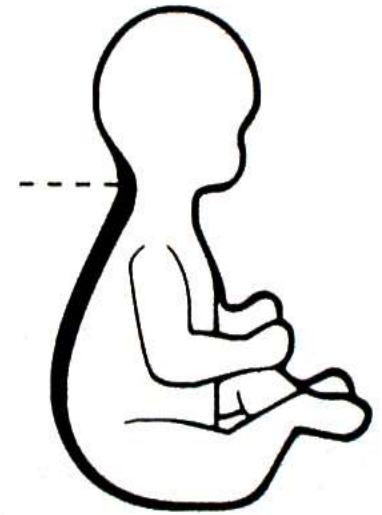




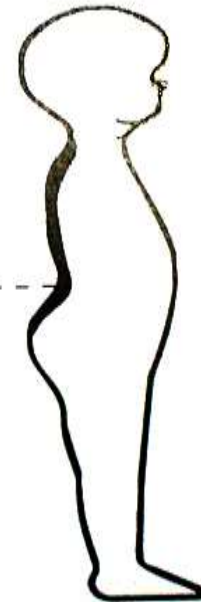
Lordosis

- In the sagittal plane
 - 'S' shape
- As a small child(c shaped)
 - When starts to sit-→**Cervical Lordosis**
- Toddler and adult
 - When starts to stand-
→**Lumbar Lordosis**
 - Allows spring-like action

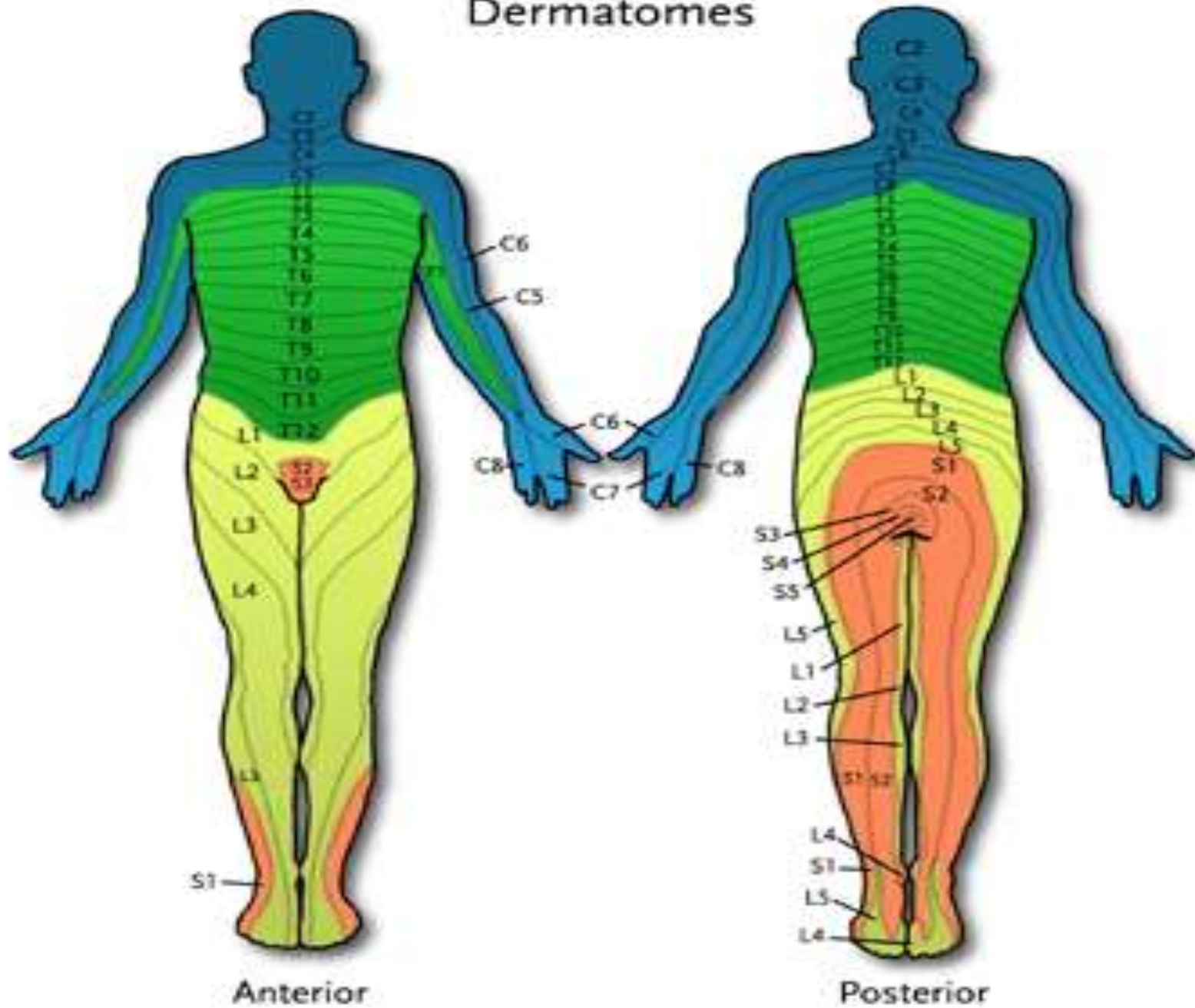
cervical
lordosis



lumbar
lordosis



Dermatomes



Orientation of facet joints with respect to transverse plane



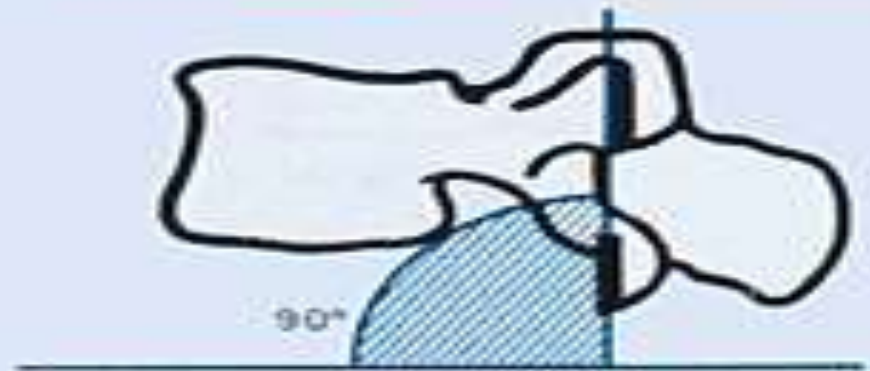
Vertèbre cervicale

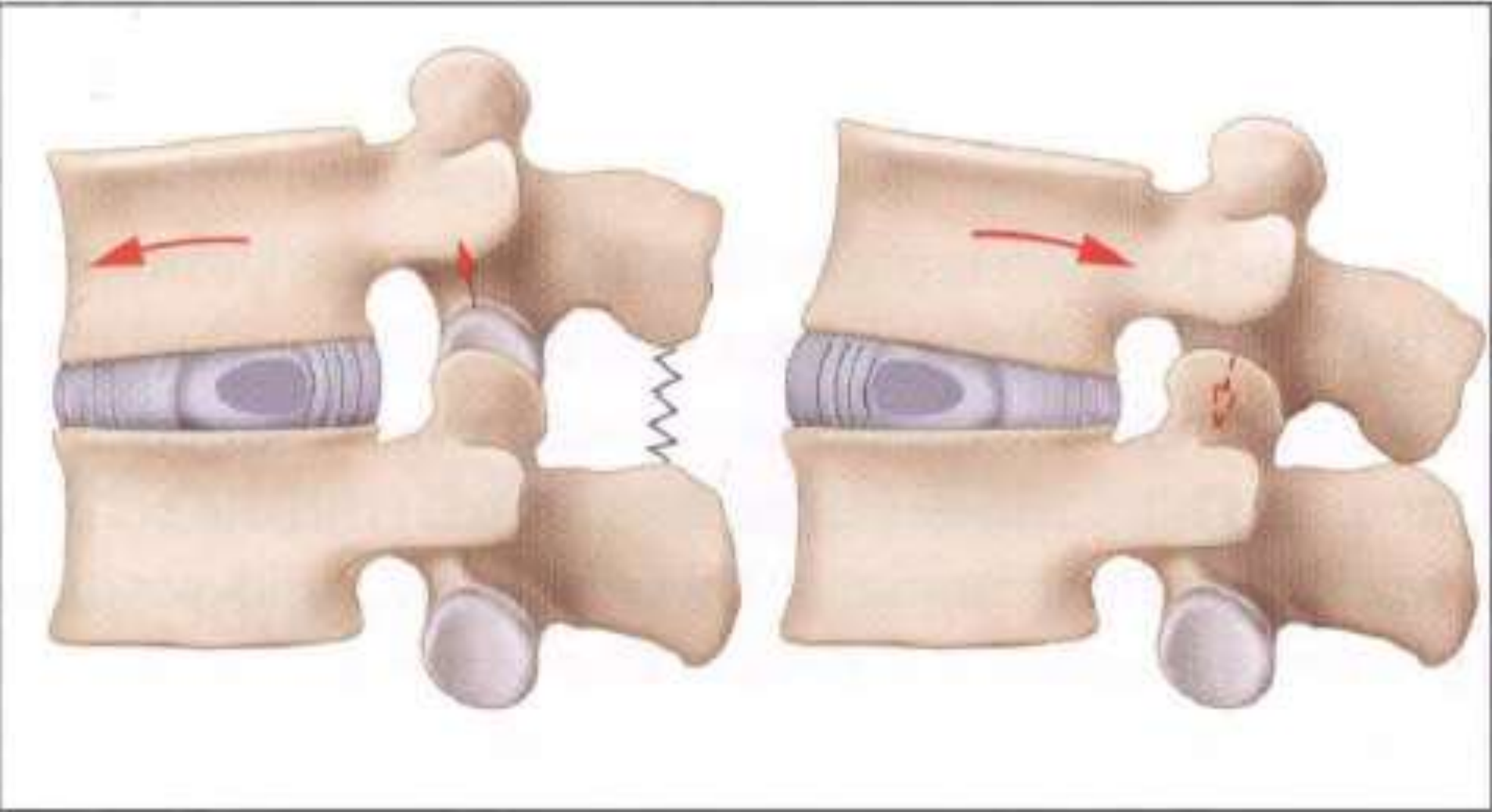


Vertèbre dorsale

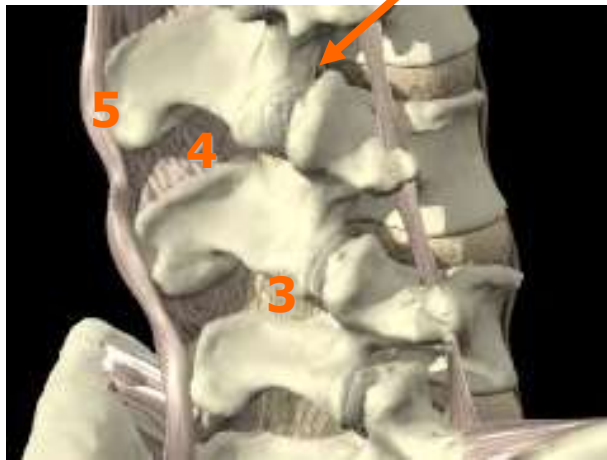


Vertèbre lombaire

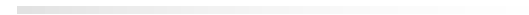
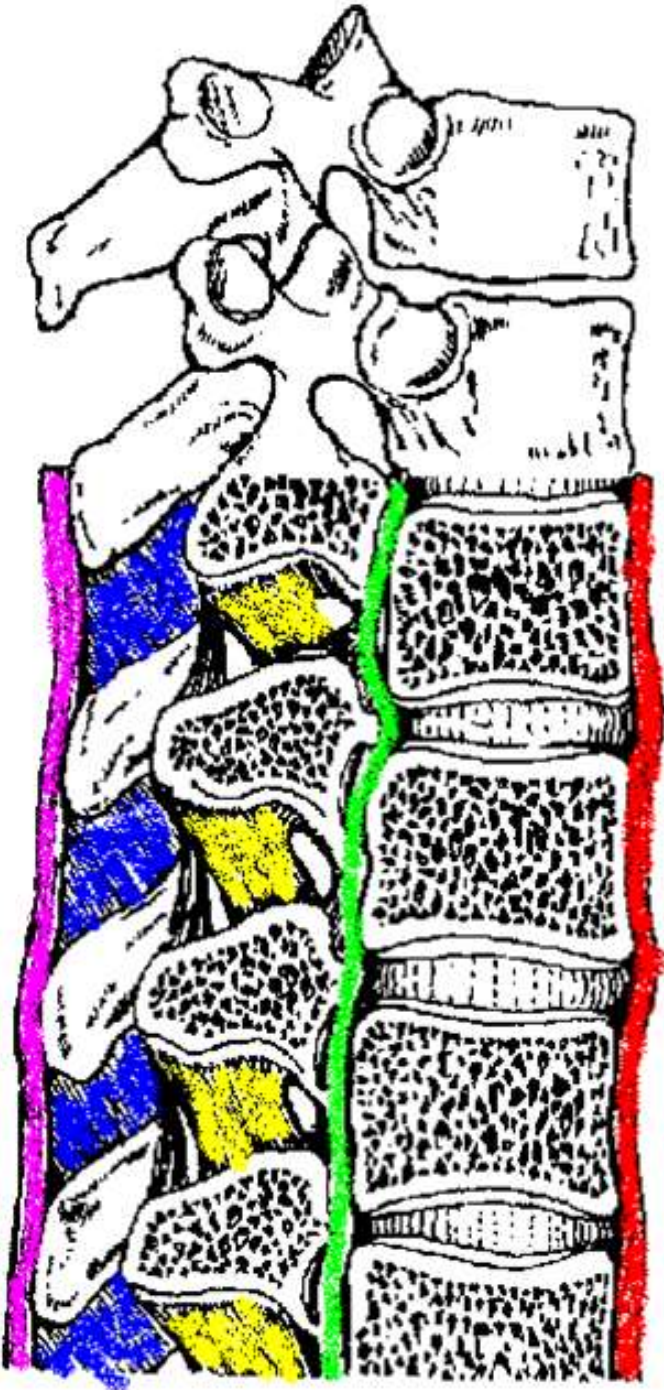
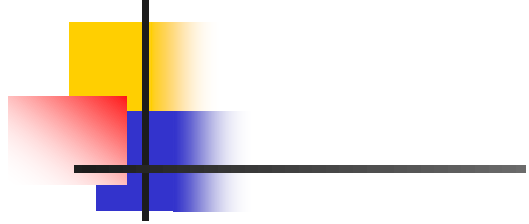




Lumbar Spine ligaments

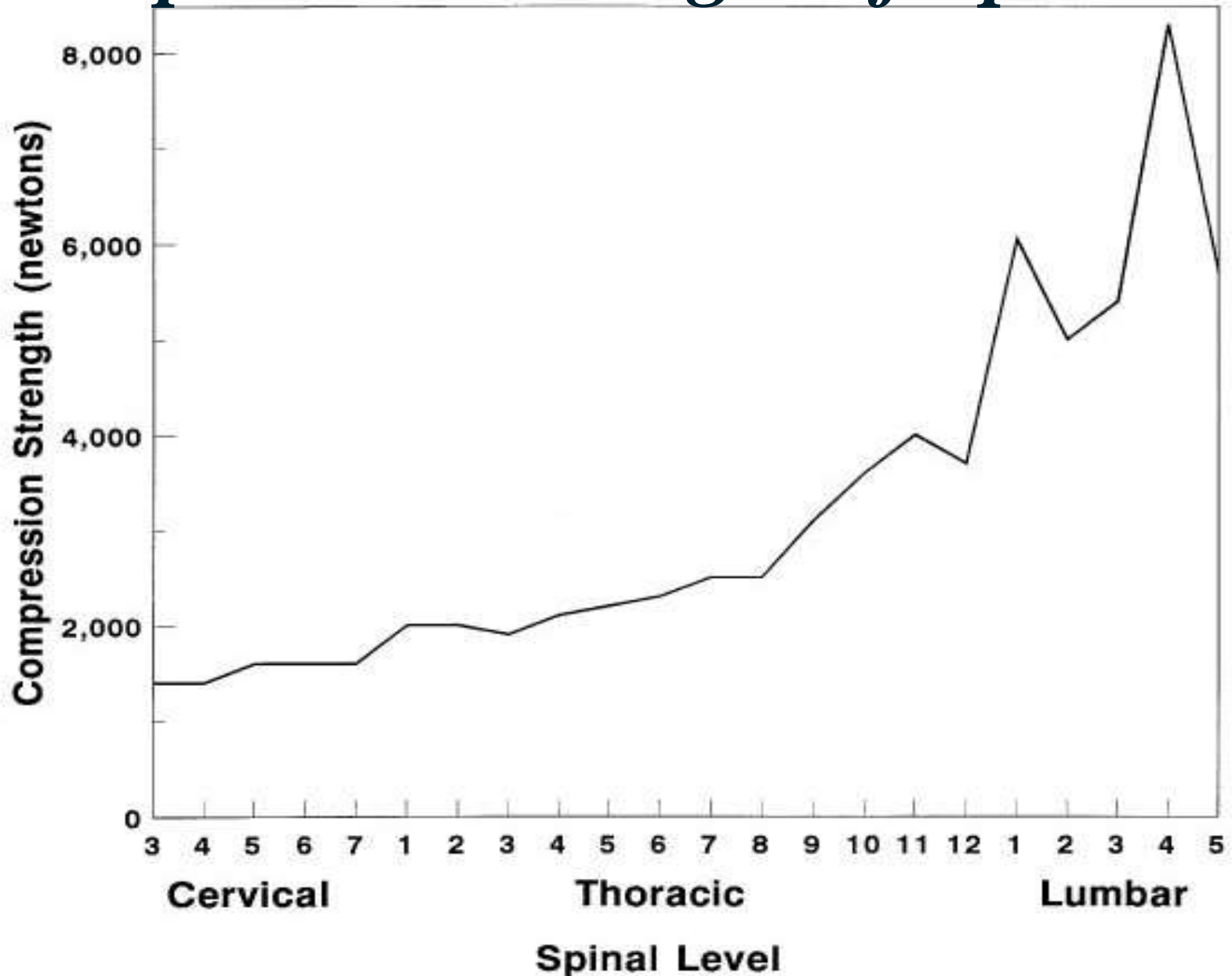


1. **Anterior longitudinal ligament**
2. **Posterior longitudinal ligament**
3. **Ligamentum flavum**
4. **Interspinous ligaments**
5. **Supraspinous ligament**
6. **Intertransverse ligaments**

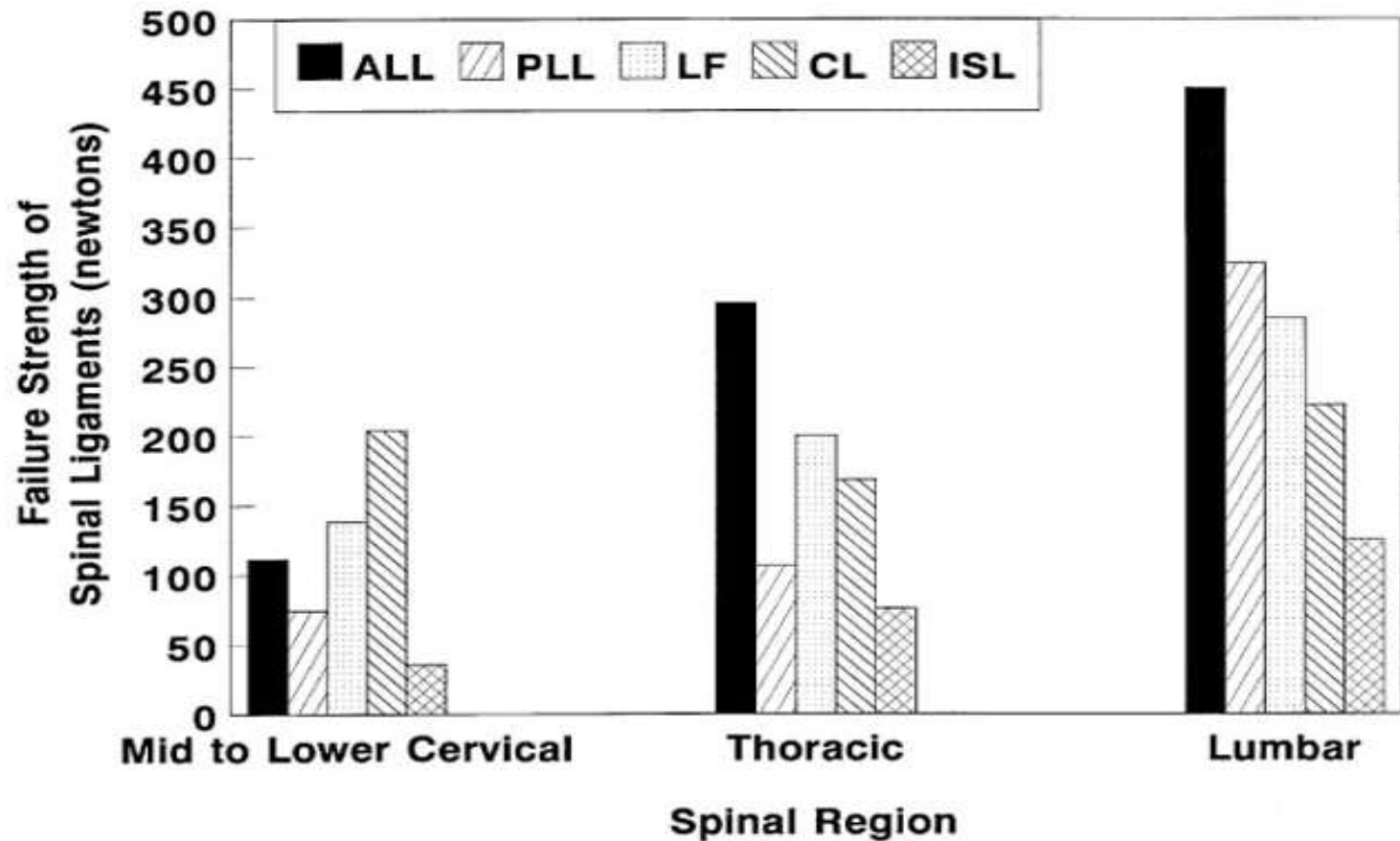


|

Compressive Strength of Spine



Failure Strength of Spinal Ligaments



ALL= anterior longitudinal ligament PLL=posterior longitudinal ligament
LF = ligamentum flavum CL = capsular ligament
ISL= interspinous ligament

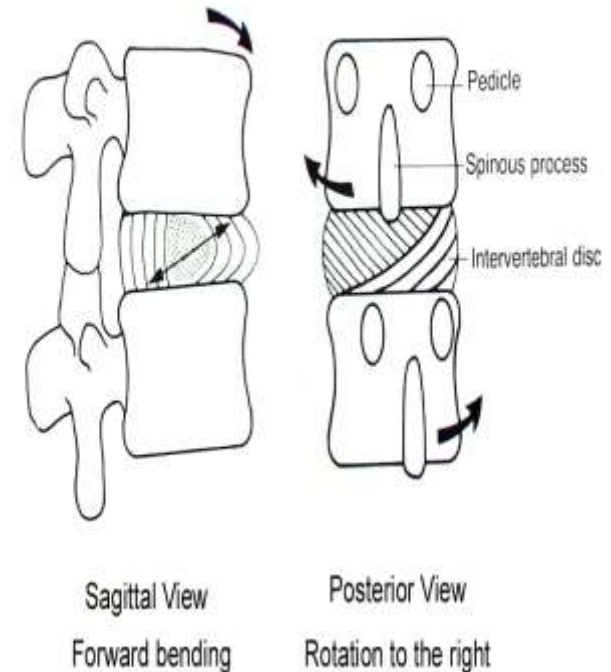
The L5-S1 Segment is the most common site of problem in the spine ???



