Al-Mustaqbal University

College of Engineering & Technology

Biomedical Engineering Department

Subject Name: Anatomy II

2nd Class, Second Semester

Subject Code: [UOMU01104]

Academic Year: 2024-2025

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Lecture No.: - 10-

Lecture Title: [spinal cord anatomy]

ANATOMY

2nd Stage

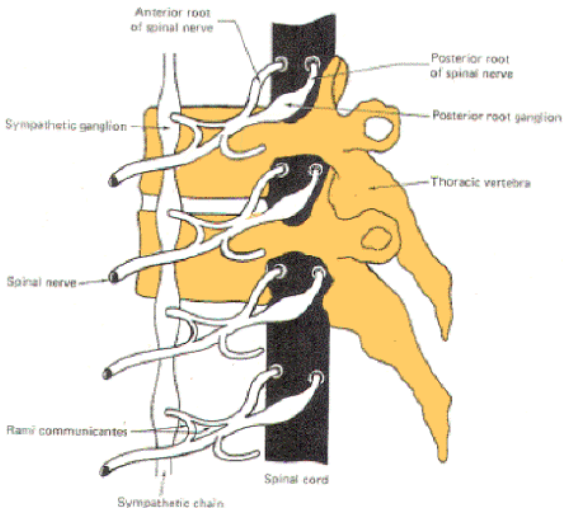
Term 2

Lec.10

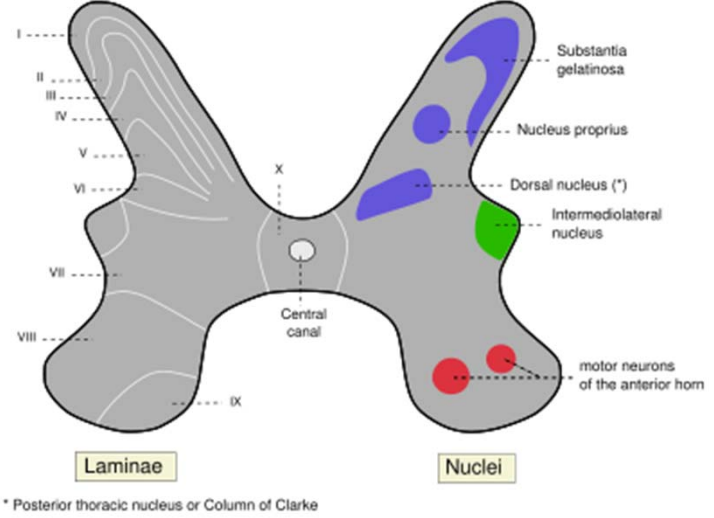
Spinal Cord Anatomy

- **Central Nervous System (CNS)**
  - **Brain**
  - **Spinal Cord**

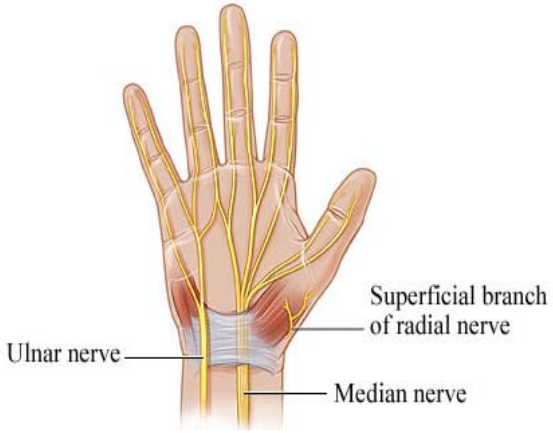
- **Peripheral Nervous System (PNS)**
  - **Cranial nerves**
  - **Spinal nerves**



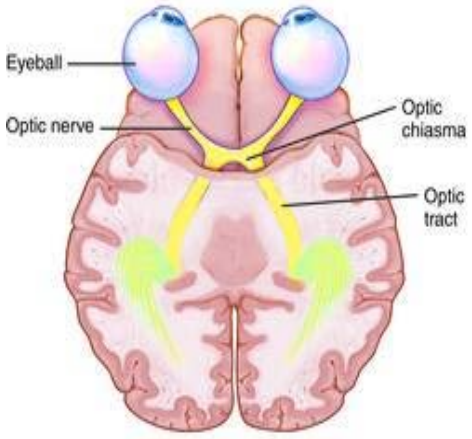
Ganglion
A group of neurons outside the CNS



Nucleus
A group of neurons within the CNS



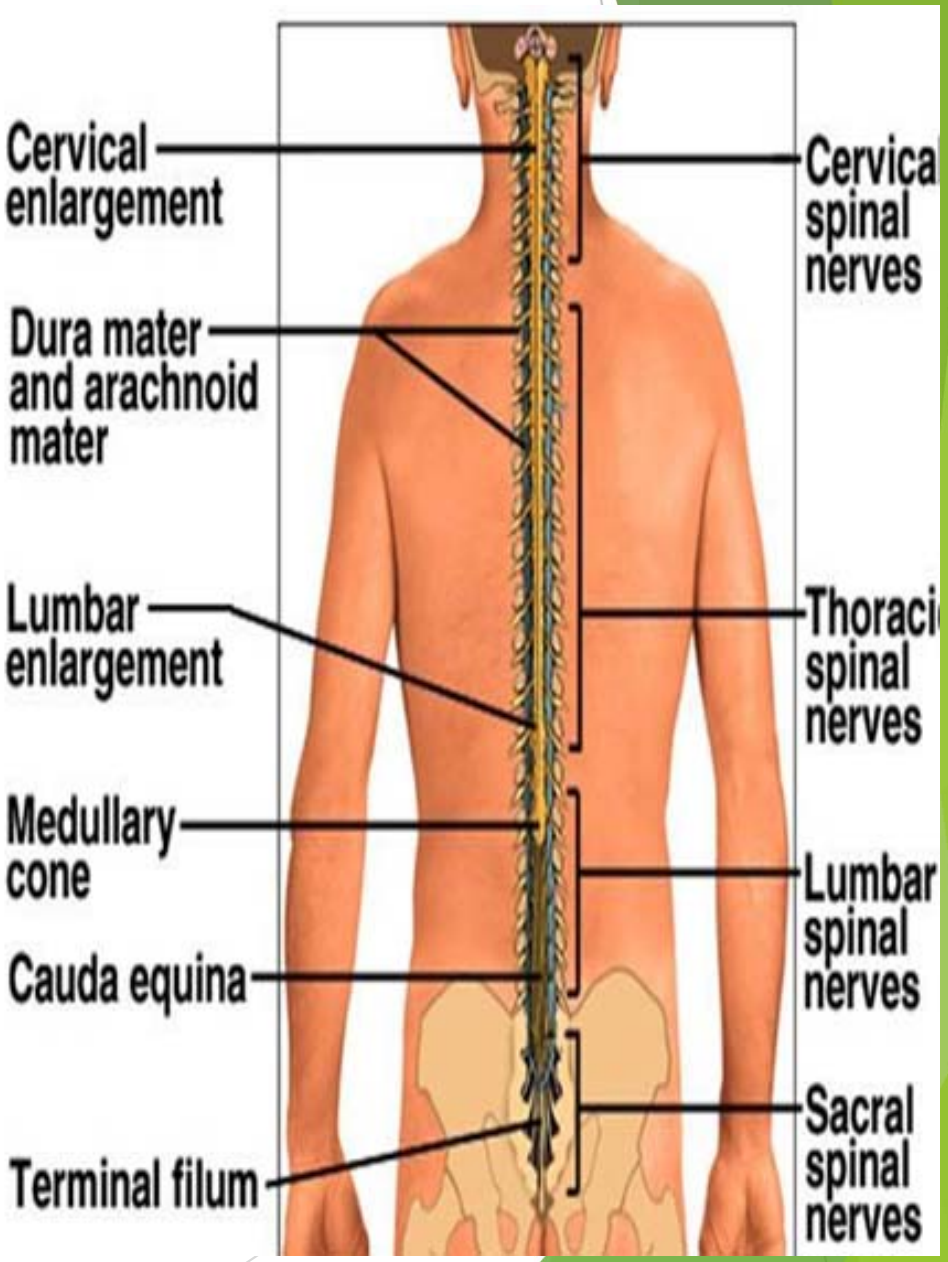
Nerve
A group of nerve fibers (axons) outside the CNS



Tract
A group of nerve fibers (axons) within the CNS

Spinal Cord

- Runs through the vertebral canal
- Extends from foramen magnum to second lumbar vertebra



The spinal cord

External features:

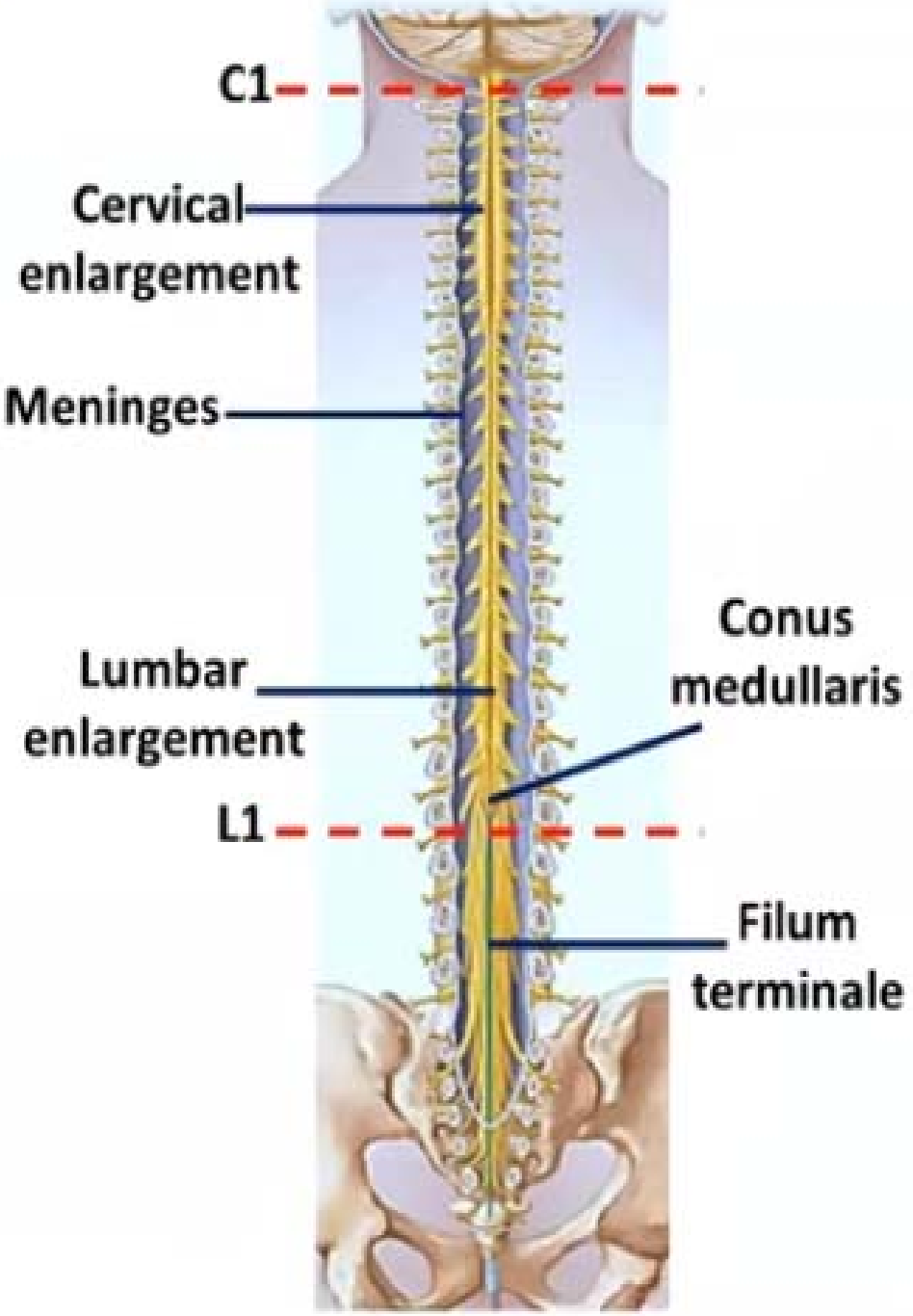
- Length: 45 cm, occupying only the upper 2/3 of the vertebral canal.
- Begins: at the upper border of atlas vertebra as the continuation of the medulla oblongata.
- Ends: at the level of L1-L2 intervertebral disc in adults. In infants, it reaches the level of L3 vertebra.

- Shape: it is cylindrical in shape having 2 enlargements:

a) Cervical enlargement: giving the roots of the brachial plexus.

b) Lumbar enlargement: giving the roots of the lumbar and sacral plexuses.

- Its lower end is tapered: it is called "conus medullaris". From the apex of conus medullaris: a pia matter filament "filum terminale" extends downwards to be attached to the back of the coccyx.



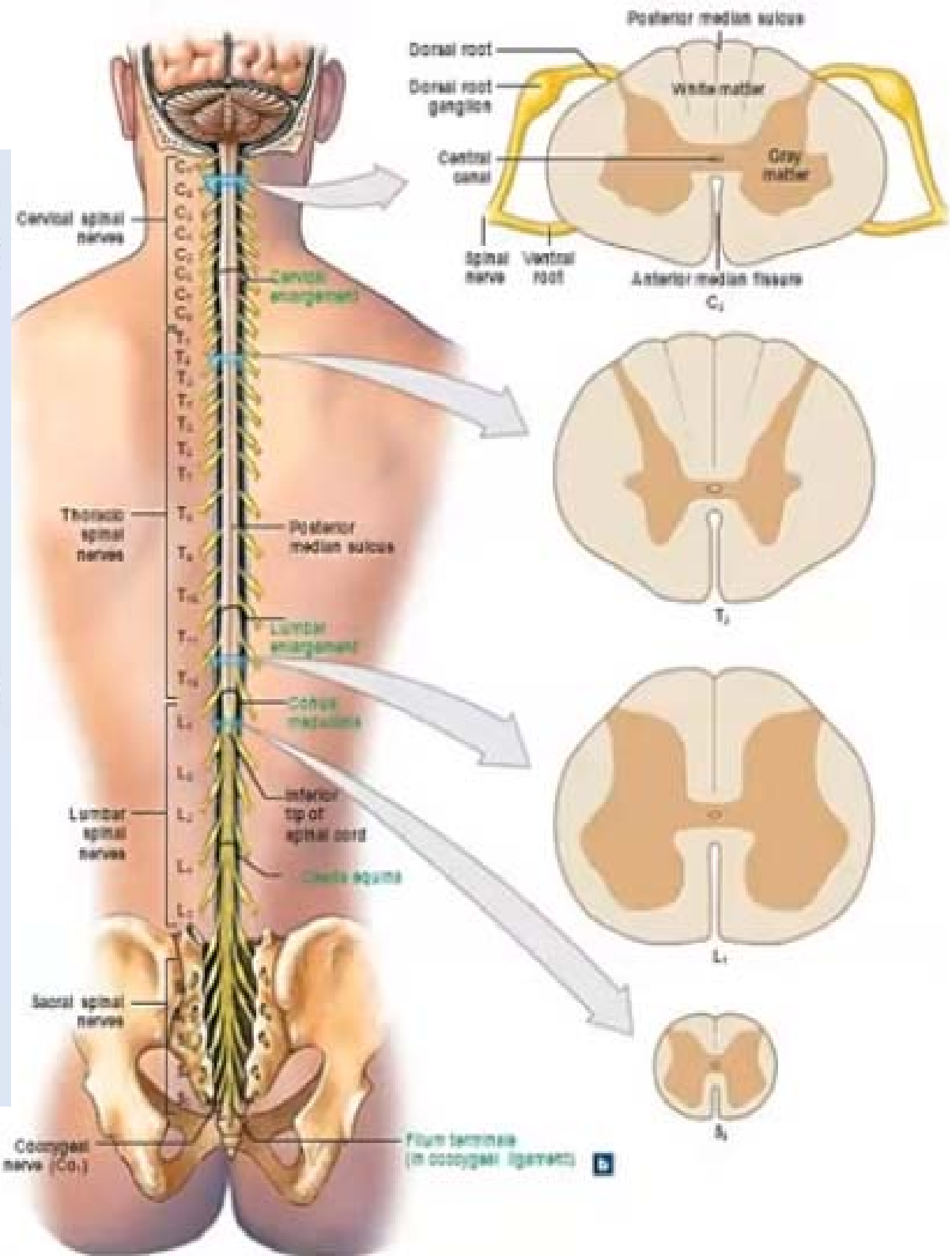
- **Segments:** it has 31 segments. They are not demarcated externally. Each segment gives origin to a pair of spinal nerves (8 cervical, 12 thoracic, 5 lumbar, 5 sacral, and 1 coccygeal).

