



Nervous System Module

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Spinal Cord

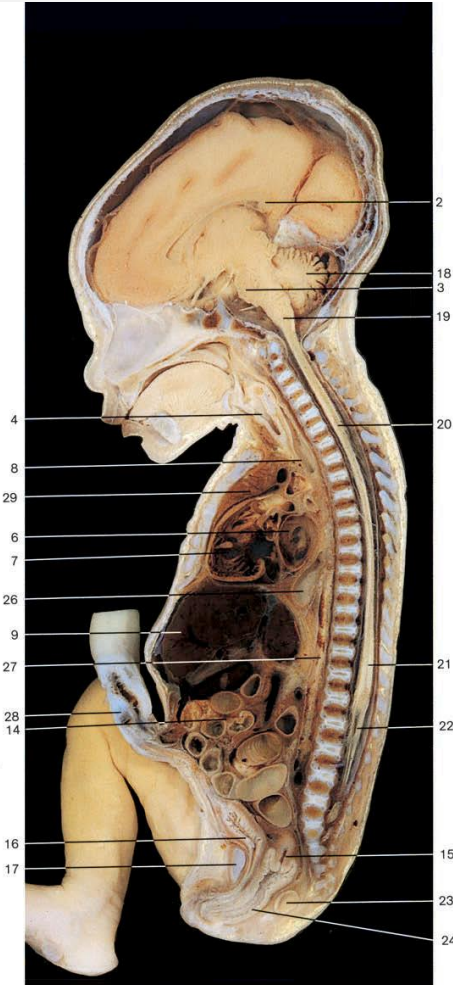


Spinal Cord

- **By the end of this session, you should be able to know:**
 1. Where the spinal cord starts and ends
 2. The spinal cord enlargements
 3. How the spinal cord ends
 4. Derivatives of the spinal cord and the reflex arc
 5. Blood Supply of the spinal cord

Spinal Cord

- Part of the central nervous system
- ***Length:*** 45 cm
- Occupies the whole length of the spinal canal by the 3m IU life
- Reaches L3 at birth