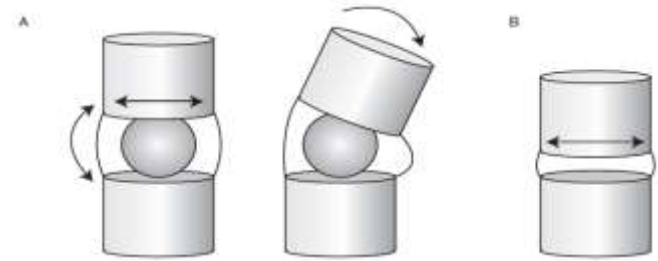
- This level bears more weight.
- COG pass directly through this vertebra
- Transition L5 Mobile and S1 Stable
- Large angle B/w L5 & S1
- Great amount of movement

Motion Segment

- Two adjacent vertebrae
- Intervertebral disc
- (facet joints)
- Six degrees of freedom
 - Flexion-extension
 - Lateral flexion
- Axial rotation or Rotation (RT & LT)
- Lateral Flexion / Side bending (RT & LT)



Motion segment



- Movement at the spinal segment in relation to the spinal articulations

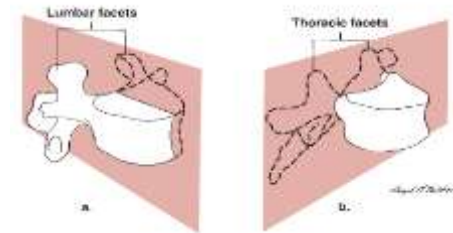
- Motion at the interbody and zygapophyseal joints are interdependent

- **Amount of motion**

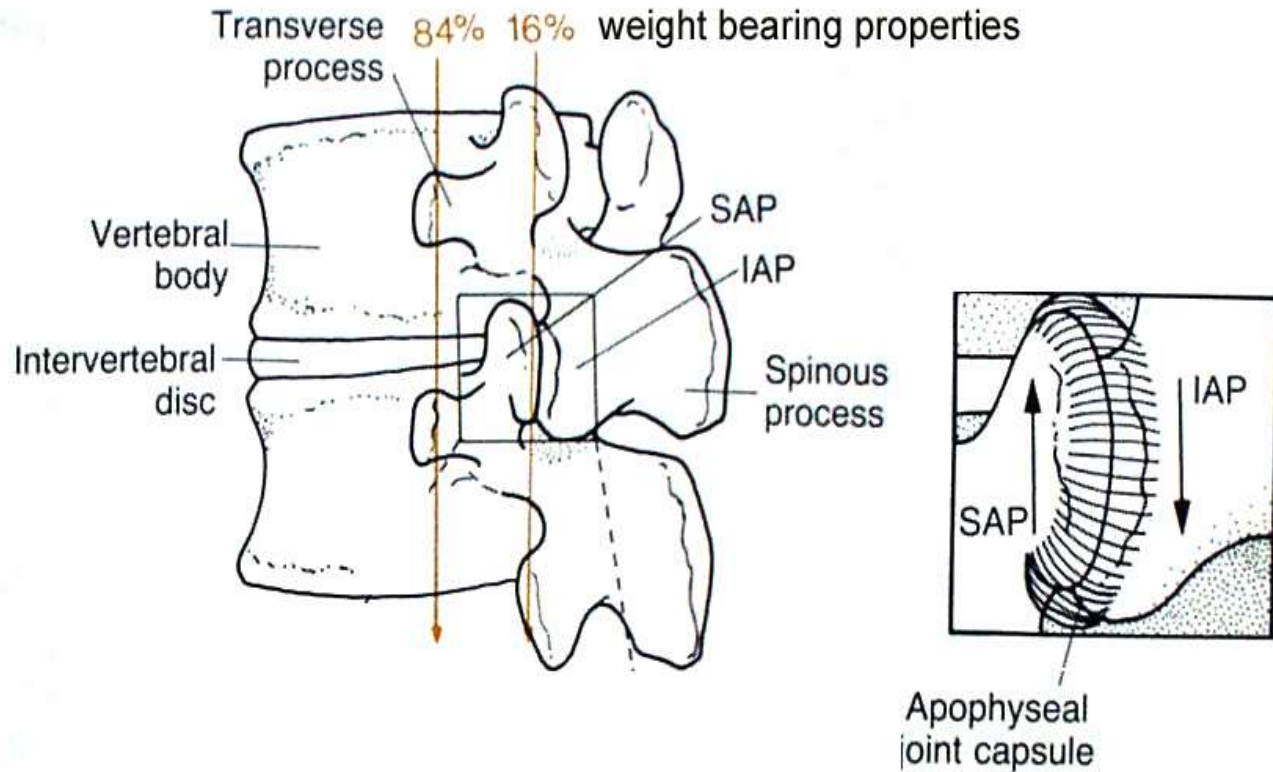
- Primarily depends upon the size of the disc

- **Direction of motion**

- Primarily depends upon the orientation of the articulating facets



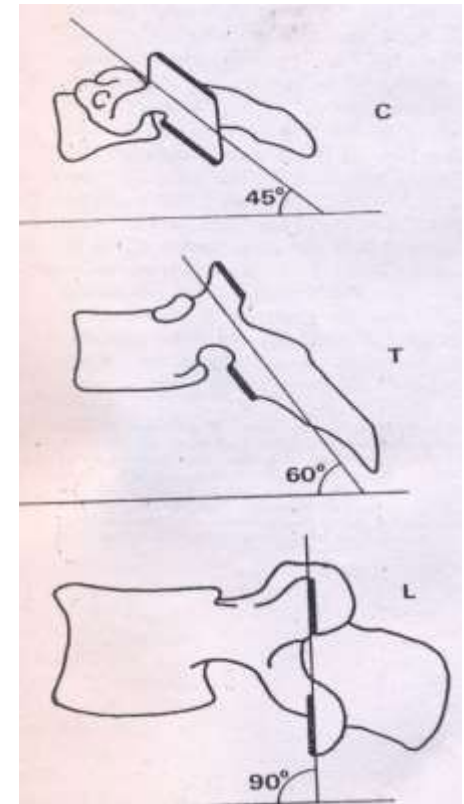
Weight bearing properties of motion segment unit



Posterior oblique view of a functional segment unit

Factors on which spinal mobility depends upon ???

- **The Disc to vertebral Height ratio**
 - 1:3 Cervical, **1:6 Thoracic**, 1:3 Lumbar spine
- **The Vertebra's Width to Height ratio**
 - C Vertebra has relatively small anteroposterior and transverse diameters in relation to the body height
- Orientation of Articular processes
 - Superior articular facet of **C Spine faces Posteriorly and slightly laterally**, T- Spine faces Posteriorly, Lumbar spine faces medially
- The extent of Mechanical Displacement



Shape of Superior Articular facets (Maigne)



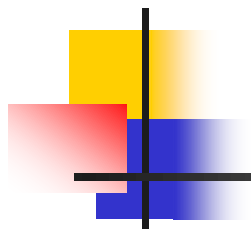
Intervertebral Disc

- Soft fibro-cartilaginous cushions
 - Between two vertebra
 - Allows some motion
 - Serve as shock absorbers
- Total – 23 discs
- $\frac{1}{4}$ th of the spinal column's length
- Avascular
- Nutrients diffuse through end plates



Intervertebral Disc Functions

- Movement of fluid within the **nucleus**
 - Allows vertebrae to rock back and forth
 - Flexibility
- Act to pad and maintain the space between the twenty-four movable vertebrae
- Act as shock absorbers





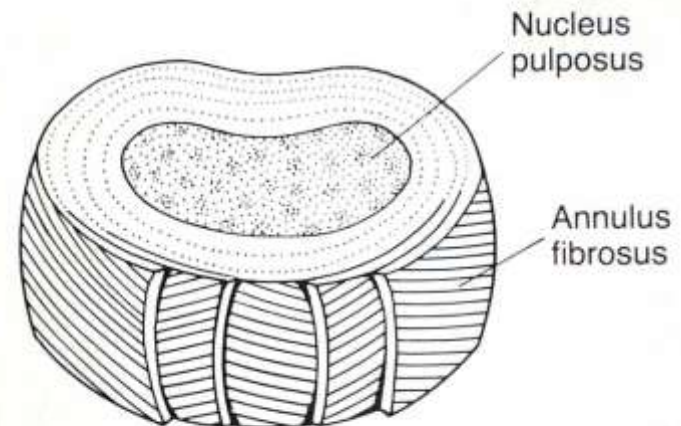
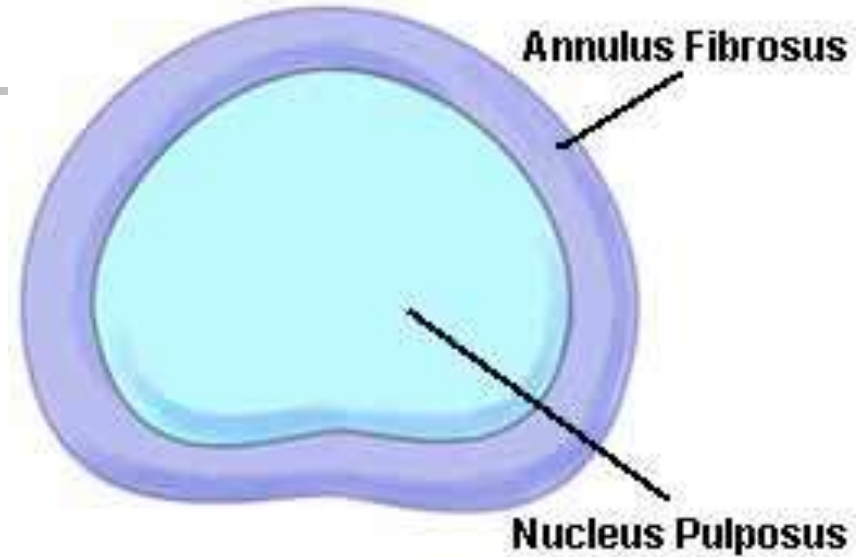
خوبصورتی کی کمی کو
اخلاق پورا کر سکتا ہے
مگر اخلاق کی کمی کو
خوبصورتی پورا نہیں کر سکتی



Intervertebral Disc Anatomy

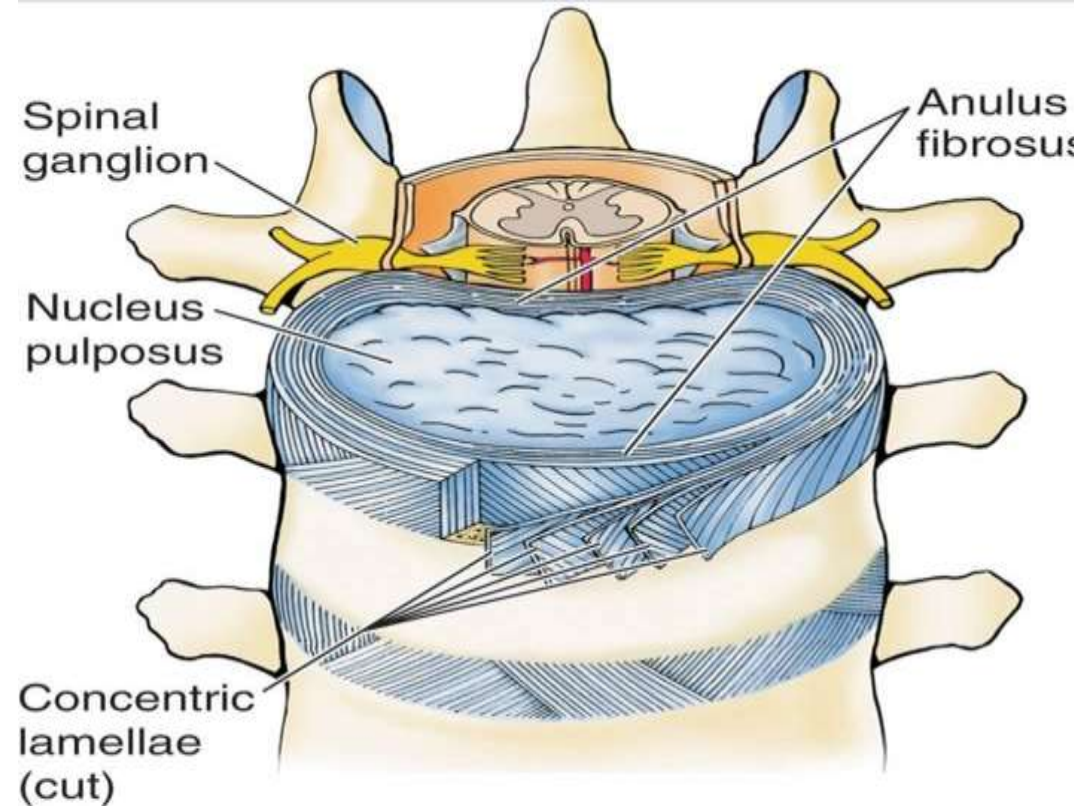
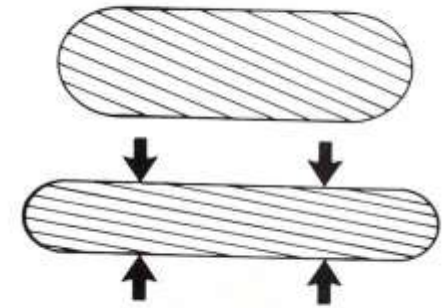
- Spongy center
 - *Nucleus pulposus*
- Surrounded by a tougher outer fibrous ring
 - *Annulus fibrosus*

Axial (Overhead) View
of Intervertebral Disc



Annulus Fibrosus

- Strong radial tire-like structure
- Series of lamellae
- Concentric sheets of collagen fibers
 - Orientated at various angles
 - Connected to end plates
- Encloses nucleus pulposus



Anterosuperior view, vertebral column transversely sectioned through IV disc

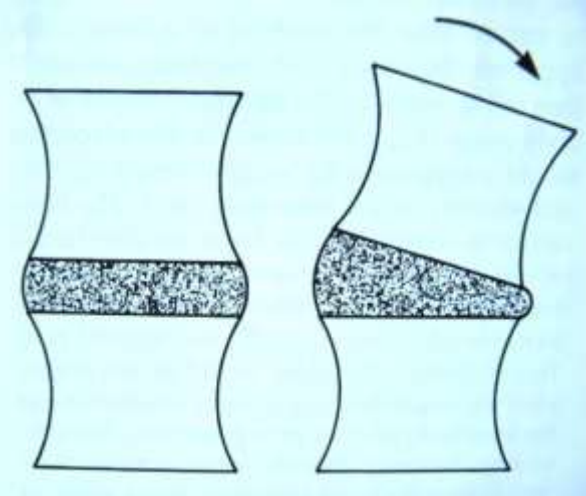
Annulus

■ In Bending (flexion)

- Increased tensile force posteriorly
- Increased compressive force anteriorly (vice versa)

■ In Rotation

- Reorientation of collagenous fibers
- Tightening of fibers in one direction
- Loosening of fibers in opposite direction





Nucleus Pulposus

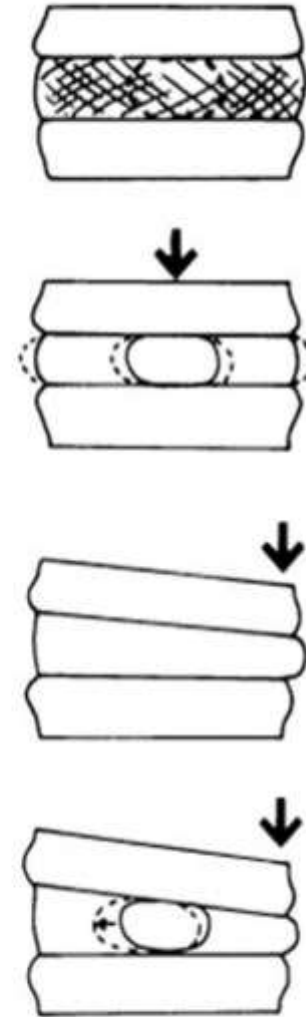
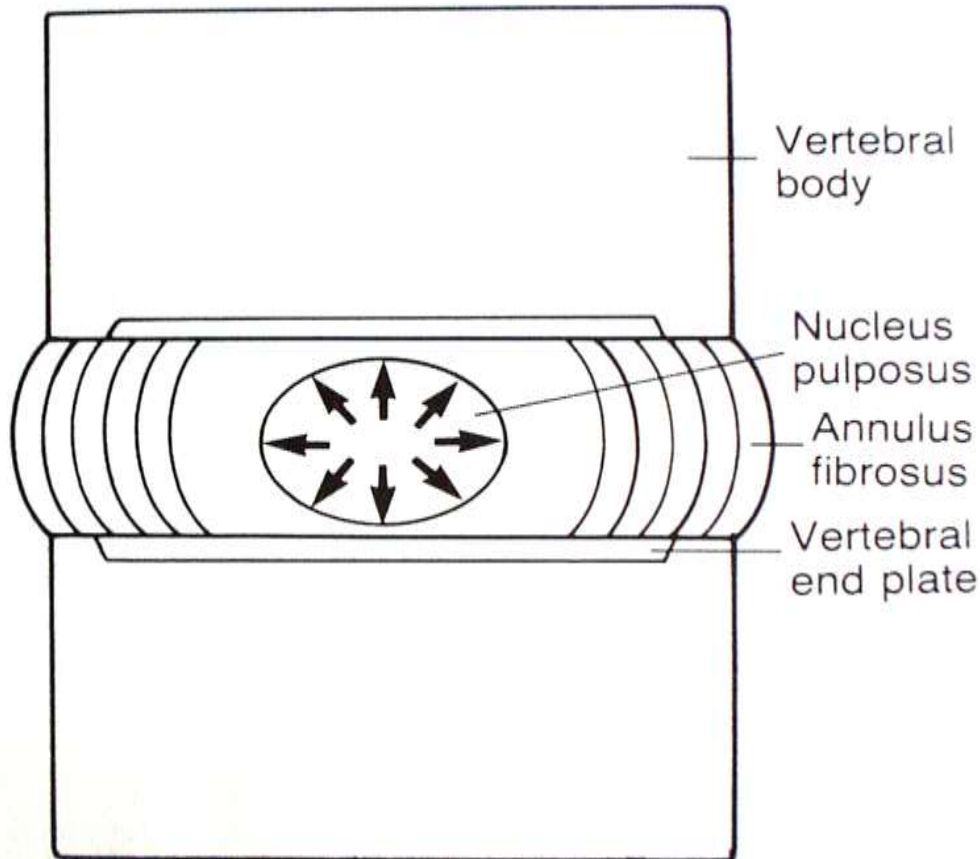
- Has more water and PGs
- PG are macro-molecules
 - Attract and retain water
 - Hydrophilic gel-like matter
 - Resists compression
- Amount of water
 - Activity related
 - Varies throughout the day