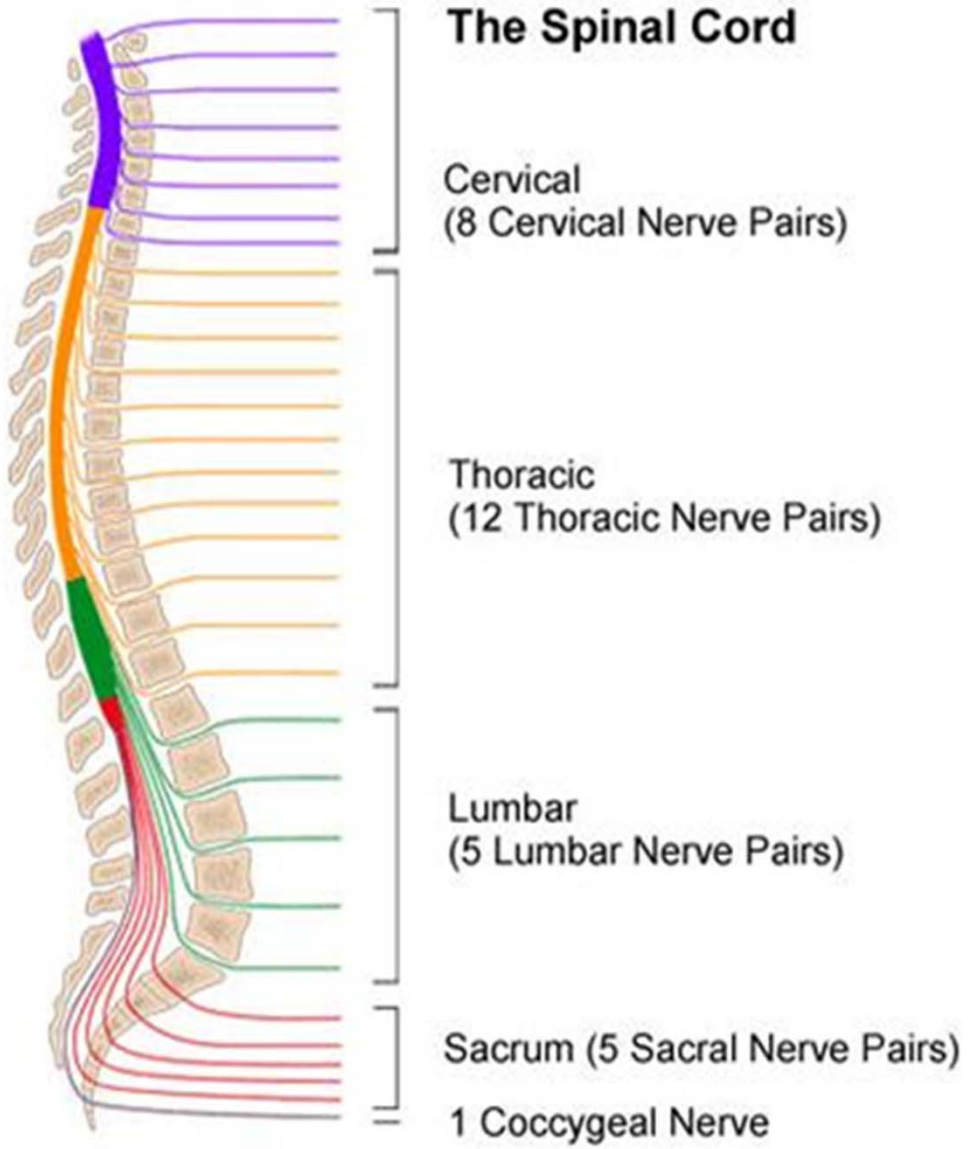
- **Grooves:** it has 6 longitudinal grooves:

a) **Anterior median fissure and posterior median septum:** they divide the spinal cord almost completely into right and left halves.

b) **2 anterolateral sulci:** correspond to attachments of anterior roots of spinal nerves.

c) **2 posterolateral sulci:** correspond to attachments of posterior roots of spinal nerves.





Spinal Cord Regions

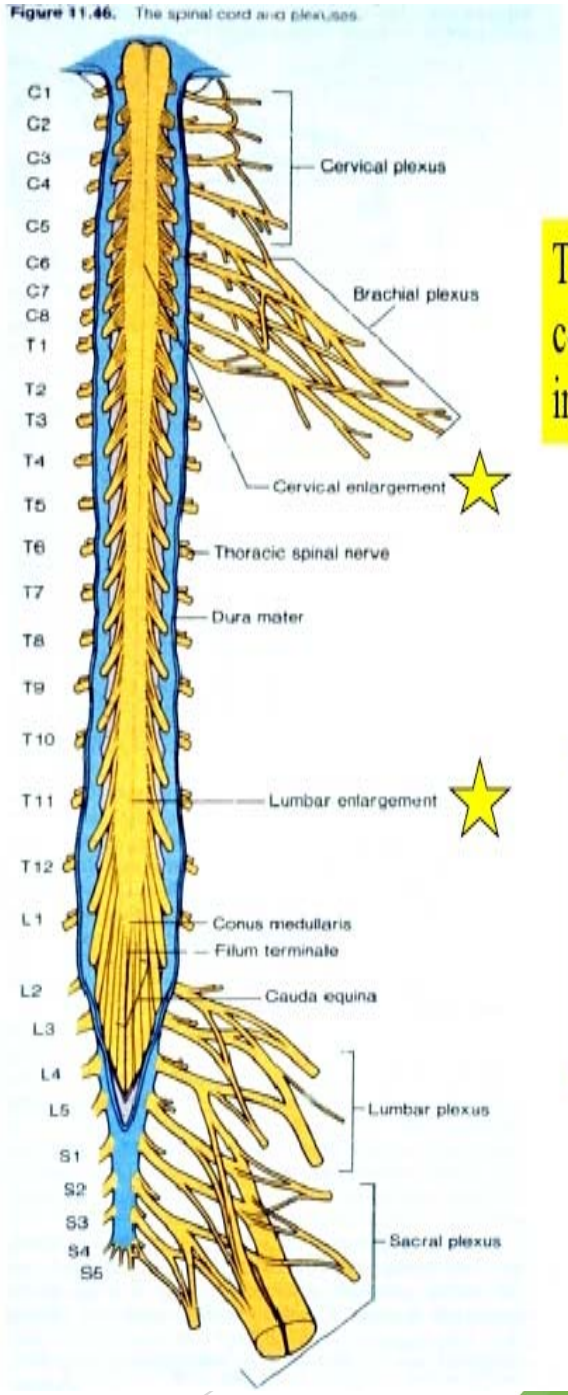
- Cervical
- Thoracic
- Lumbar
- Sacral

Spinal cord

Gives rise to **31 pairs** of **spinal nerves**. All are mixed nerves

Not uniform in diameter

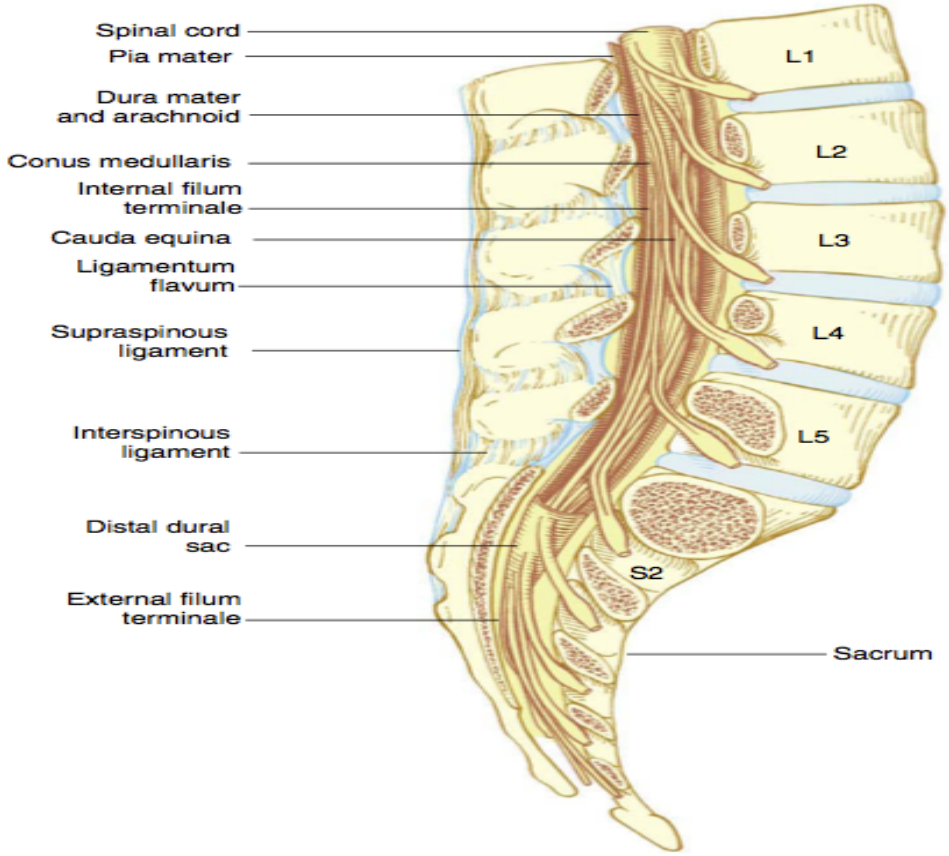
- **Cervical enlargement**: supplies upper limbs
- **Lumbar enlargement**: supplies lower limbs

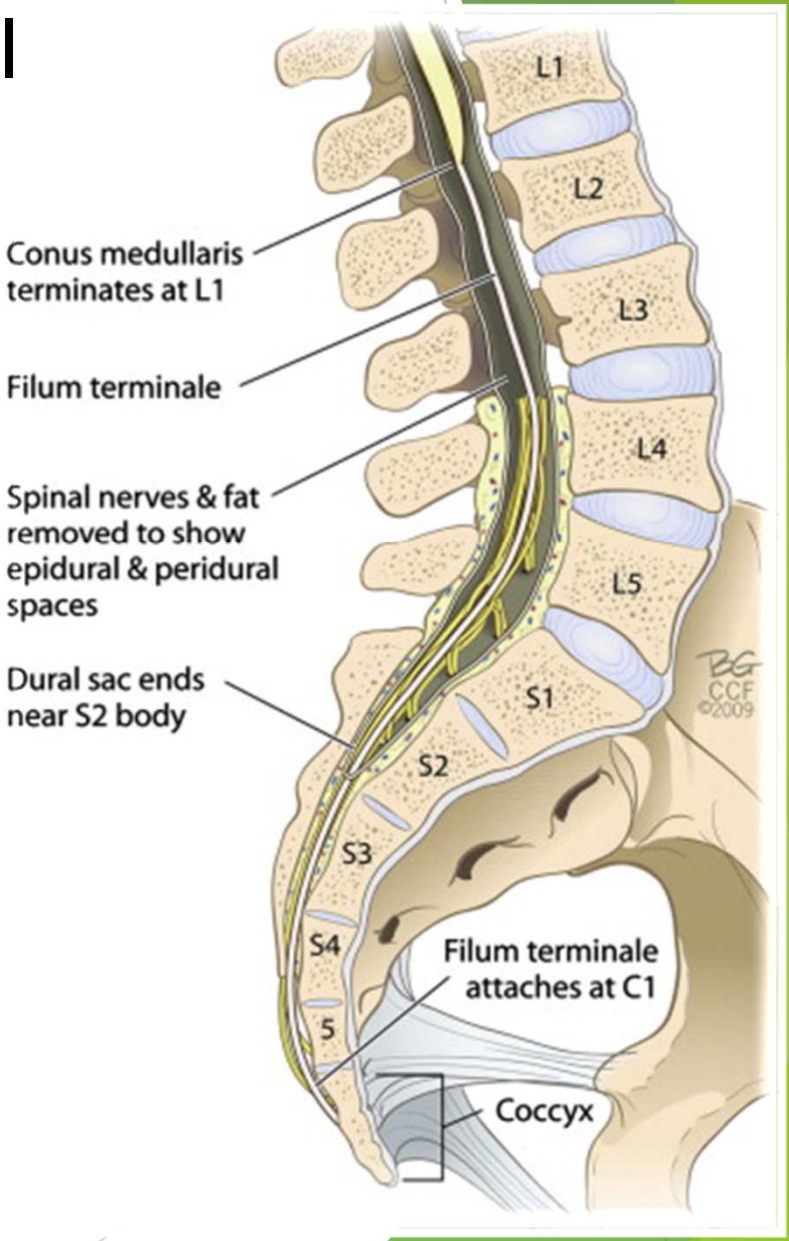


The **cervical enlargement** contains the neurons that innervate the upper limbs

The **lumbar enlargement** contains the neurons that innervate the lower limbs.

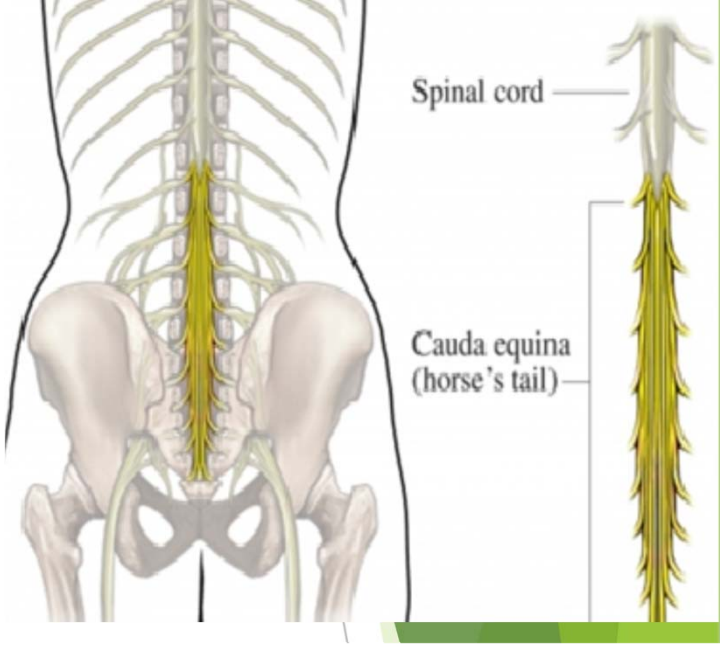
- **Conus medullaris:**
  Tapered inferior end of spinal cord.
- Ends between L1 and L2

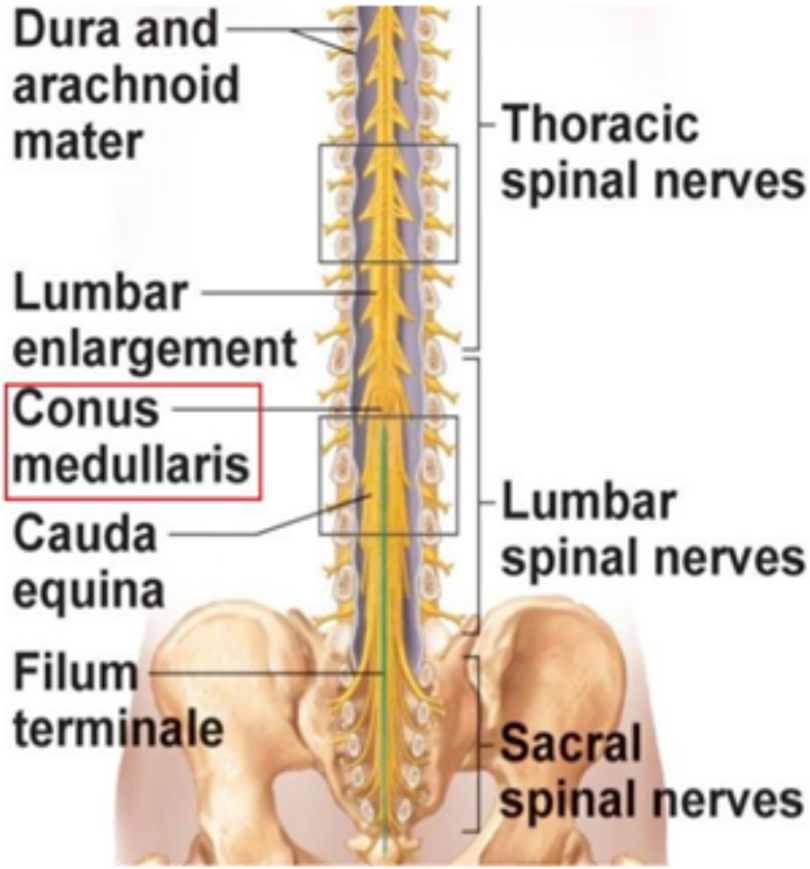




Inferior End of Spinal Cord

- **Conus medullaris** - inferior end of spinal cord .
- **Cauda equina** - individual spinal nerves within spinal canal
- **Filum terminale** - filamentous end of meninges.