Spinal Cord

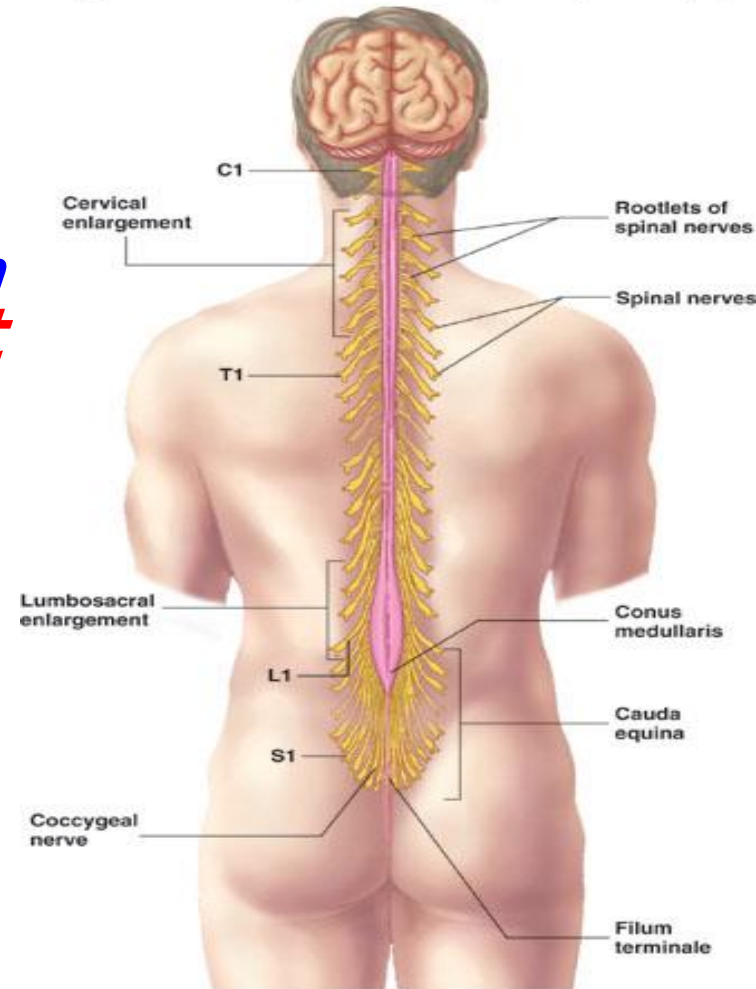
Runs through the vertebral canal

Extends from **foramen magnum** to the lower border of **first lumbar vertebra**

Regions

1. Cervical