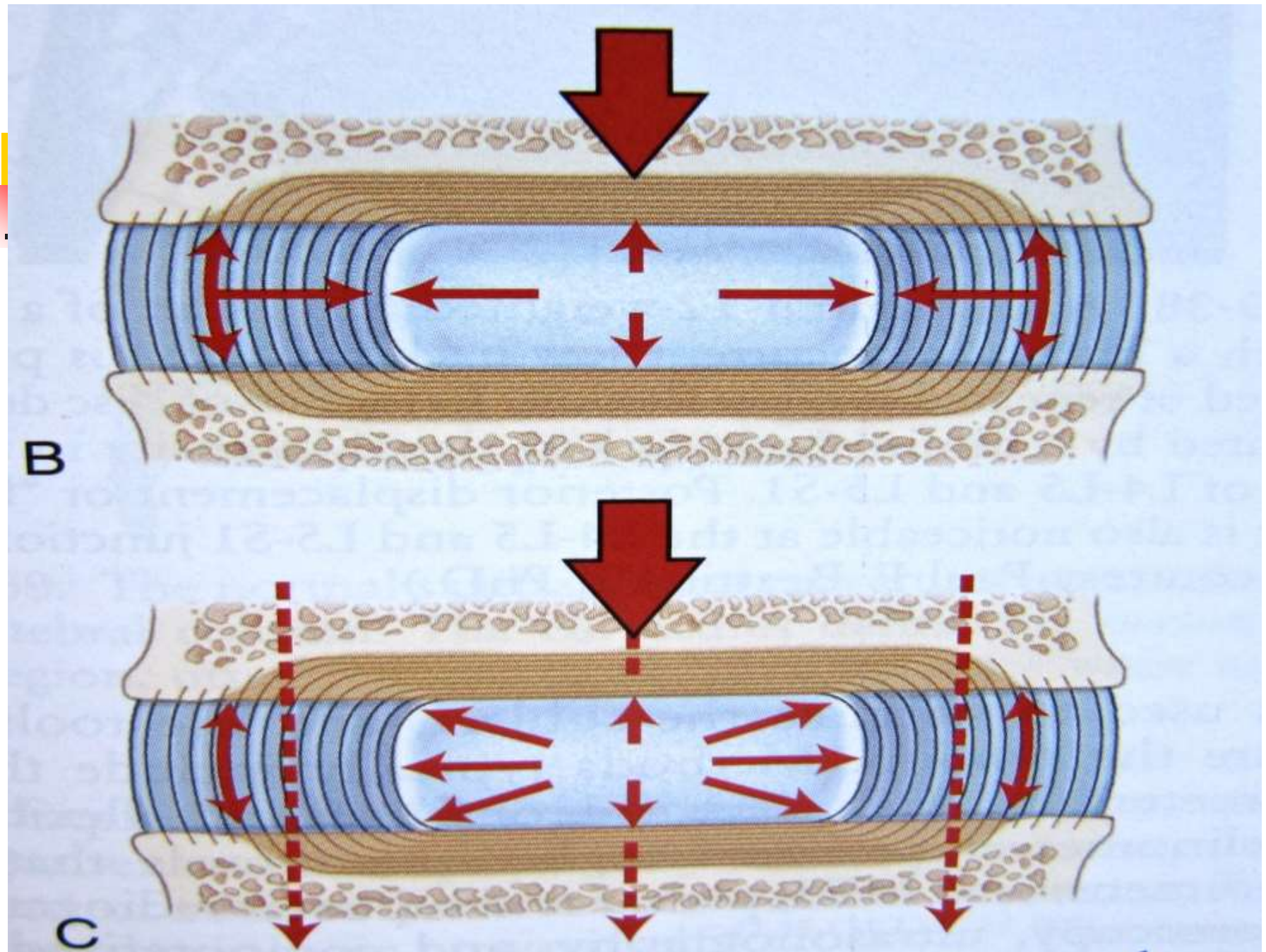
Theory of weight bearing

- Nucleus pulposus *imbibes water*
- Develops internal pressure
- Pressure exerted in all directions
 - **Lateral forces**
Against annulus
 - **Superiorly and inferiorly directed forces**
Against end plates
 - Increases stiffness of end plate and annulus fibrosus

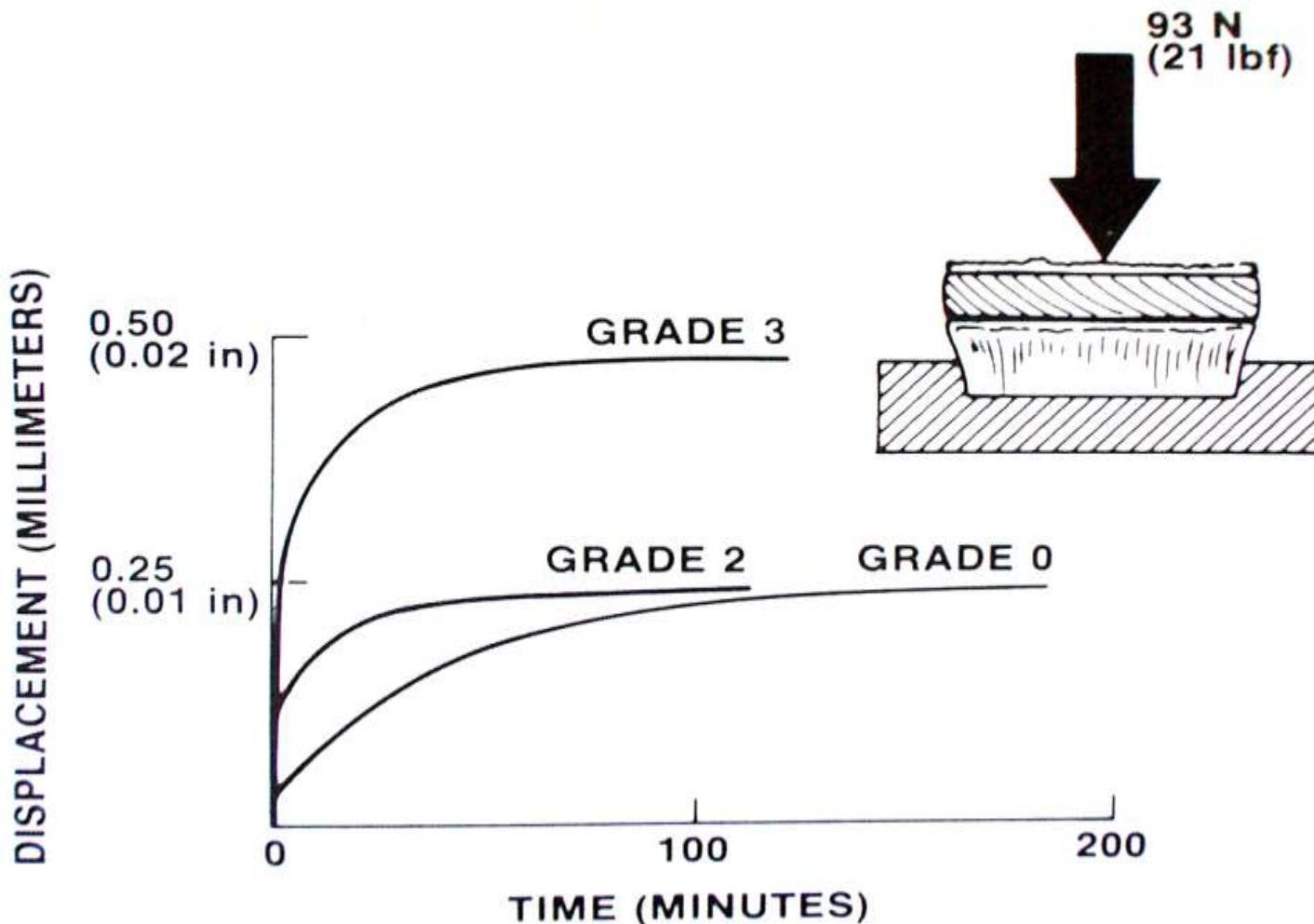
Theory of weight bearing (cont'd)



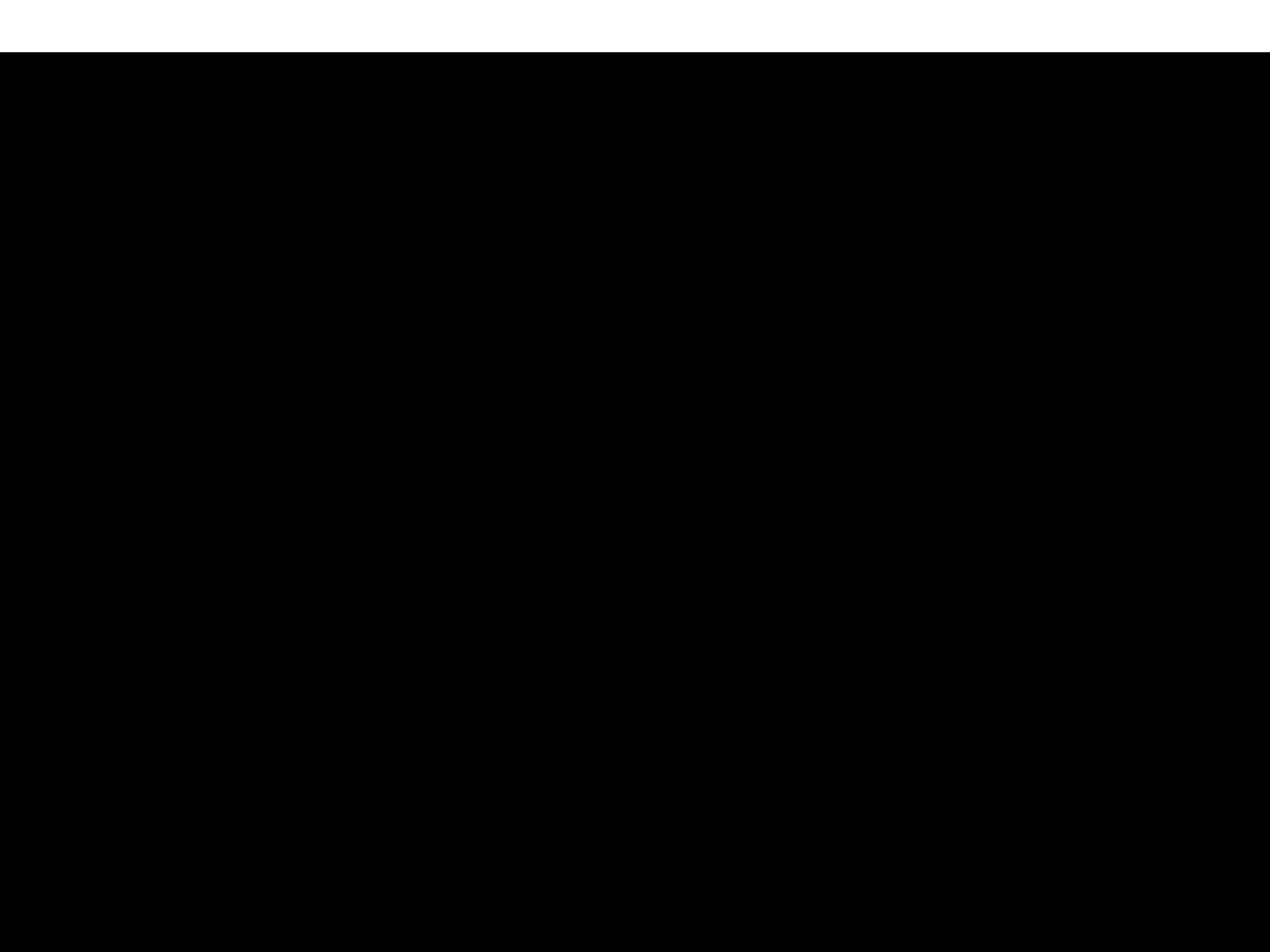
when uneven loading takes place



Creep Characteristics

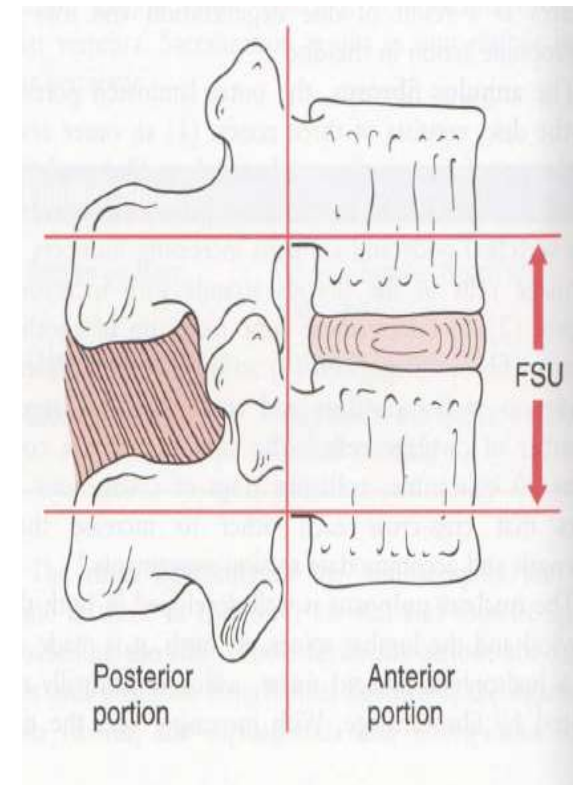


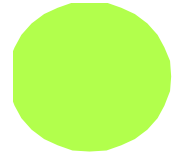
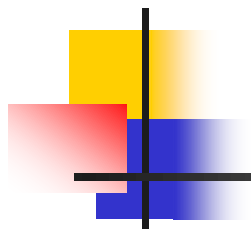
- Grade 0 - Non-degenerative disc (more viscoelastic)**
- Grade 2 – Mild degenerative disc (less sustenance)**
- Grade 3 – Severe degenerative disc (more deformation)**



Applied Anatomy

- The water binding capacity of the disc decrease with age and degenerative changes begin to occur after 2nd decade of the life.
- The disc contain 85% to 90% of water, but the amount decrease up to 65% with age.





بِسْمِ اللّٰهِ الرَّحْمٰنِ الرَّحِیْمِ

حضرت ابو ہریرہ رضی اللہ تعالیٰ عنہ سے مروی ہے
کہ حضور نبی اکرم ﷺ نے فرمایا: اللہ تعالیٰ فرماتا ہے
میں اپنے بندے کے گمان کے ساتھ ہوتا ہوں
جو وہ میرے بارے میں رکھتا ہے،
اور میں اس کے ساتھ ہوتا ہوں جب وہ مجھے پکارتا ہے۔



Shear & Tensile Characteristics

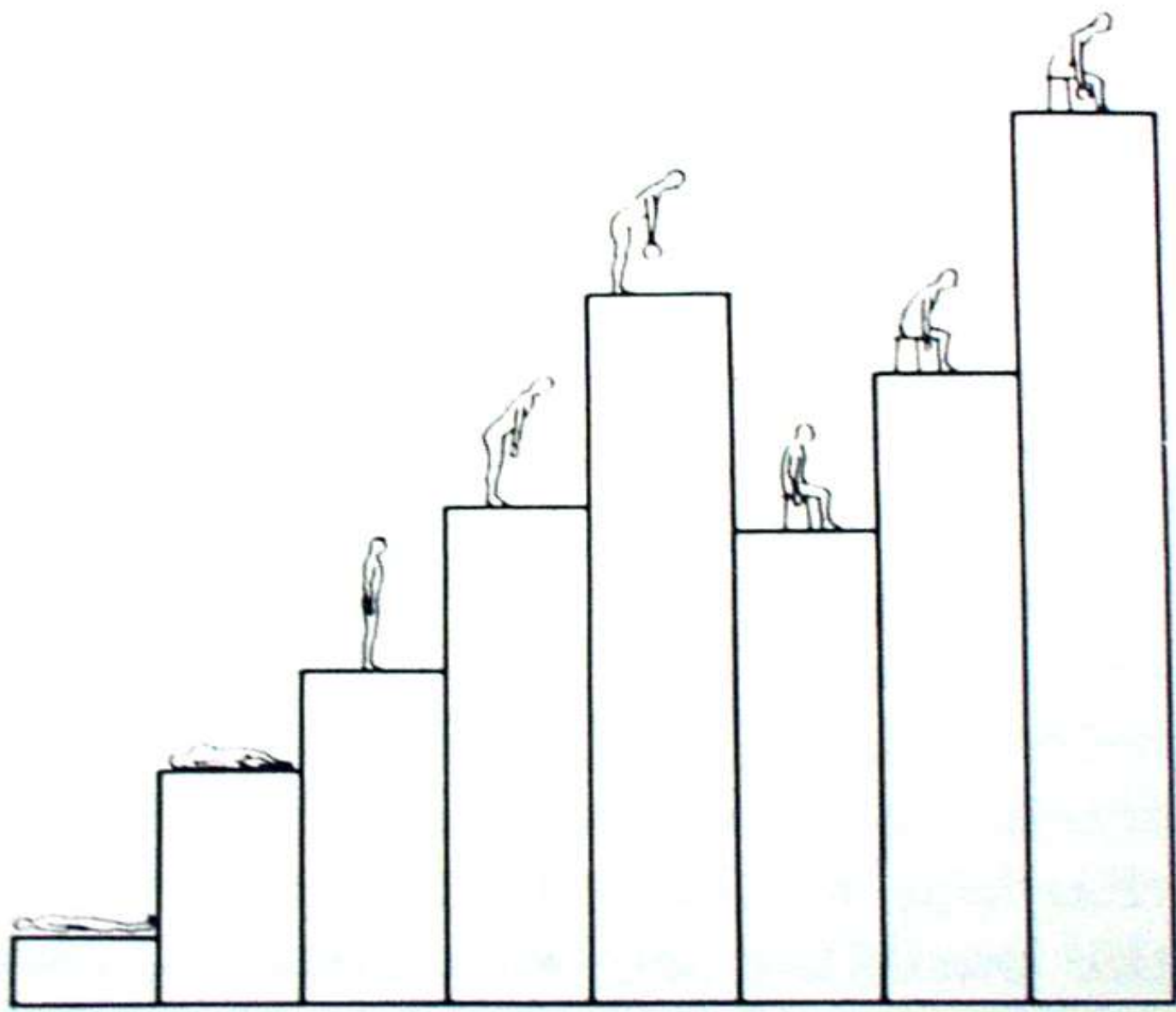
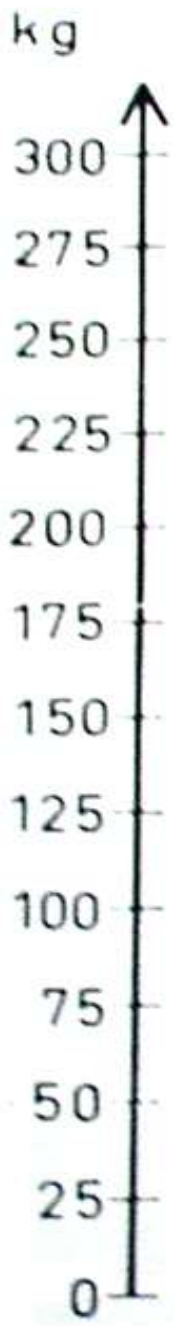
- In direct shear tests
- Shear stiffness in horizontal direction=260 N/mm² (Spine rarely fails in pure shear)
- Similarly under normal physiologic activities
 - Pure tensile loading doesn't occur
 - But annulus undergoes tensile loading during, Bending , Axial rotation, Extension



Compressive load characteristics

- Cancellous bone
 - Large deformation
 - Up to 9.5% before failure
- Cortical bone
 - Small deformation
 - Up to 2% before failure

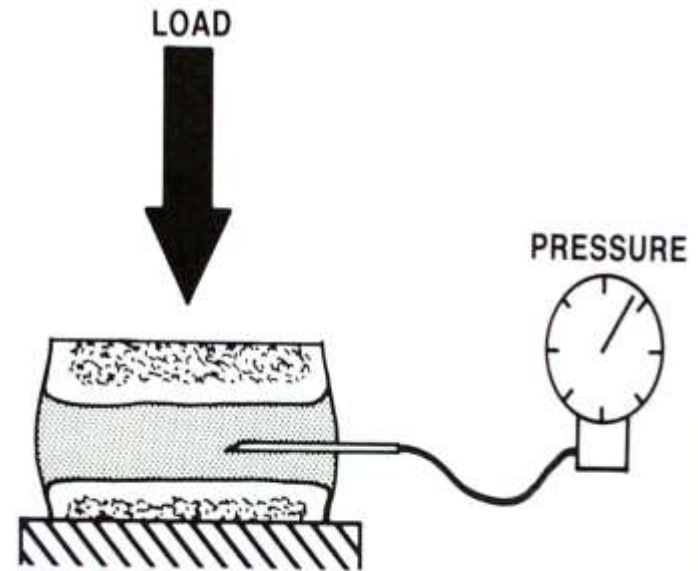
Total load on third lumbar disc
in a subject of 70 kg.