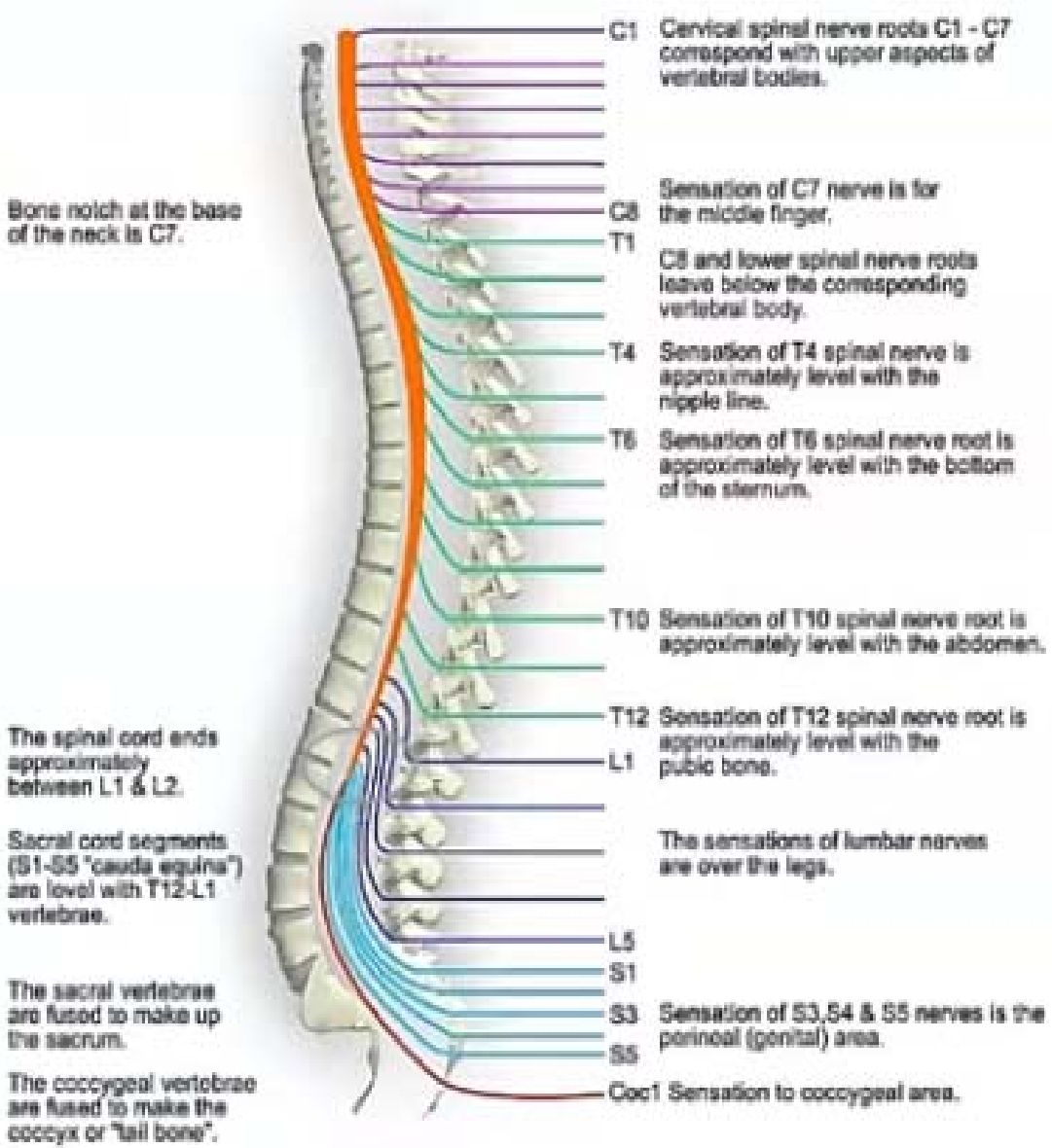




- **Vertebral levels of spinal cord segments:**
- As the spinal cord occupies only the upper 2/3 of the vertebral canal, so the spinal cord segments do not lie opposite their corresponding vertebrae.

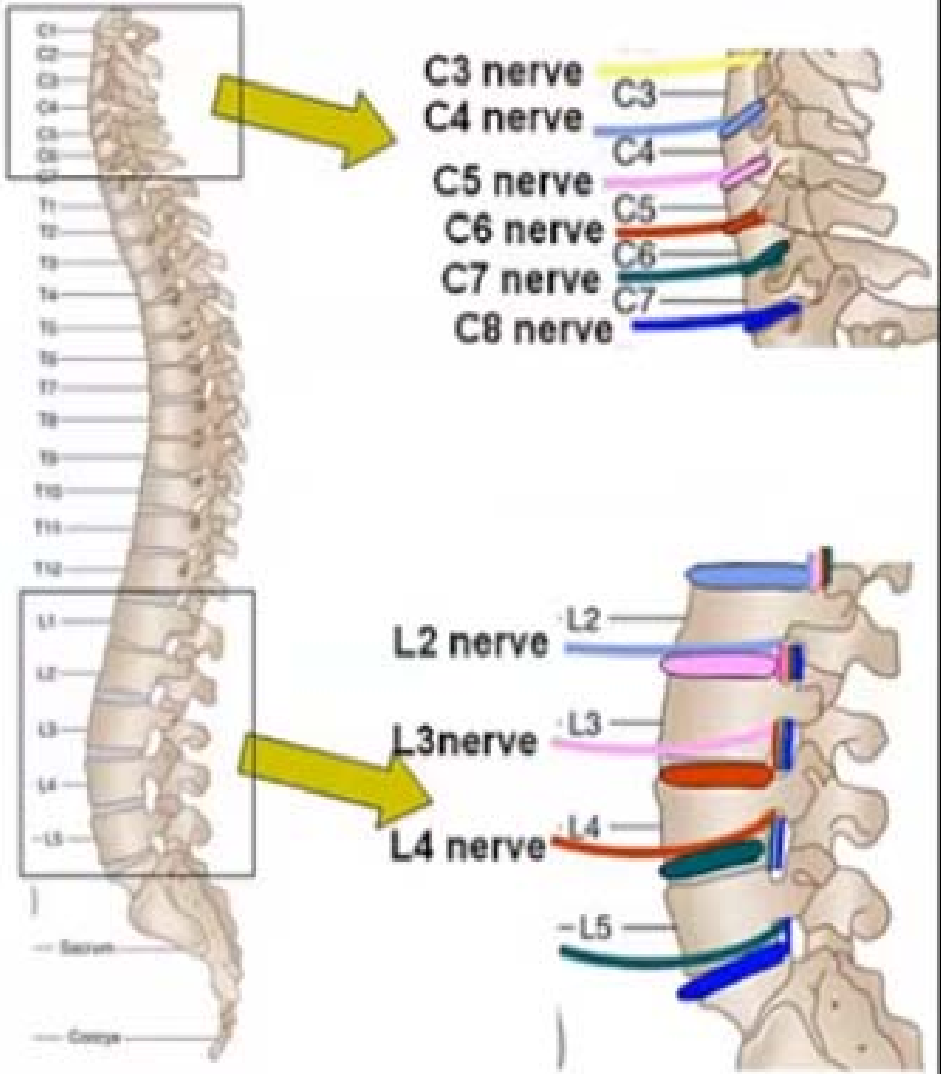
- To calculate the vertebral level:
- In cervical region: vertebral level = spinal segment – 1
- In upper thoracic region (T1-T6): vertebral level = spinal segment – 2
- In lower thoracic region (T7-T12): vertebral level = spinal segment – 3
- In lumbar region: vertebral level = spinal segment – 4
- All sacral segments + coccygeal segment are at the level of L1-L2 vertebra.

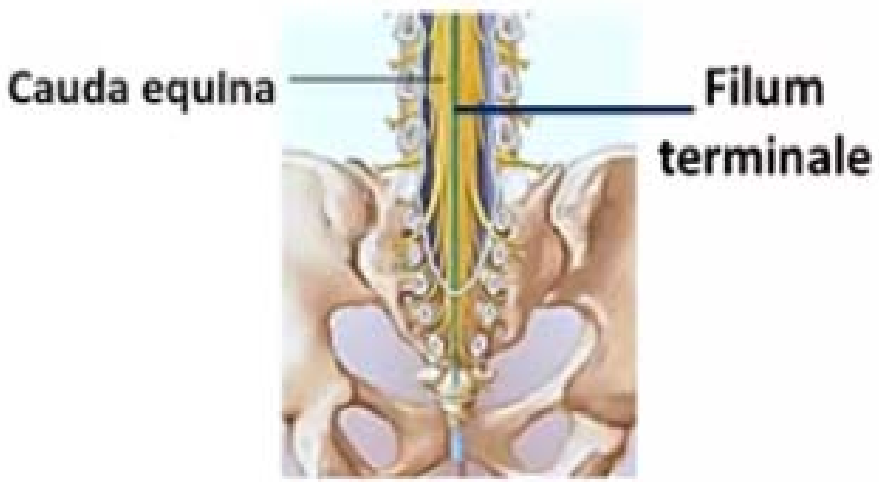
➢ So, roots of spinal nerves C1 and C2 in the vertebral canal are horizontal in direction, C3-T12 are oblique, while L1-Co are vertical.



- **Exit of spinal nerves from the vertebral canal:**
- C1-C7: above the corresponding vertebra.
- C8: below C7 vertebra.
- T1-L5: below corresponding vertebra.
- S1-S4: anterior and posterior sacral foramina.
- S5 and Co: from the sacral hiatus.

➢ So, the collection of nerves that will surround the filum terminale below the level of L2 vertebra resembling a horse tail is called "the cauda equina". It occupies the lower 1/3 of the vertebral canal and the whole sacral canal.

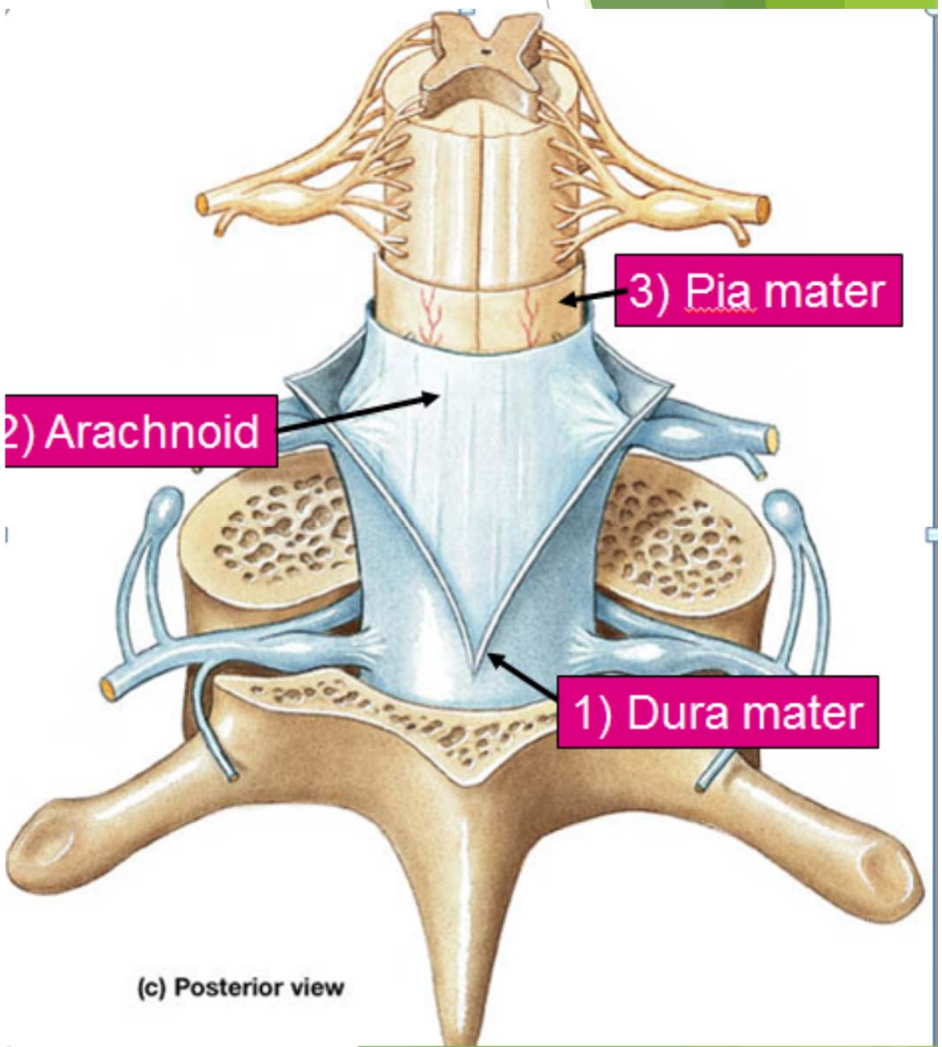




- **N.B:** The size of spinal nerves increases gradually from above downwards, while the size of the intervertebral foramen decreases. So lower spinal nerves (e.g. L4,5) are more liable to nerve compression.

