

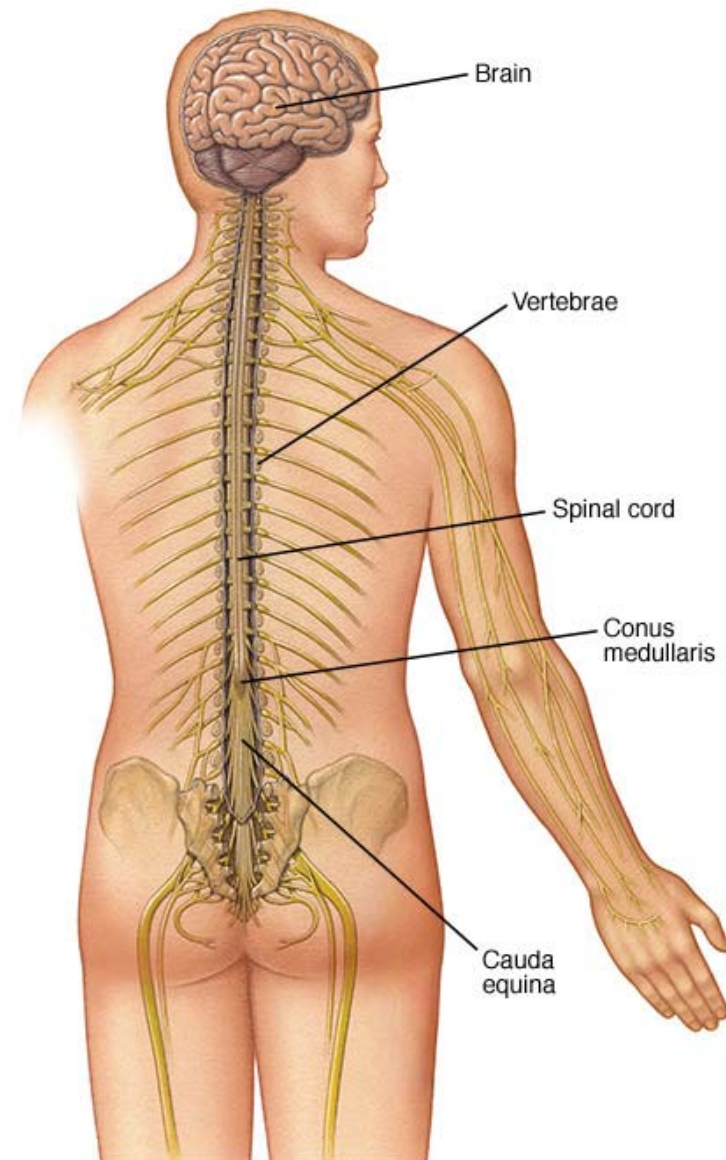
Gross Morphology of Spinal Cord

Lecture Objectives

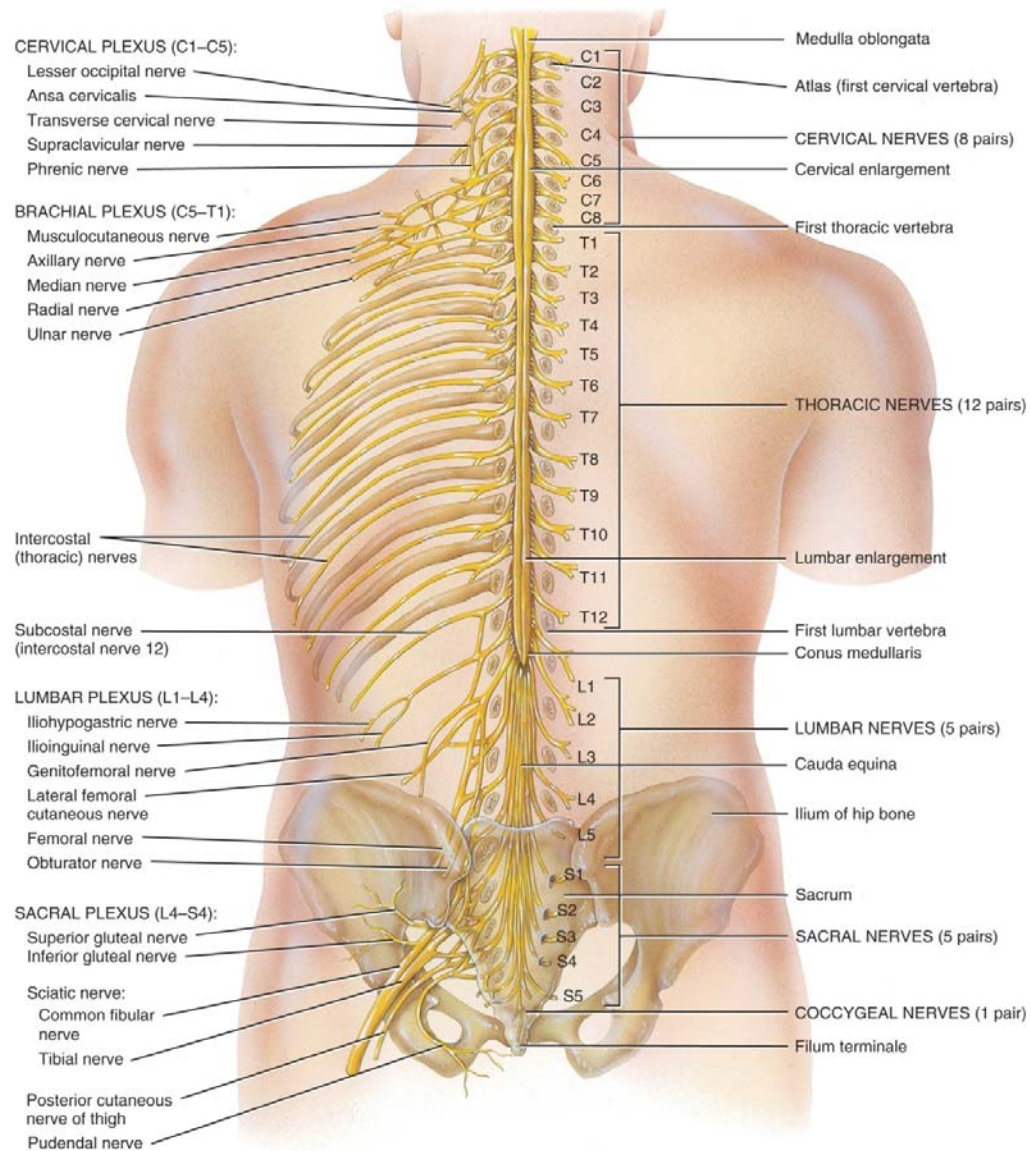
- Describe the gross anatomical features of the spinal cord.
- Describe the level of the different spinal segments compared to the level of their respective vertebrae.
- Identify important gross features of spinal cord, nerve roots, and spinal ganglia.
- Describe the internal features of spinal cord (gray matter and white matter) in the different regions.
- Summarize the location, origin, course and termination of the important ascending and descending tracts of spinal cord.

The Spinal Cord

- Together with brain forms the CNS
- Functions
 - spinal cord reflexes
 - integration (summation of inhibitory and excitatory) nerve impulses
 - highway for upward and downward travel of sensory and motor information