Position of body

Measurements of In vivo Loads

- Needle pressure transducer used to measure mechanical pressure on intervertebral disc.
- Calibrated (tuned) to zero.
 - Introduced into nucleus pulposus of cadaveric functional unit
- Inserted in vivo in L3-4 disc

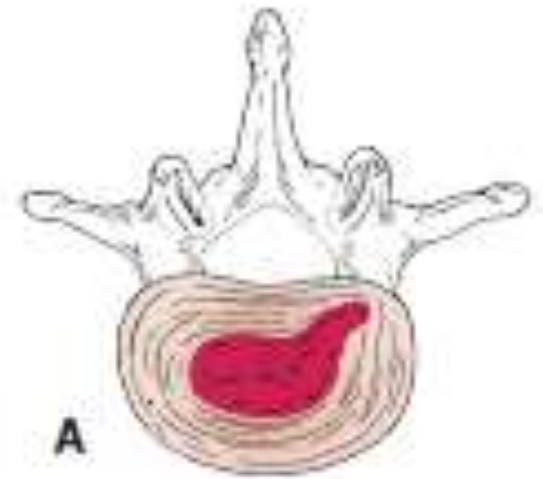


Pathology of Intervertebral Disc

*Injury **Disc Bulge***

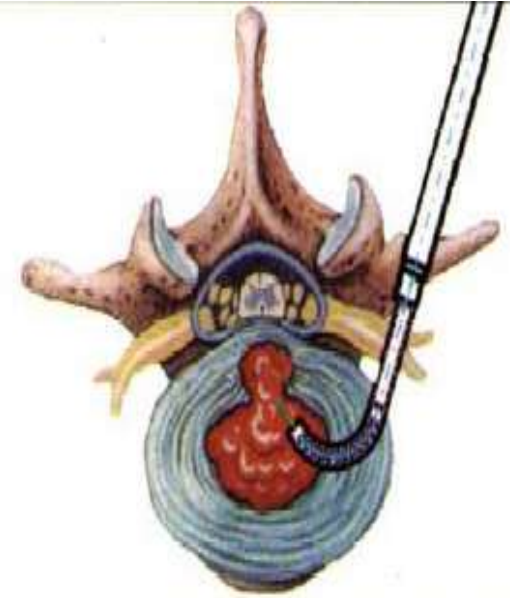
- **Herniation:**

a general term used when there is any change in the shape of the annulus that causes it to bulge beyond its normal perimeter

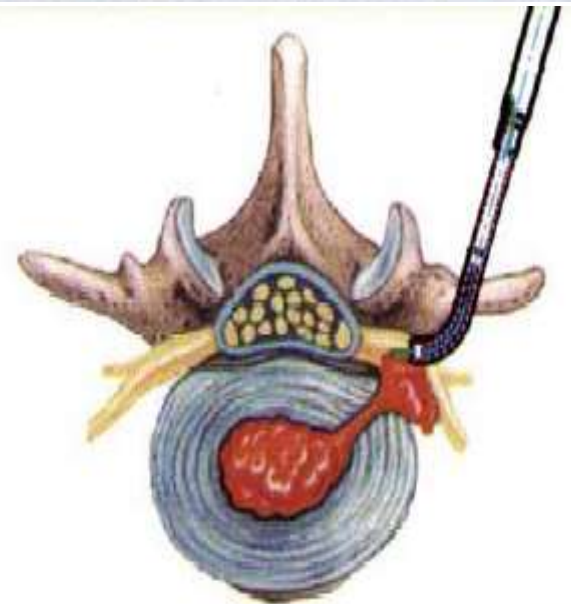


Pathology of Intervertebral Disc injury, disc bulge

- ***Prolapses***
- Fissures provide pathway for irritating nuclear fluid to escape onto perineurial tissue **OR**
 - rupture of the nuclear material into the vertebral canal
 - Persistent and chronic back pain



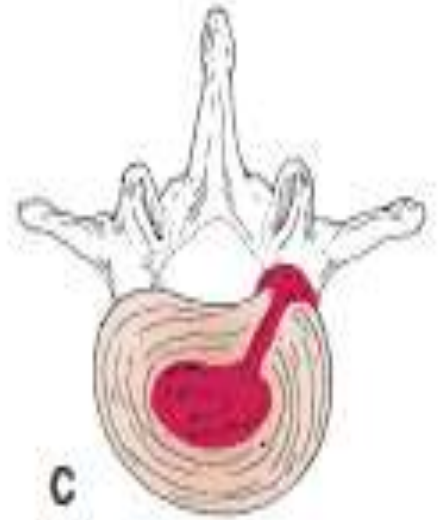
Contained prolapse.



Intraforaminal prolapse

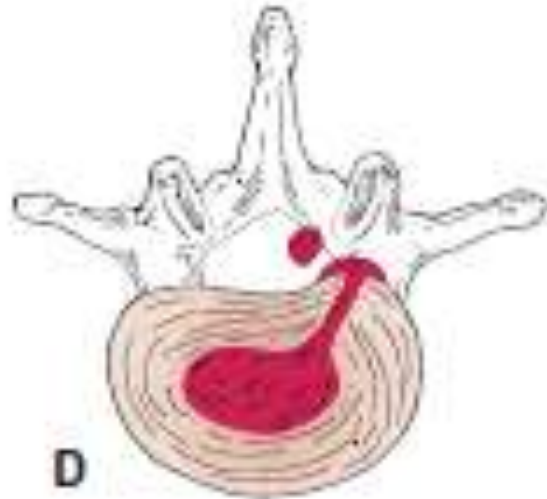
Extrusion

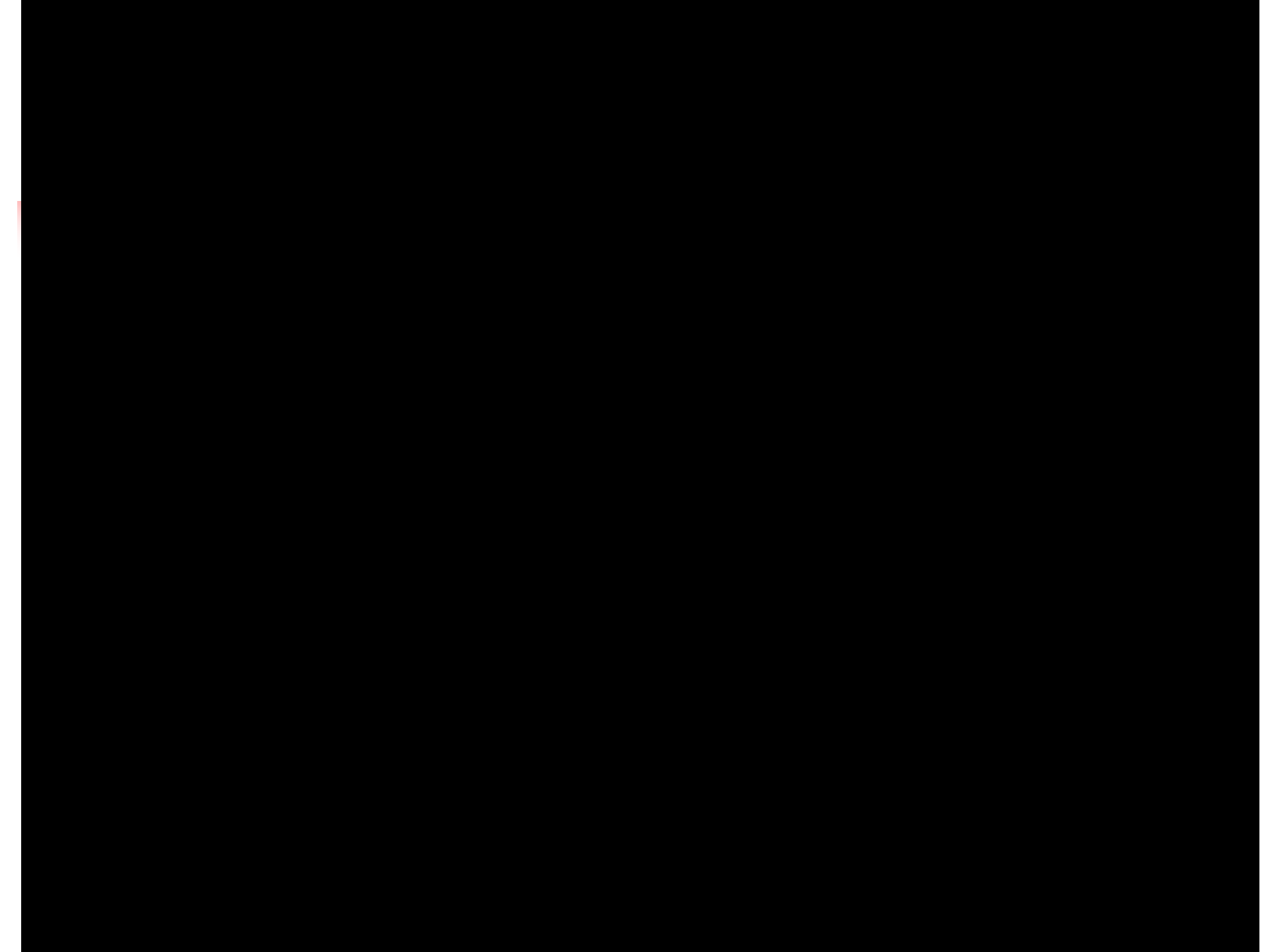
- Extension of nuclear material beyond the confines of the posterior longitudinal ligament or above and below the disc space, as detected on MRI , but still in contact with the disc **OR**
 - Nuclear material dissects its way through breaches in annulus fibrosus

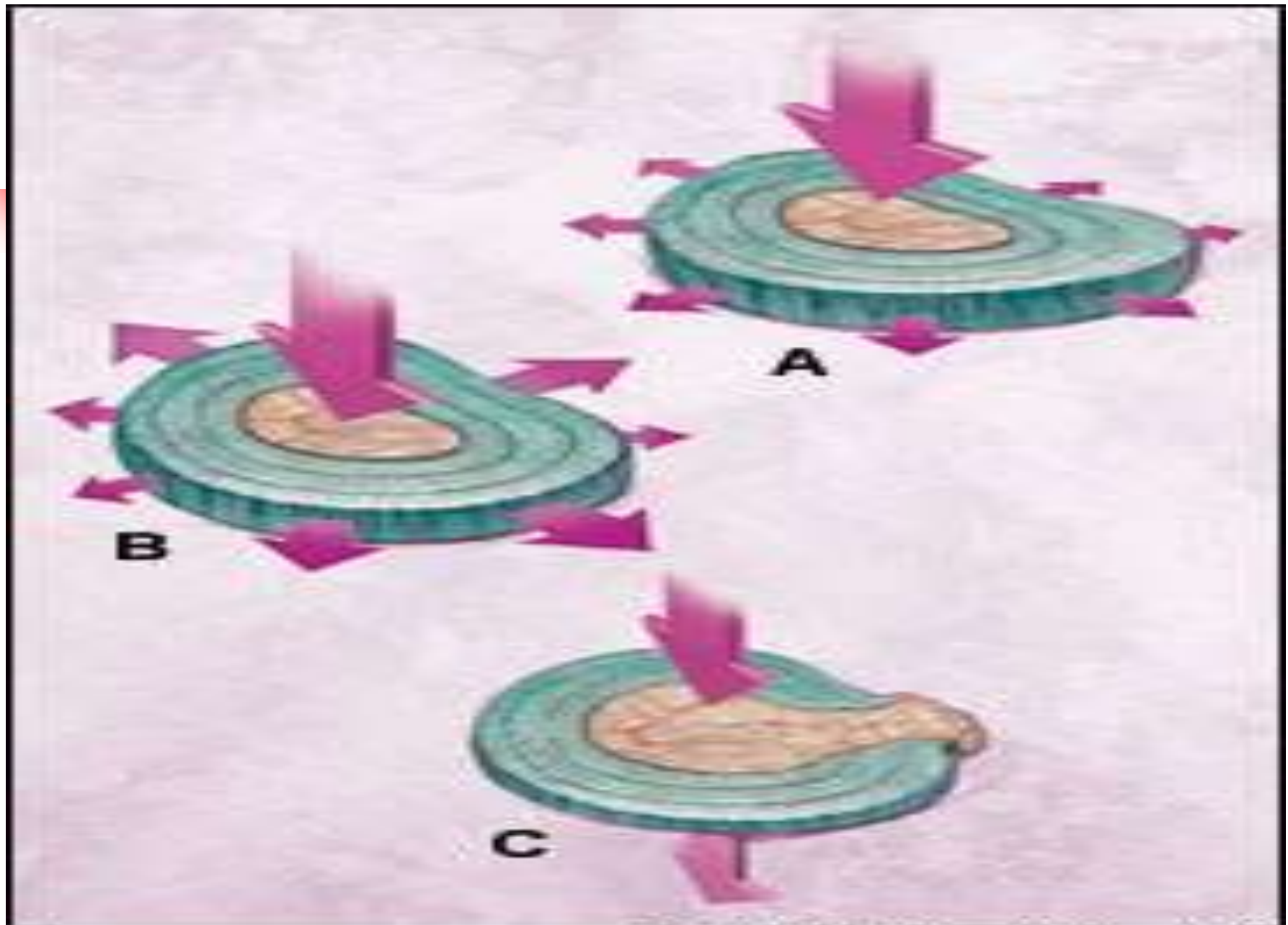


Free sequestration

- the extruded nucleus has separated from the disc and moved away from the prolapsed area









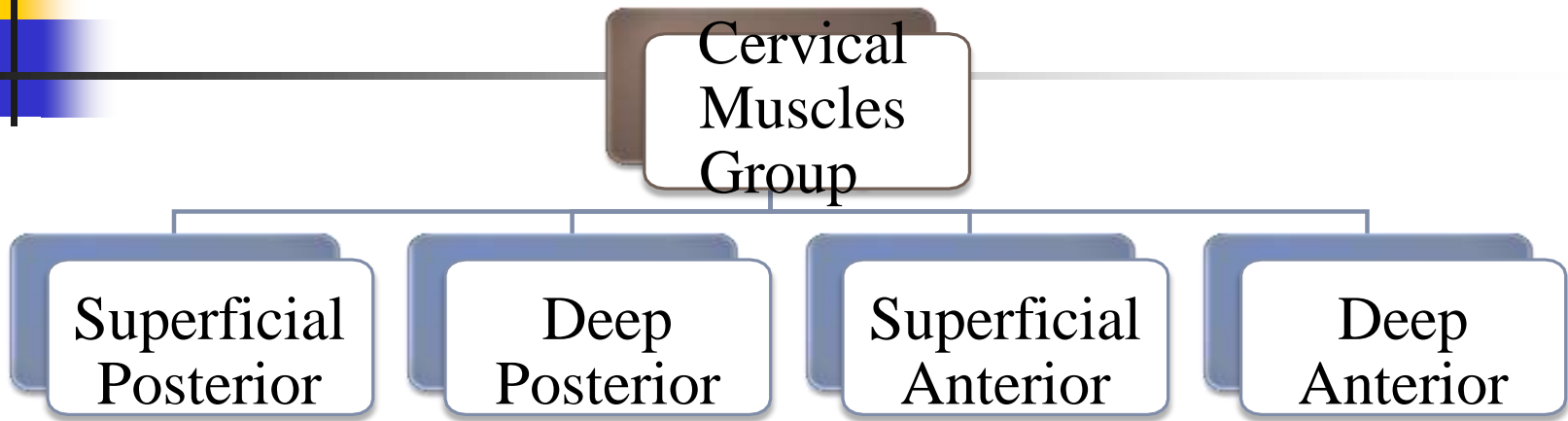
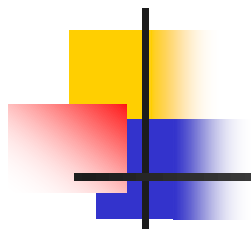
Muscles of the Spine

- Muscles of neck and trunk named in pairs, with one on the left and the other on the right side of body
- Anterior Aspect
- Posterior Aspect
- Lateral Aspect

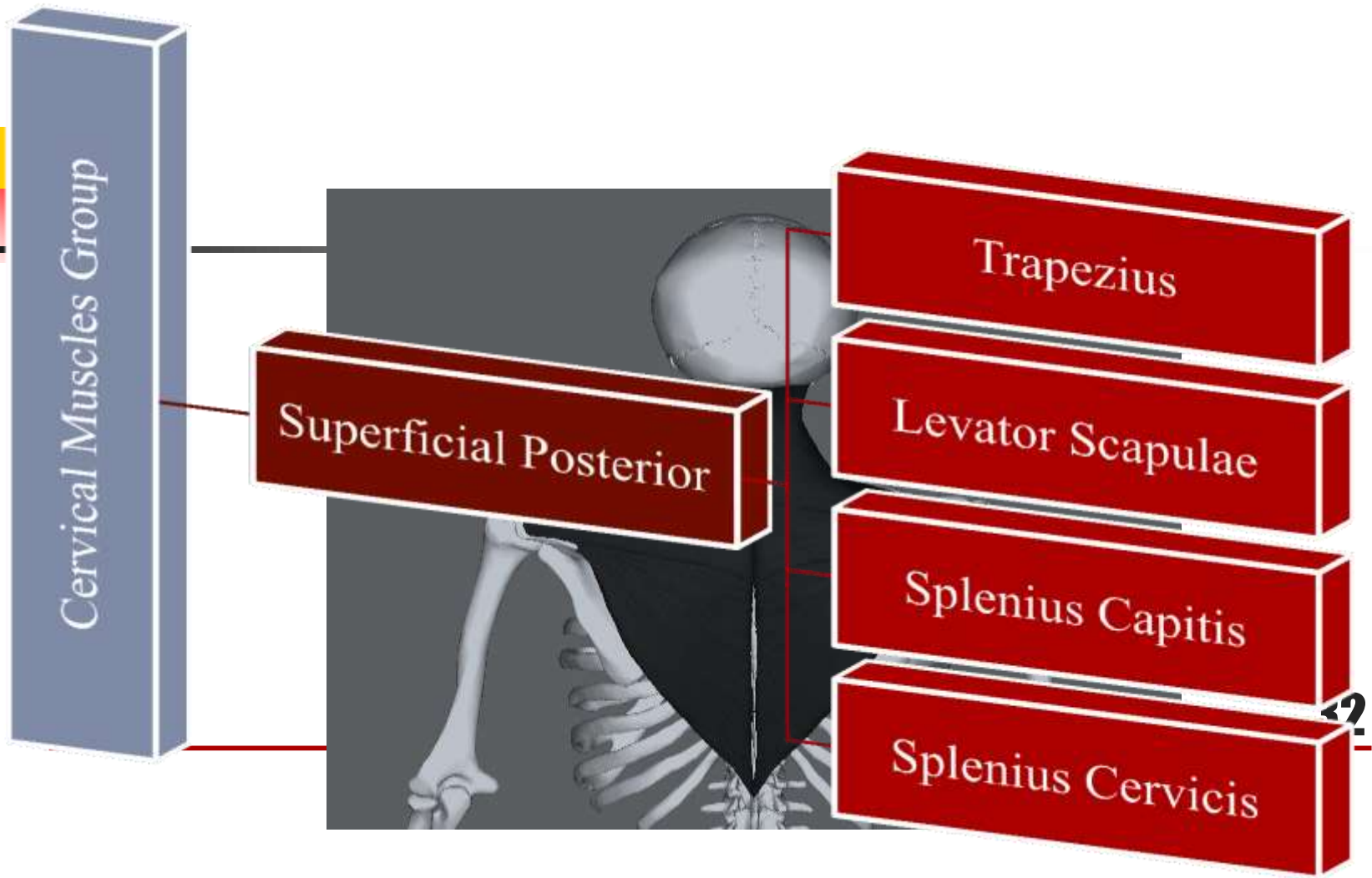


Anterior Aspect

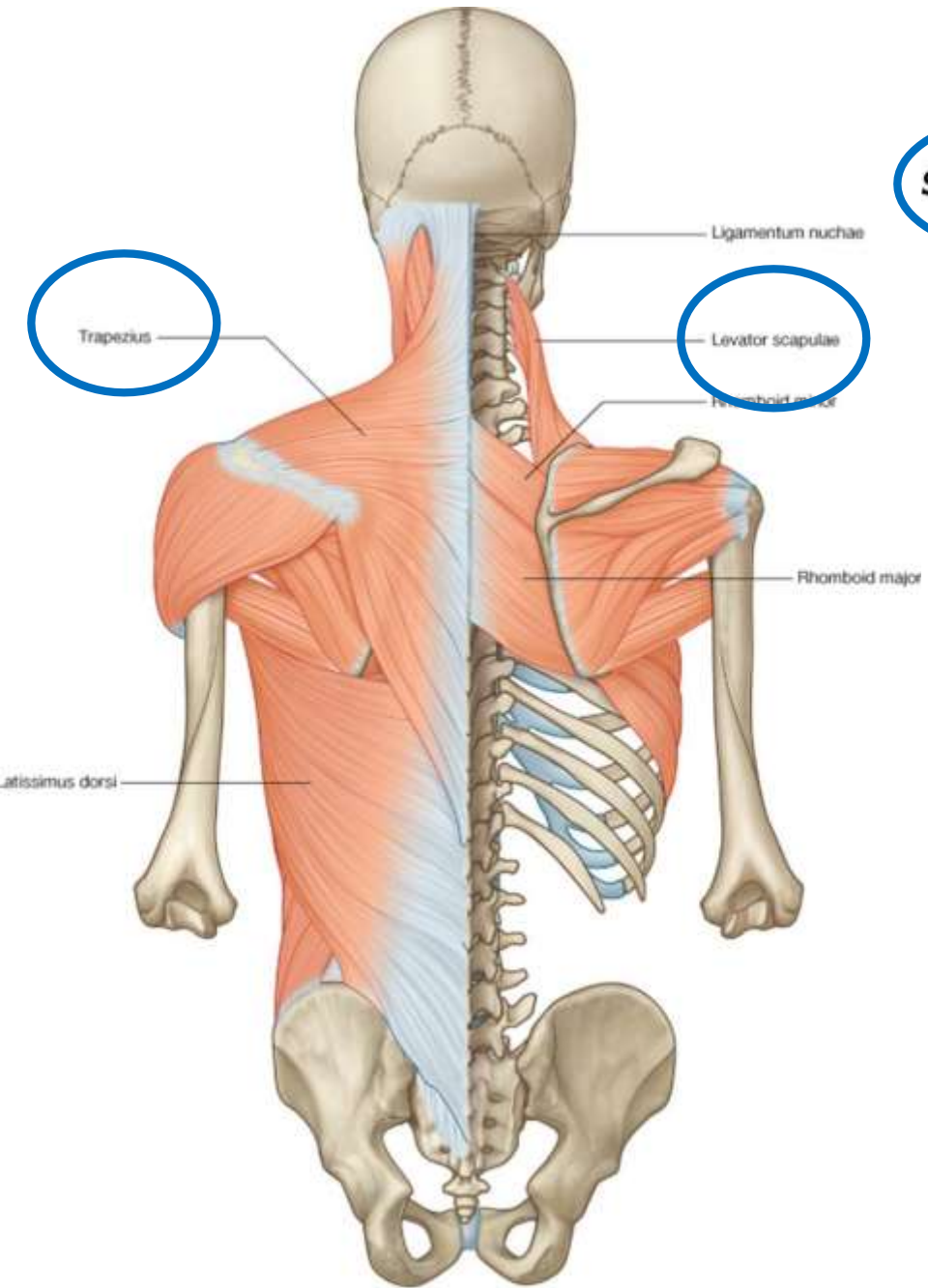
- **Cervical spine:::** Bilateral tension development results in flexion of head.
- Unilateral tension development in prevertebrals contributes to:
 - lateral flexion of head toward contracting muscles or,
 - to rotation of head away from contracting muscles
 - **Thoracic muscles**
- **Abdominals**