Spinal Meninges

- 1**) Dura mater** - "tough mother", strong.
- **2) Arachnoid** spidery looking, carries blood vessels.
- **3) Pia mater** - "delicate mother", adheres tightly to surface of spinal cord

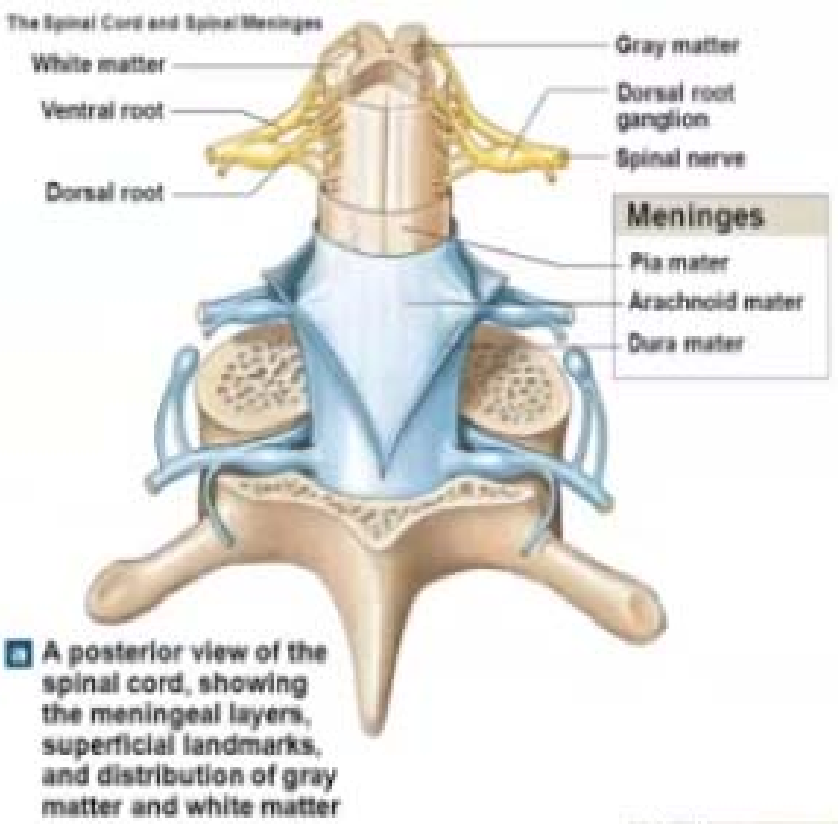


Meningeal covering of the spinal cord:

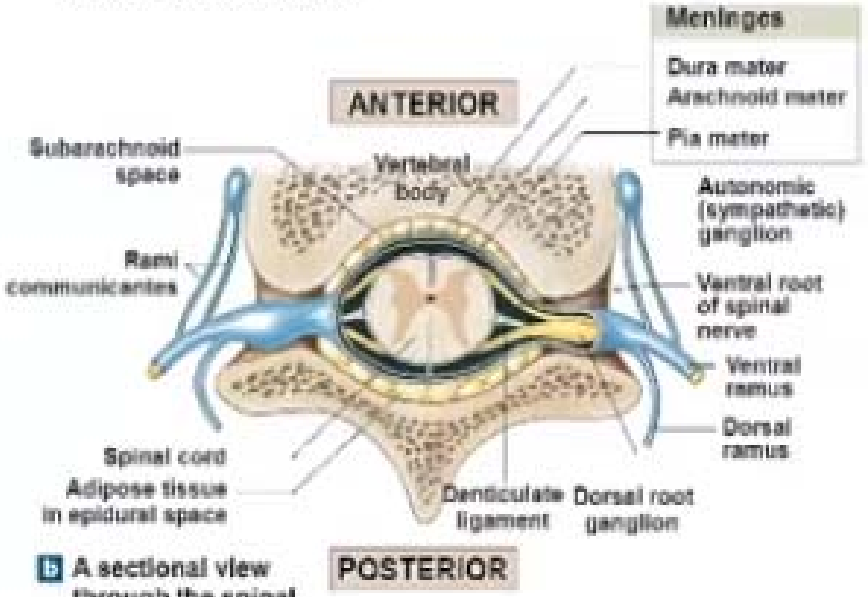
- Dura matter (outer layer)
- Arachnoid matter (middle layer)
  - Both form a single tube around the cord, superiorly continuous with the cerebral meninges, inferiorly ends at the level of S2 vertebra.
- Pia matter (inner layer): adherent to the spinal cord, extending from the tip of conus medullaris as filum terminale, which pierces the dural tube and goes downwards to be attached to the back of the coccyx.

Meningeal spaces:

- Extradural space: between dura and walls of the vertebral canal
- Subdural space: between dura and arachnoid matters
- Subarachnoid space: between arachnoid and pia matters.



a A posterior view of the spinal cord, showing the meningeal layers, superficial landmarks, and distribution of gray matter and white matter

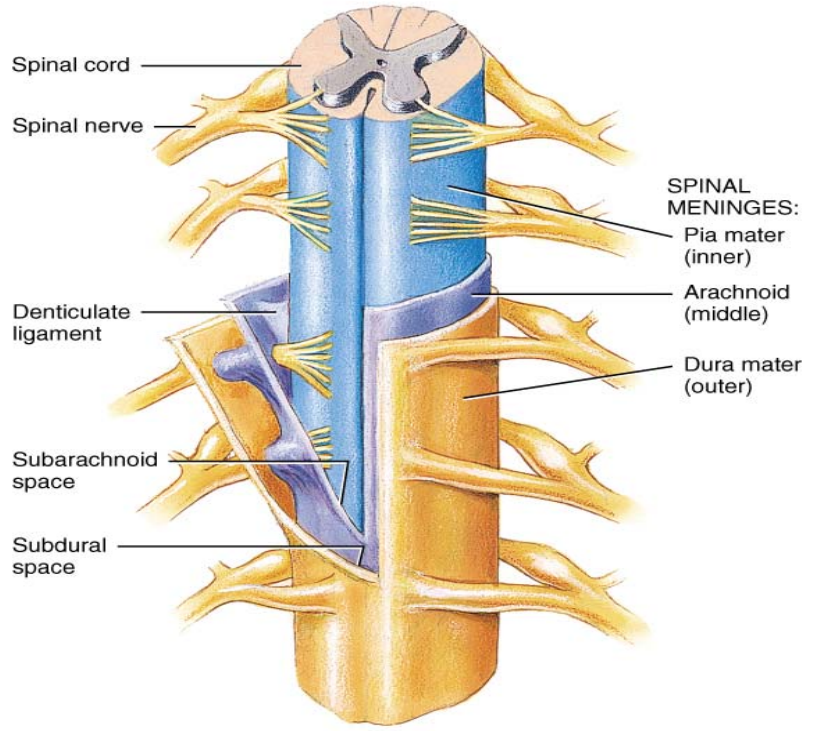


b A sectional view through the spinal cord and meninges, showing the peripheral distribution of spinal nerves

Meninges Spaces

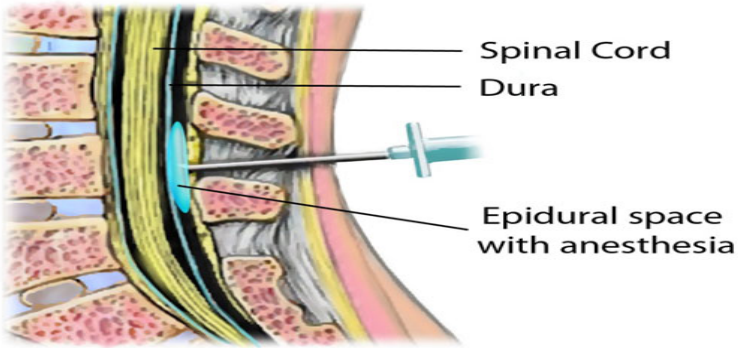
1. **Epidural**: external to the dura
   - ▶ Fat-fill
2. **Subdural space**: serous fluid
3. **Subarachnoid**: between pia and arachnoid

▶Filled with **CerebroSpinal Fluid (CSF)**



(a) Anterior view and transverse section through spinal cord

Epidural Needle Placement



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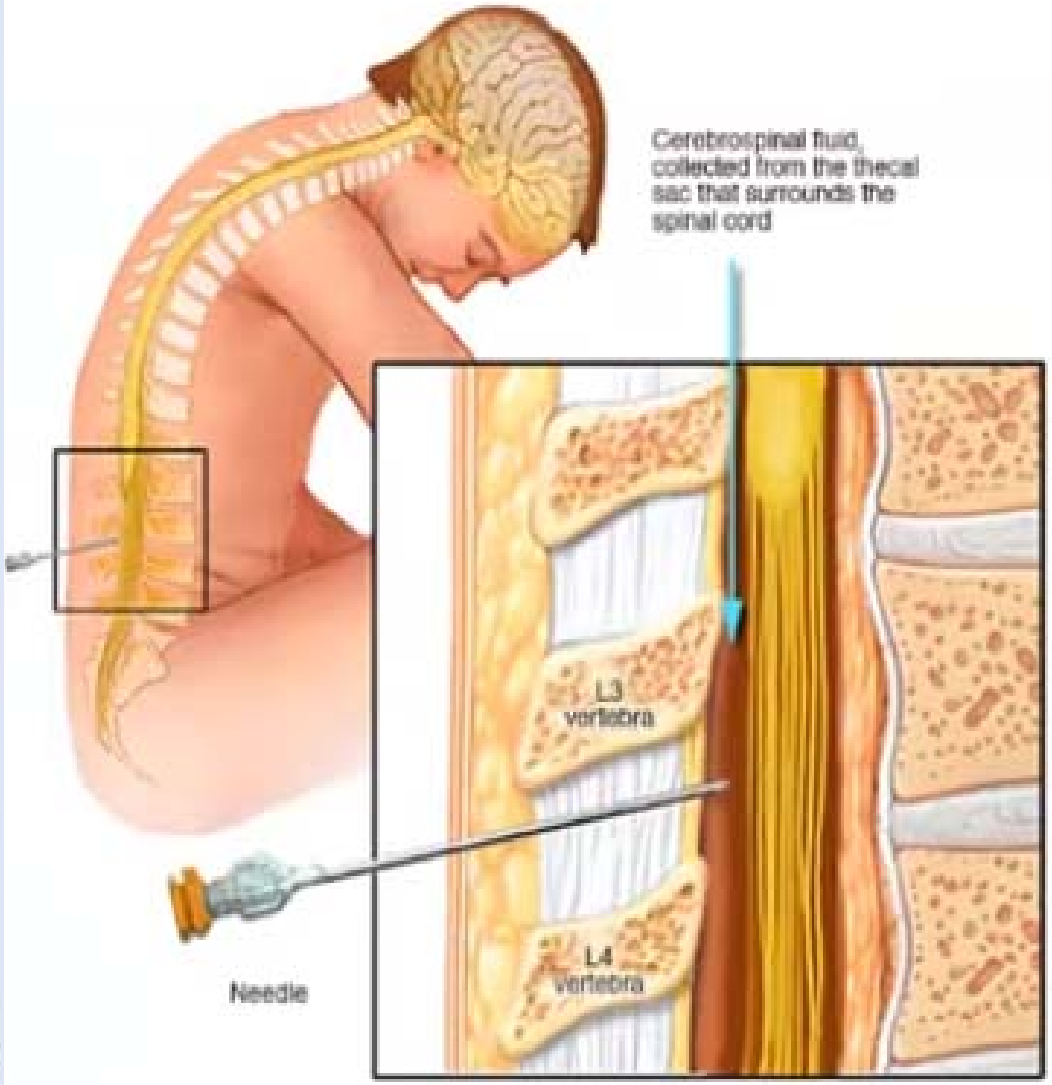
- **N.B: lumbar puncture:**
- It is the procedure of introducing a needle into the subarachnoid space below the level of termination of the spinal cord.

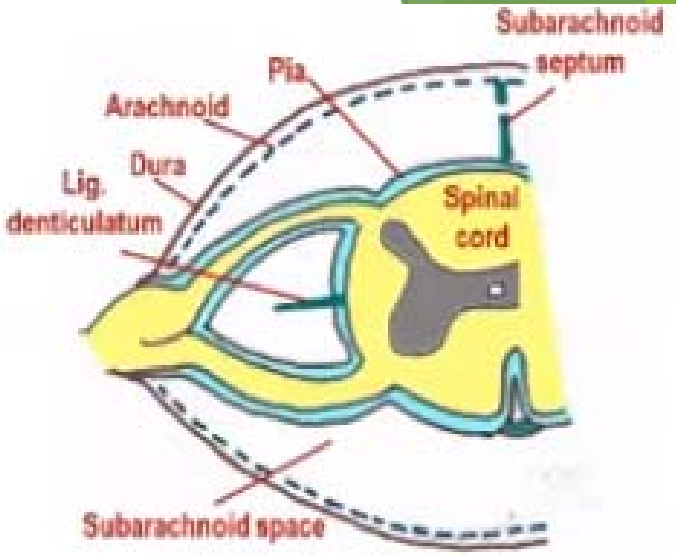
- Site: at the level of imaginary line connecting the highest points of both iliac crests (just above or just below the tip of the spine of 4th lumbar vertebra).

- Indications: it is useful as:
  - Therapeutic: to inject antibiotics or spinal anesthesia into the subarachnoid space, or to remove some CSF to relieve an increased intracranial tension.
  - Diagnostic: to collect a CSF sample for analysis, to measure CSF pressure, or to inject air as in some radiological procedures (air encephalography).

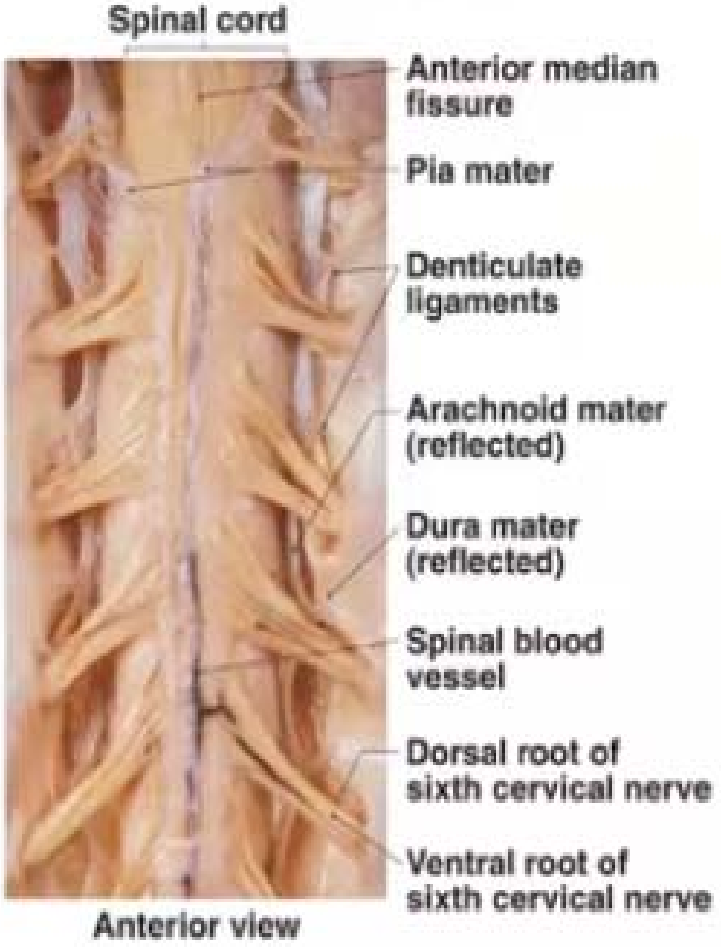


- **Supporting ligaments of the spinal cord:**
- Filum terminale: (see before).
- Subarachnoid septum: extending between posterior median septum and the arachnoid matter.
- Ligamentum denticulatum: (dentate ligament):
  - One on each side of the cord.
  - Each one has about 21 teeth.
  - These teeth extend laterally between anterior and posterior roots of spinal nerves.
  - Each tooth connects the pia matter to both arachnoid and dura matters.

- **N.B: contents of the subarachnoid space:**
- Cerebrospinal fluid (CSF).
- Filum terminale.
- Subarachnoid septum.
- Ligamentum denticulatum.



Spinal cord meninges – T.S.