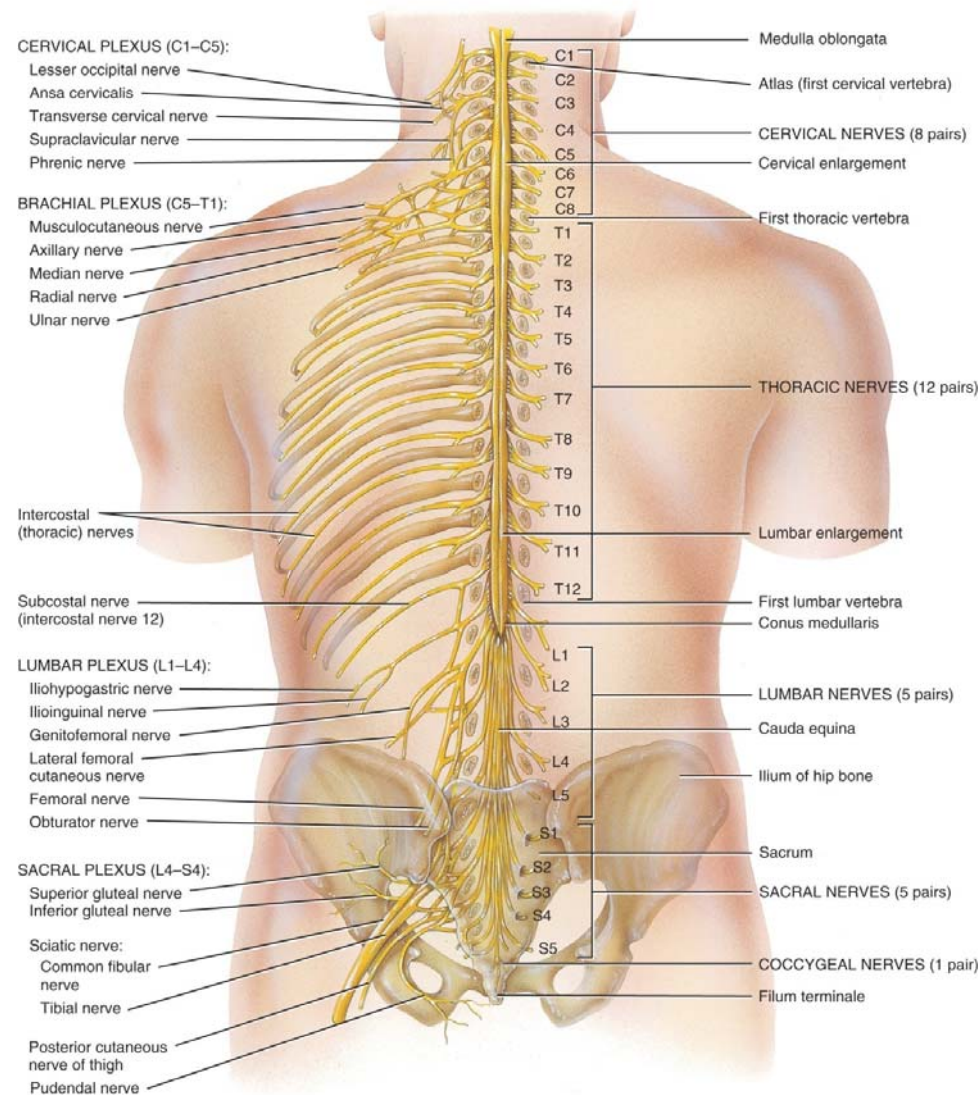
Spinal Cord



(a) Posterior view of entire spinal cord and portions of spinal nerves

- Flattened cylinder
- 16-18 Inches long & 3/4 inch diameter
- In adult ends at L2
- In newborn ends at L4
- Growth of cord stops at age 5
- Cervical enlargement (C4-T1)
 - upper limbs
- Lumbar enlargement (L2-S3)
 - lower limbs

Inferior End of Spinal Cord

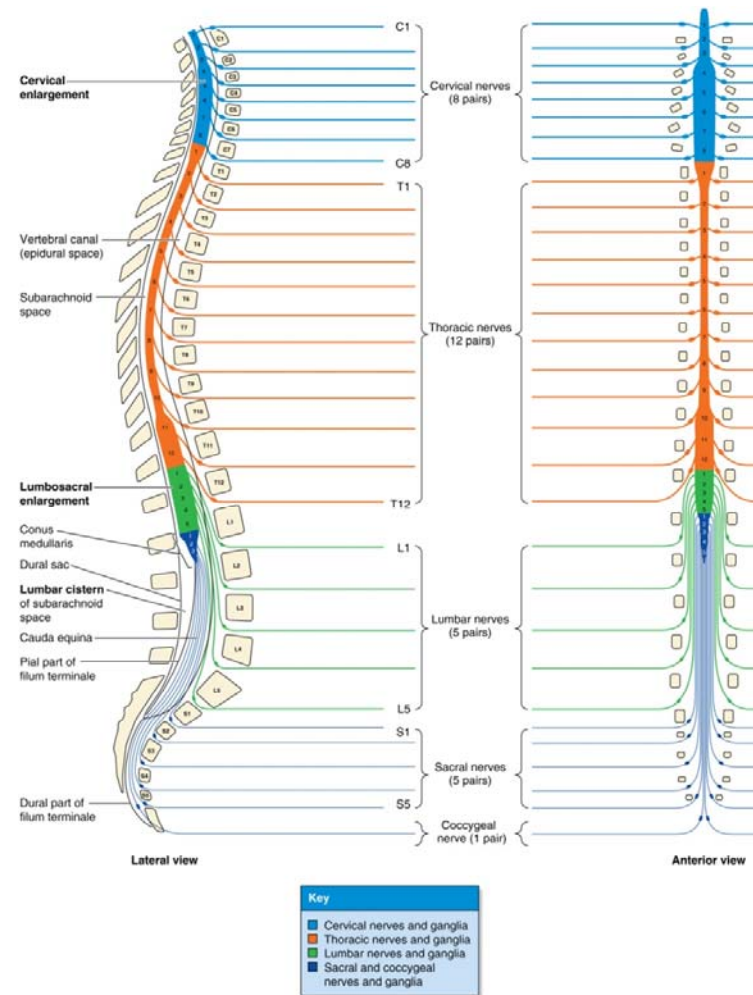


(a) Posterior view of entire spinal cord and portions of spinal nerves

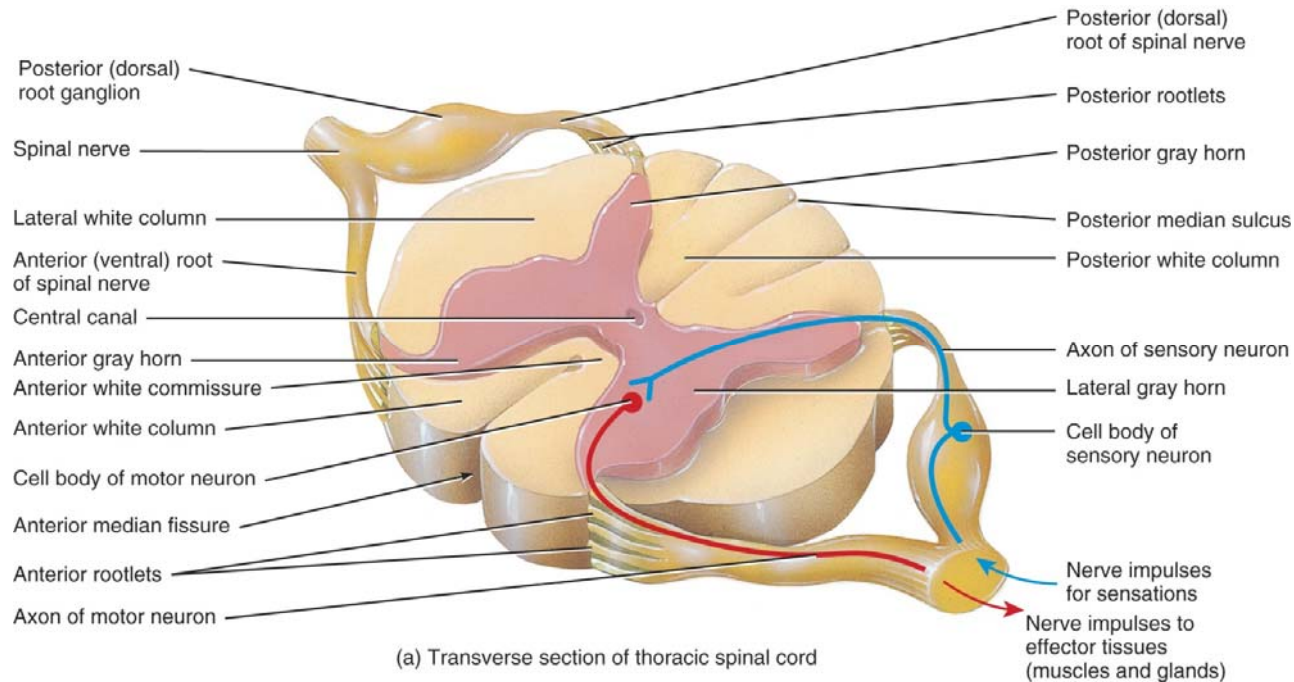
- Conus medullaris
 - cone-shaped end of spinal cord
- Filum terminale
 - thread-like extension of pia mater
 - stabilizes spinal cord in canal
- Caudae equinae (horse's tail)
 - dorsal & ventral roots of lowest spinal nerves
- Spinal segment
 - area of cord from which each pair of spinal nerves arises

Spinal Nerves

- 31 Pairs of spinal nerves
- Named & numbered by the cord level of their origin
 - 8 pairs of cervical nerves (C1 to C8)
 - 12 pairs of thoracic nerves (T1 to T12)
 - 5 pairs of lumbar nerves (L1 to L5)
 - 5 pairs of sacral nerves (S1 to S5)
 - 1 pair of coccygeal nerves
- Exit through the IVF