2. Thoracic
3. Lumbar
4. Sacral
5. Coccygeal

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Posterior view



Spinal Cord

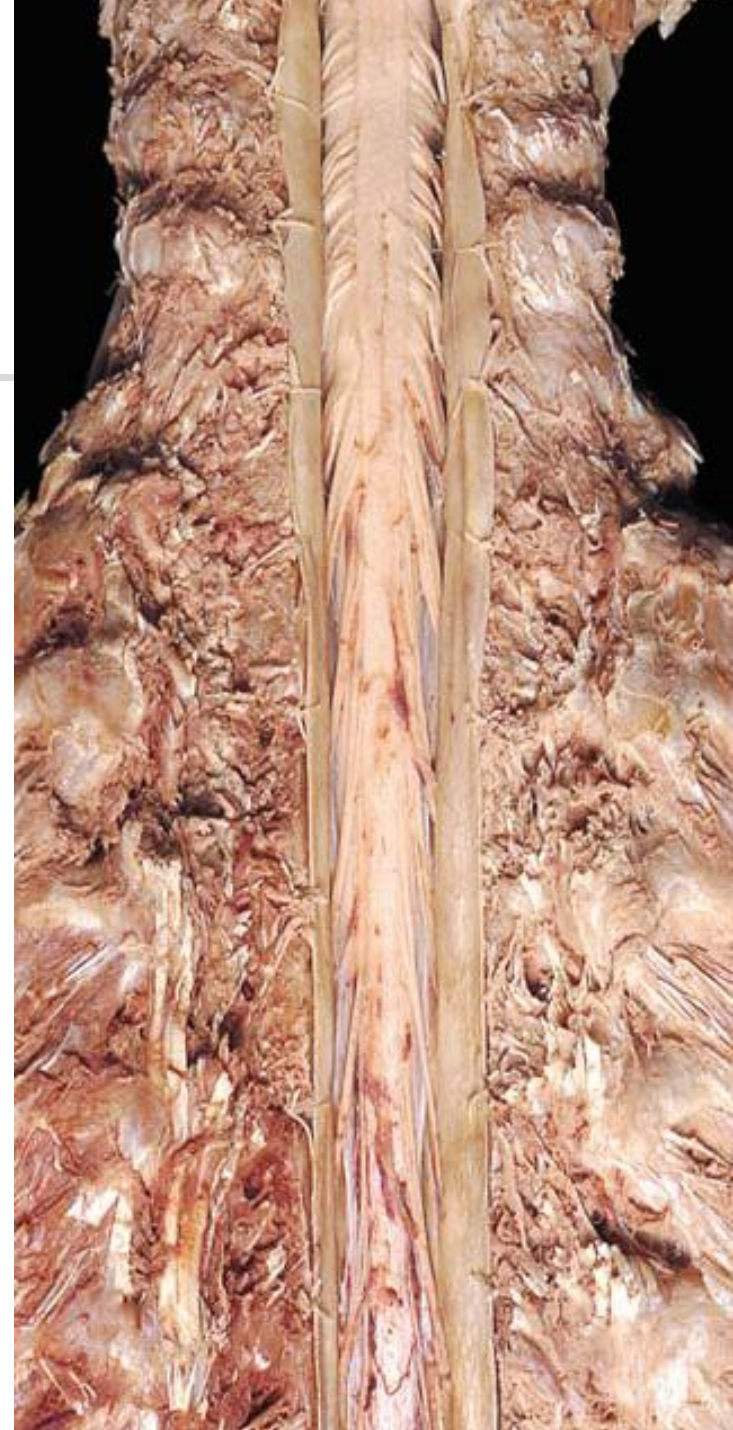
Gives rise to 31 pairs of spinal nerves