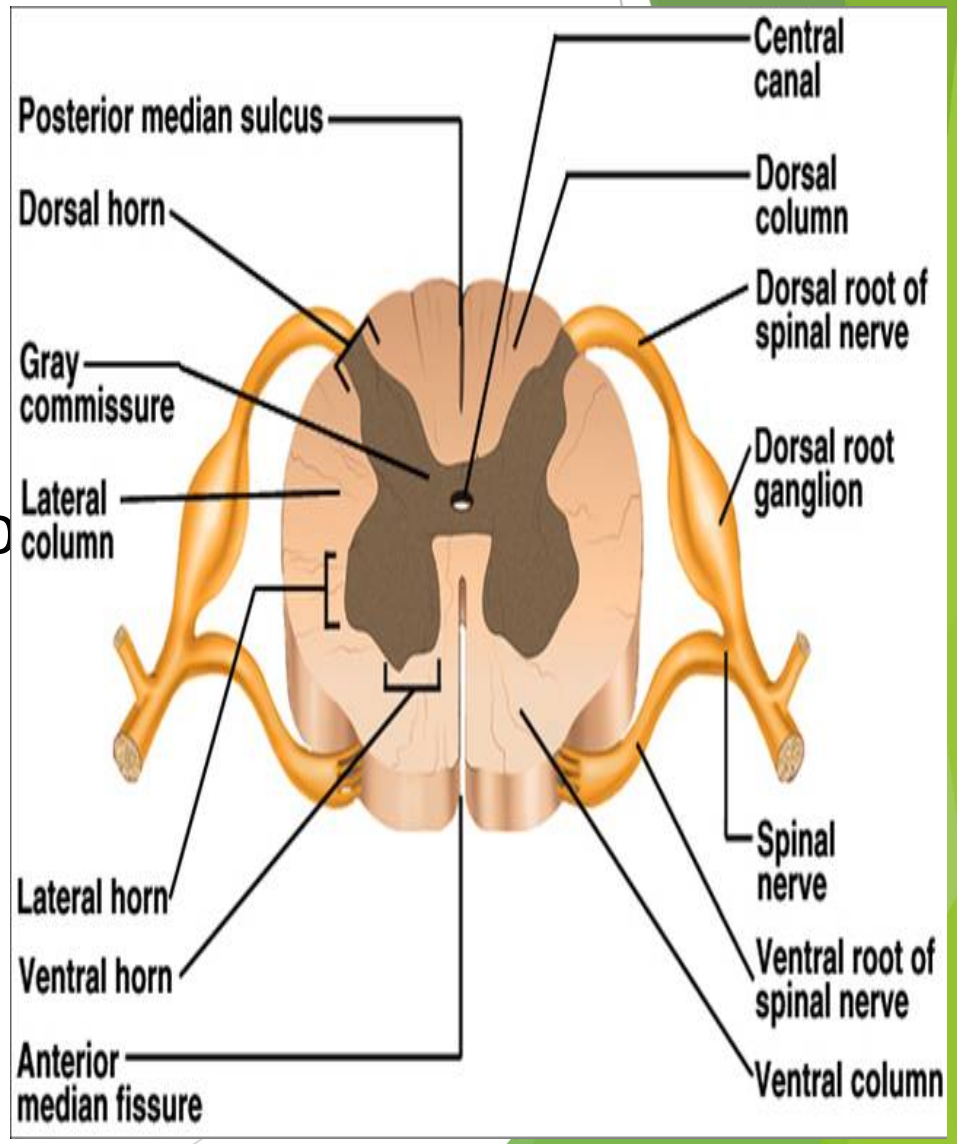
Anterior view

Cross Section of Spinal Cord

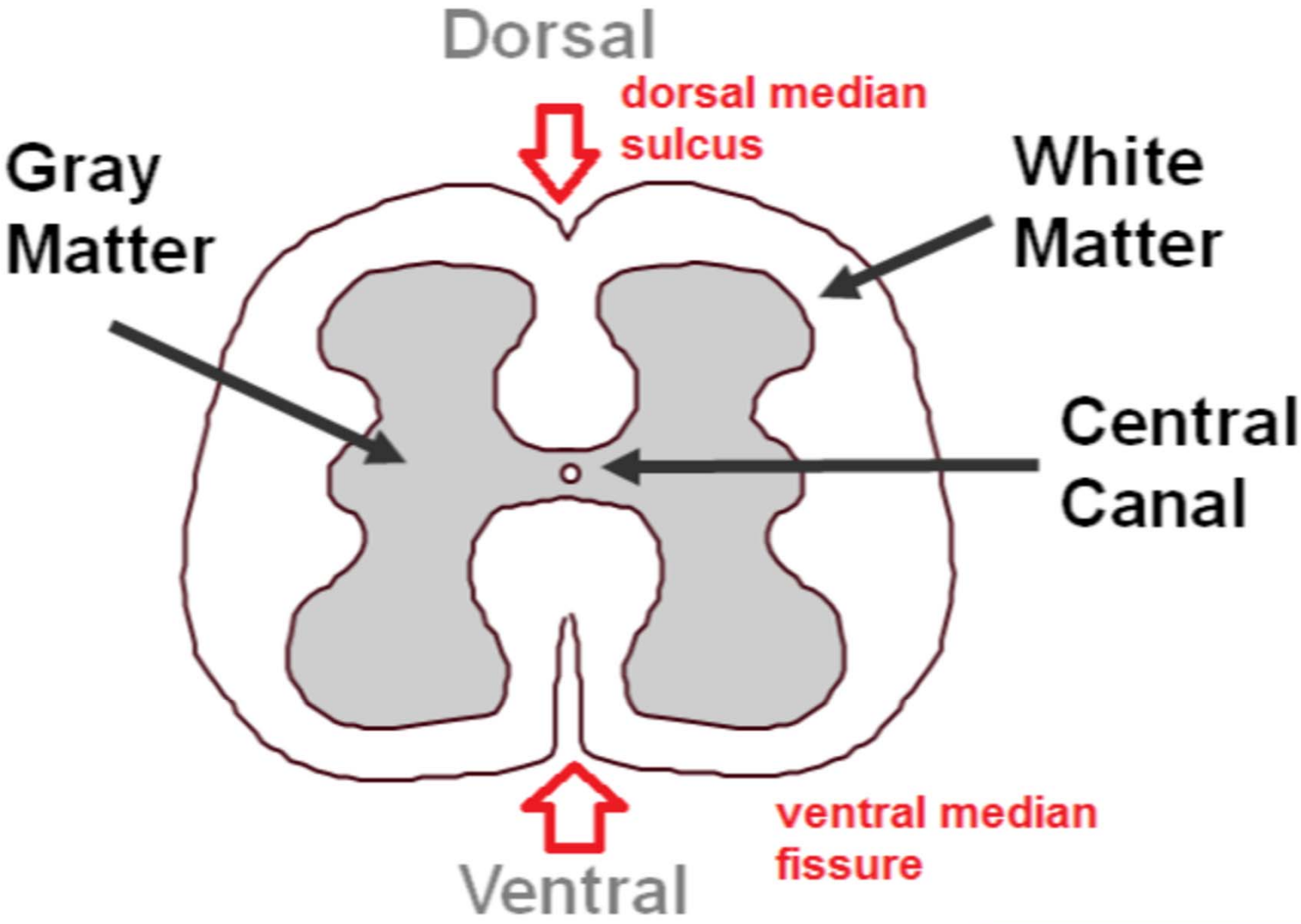
- **Dorsal median sulcus & ventral median fissure**
- **Gray matter**: neuron cell bodies, dendrites axons divided into horns:
  - Posterior (dorsal) horn.
  - Anterior (ventral) horn.
  - Lateral horn.
- **White matter**

  Myelinated axons divided into three *columns:*
  - Ventral
  - Dorsal
  - lateral

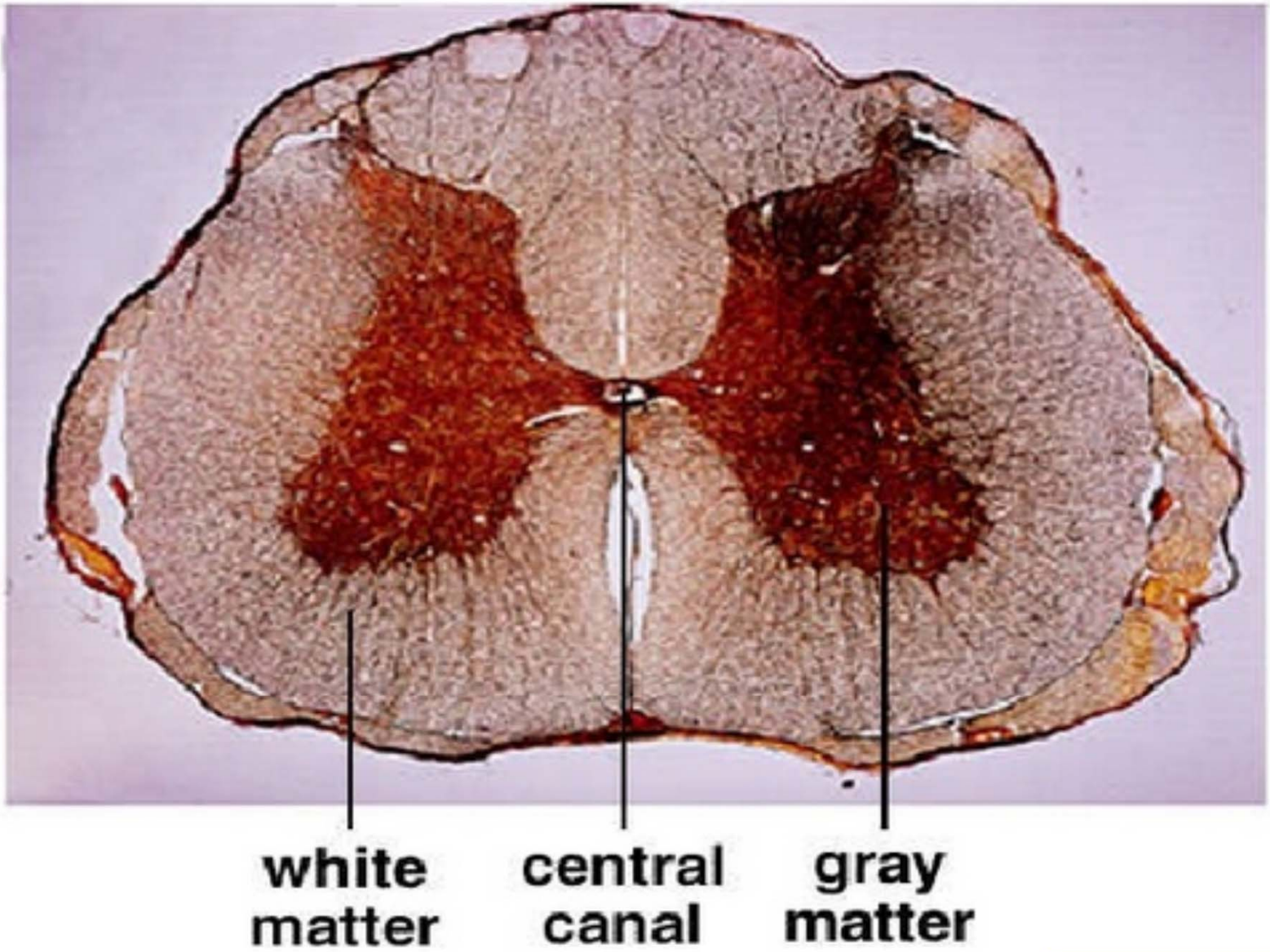
  Each of these divided into sensory or motor tracts



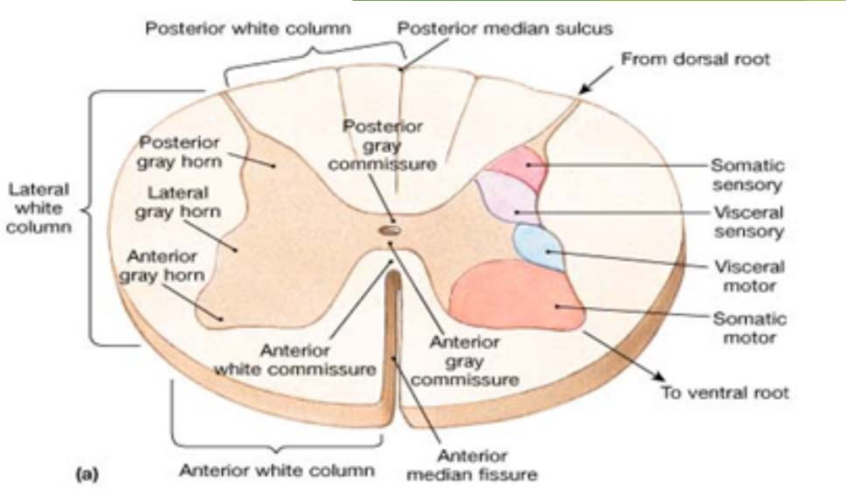
Spinal Cord


Dorsal
dorsal median sulcus
Gray Matter
White Matter
Central Canal
ventral median fissure
Ventral

Spinal Cord

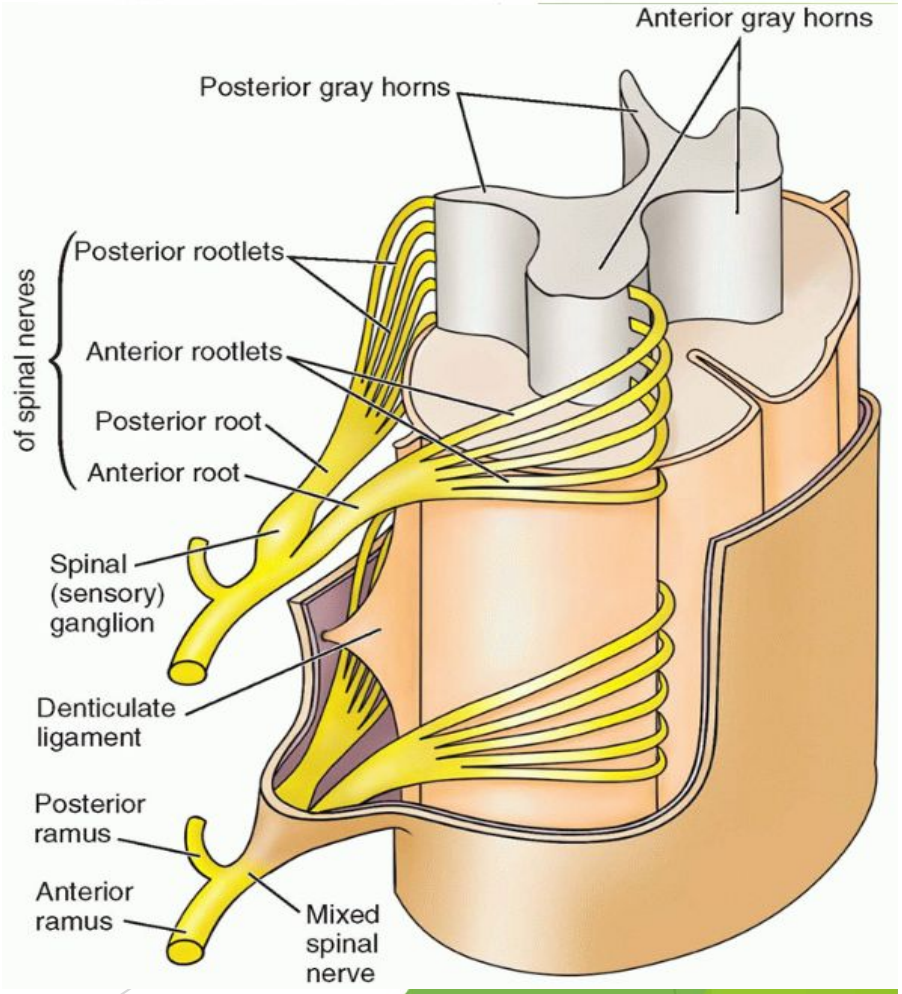


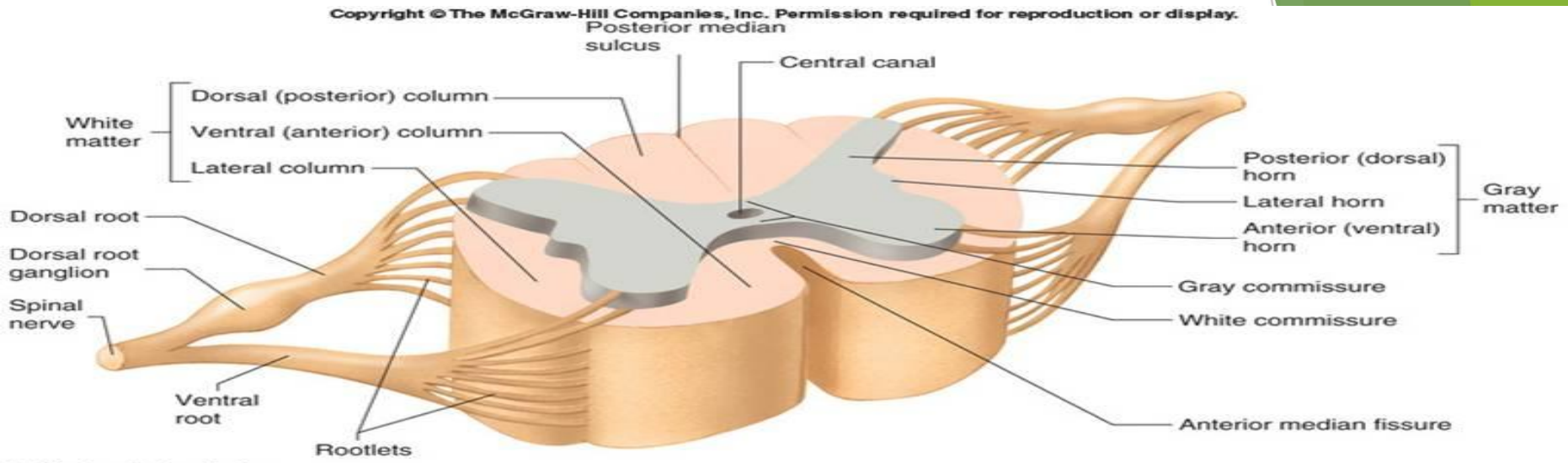
Commissures: connections between left and right halves of gray and white mater with central canal in the center