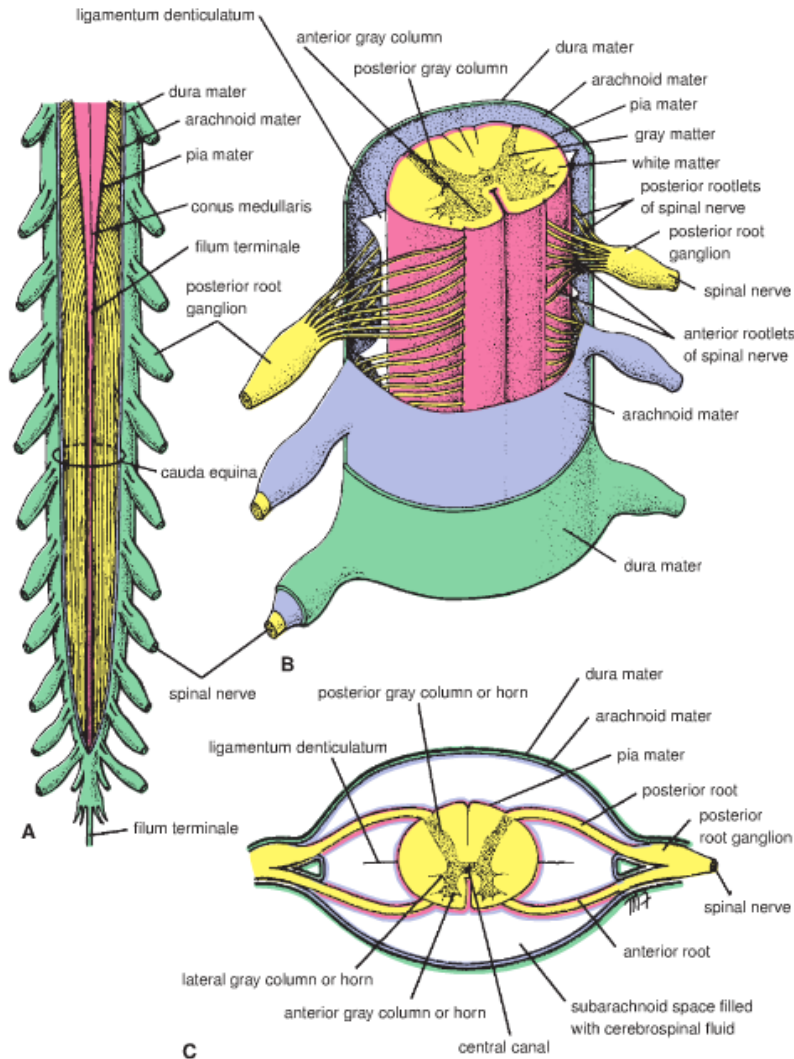


Spinal Cord & Spinal Nerves



- Spinal nerves begin as roots
- Dorsal or posterior root is incoming sensory fibers
 - dorsal root ganglion (swelling) = cell bodies of sensory nerves
- Ventral or anterior root is outgoing motor fibers

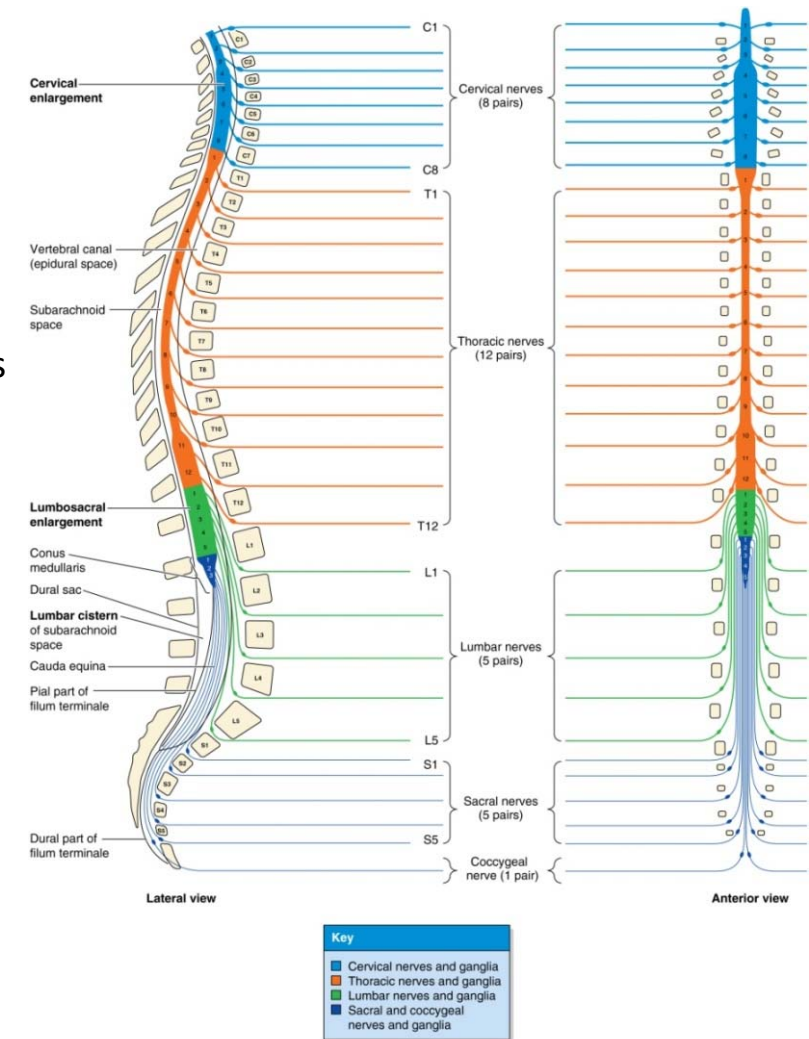
Structures Covering the Spinal Cord



- **Vertebrae**
- **Epidural space** filled with fat
- **Dura mater**
 - Dense irregular CT tube
 - Ends at the lower border of S2
 - Follows the nerve roots and become continuous with epineurium
- **Subdural space** filled with interstitial fluid
- **Arachnoid** = spider web of collagen fibers
 - Ends at the lower border of S2
 - Follows the nerve roots into the IVF
- **Subarachnoid space** = CSF
 - Lumbar cistern (enlargement in subarachnoid space)
 - L2-S2
- **Pia mater**
 - Thin layer covers BV
 - Denticulate ligaments hold SC in place

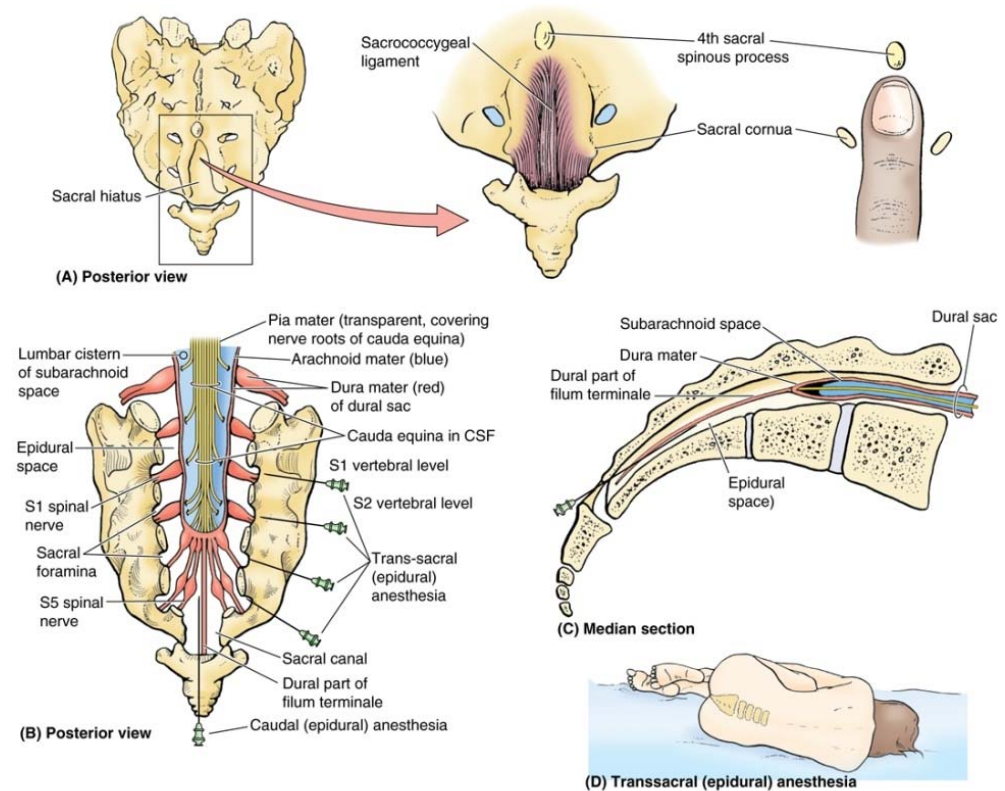
Cervical Vertebral Canal: Content

- Meninges
 - Dura matter
 - Continuous with cranial dura matter (meningeal layer)
 - Arachnoid matter
 - Pia matter
- Lower part of medulla oblongata
- Cervical segments of the spinal cord
 - Contain the upper motor neurons for the upper and lower limbs
 - Other descending fibers to the spinal cord (e.g. reticulospinal fibers)
 - Contain the ascending (sensory) fibers from the neck below
 - Cervical enlargement
 - Innervation for the upper limb
 - Lower motor neurons
- Cervical spinal nerves
 - C1-C8
 - C1-C7 exit above the corresponding vertebra
 - C1 exit between the atlas and the occipital bone
 - C8 exit between the C7 and T1 vertebrae
 - C1-C4 form the cervical plexus
 - C5-T1 form the brachial plexus