All are ***mixed*** nerves

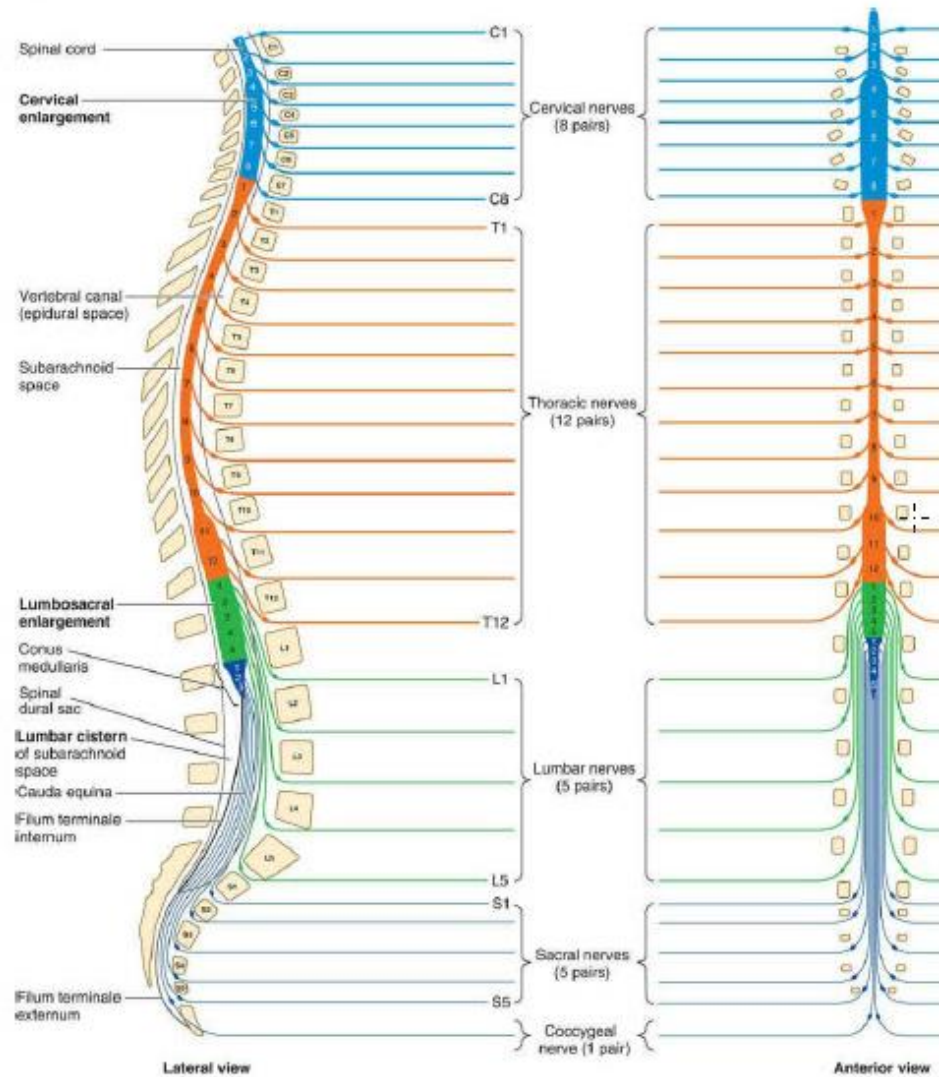
Not uniform in diameter

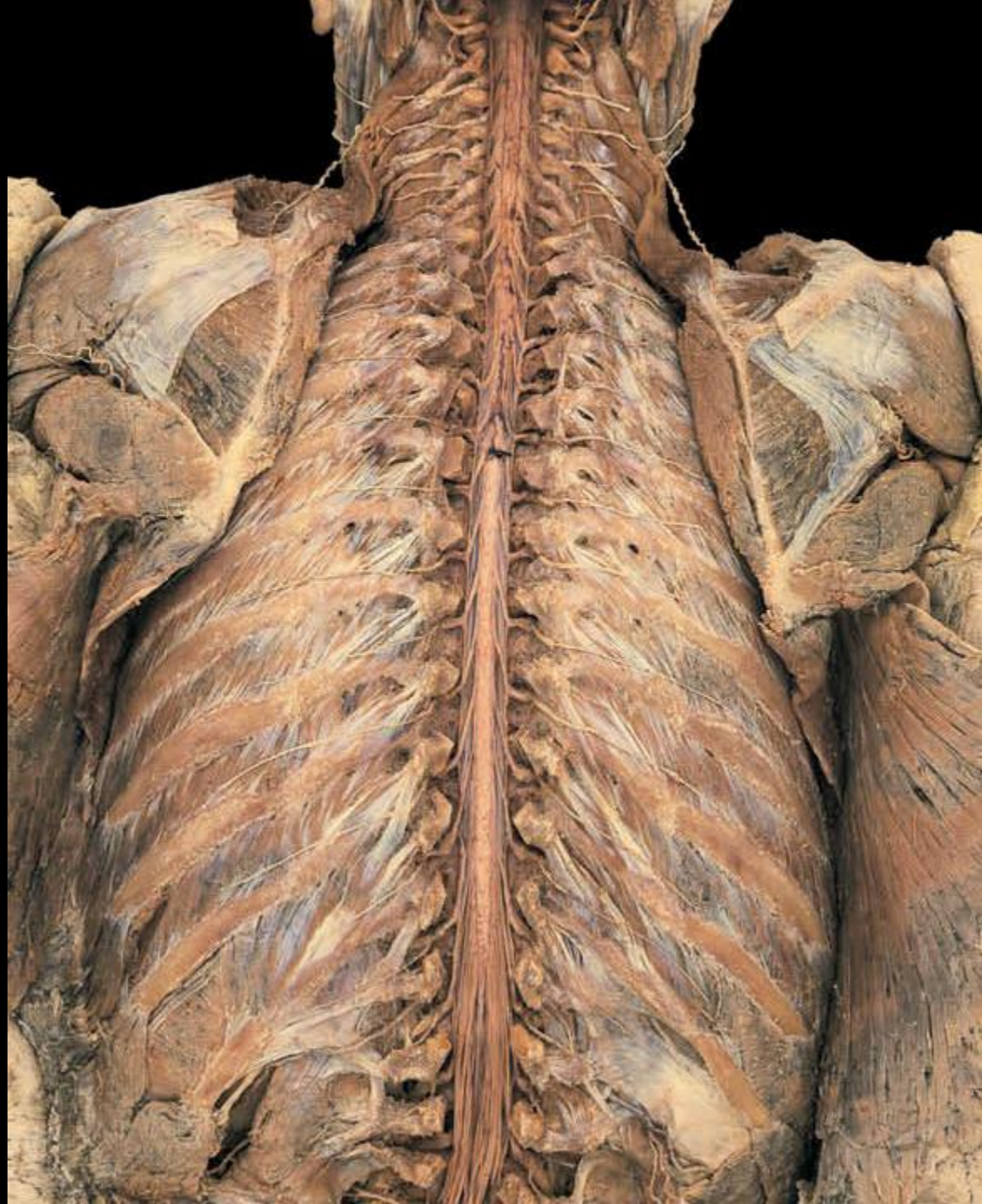
Cervical enlargement: *supplies upper limbs*