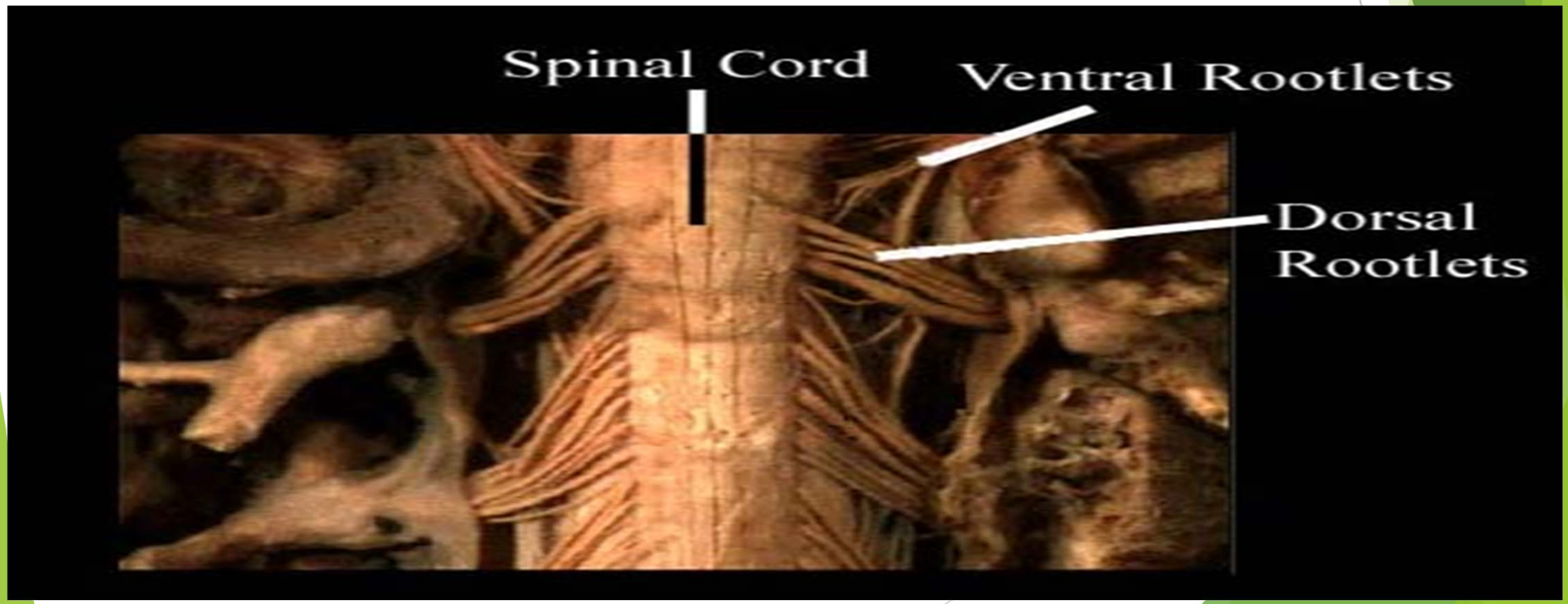
Roots

- Spinal nerves arise as **rootlets** then combine to form dorsal and ventral roots
- Dorsal and ventral roots merge and form the spinal nerve





(a) **Anterolateral view**



Organization of Spinal Cord

Gray Matter

- It is divided into *horns:*
- Dorsal – sensory roots and ganglia
- Ventral – motor roots
- lateral (only in thoracic region) - visceral neurons

Gray Matter: Organization

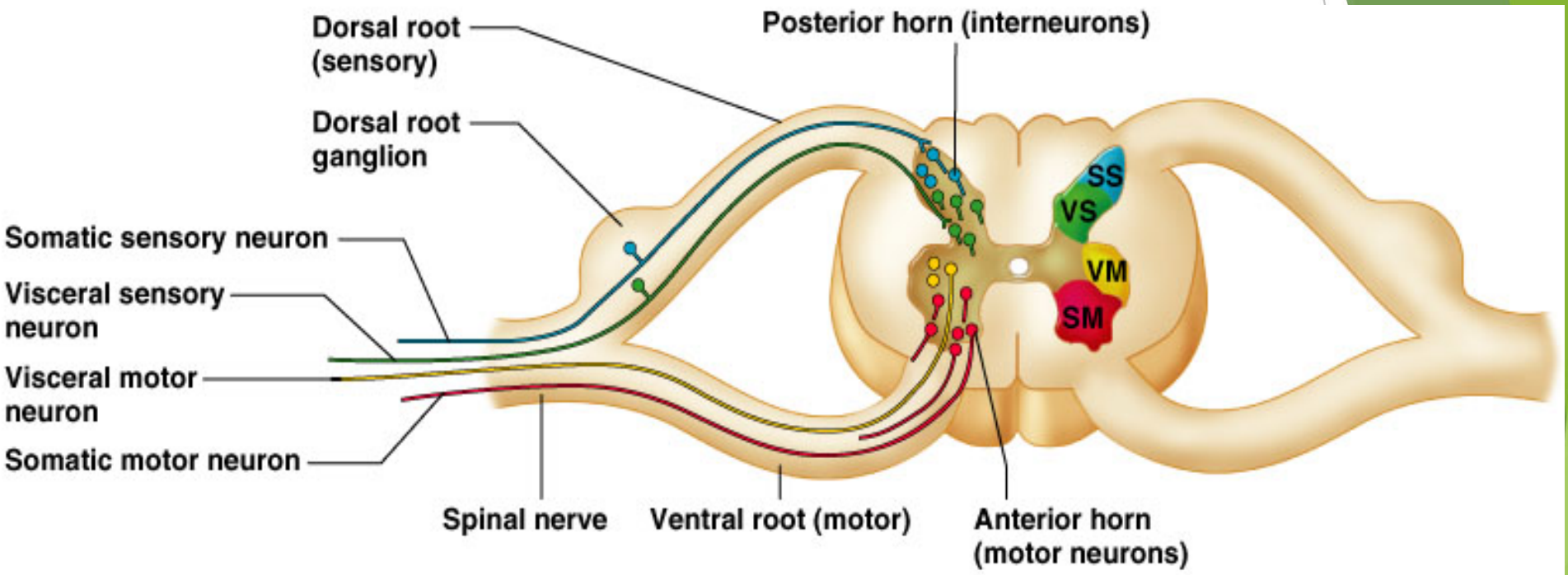


Figure 12.31

- The nerve cells are multipolar, and are of THREE main categories:

Sensory neurons (Tract cells)

- receive impulses from the periphery of the body and whose axons constitute the ascending fasciculi of the white matter.
- located in the dorsal horns.

Lower motor neurons

- transmit impulses to the skeletal muscles.
- located in the ventral horns
  - similar neurons in the lateral horn are the preganglionic neurons of the autonomic system.

Interneurons (connector neurons)

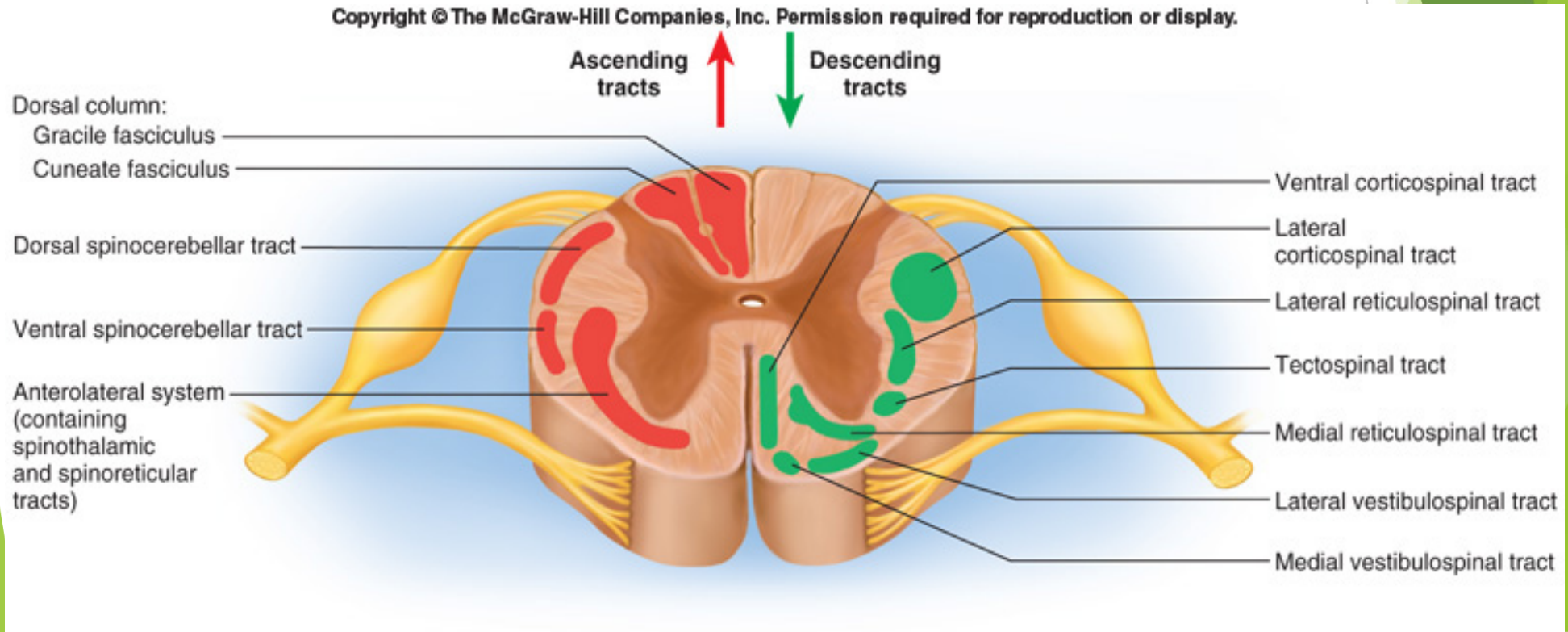
- linking sensory and motor neurons, at the same or different levels, which form spinal reflex arcs.

White Matter in the Spinal Cord

- Divided into three columns – posterior, lateral, and anterior

  Columns contain 3 different types of fibers that run in three directions

  - **Ascending fibers** - compose the sensory tracts
  - **Descending fibers** - compose the motor tracts
  - **Commissural (transverse) fibers** - connect opposite sides of cord

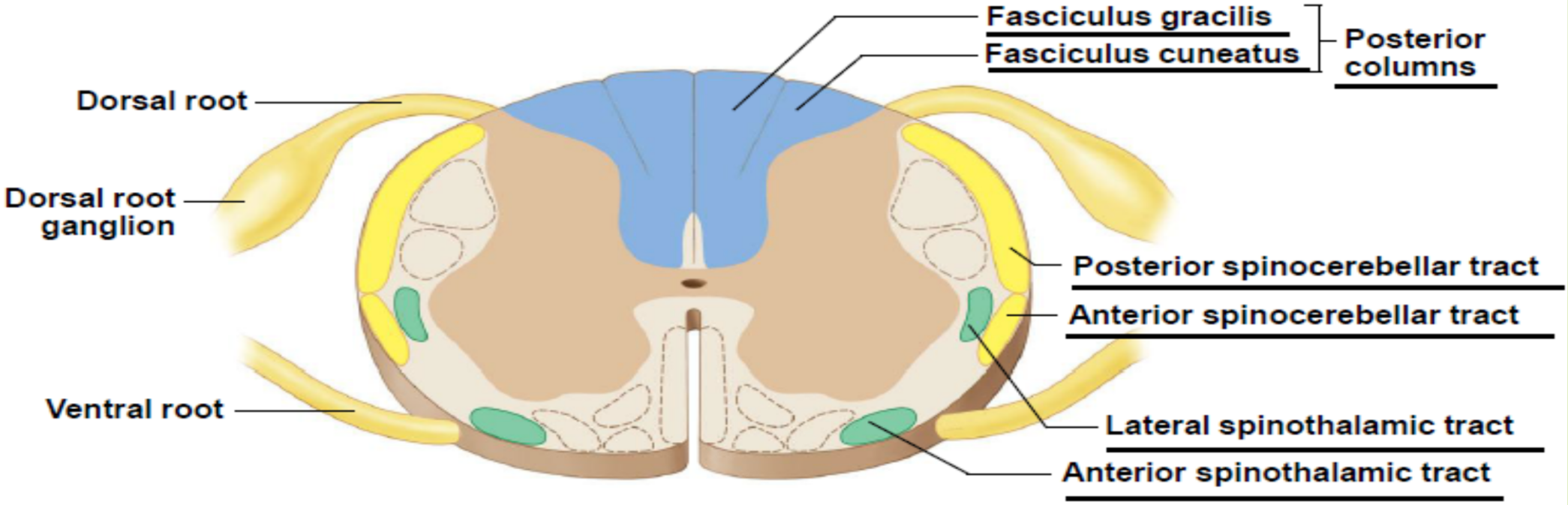


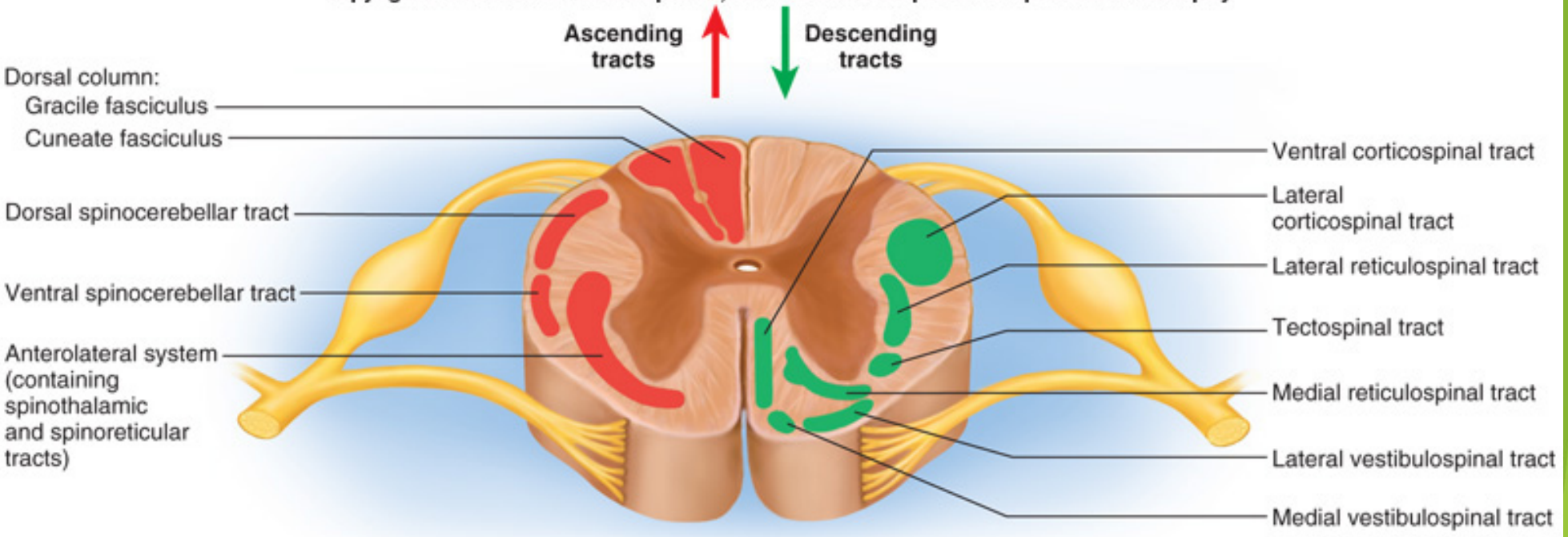
- Consists of mixture of nerve fibers, neuroglia and blood vessels.
- White color is due to high proportion of myelinated nerve fibers
- The white matter of the spinal cord is arranged in columns/funiculi; *anterior, posterior and lateral.*
- The nerve fibers are arranged as bundles, running vertically through the cord.
- A group of nerve fibers (axons) that share a common origin, termination and function form a tract or fasciculus
- These tracts are formed by sensory nerve fibers ascending to the brain, motor nerve fibers descending from the brain and fibers of connector neurons.
- Tracts are often named according to their points of origin and destination, e.g. *spinothalamic*, *corticospinal*.