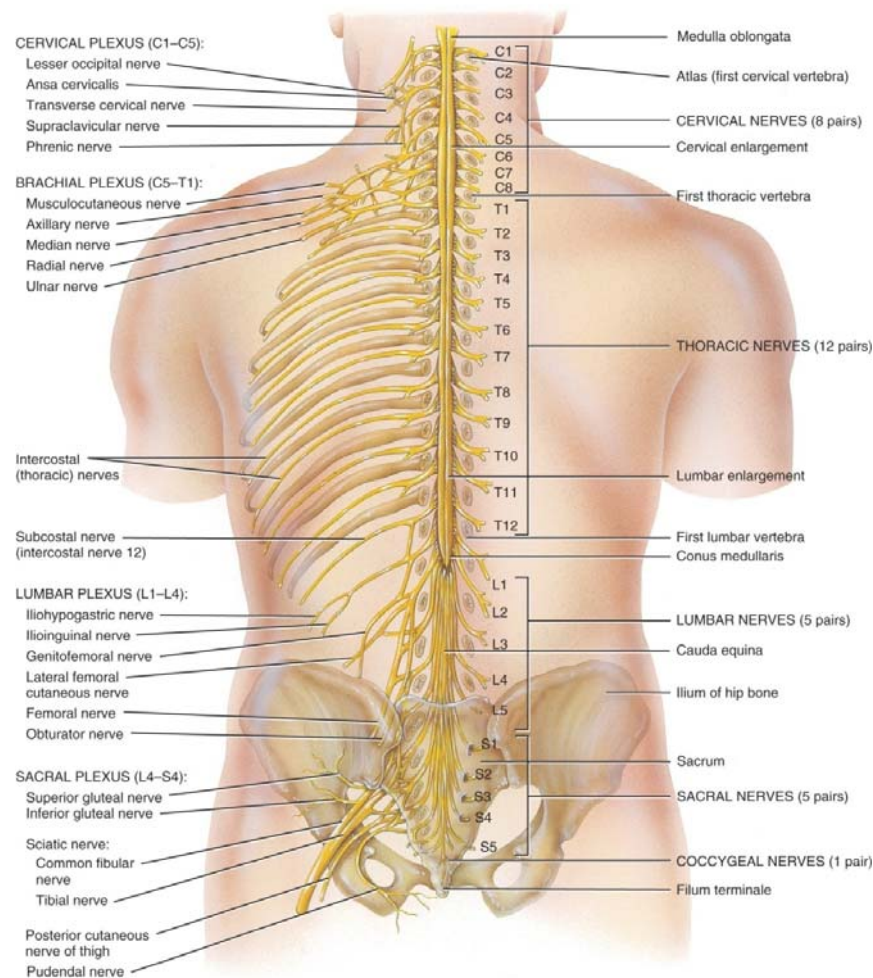


Caudal Epidural Anesthesia

- Caudal epidural anesthesia during delivery
- Into sacral hiatus
- Sacral and coccygeal cornua are important landmarks
- Anesthetize S2-Co1 spinal nerves



Inferior End of vertebral canal: Content

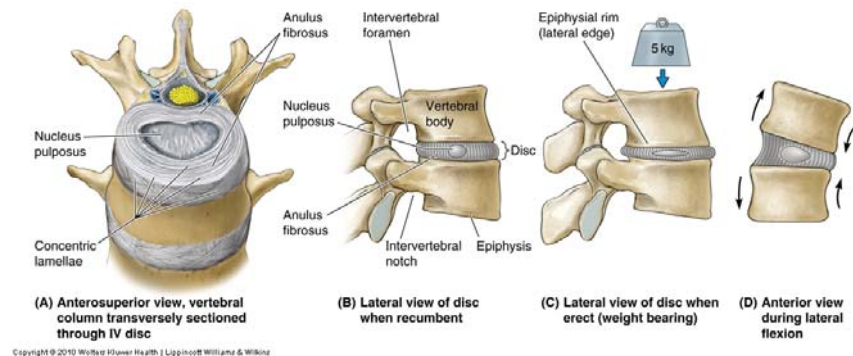
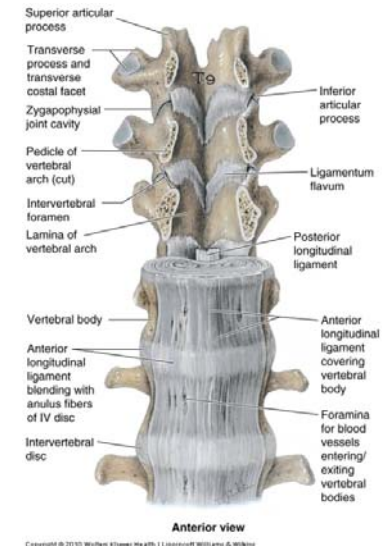
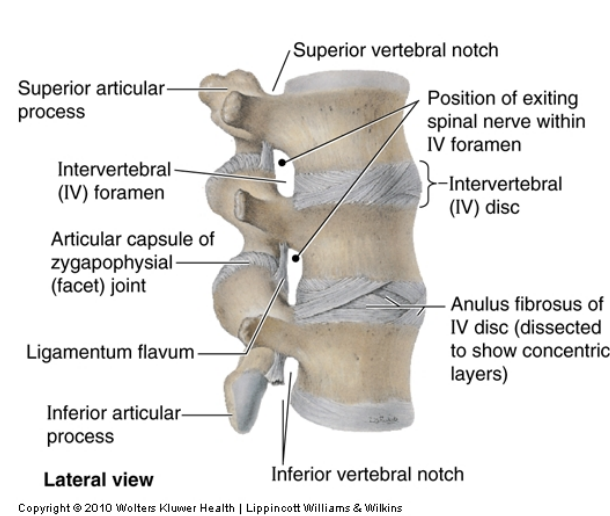


(a) Posterior view of entire spinal cord and portions of spinal nerves

- Conus medullaris
 - In adult ends at L2
 - In newborn ends at L4
- Cauda equina (horse's tail)
 - dorsal & ventral roots of lowest spinal nerves (L1-Co1)
- Spinal meninges
 - Dura matter
 - Ends at S2-S3
 - Arachnoid matter
 - Ends at S2-S3
 - Subarachnoid space = CSF
 - Lumbar cistern (enlargement in subarachnoid space)
 - L2-S2
- Pia matter
 - Filum terminale
 - thread-like extension of pia mater
 - stabilizes spinal cord in canal

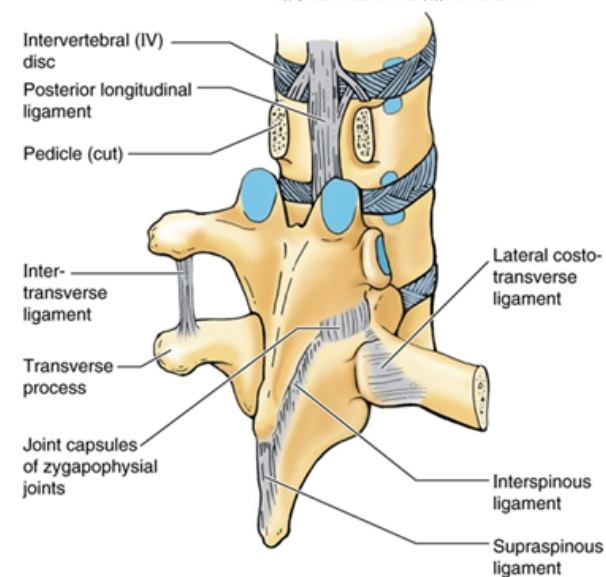
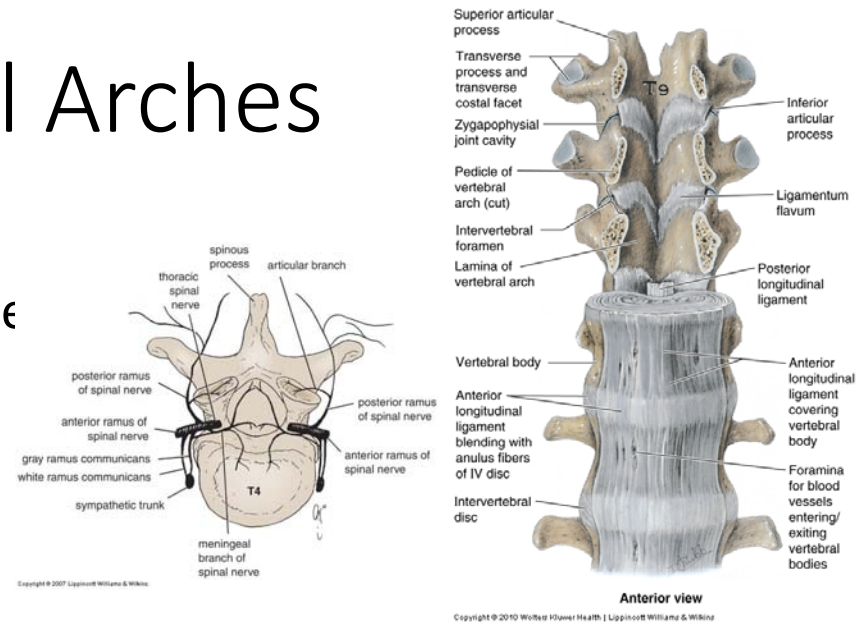
Joints of Vertebral Bodies