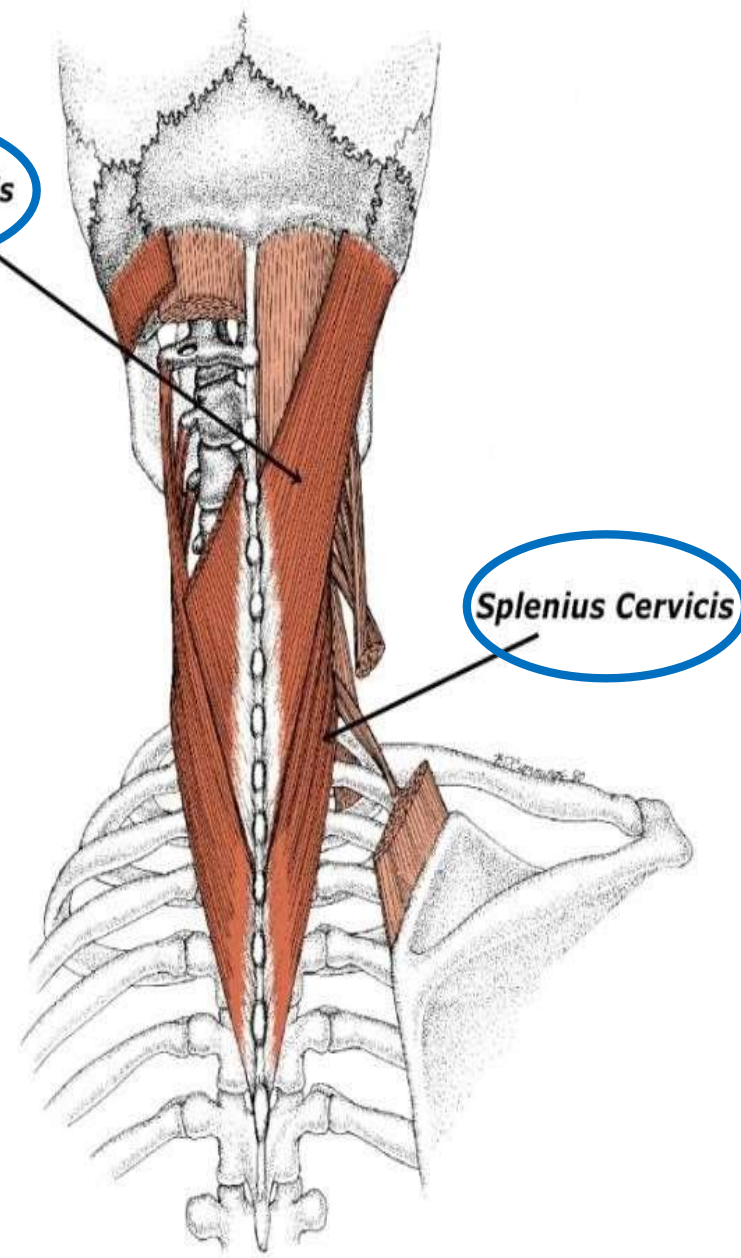
Cervical Muscles Group



Cervical Muscles Group



Splenius Capitis



Cervical Muscles Group

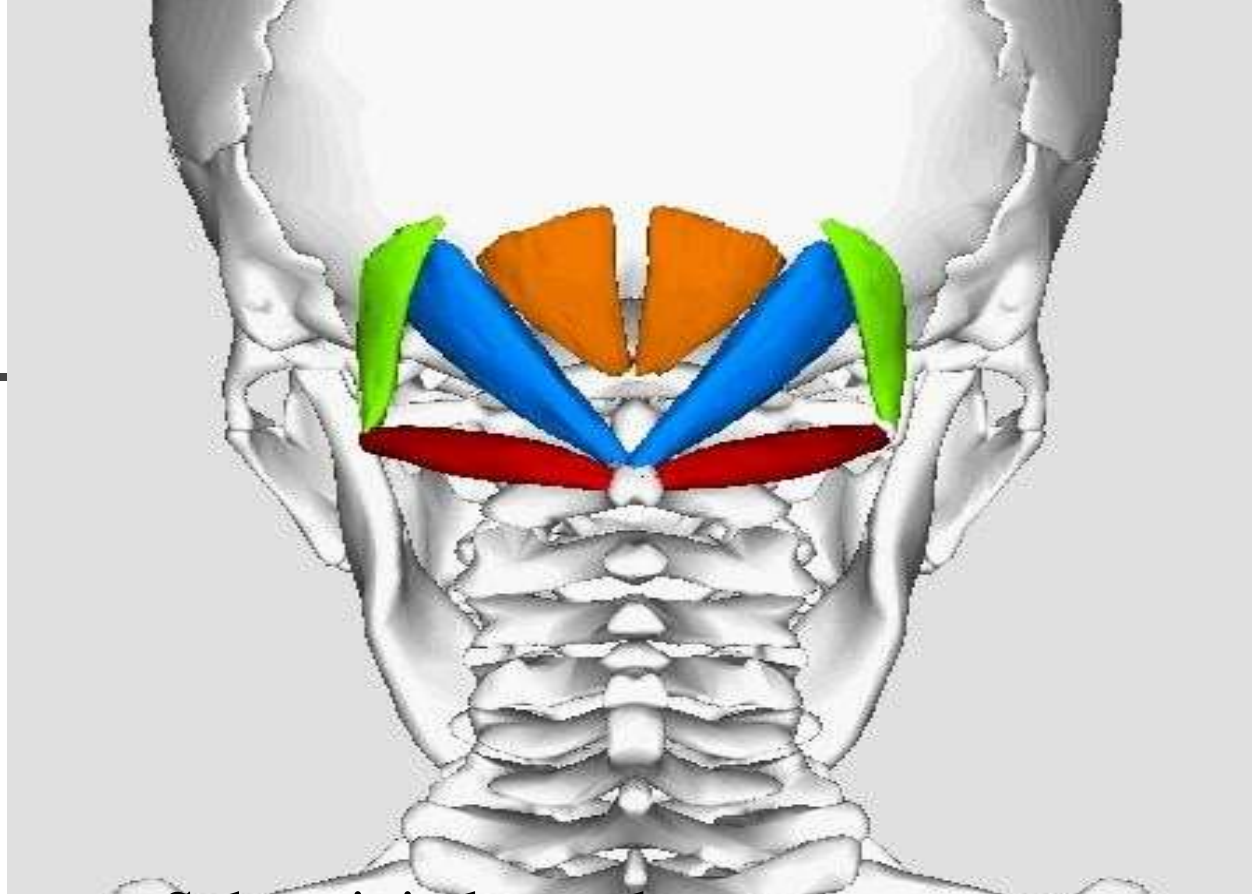
Deep Posterior

Multifidi

Suboccipital

Cervical Muscles Group





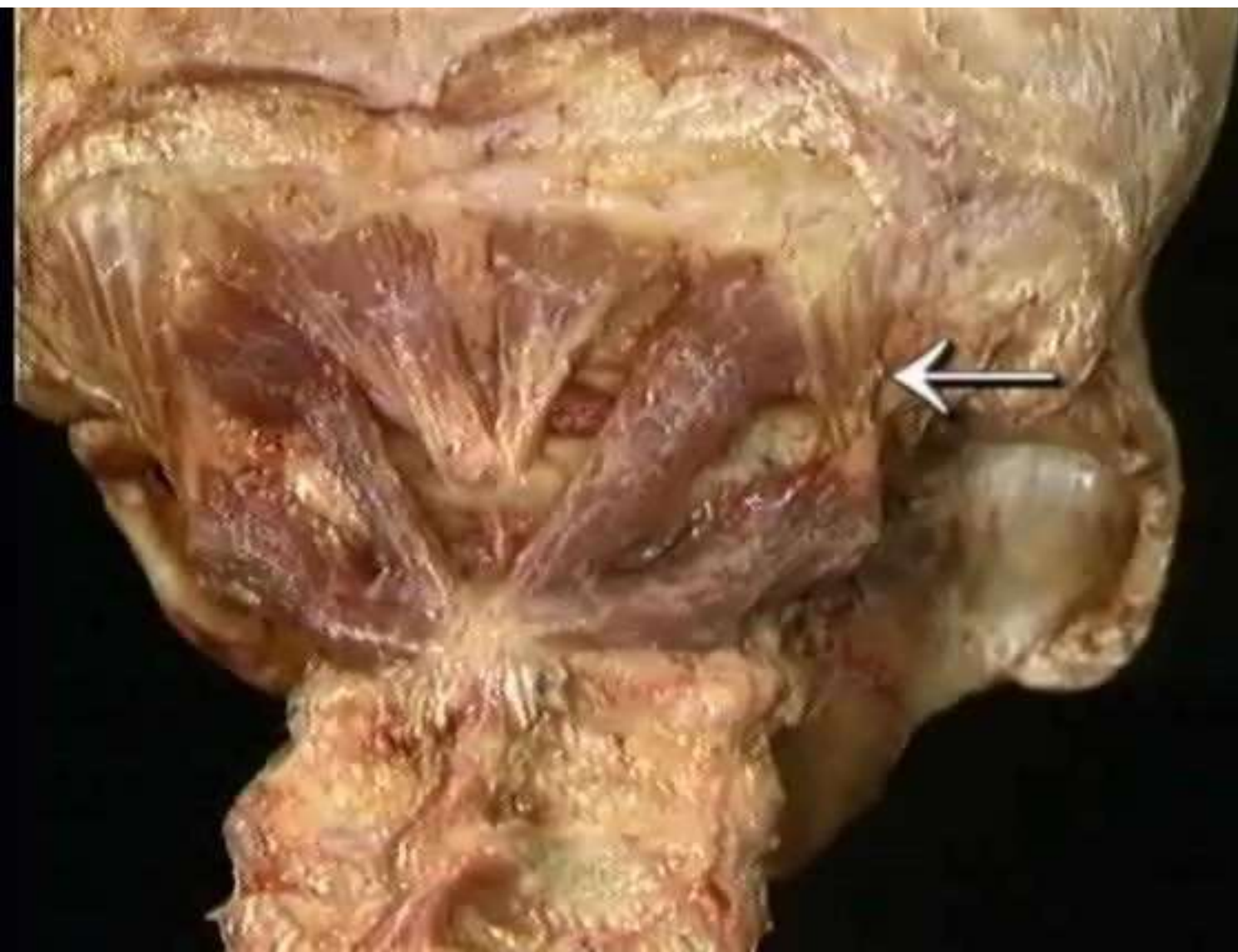
Suboccipital muscles.

— **Rectus capitis posterior major muscle**

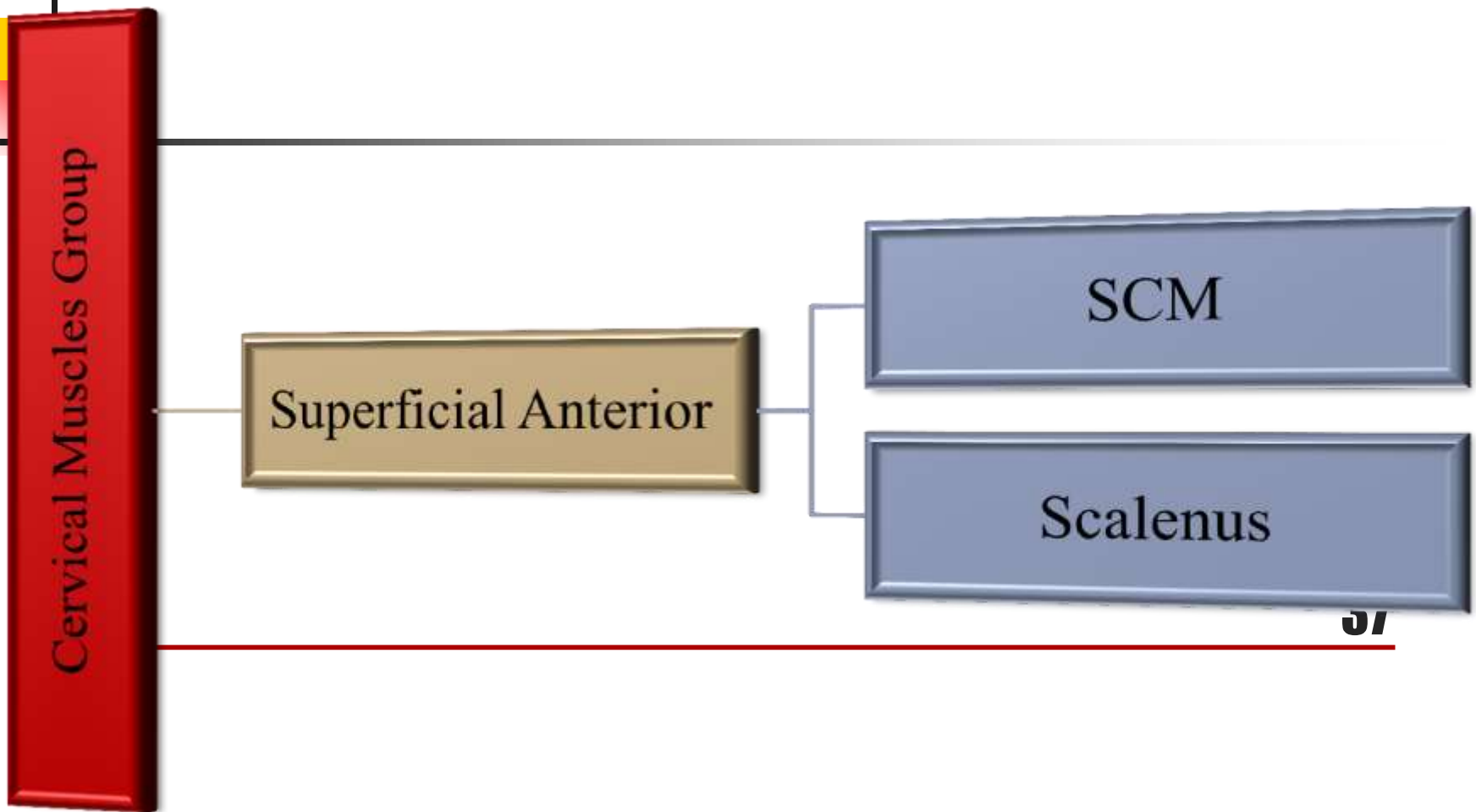
Rectus capitis posterior minor muscle

Obliquus capitis superior muscle

Obliquus capitis inferior muscle



42



Cervical Muscles Group

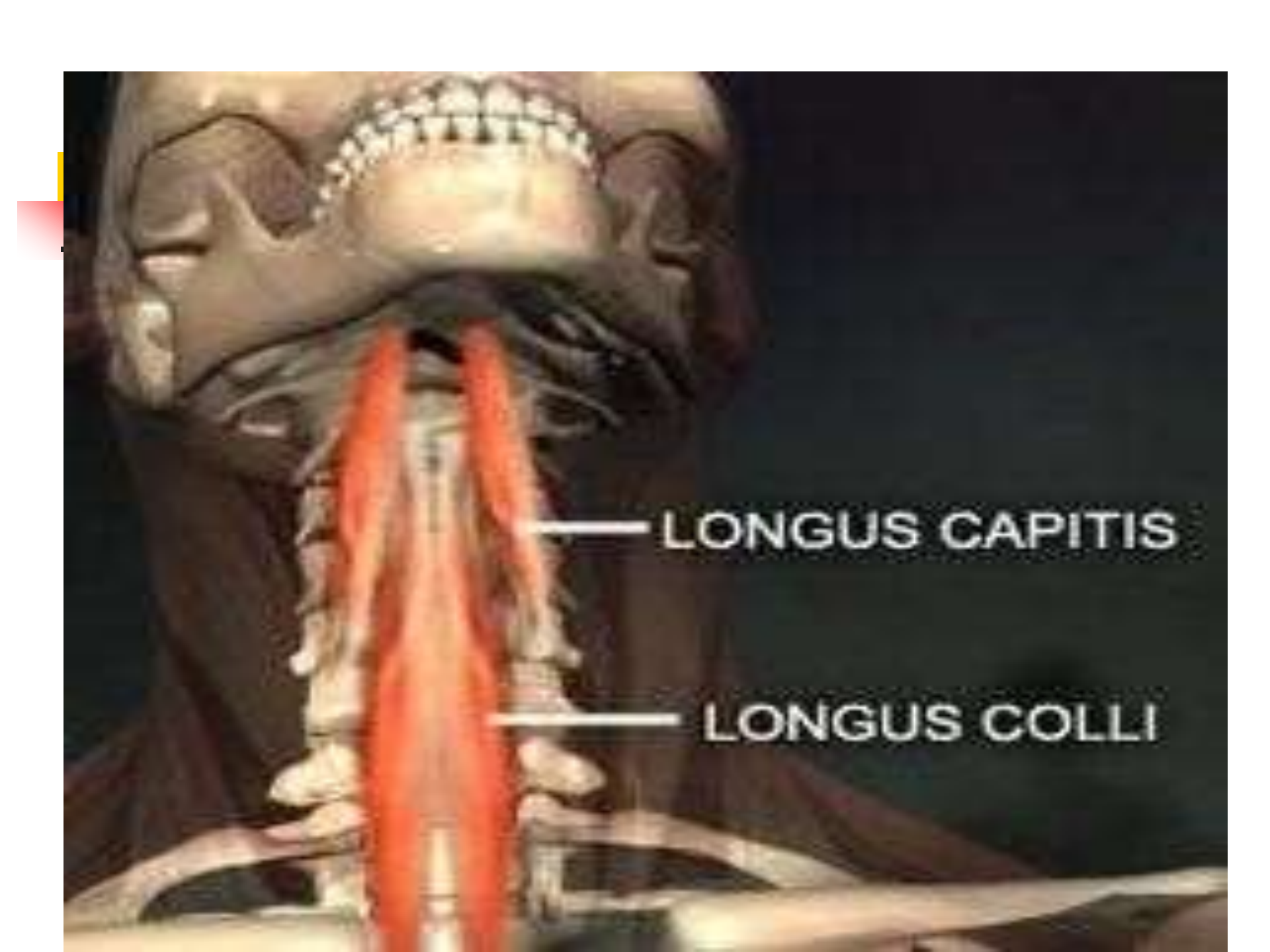
Cervical Muscles Group

```
graph LR; A[Cervical Muscles Group] --- B[Deep Anterior]; B --- C[Longus Colli]; B --- D[Longus Capitis]
```

Deep Anterior

Longus Colli

Longus Capitis

An anatomical illustration of the human neck and upper thorax. The skull is shown at the top, with the hyoid bone and larynx visible. Two muscles are highlighted in a reddish-orange color. The upper muscle, labeled 'LONGUS CAPITIS', originates from the transverse processes of the upper cervical vertebrae and extends upwards towards the skull. The lower muscle, labeled 'LONGUS COLLI', originates from the anterior tubercles of the transverse processes of the lower cervical vertebrae and extends upwards towards the hyoid bone. The vertebrae and ribs are shown in a light tan color, and the background is dark.