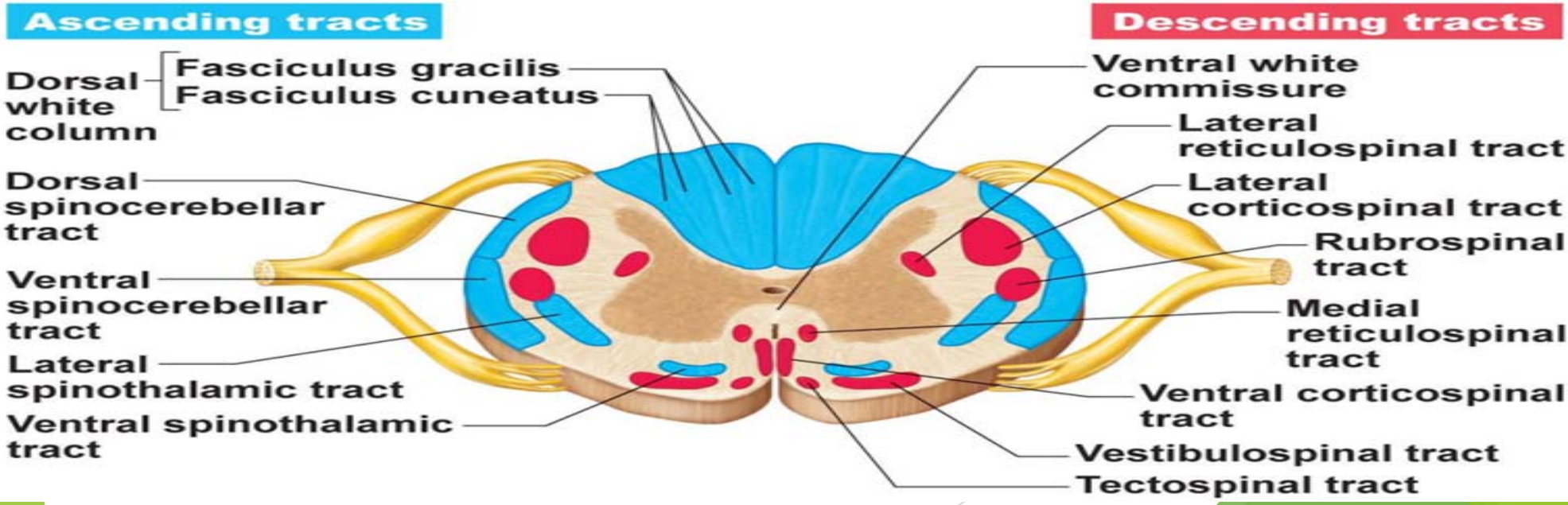
There are three major sensory tracts

- **The posterior column tract**
- **Spinothalamic tract:** Transmits pain and temperature sensations to the thalamus and then to the cerebrum
- **Spinocerebellar tract**

Transmits proprioception sensations to the cerebellum







Motor tracts

There are two major descending tracts:

- **Corticospinal tract**: Conscious control of skeletal muscles.
- **Subconscious tract:** Subconscious regulation of balance, muscle tone, eye, hand, and upper limb position.

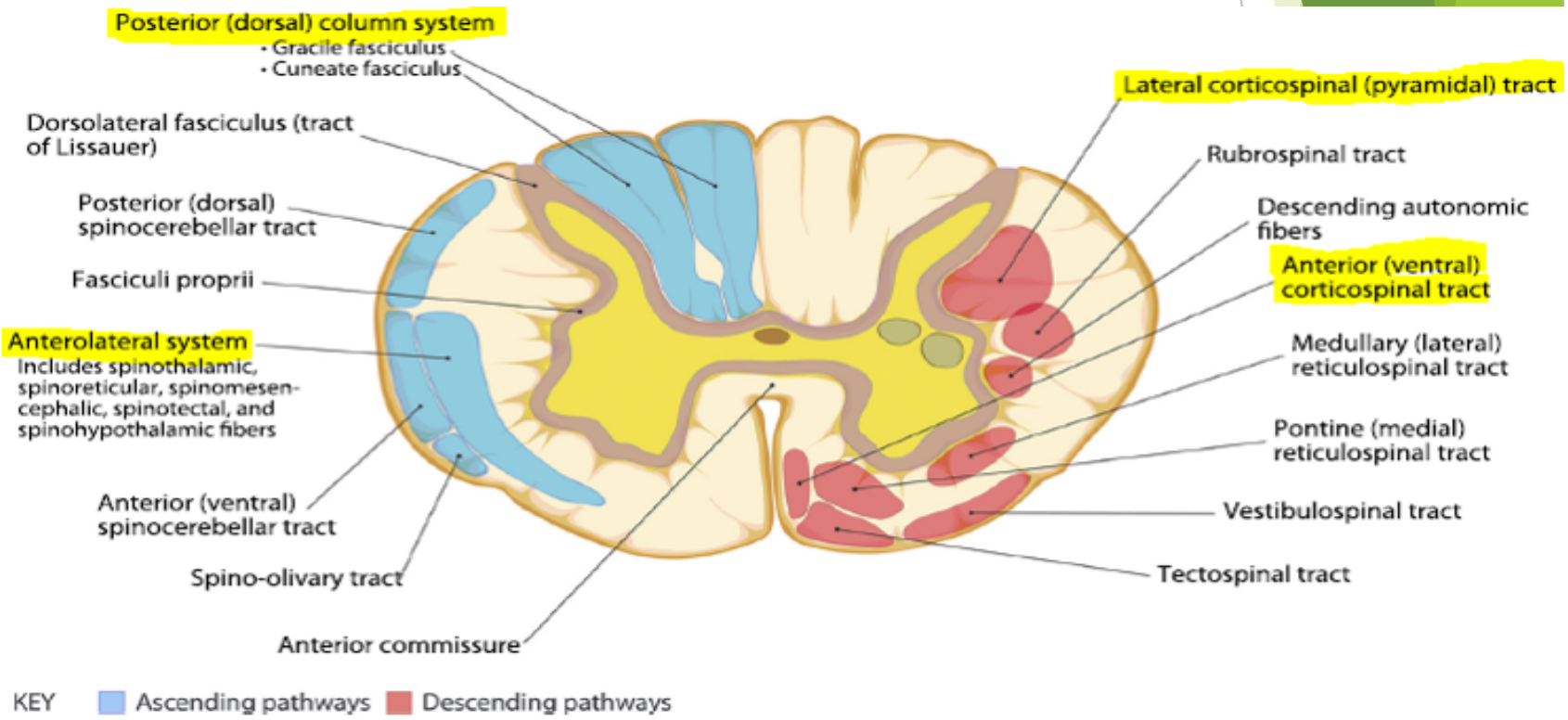
The Corticospinal Tracts

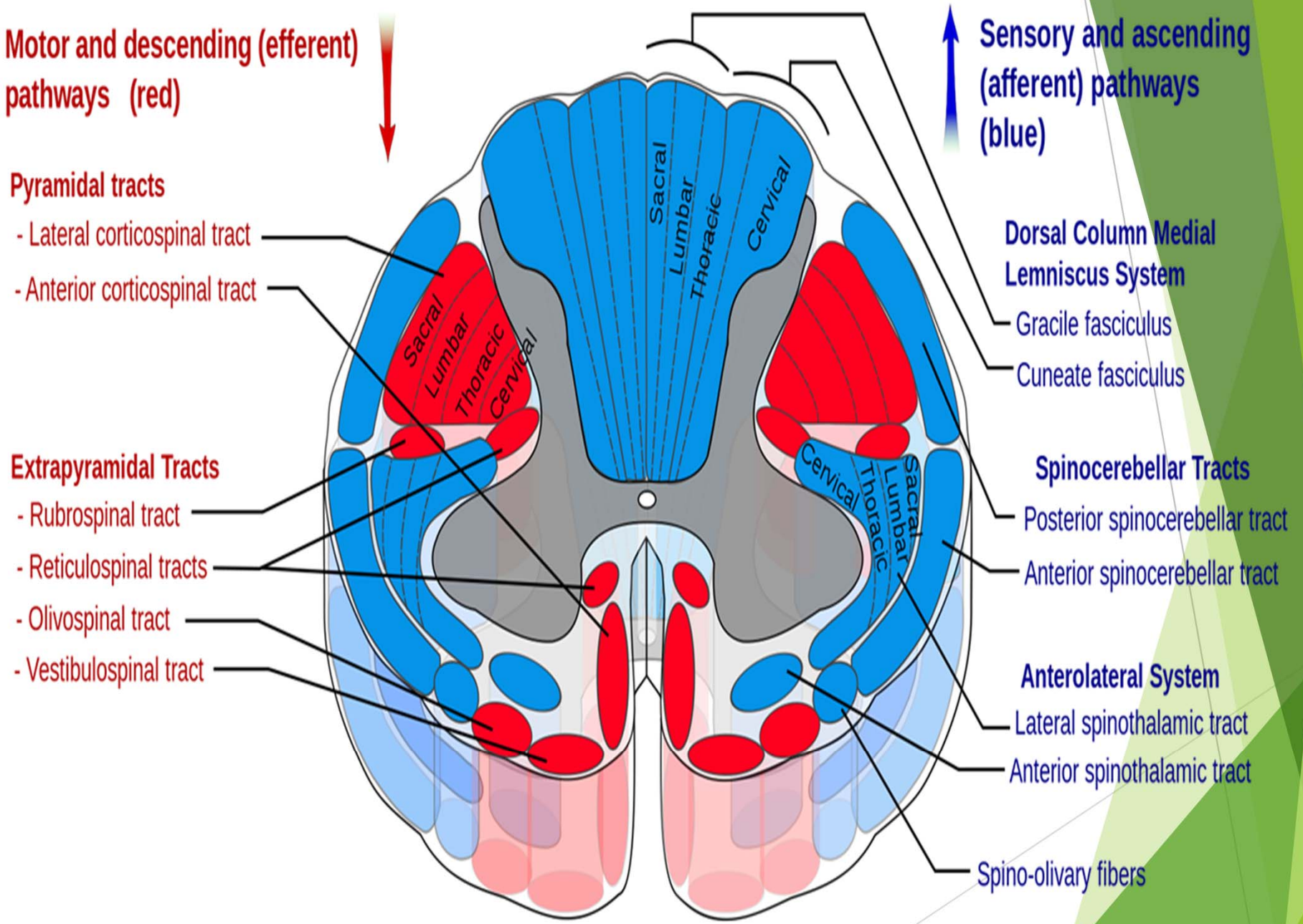
Consists of three pairs of descending tracts

Corticobulbar tracts: conscious control over eye, jaw, and face muscles

Lateral corticospinal tracts: conscious control over skeletal muscles

Anterior corticospinal tracts: conscious control over skeletal muscles

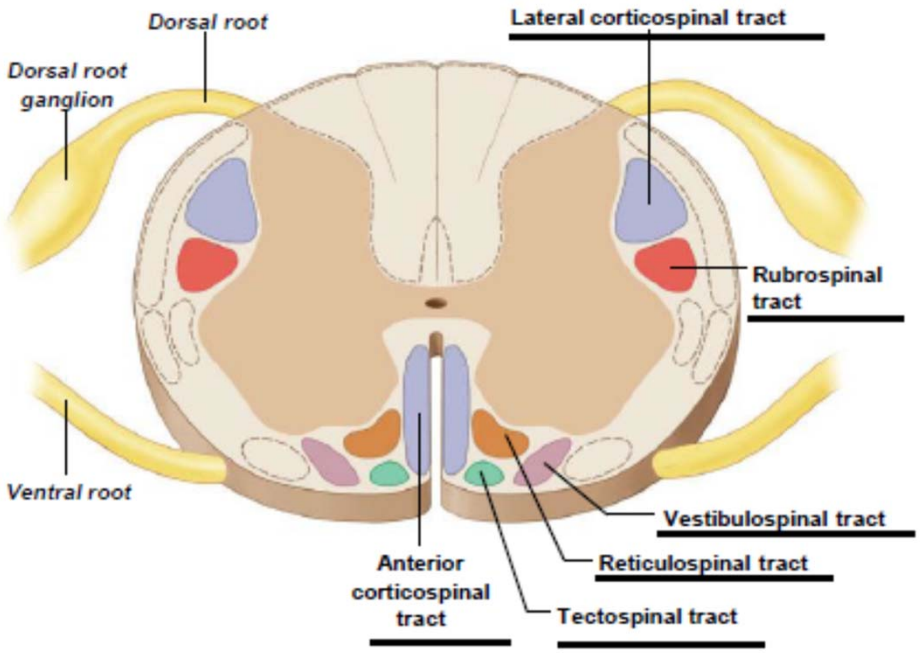



Motor and descending (efferent) pathways (red)
Pyramidal tracts
- Lateral corticospinal tract
- Anterior corticospinal tract
Extrapyramidal Tracts
- Rubrospinal tract
- Reticulospinal tracts
- Olivospinal tract
- Vestibulospinal tract
Sacral
Lumbar
Thoracic
Cervical
Sensory and ascending (afferent) pathways (blue)
Dorsal Column Medial Lemniscus System
Gracile fasciculus
Cuneate fasciculus
Spinocerebellar Tracts
Posterior spinocerebellar tract
Anterior spinocerebellar tract
Anterolateral System
Lateral spinothalamic tract
Anterior spinothalamic tract
Spino-olivary fibers