- Cartilaginous joint- Symphysis
- Vertebral bodies covered with thin plates of hyaline cartilage
- IVD
- Ligaments
 - Anterior longitudinal ligaments
 - Wider & stronger
 - Attached to the vertebral bodies and the IVD
 - Posterior longitudinal ligaments
 - Weak and narrow
- Nerve supply: meningeal branches of the spinal nerves



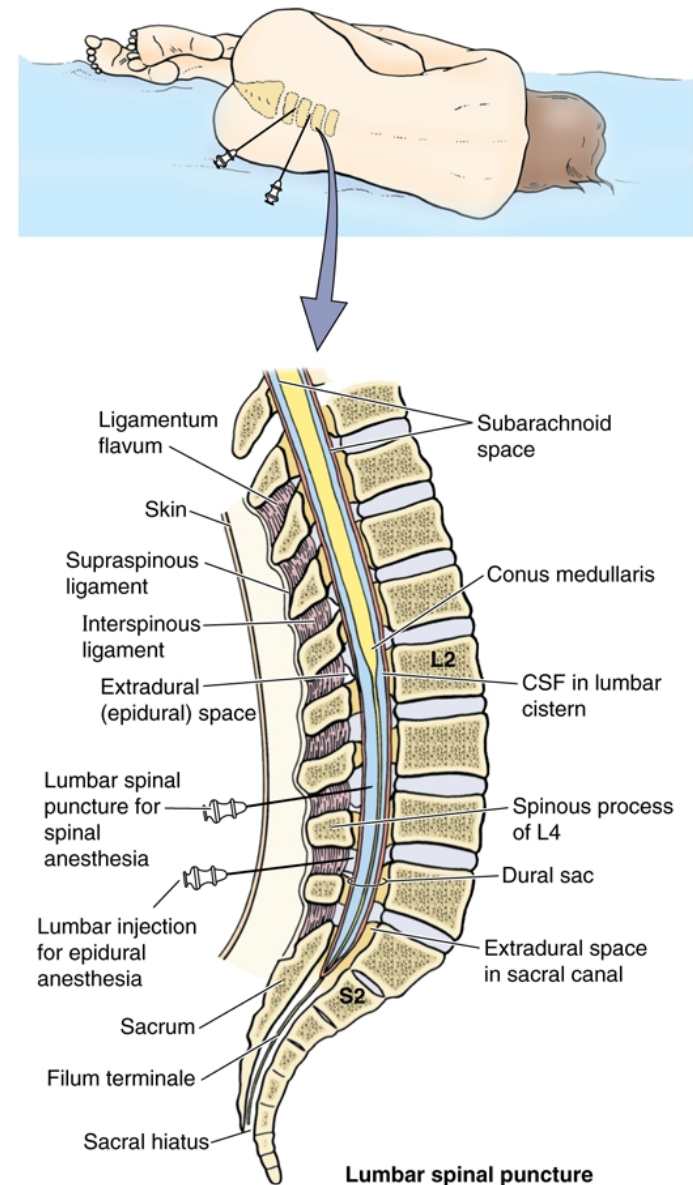
Joints of Vertebral Arches

- Also called **zygapophysial joints**
- Plane synovial joint between the superior & inferior articular processes
 - Articular facets
 - Capsular ligament
- Ligaments
 - Supraspinous ligament
 - Between tips of spines
 - Intraspinous ligament
 - Between spines
 - Intertransverse ligaments
 - Between transverse processes
 - Ligamentum flavum
 - Between laminae
- Nerve supply: articular branches from posterior rami of the spinal nerves



Lumbar Puncture

- Lumbar puncture is used to withdraw CSF for diagnostic purposes
- LP performed from lumbar cistern to avoid the damage to the spinal cord
- LP approached mostly in L3-L4 or L4-L5
- Epidural anesthesia
 - Target the epidural space
 - Same approach as LP
 - Could be approached from the sacral hiatus



Spinal Nerves: Level of Exit

- From T1 to L5, spinal nerves exit from the IVF below their encountered vertebrae
- S1-S4 rami exit from their encountered sacral foramina
- S5 & Co1 exit from sacral hiatus

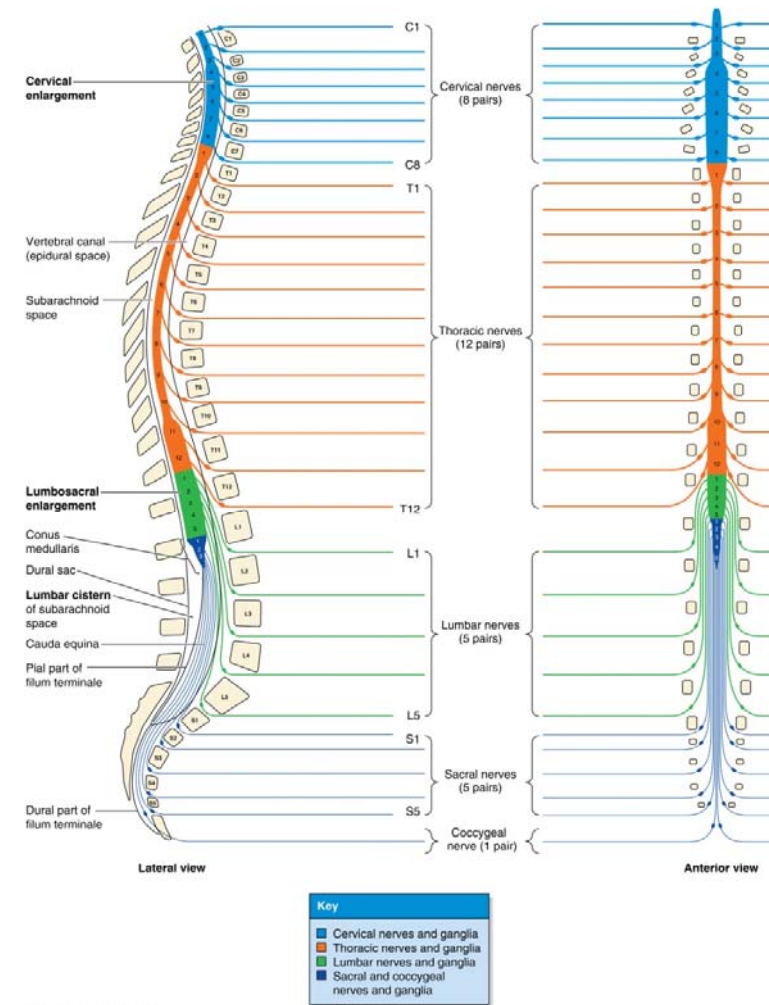


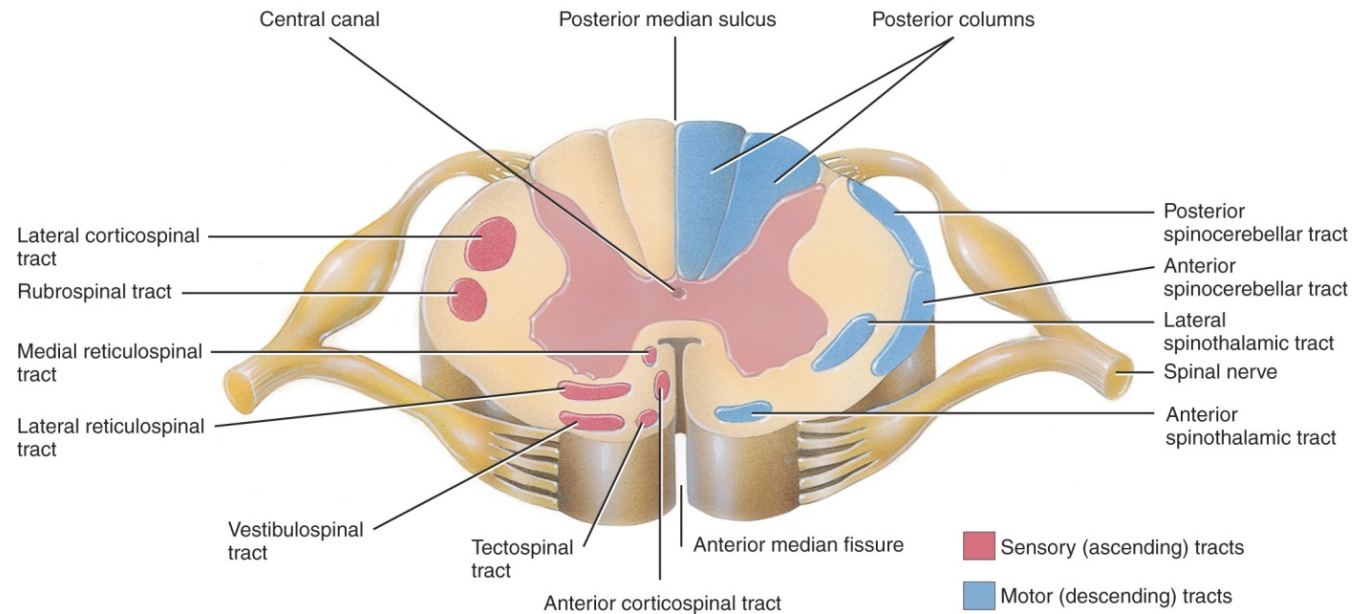
TABLE 4.13. NUMBERING OF SPINAL NERVES AND VERTEBRAE