LONGUS CAPITIS

LONGUS COLLI

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

آپ ﷺ نے فرمایا: جو شخص یہ کلمات کہے تو اللہ تعالیٰ اسے بخش دیتے ہیں

أَسْتَغْفِرُ اللَّهَ

الَّذِي لَا إِلَهَ إِلَّا هُوَ الْحَيُّ الْقَيُّومُ وَآتُوبُ إِلَيْهِ

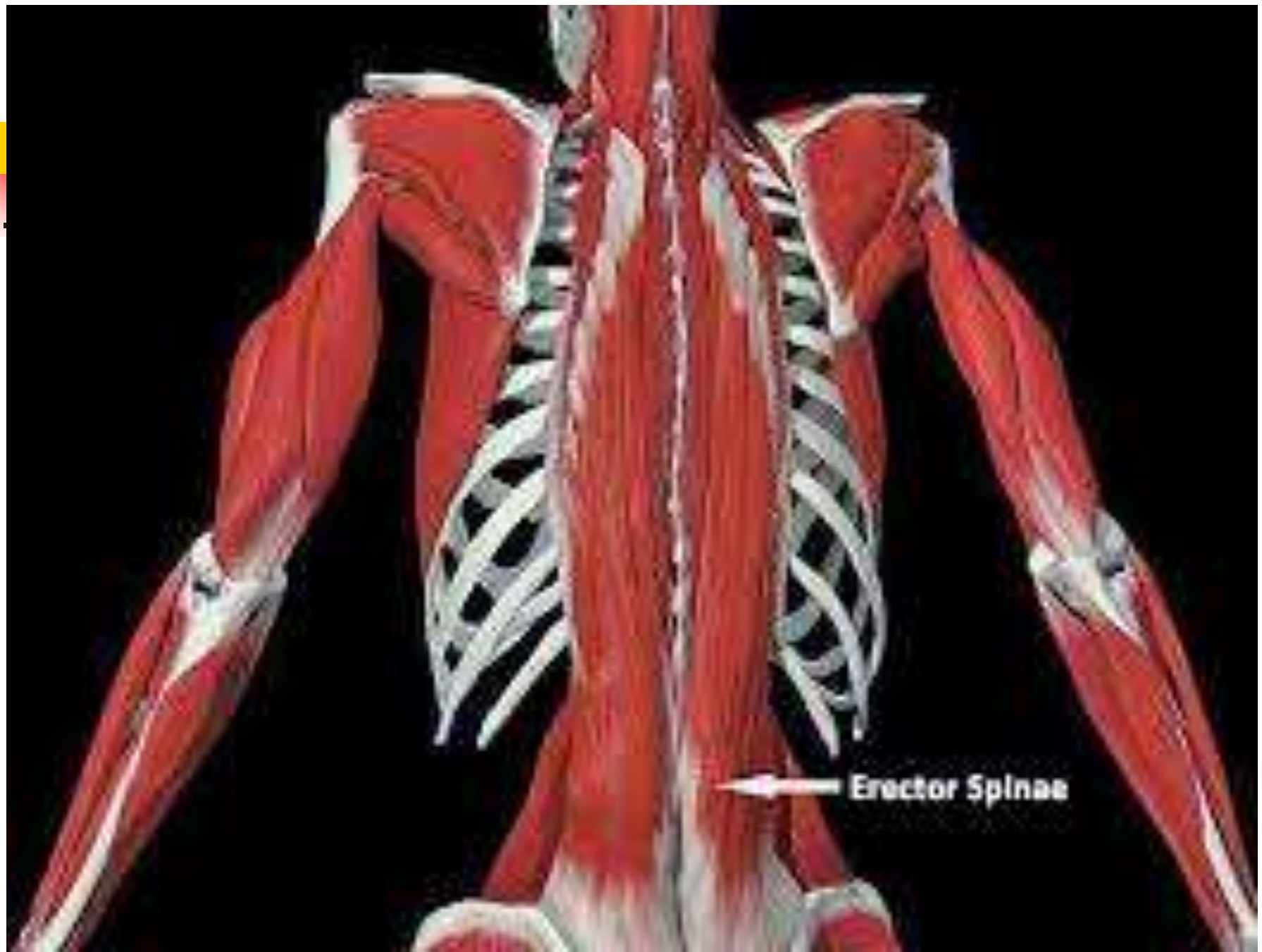
(پہلا، ۸۵۳، بکے، قرآنی، سورۃ)

میں بخشش طلب کرتا ہوں اللہ تعالیٰ سے کہ نہیں ہے کوئی (معبود برحق) مگر وہی جو زندہ اور قائم رکھنے والا ہے اور میں اس کی طرف تو یہ کرتا ہوں

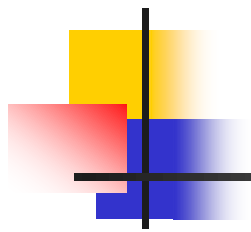


Posterior Aspect

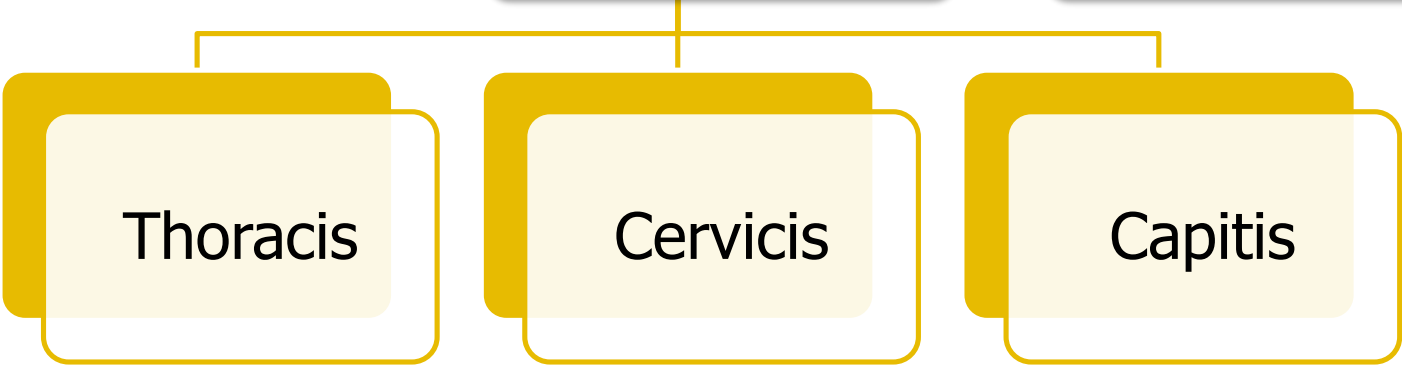
- Thoracic and Lumbar Muscle groups:
 - erector spinae (iliocostalis, longissimus, spinalis)
 - Semispinalis
 - deep segmental spinal muscles (multifidi, rotators)