The Subconscious Motor Tracts

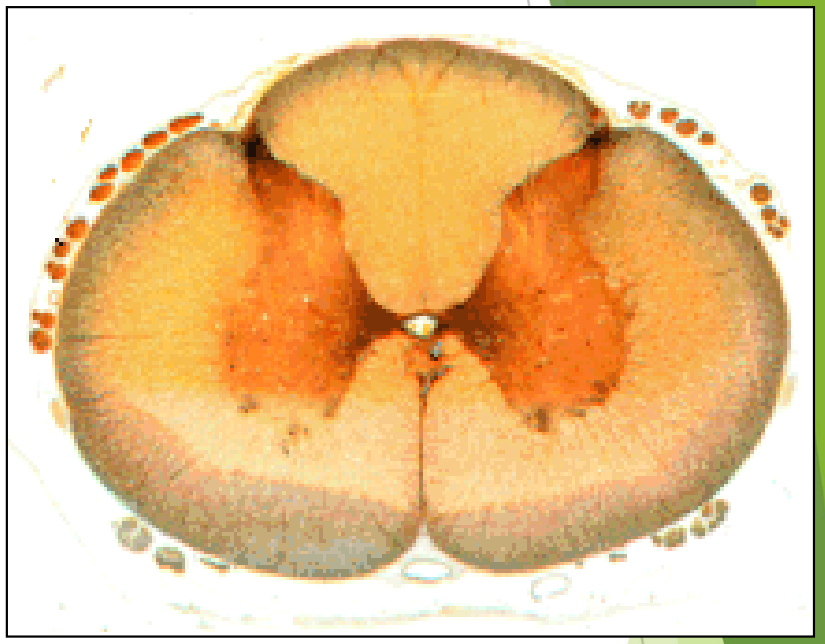
- **Vestibulospinal tracts**: Send information from the inner ear to monitor position of the head
- **Tectospinal tracts:** Send information to the head, neck, and upper limbs in response to bright and sudden movements and loud noise
- **Reticulospinal tracts:** Send information to cause eye movements and activate respiratory muscles
- **Rubrospinal tracts:** Send information to the flexor and extensor muscles

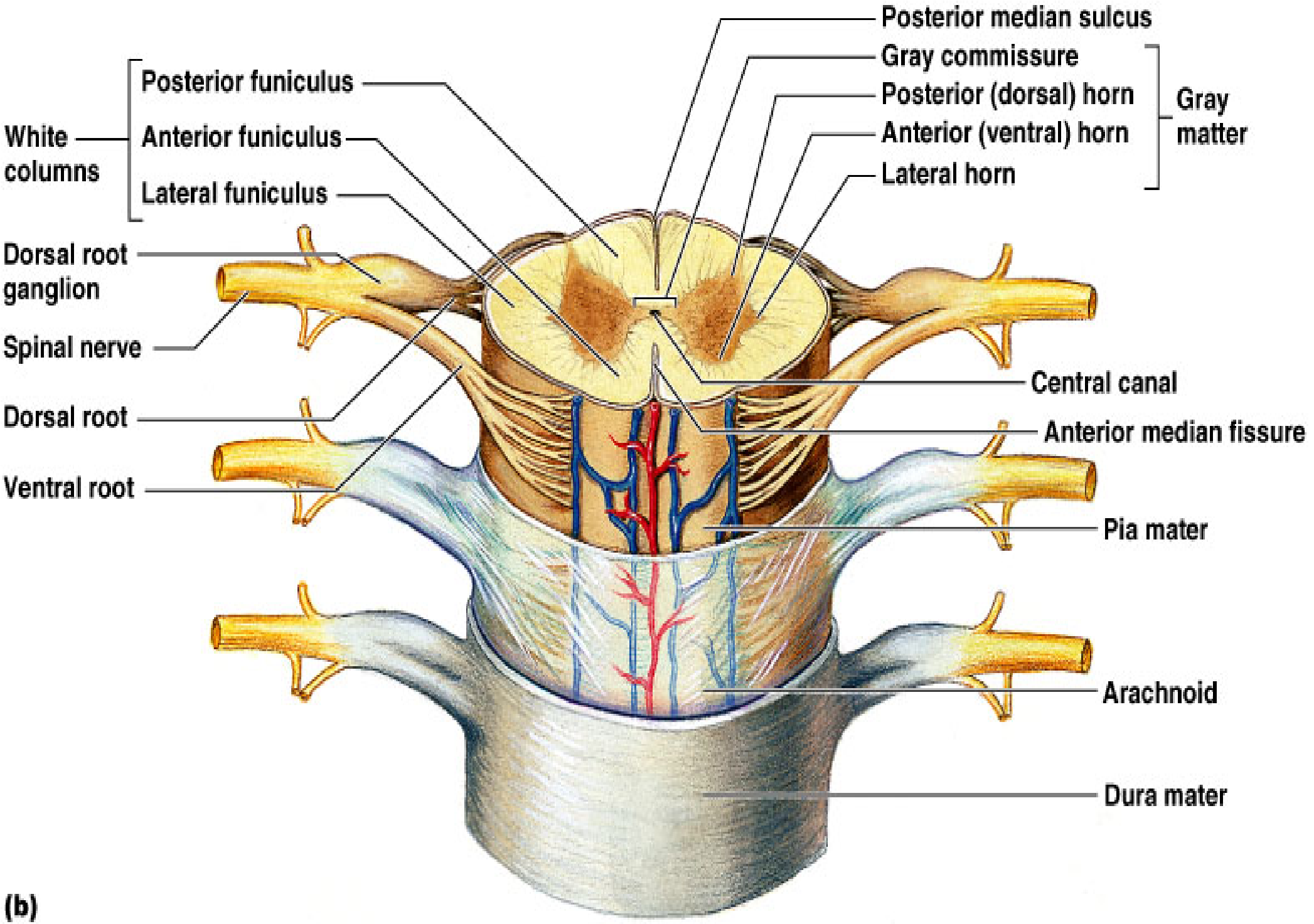
The Corticospinal Tracts and Other Descending Motor Tracts in the Spinal Cord



CENTRAL CANAL

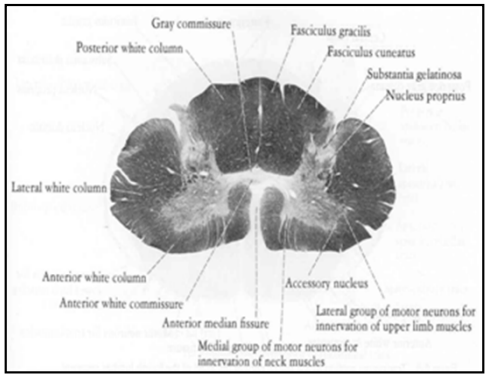
- The cerebrospinal-filled space that runs longitudinally through the entire length of the spinal cord.
- Lined by ependyma (ciliated columnar epithelium)
- Continuous with the ventricular system of the brain
- Superiorly opens into the 4th ventricle
- Inferiorly in the conus medullaris, it expands into the fusiform terminal ventricle and terminates below at the root of filum terminale



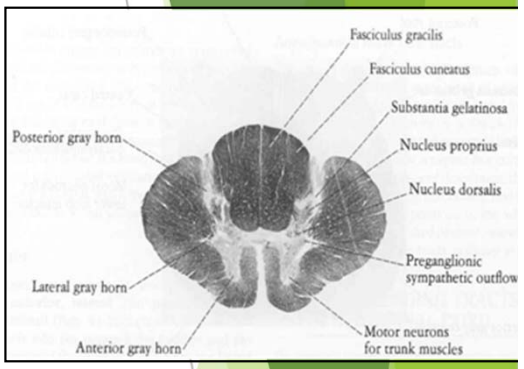


REGIONAL DIFFERENCES

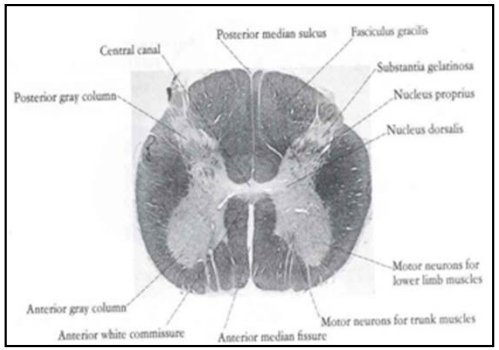
- Although the general pattern of gray matter is the same throughout spinal cord, **regional differences** are apparent in transverse sections
- The **amount of white matter** increases in a caudal-to-cranial direction because fibers are added to ascending tracts and fibers leave descending tracts
- The **gray matter** is in increased volume in **cervical & lumbosacral enlargements** for innervation of upper & lower limbs
- The **lateral horn** is characteristics of **thoracic and upper lumbar segments**



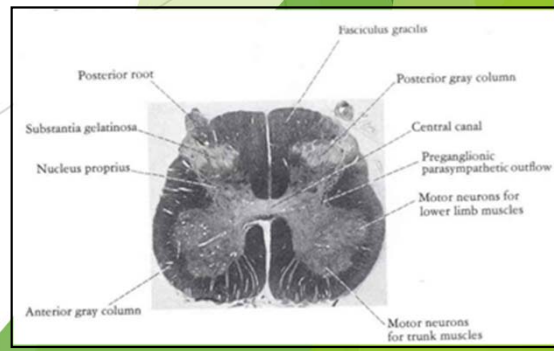
Cervical



Thoracic



Lumbar

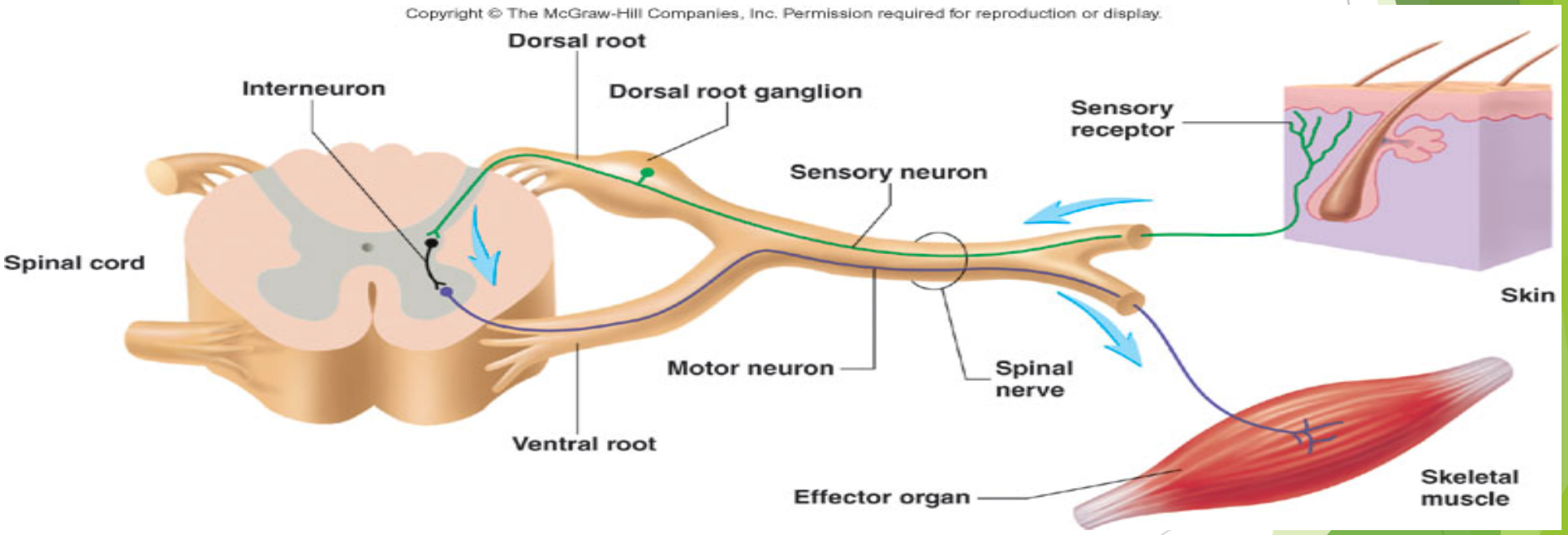


Sacral

REFLEX & REFLEX ARC

A reflex is a rapid, involuntary, stereotyped pattern of response brought by a sensory stimulus

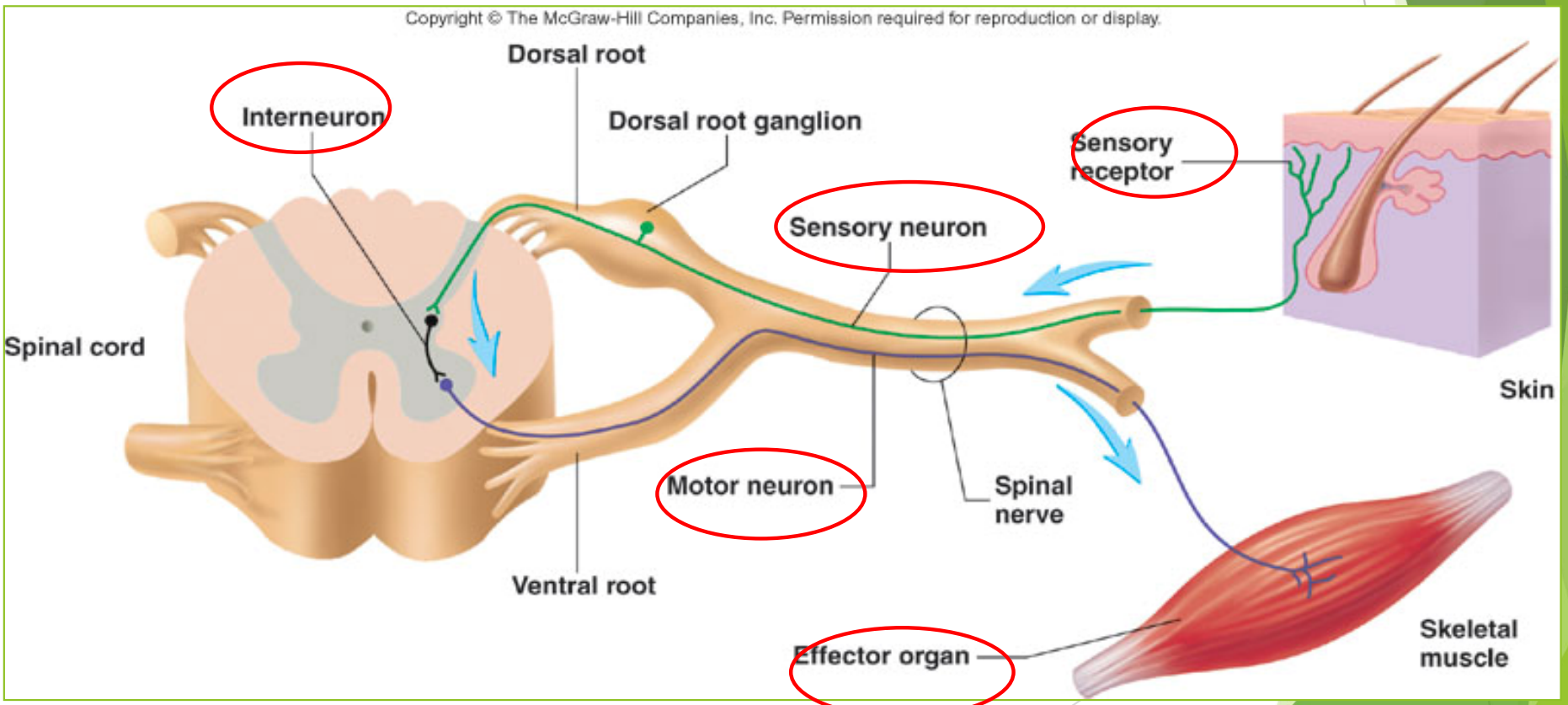
A neural pathway mediating the reflex actions is called reflex arc.



COMPONENTS OF A REFLEX ARC

Action potentials produced in

Sensory receptor → Sensory neuron → Interneuron → Motor neuron → Effector organ which responds with a reflex



Function Of Spinal Cord

- Forms a connecting link between the brain and the PNS.
- Provides structural support and builds a body posture.
- Facilitates flexible movements.
- Myelin present in the white matter acts as an electrical insulation.
- Communicates messages from the brain to different parts of the body.
- Coordinates reflexes.
- Receives sensory information from receptors and approaches towards the brain for processing.