Segmental Level	Number of Nerves	Level of Exit from Vertebral Column
Cervical	8 (C1–C8)	Nerve C1 ^a (suboccipital nerve) passes superior to arch of vertebra C1 Nerves C2–C7 pass through IV foramina superior to the corresponding vertebrae Nerve C8 passes through the IV foramen between vertebra C7 and T1
Thoracic	12 (T1–T12)	Nerves T1–L5 pass through IV foramina inferior to the corresponding vertebrae
Lumbar	5 (L1–L5)	
Sacral	5 (S1–S5)	Nerves S1–S4 branch into anterior and posterior rami within the sacrum, with the respective rami passing through the anterior and posterior sacral foramina
Coccygeal ^a	1 (Co1)	The 5th sacral and coccygeal nerves pass through the sacral hiatus

^aThe first cervical nerves lack posterior roots in 50% of people, and the coccygeal nerves may be absent.

(Modified from *Barr's The Human Nervous System*.)

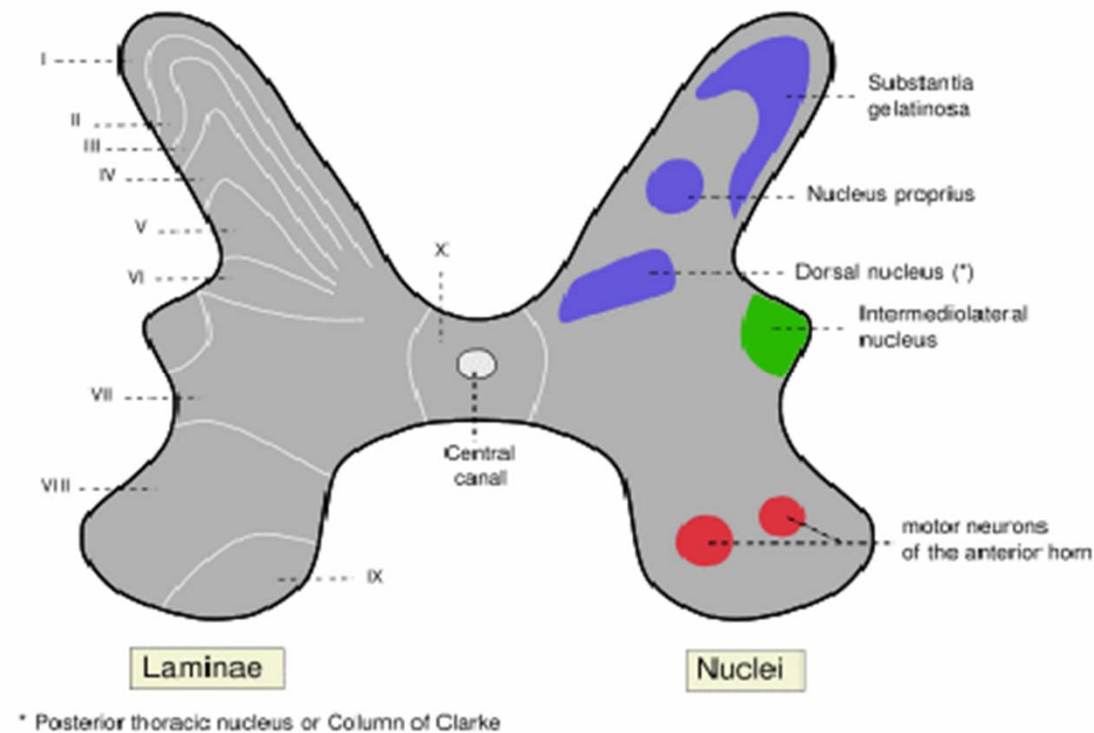
Gray Matter of the Spinal Cord



- Gray matter is shaped like the letter H or a butterfly
 - contains neuron cell bodies, unmyelinated axons & dendrites
 - dorsal gray horns (sensory neurons)
 - ventral gray horns (motor somatic neurons)
 - lateral horns (motor autonomic neurons) only present in thoracic spinal cord
 - gray commissure crosses the midline
- Central canal continuous with 4th ventricle of brain

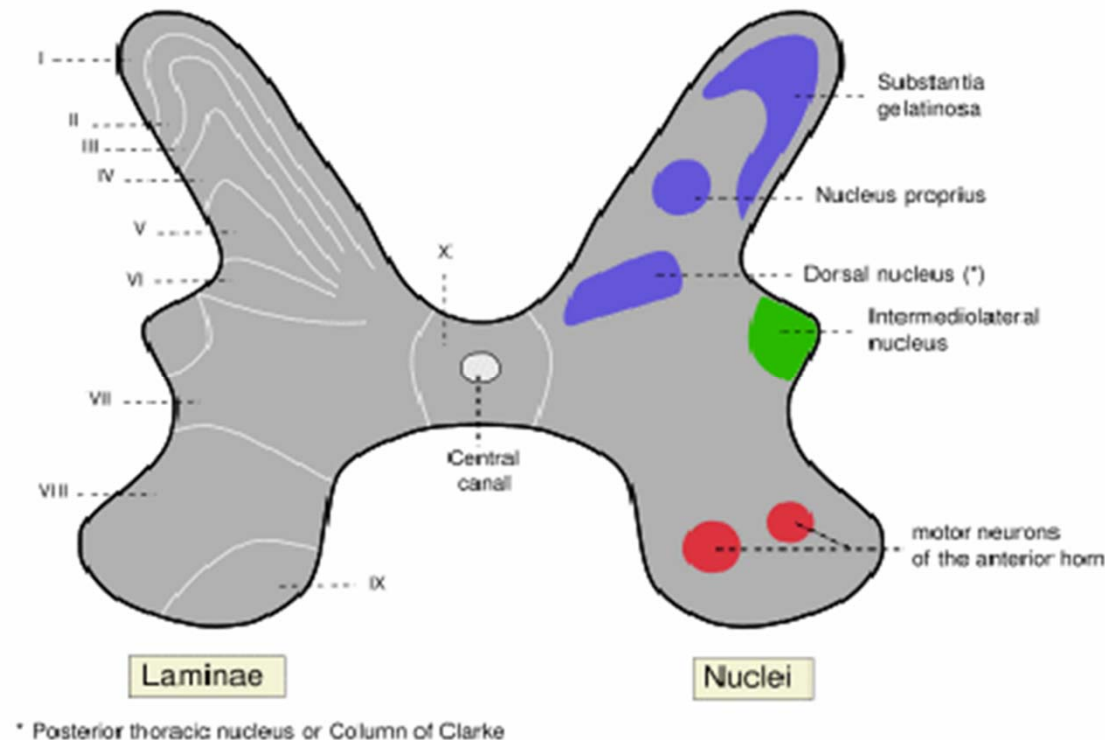
Nerve Cell Columns in the Gray Matter

- Motor
 - Medial motor nucleus (cell column)
 - Axial muscles
 - Entire SC
 - Lateral motor nucleus
 - Limb muscles
 - Enlargements
 - Intermediolateral cell column
 - Autonomic
 - T1-L2, S2-4