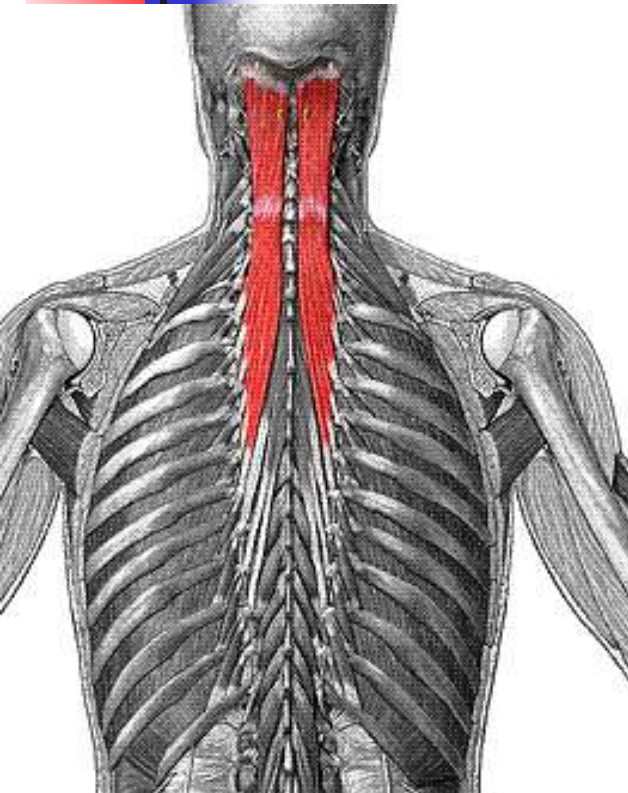
Erector Spinae



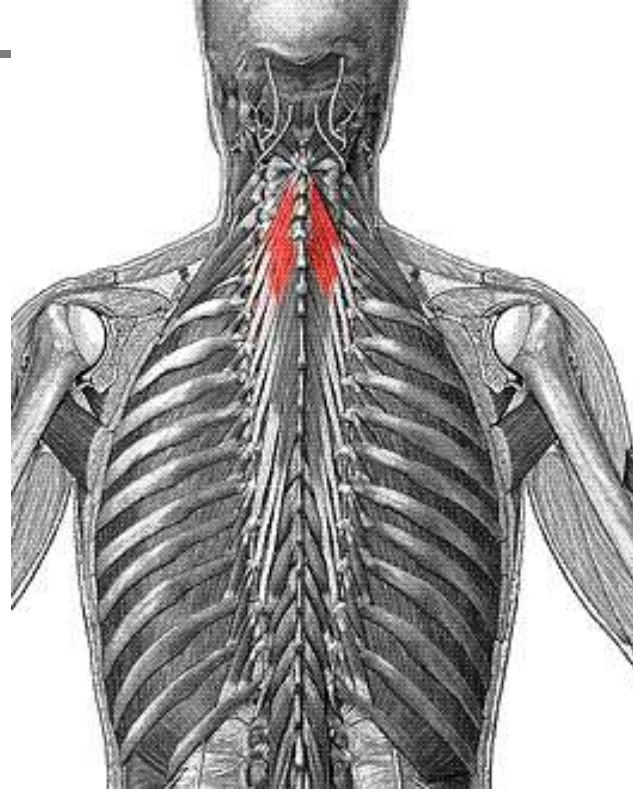
Transvers spinalis



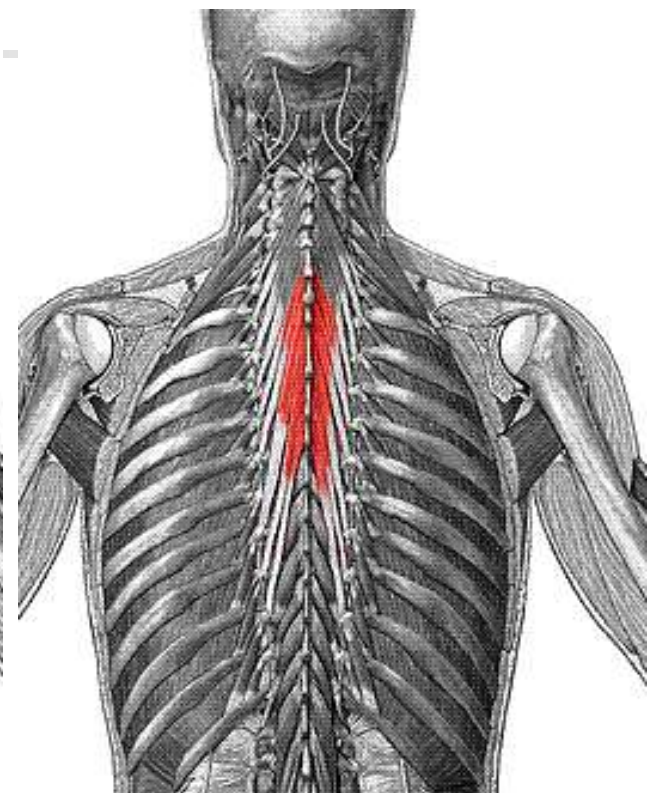
2a. Semispinalis



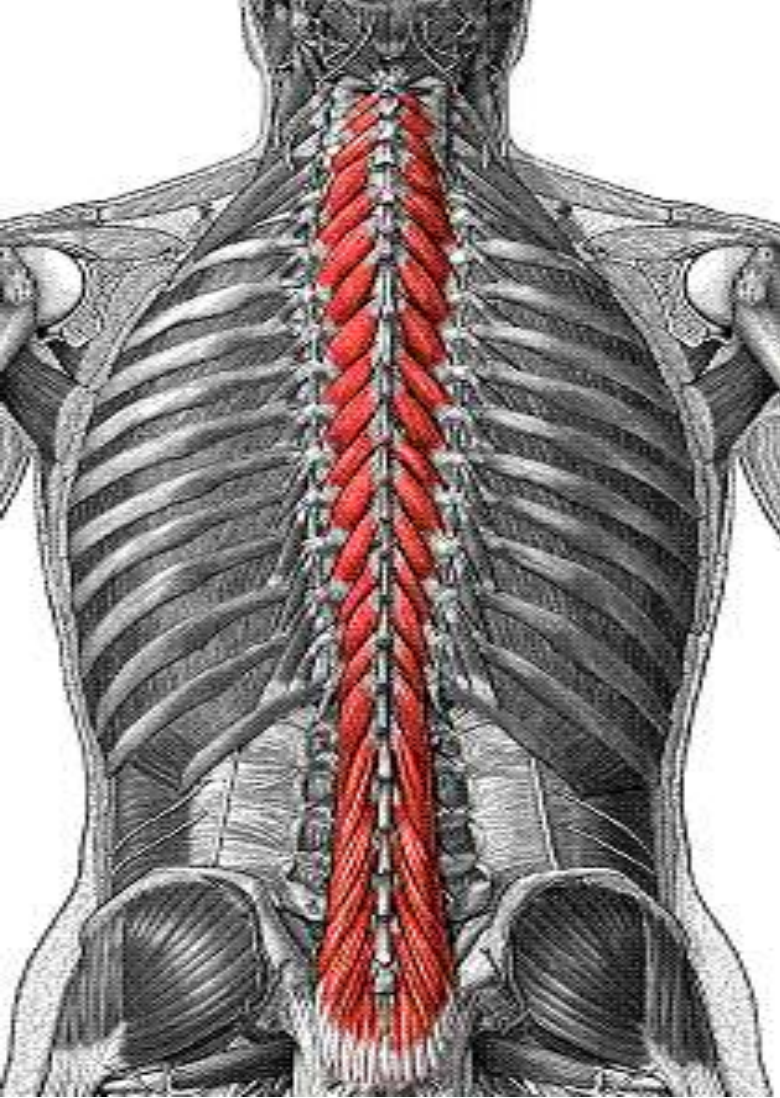
capitis



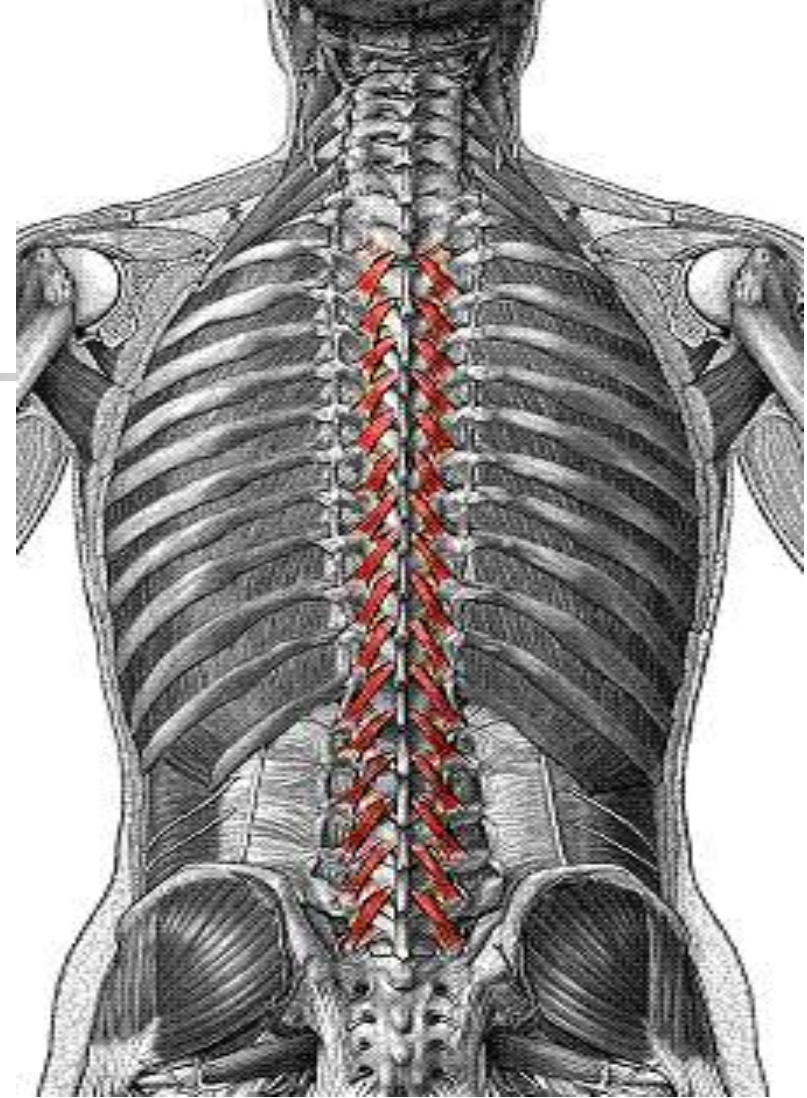
cervicis



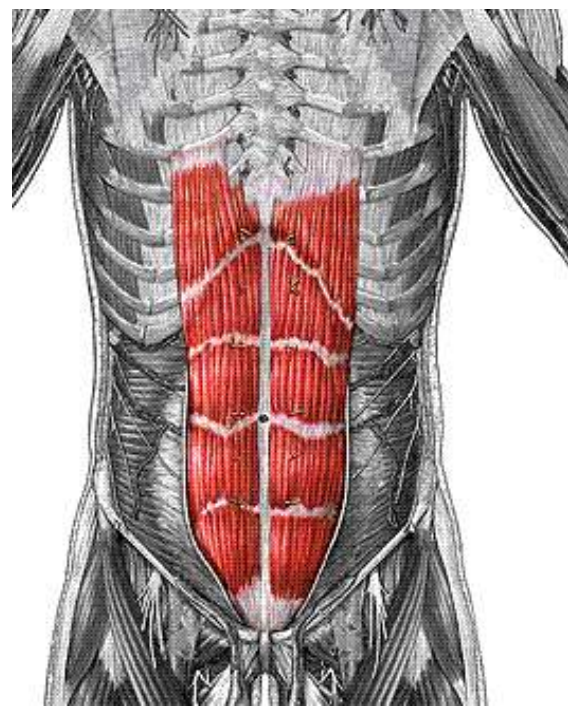
thoracis



2B
Multifidus

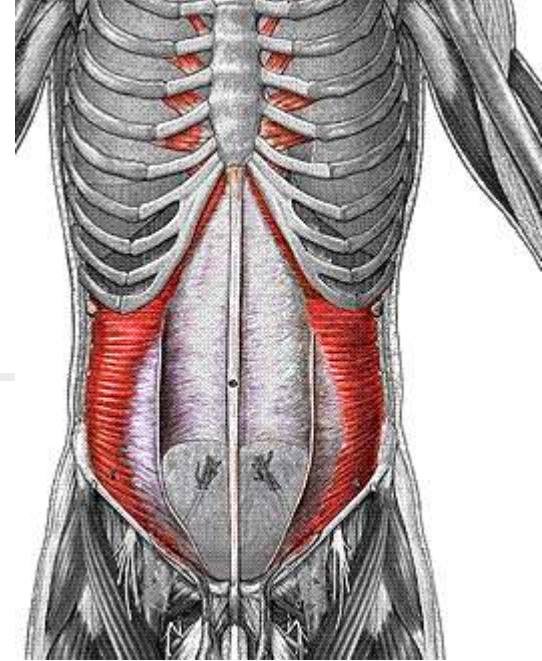


2C
Rotatores



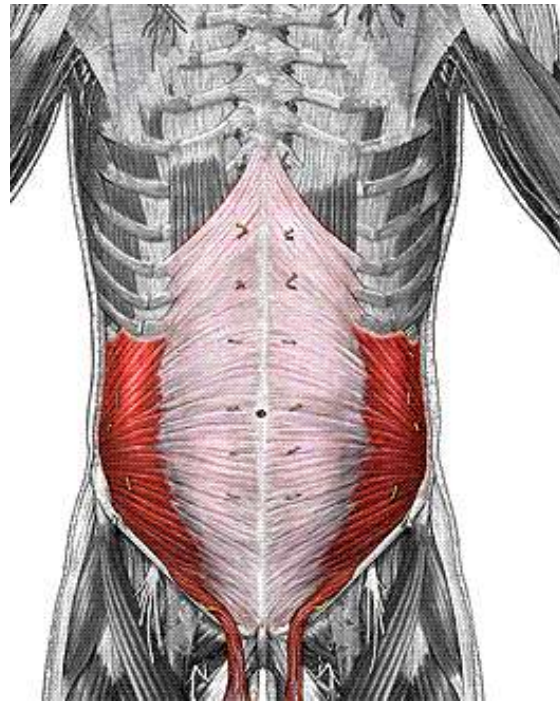
**Rectus
abdominis**

Abdominals

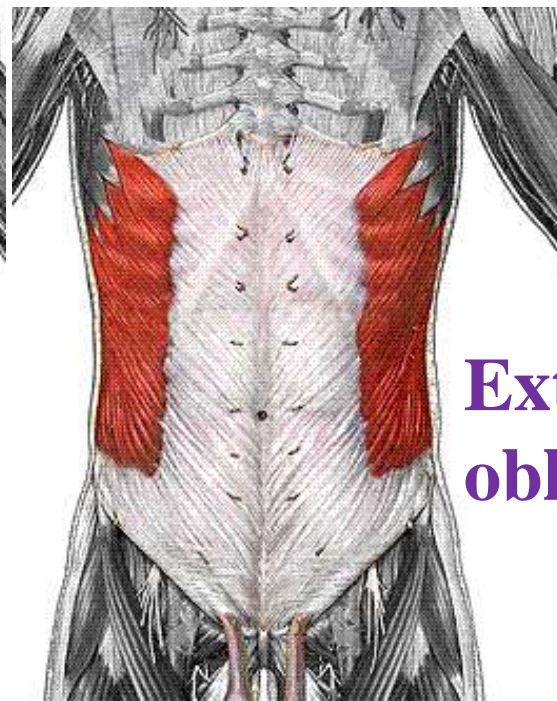


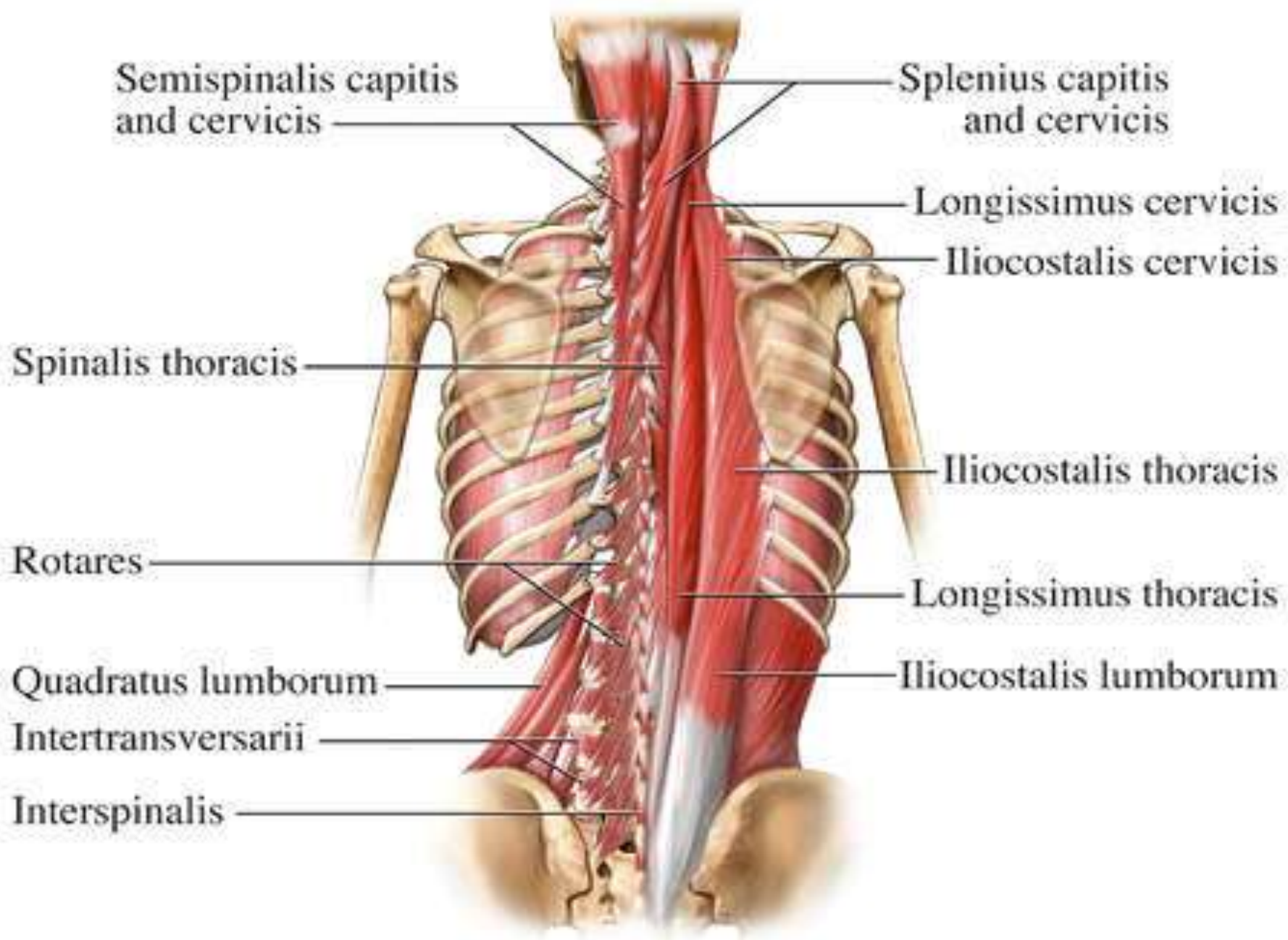
**Transverse
abdominus**

**Internal
oblique**



**External
oblique**





Semispinalis capitis
and cervicis

Splenius capitis
and cervicis

Longissimus cervicis

Iliocostalis cervicis

Spinalis thoracis

Iliocostalis thoracis

Rotares

Longissimus thoracis

Quadratus lumborum

Iliocostalis lumborum

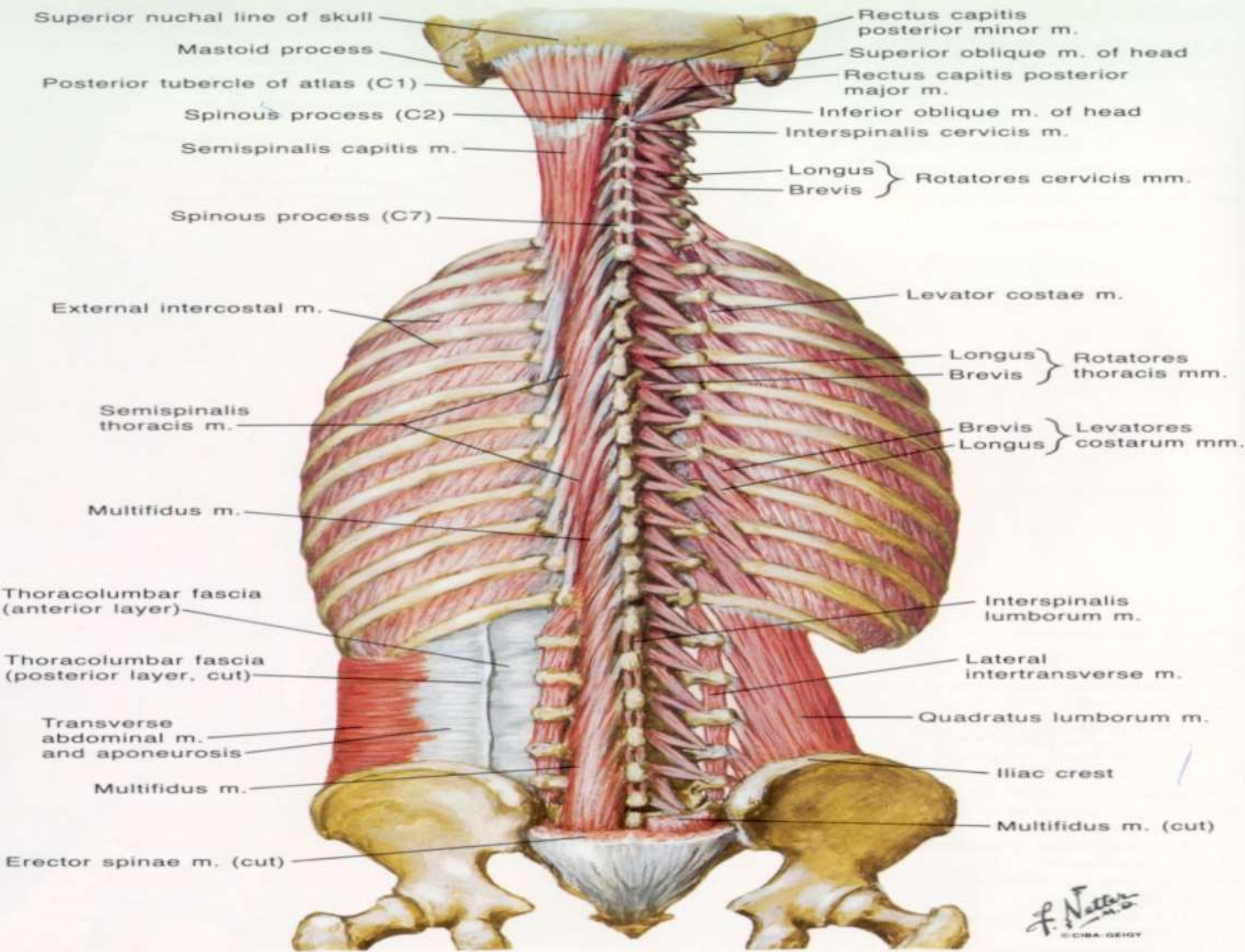
Intertransversarii

Interspinalis



Lateral Aspect

- Many muscles of neck and trunk cause lateral flexion when contracting unilaterally, but either flexion or extension when contracting bilaterally.
- **Muscles:** sternocleidomastoid
levator scapulae, scalenus anterior, posterior and medius
- **Lumbar region:** quadratus lumborum, psoas major





Loads on the Spine


- Forces acting on spine:
 - Body weight
 - Tension in the spinal ligaments
 - Tension in surrounding muscles
 - Intraabdominal pressure
 - Any applied external loads
- Body Movement Speed



MECHANICAL STABILITY OF THE LUMBAR SPINE

- IAP (intra-abdominal pressure)
- Co contraction of the trunk muscles
- external support

Intra-Abdominal Pressure

- 
- IAP contribute to both unloading and stabilization of the lumbar spine.
 - IAP within the abdominal cavity by a coordinated contraction of the diaphragm and the abdominal and pelvic floor muscles
 - Act as a "pressurized balloon" attempting to separate the diaphragm and pelvic floor
 - *This creates an extensor* moment that decreases the compression forces on the lumbar discs

Diaphragm

Downward Pressure

Abdomen

Erectors

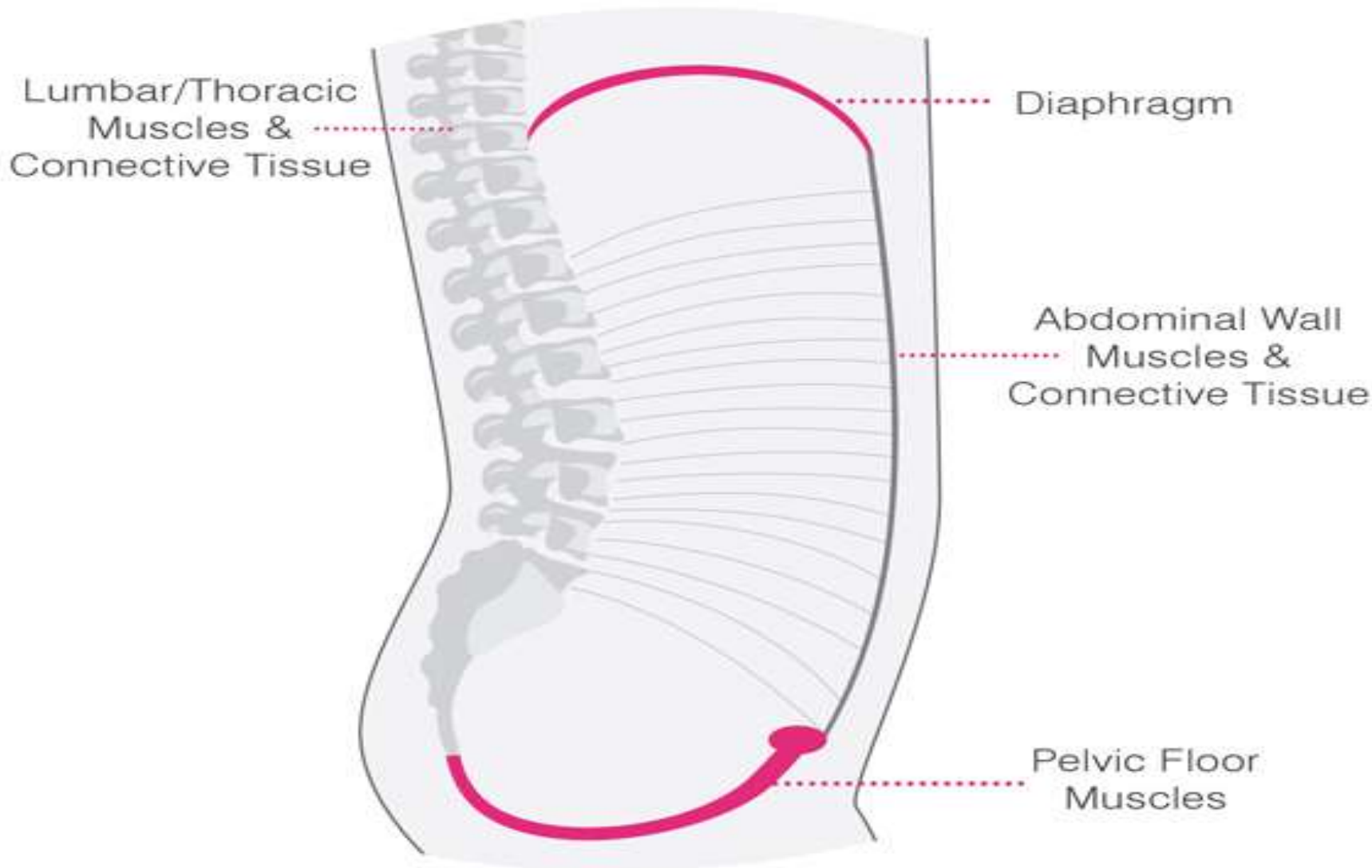
BRACING

Outward pressure

Stability pressure

Resistance

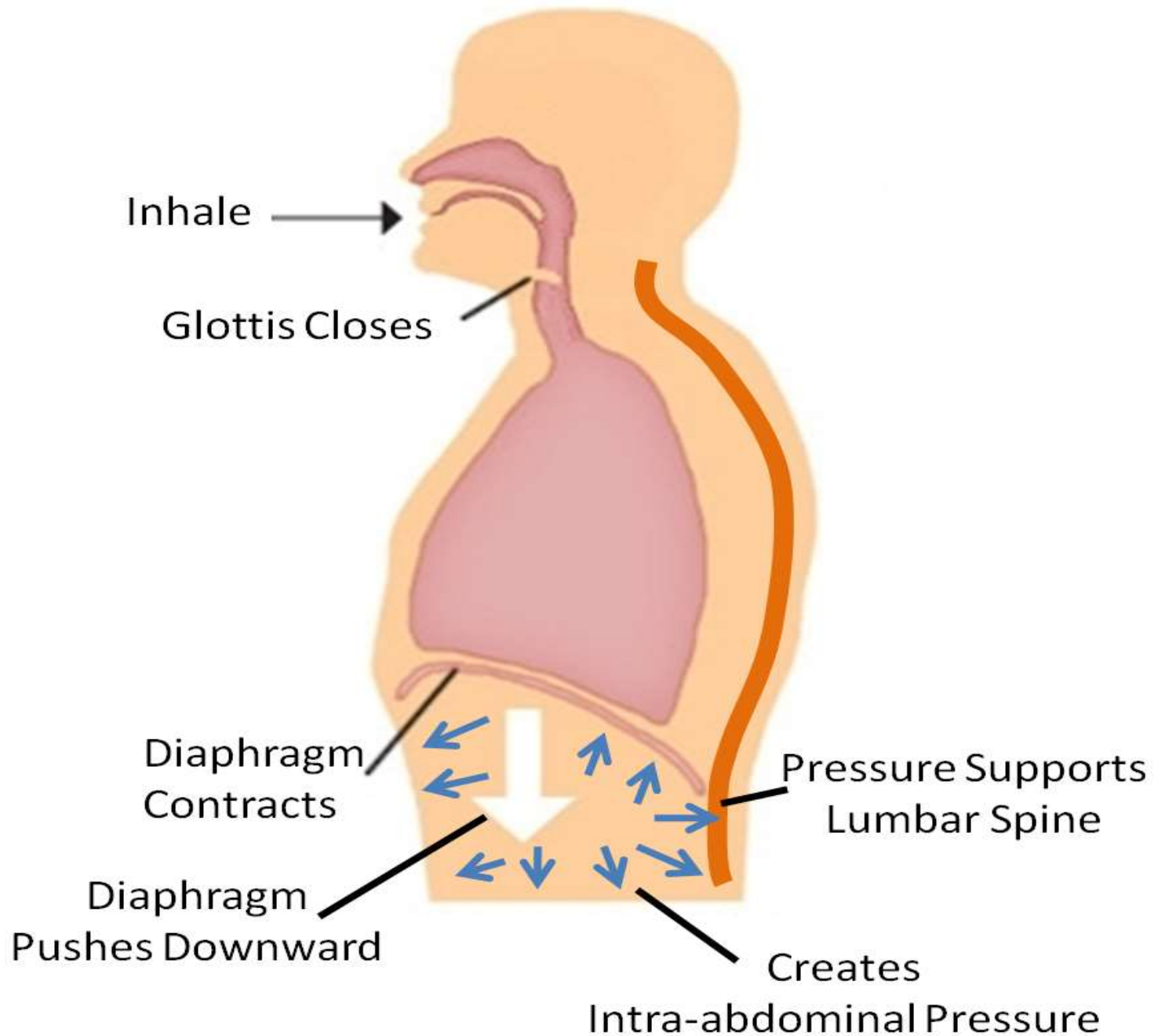
Pelvic Floor



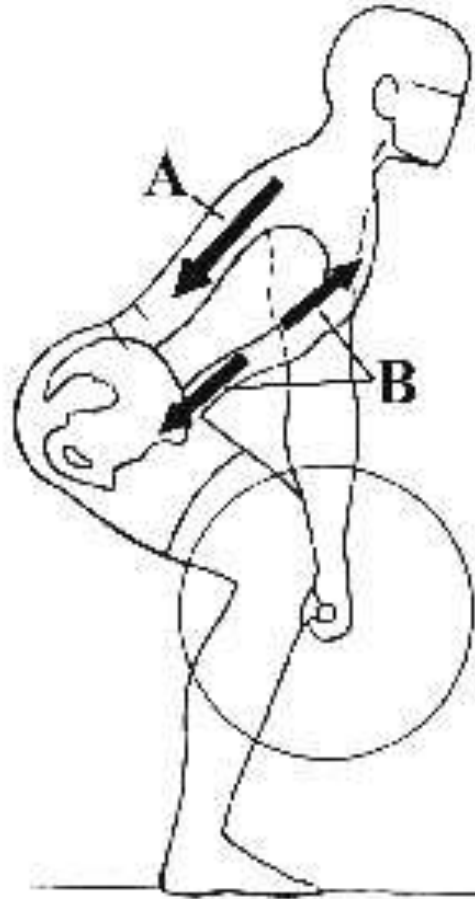
Core Activation: The 'Expansion and Compression' cycle of the Core driven by the breath

www.burrelleducation.com

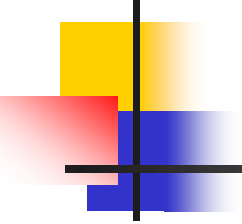
©Burrell Education 2012



The Role of Intraabdominal Pressure?