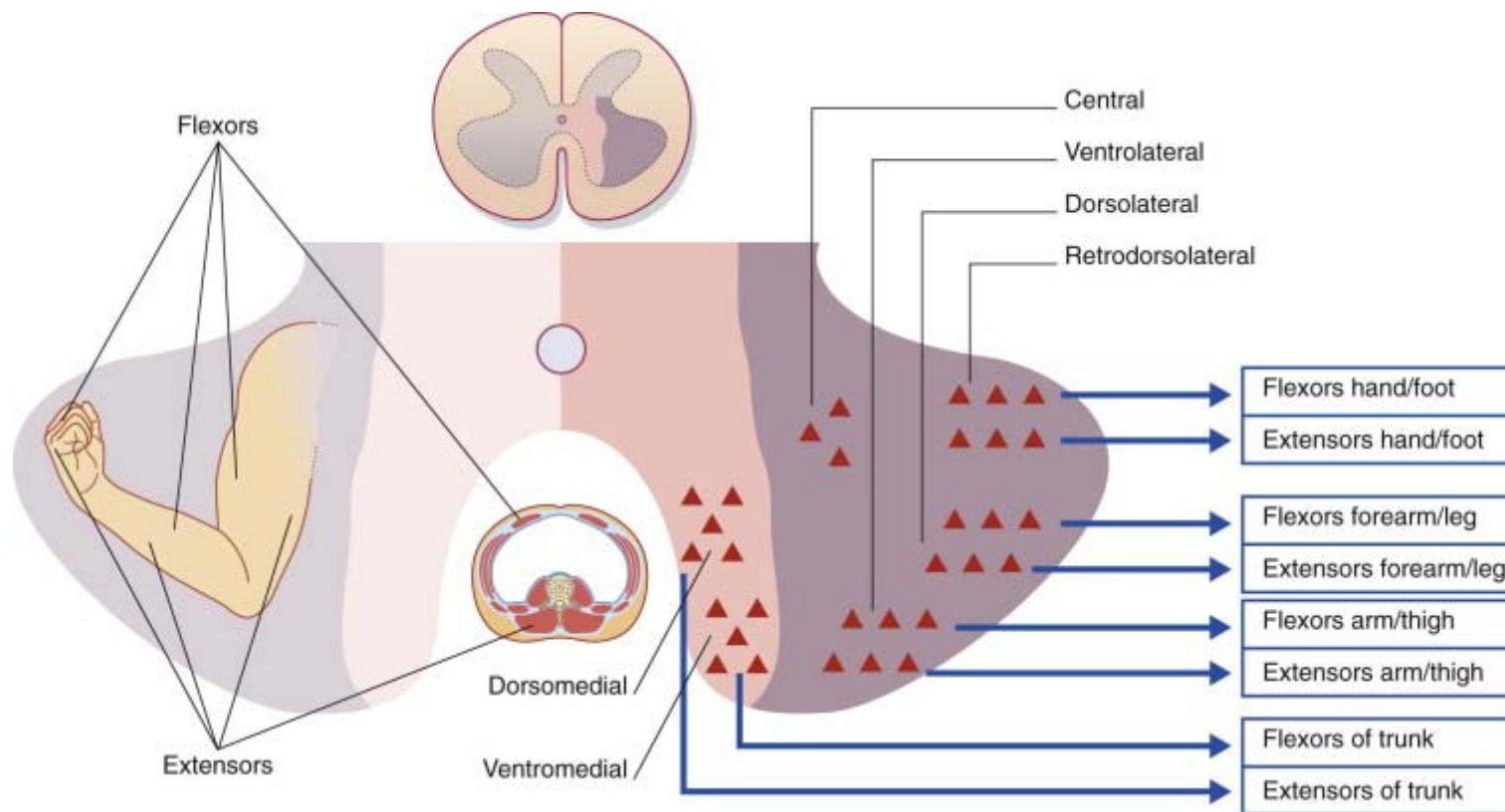


Nerve Cell Columns in the Gray Matter

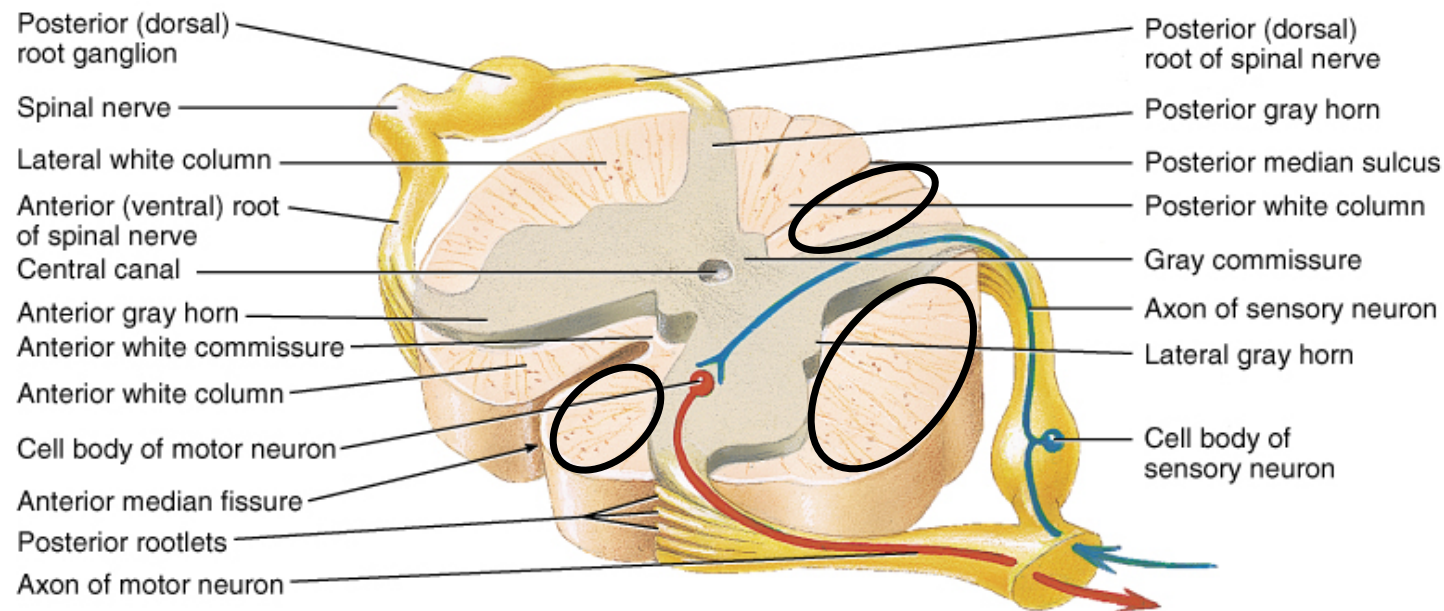
- Sensory
 - Substantia gelatinosa
 - Entire SC
 - Pain, temperature & touch
 - Nucleus proprius
 - Entire SC
 - Proprioception (sense of position & movement), two-point discrimination & vibration
 - Nucleus dorsalis (Clarke's column)
 - C8-L2
 - Proprioceptive endings



Cell columns in the anterior gray horn of the spinal cord: somatotopic organization



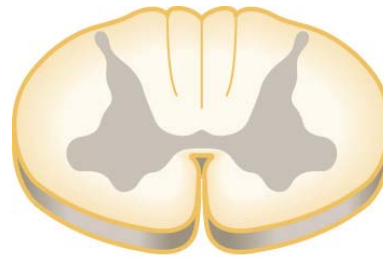
White Matter of the Spinal Cord



- White matter covers gray matter
- Anterior median fissure deeper than Posterior median sulcus
- Anterior, Lateral and Posterior White Columns contain axons that form ascending & descending tracts



(Segment C1)



(Segment C8)



(Segment T2)



(Segment L4)

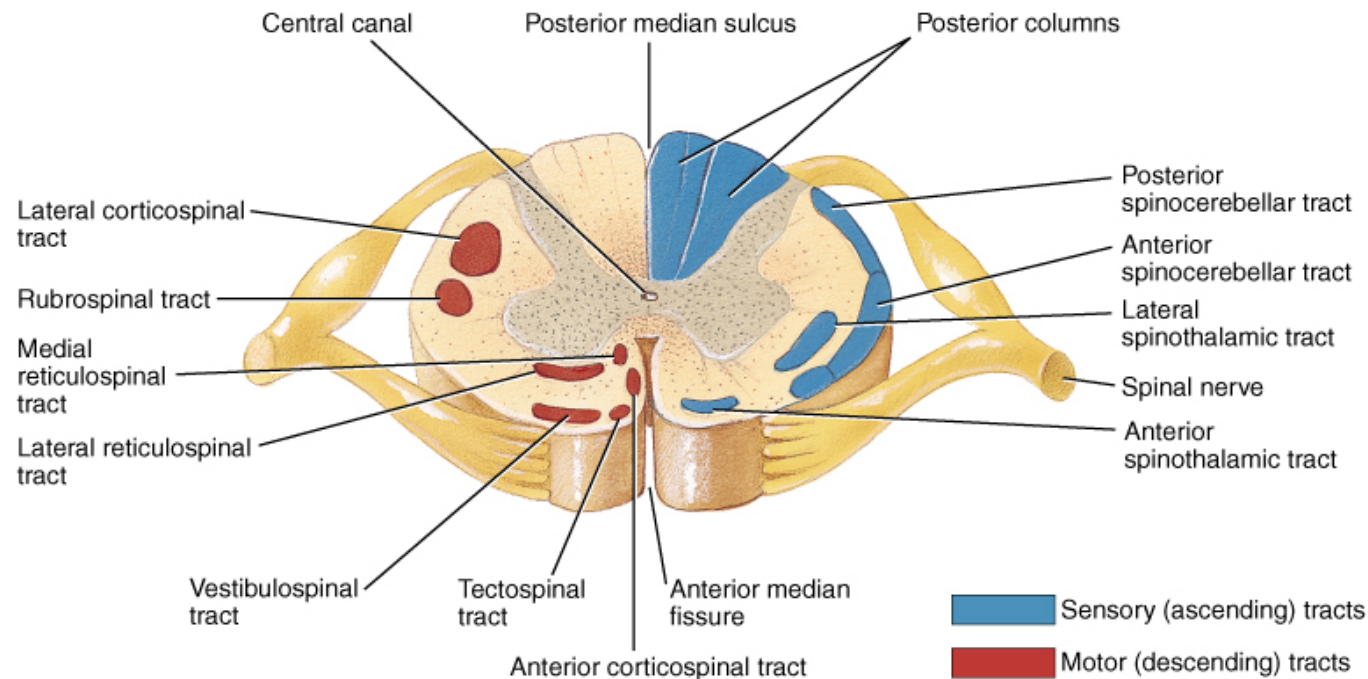


(Segment S3)