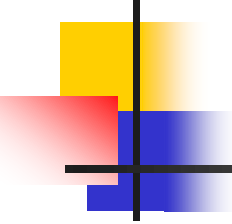


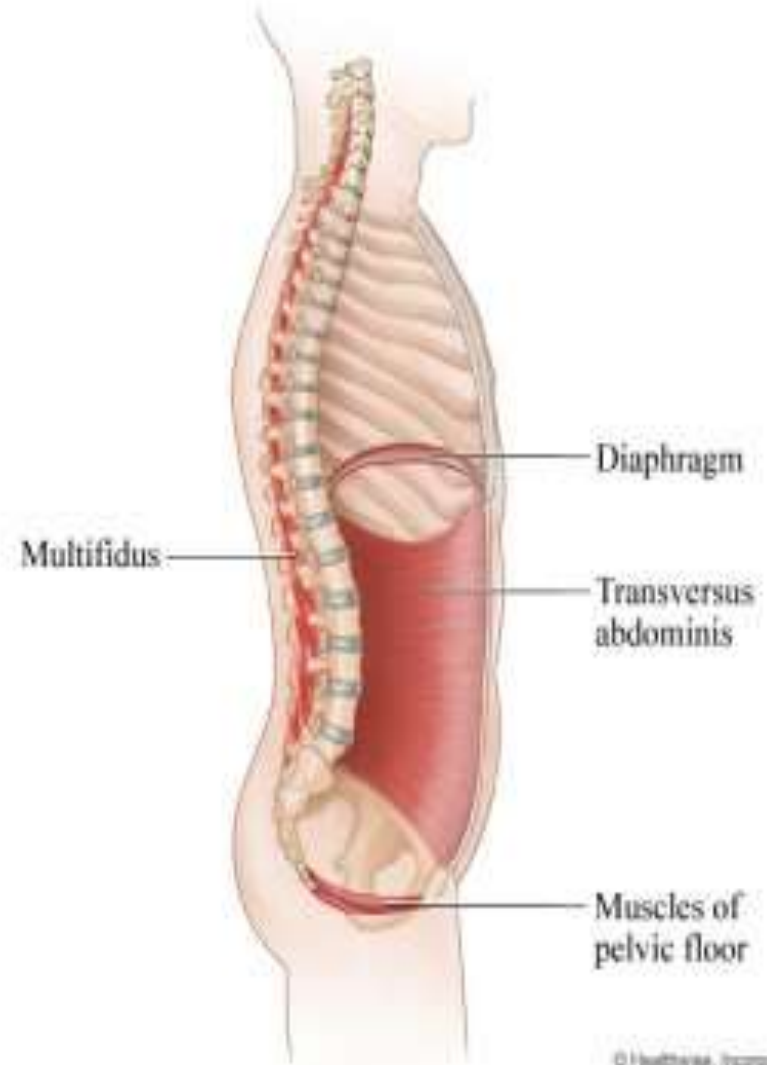
McGill, author of our text chapter, thinks it stiffens trunk which reduces tissue strain and tendency to buckle – but not pressure in the IVDs

- 
- Recent studies using fine-wire EMG of the deeper abdominal muscles found that the transversus abdominis is the
-

primary abdominal muscle responsible for IAP generation

- As the abdominal musculature contracts, IAP increases and converts the abdomen into a rigid cylinder that greatly increases stability as compared with the multisegmental spinal column

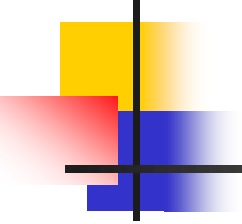
- 
-
- Current research suggests that the transversus abdominis muscle, together with the diaphragm, plays an important role in stabilizing the spine in preparation for limb movement





Trunk Muscle Co-Contraction

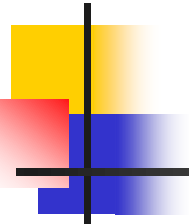
- With higher levels, co-contraction, spine compression and trunk muscle stiffness increase Loss of spine stability can be achieved through repetitive loading.
- This can be achieved through repetitive continuous motions that fatigue the trunk muscles

- 
-
- The reduction in the functional capacity of the flexion extension muscles was compensated for by secondary Muscle groups and led to an increased couple motion pattern that is more injury prone

External Stabilization

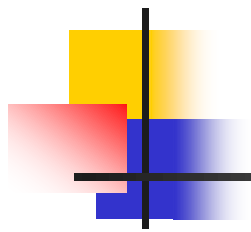
- Restriction of motion at any level may increase motion at another level.
- The use of back belts as a means of preventing low back injury remains controversial.





■ Originally it was believed to assist in increasing IAP as a way of unloading the spine during lifting, however, inconclusive evidence exists as to the biomechanical effectiveness of these devices





عَنْ عَبْدِ اللَّهِ بْنِ مَسْعُودٍ

﴿ حدیث نبوی ﷺ ﴾

"آپ ﷺ کو جب کوئی مشکل درپیش ہوتی تو آپ ﷺ فوراً

نماز کی طرف متوجہ ہو جاتے۔"

(ابوداؤد: حدیث نمبر: ۱۳۱۹)

Lawrence Halmat

Low Back Pain

- 75-80% of population will experience it at some time in their life
- Mechanical stress plays a significant role
- Relative Stability of Spine
- 60% of cases is idiopathic (unknown origin)
- Abdominal & back extensors exercises help in treatment





Soft Tissue Injuries

- Contusions
- Laceration
- Muscle Strains
- Ligament Sprains
- laceration
- Spasms result usually from underlying problems.







Grading muscle strain

	Pain	Weakness	Loss of function
Grade 1	<input type="checkbox"/>		
Grade 2	<input type="checkbox"/>	<input type="checkbox"/>	
Grade 3	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>



Acute Fractures

- Transverse or Spinous fractures from hard blow (contact sports) or extremely forceful contraction
- Extremely serious because of fragile spinal cord.
- Rib fractures usually due to blows from sports, cause pain with each inhalation.
 - Potential for serious damage to underlying soft tissues (lungs)



Stress Fractures

- Most common type of vertebral fracture is in pars interarticularis
 - Spondylolysis
 - Spondylolisthesis
- Spondylolysis and spondylolisthesis don't tend to heal with time
 - Common with sports involving repeated hyperextension of the lumbar spine.

Stress Fractures

- **Spondylolysis** is a defect of a vertebra. More specifically it is defined as a defect in the pars interarticularis of the vertebral arch. The great majority of cases occur in the lowest of the lumbar vertebrae (L5), but spondylolysis may also occur in the other vertebrae.
 - Spondylolysis can progress until one or more vertebrae slip out of place which is then called spondylolisthesis.
 - Due to fracture of pars Interarticularis bilaterally
 - It can result in
 - Narrowing of posterior joint space, Stress to spinal nerves, the spinal cord, or the cauda equina
- pain can lead to reduced mobility and inactivity. Inactivity can result in weight gain, loss of bone density, and loss of muscle strength and flexibility of other areas of the body.

LUMBAR VERTEBRA

BODY

VERTEBRAL FORAMEN

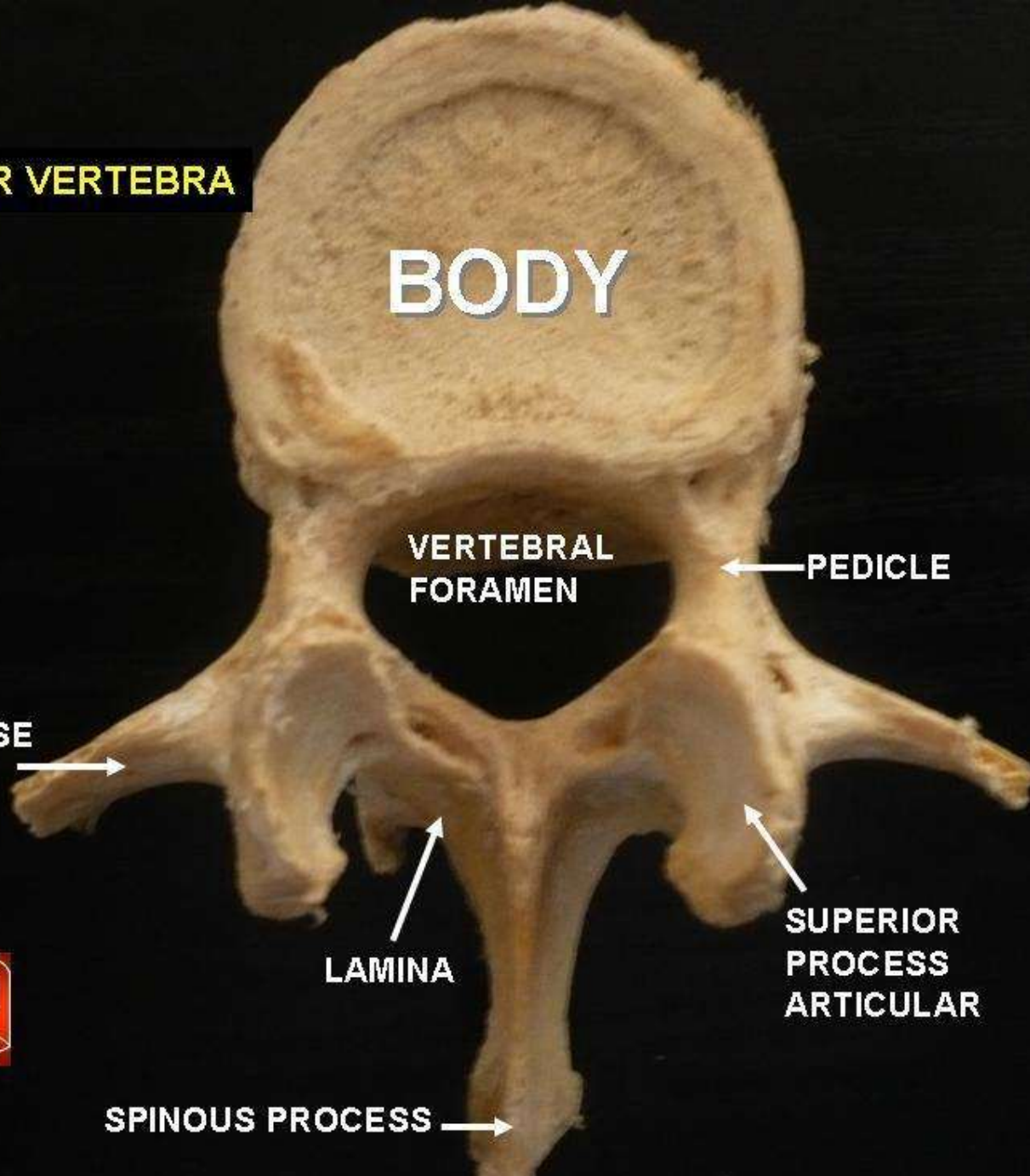
PEDICLE

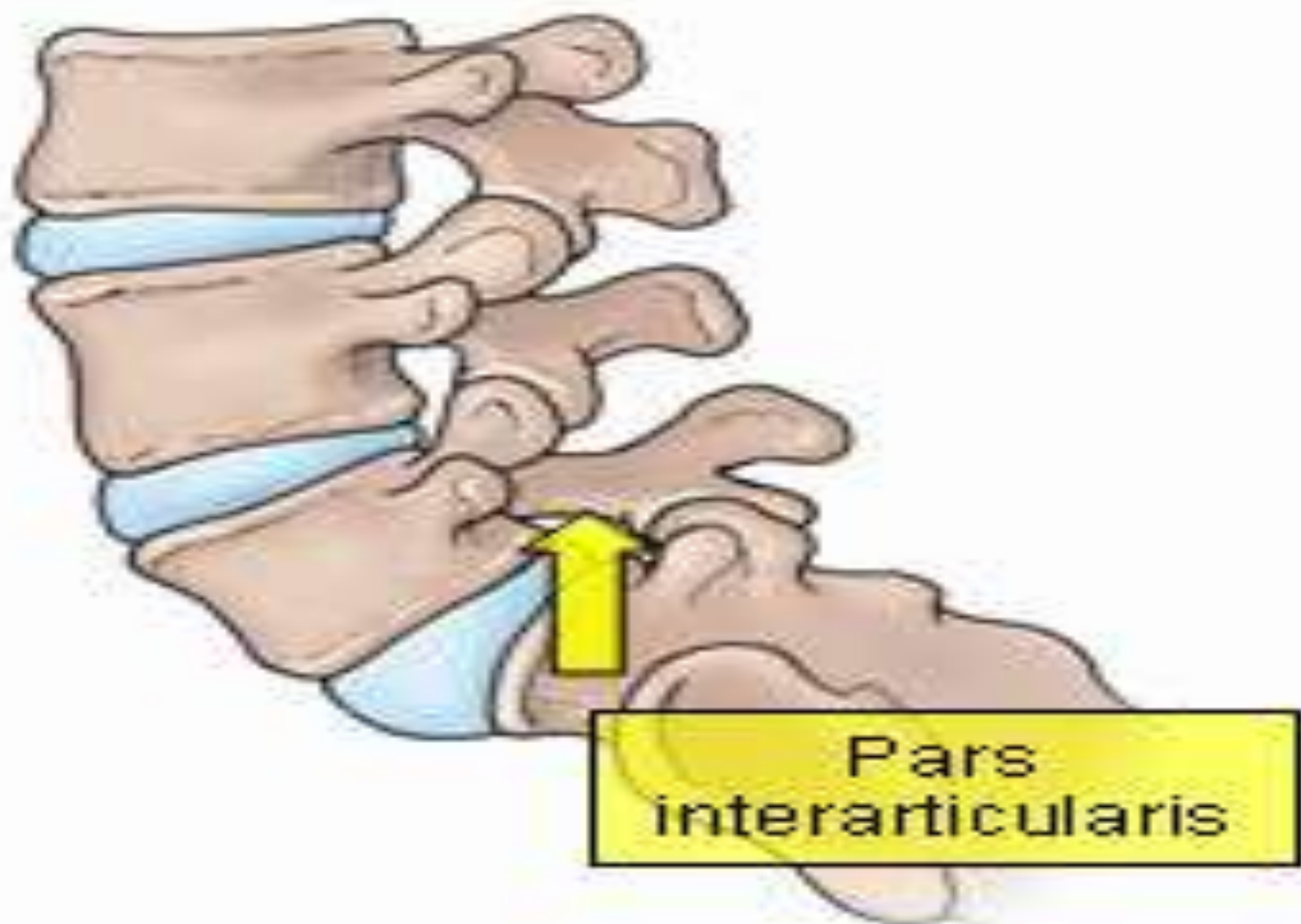
TRANSVERSE PROCESS

LAMINA

**SUPERIOR PROCESS
ARTICULAR**

SPINOUS PROCESS



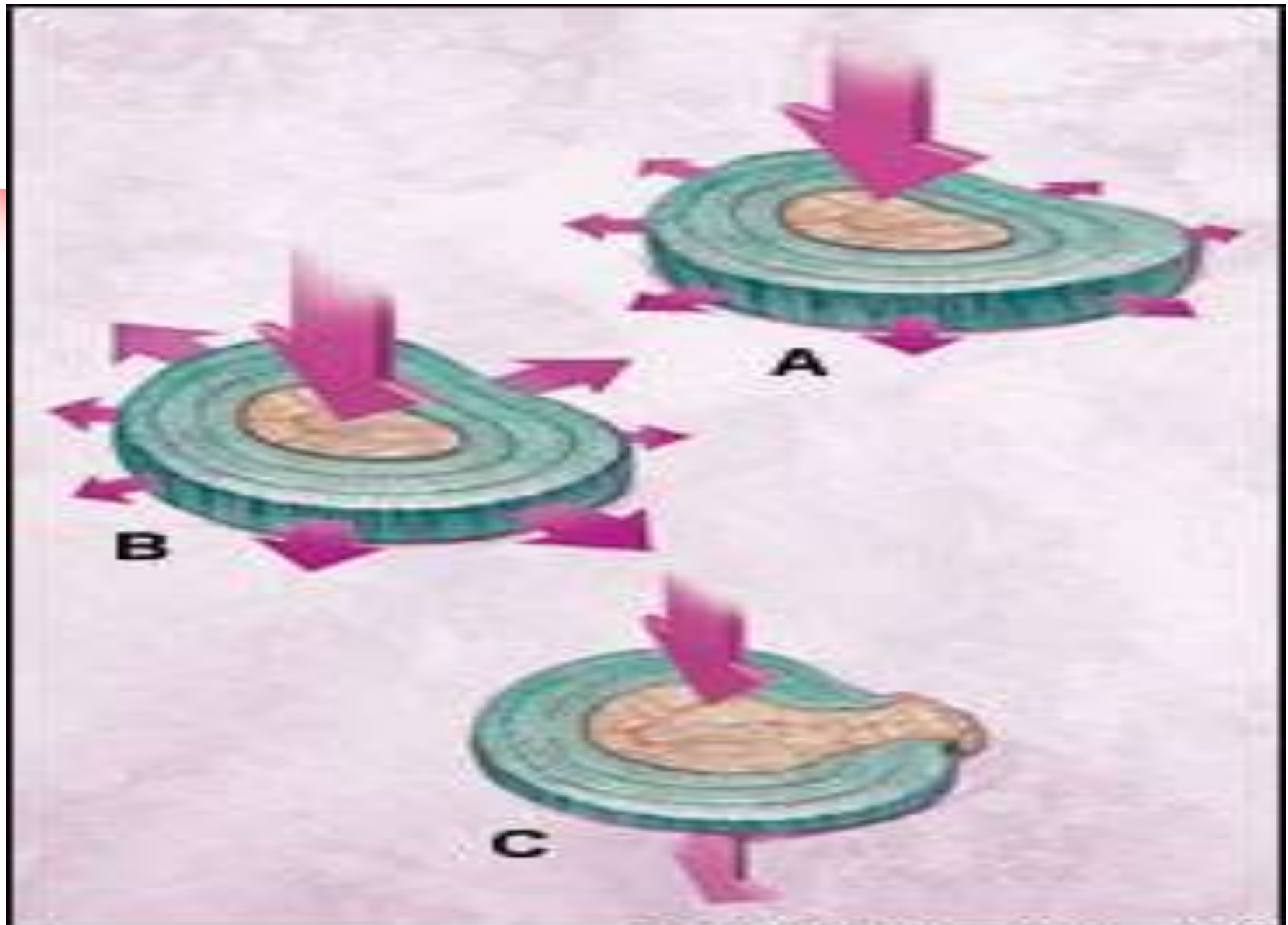






Disc Herniations

- Cause of 1-5% back pain cases
- Protrusion of part of nucleus pulposus from the annulus.
- Traumatic or stress related.
- **Common sites: between 5th-6th and 6th-7th cervical vertebrae and 4th-5th lumbar and 5th lumbar and 1st sacral.**
- Sensory nerves supplying anterior and posterior longitudinal ligaments generate pain signals.



spondylosis

Examples of Disc Problems





Airbag Injuries

- Motor vehicle accidents continue to be the leading cause of injury-related deaths in the United States.
- Studies generally concluded that front seat occupants are adequately Protected against frontal impact if belts are worn in an airbag equipped vehicle

- 
- Passenger-side airbags pose a lethal threat to children riding in the front seat of an automobile
-

- The back seat is the safest place for children of any age to ride.
- Never put an infant (less than 1 year old) in the front of a car with a passenger-side airbag. Make sure everyone is buckled up.
- Unbuckled occupants can be hurt or killed by an airbag

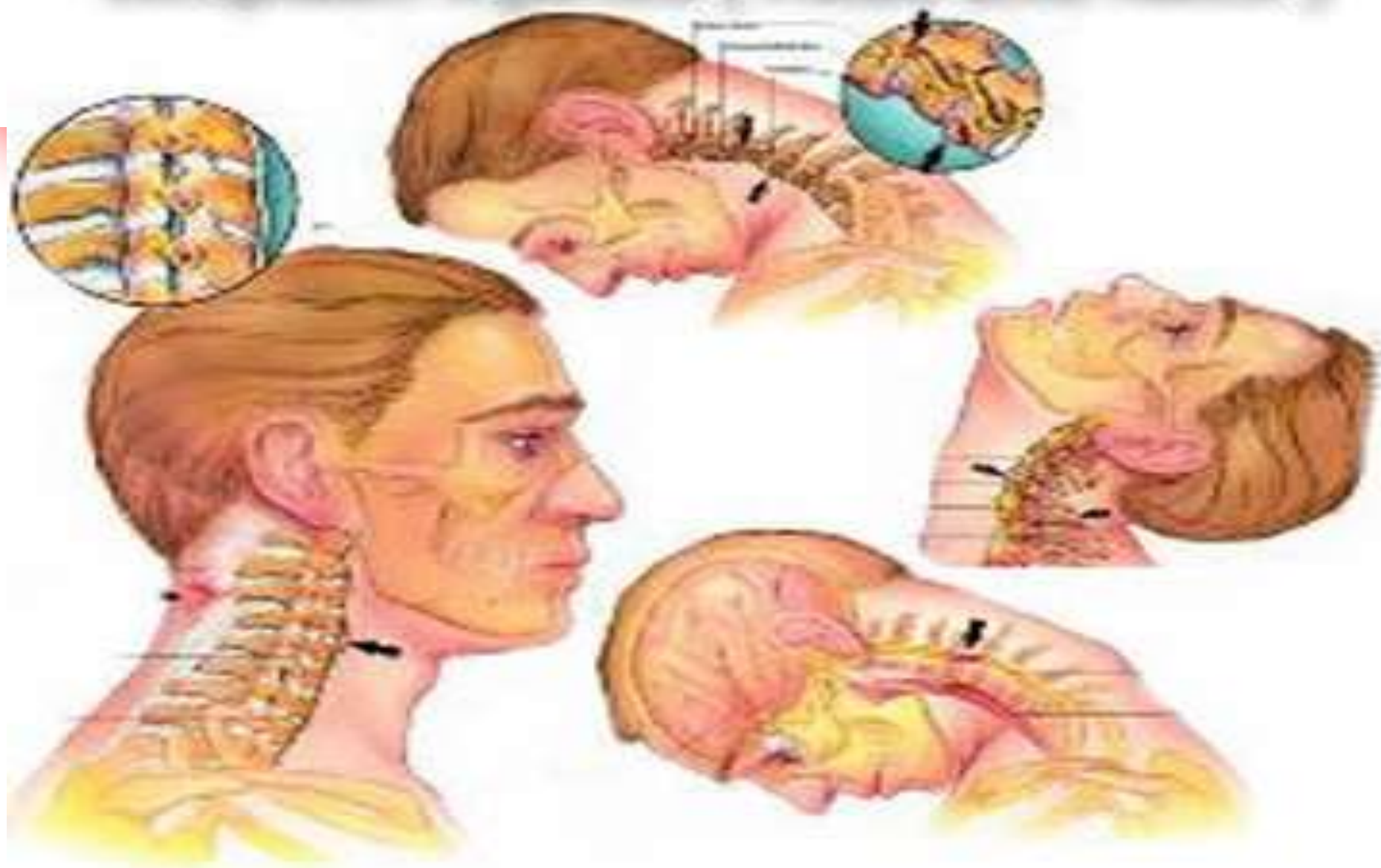




Whiplash Injuries

- Relatively common injury to cervical region.
- Usually from automobile collisions, where neck undergoes sudden acceleration and deceleration.
- Symptoms:
 - Neck pain, muscle pain, pain or numbness radiating from neck to shoulders, arms, hands and a headache (present in 50-60% of most cases)

Whiplash Injuries (Head and Neck)



The End