Tracts of the Spinal Cord

- Function of tracts
 - highway for sensory & motor information
 - sensory tracts ascend
 - motor tracts descend
- Naming of tracts
 - indicates position & direction of signal
 - example = anterior spinothalamic tract
 - impulses travel from spinal cord towards brain (thalamus)
 - found in anterior part of spinal cord

Location of Tracts inside Cord



- Motor/descending tracts
 - **pyramidal tract (corticospinal)**
 - **extrapyramidal tracts**

Sensory/ascending tracts

- spinothalamic tract**
- posterior column**
- spinocerebellar ?**

Functions of Spinal Tracts

Sensory

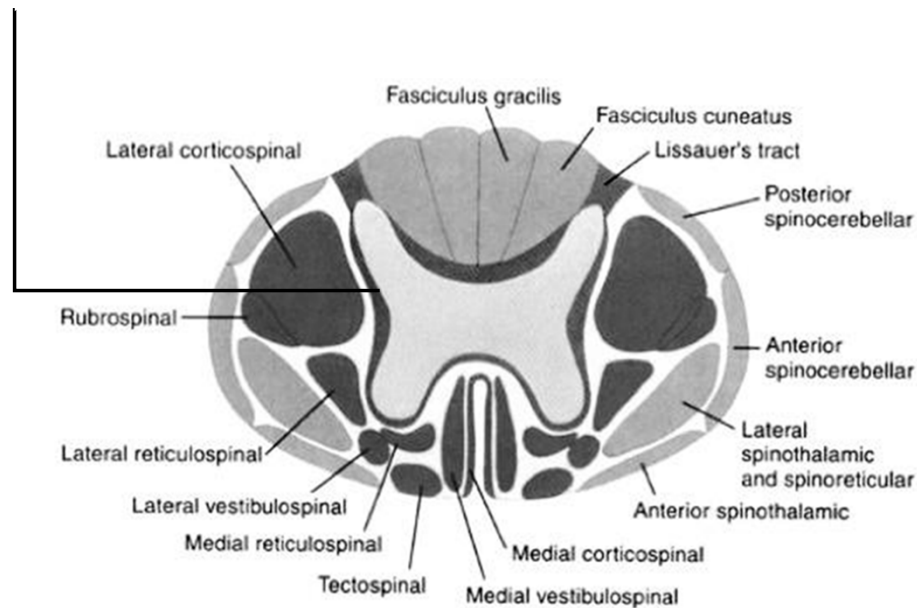
- Spinothalamic tract
 - pain, temperature, deep pressure & crude touch
- Posterior columns
 - proprioception, discriminative touch, two-point discrimination, pressure and vibration

Motor

- Direct pathways (corticospinal & corticobulbar)
 - precise, voluntary movements
- Indirect pathways (rubrospinal, vestibulospinal)
 - programming automatic movements, posture & muscle tone, equilibrium & coordination of visual reflexes

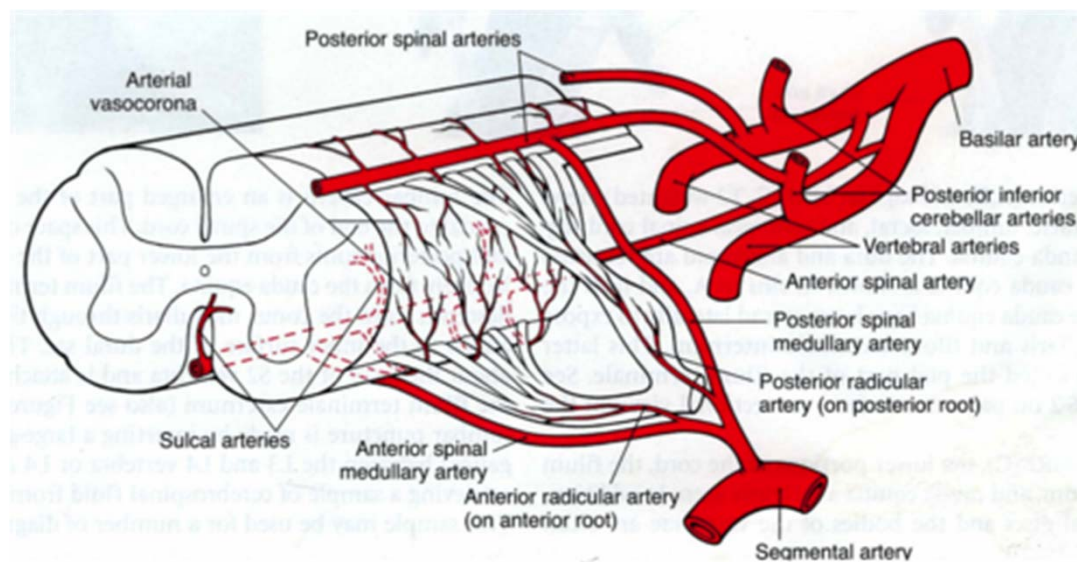
White Matter of the Spinal Cord

- Ventral white commissure
- Lissauer's tract (dorsolateral fasciculus)
- Intersegmental fibers (fasciculus proprius)



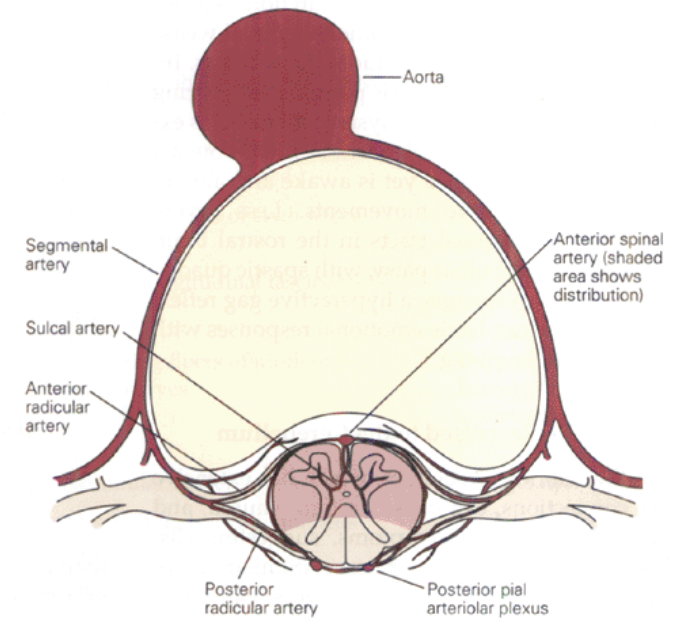
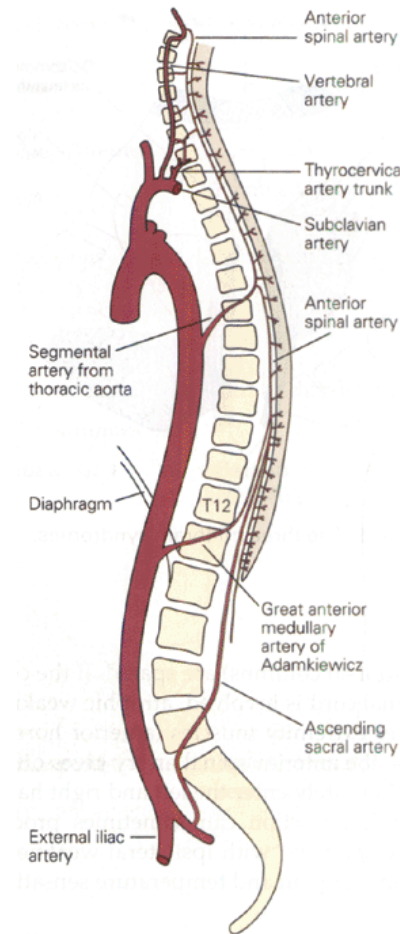
Blood Supply to SC

- One anterior spinal a.
 - Vertebral aa.
- Two posterior spinal aa.
 - Vertebral aa. 25%
 - PICA 75%
- Anterior & posterior radicular aa.
 - Arise at every spinal level
 - Serve their respective roots & ganglia



Blood Supply to SC

- Anterior & posterior spinal medullary aa.
 - Arise at intermittent levels
 - Serve to augment the BS to SC
- Artery of Adamkiewicz
 - Unusually large spinal medullary a.
 - Usually on the left
 - In low thoracic or upper lumbar levels



Blood Supply to SC

- Spinal cord Ischemia
- Anterior spinal a.
 - Small & tenuous
 - Occlusion produces bilateral damage (below lesion)
 - Affects
 - Corticospinal tracts
 - Paraplegia below lesion
 - Spinothalamic tracts
 - Thermoanesthesia and analgesia
 - Descending autonomic tracts
 - Loss of bladder & bowel control
 - Anterior gray horn
 - Near enlargement – weakness of limb muscles