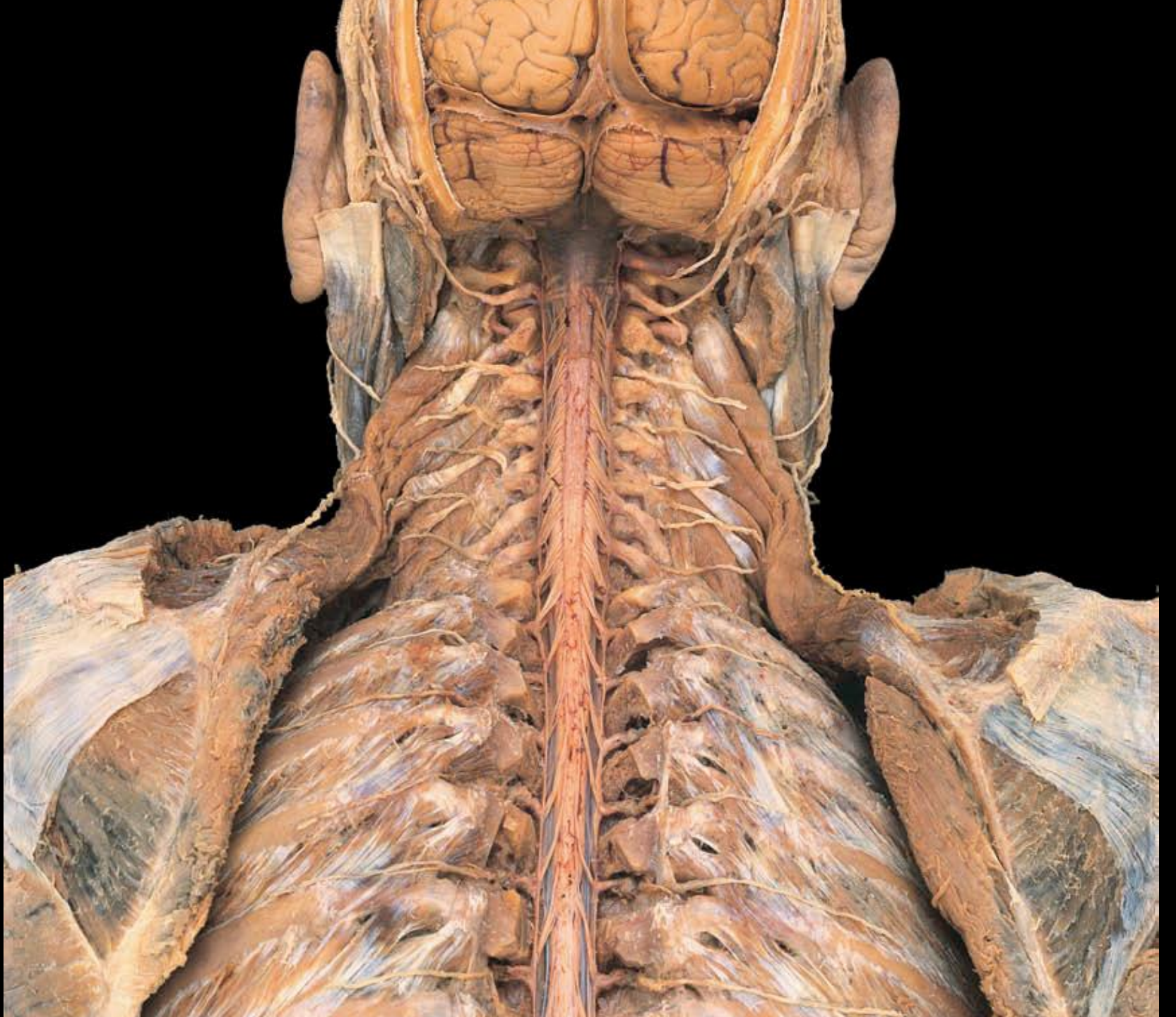
Lumbar enlargement: *supplies lower limbs*

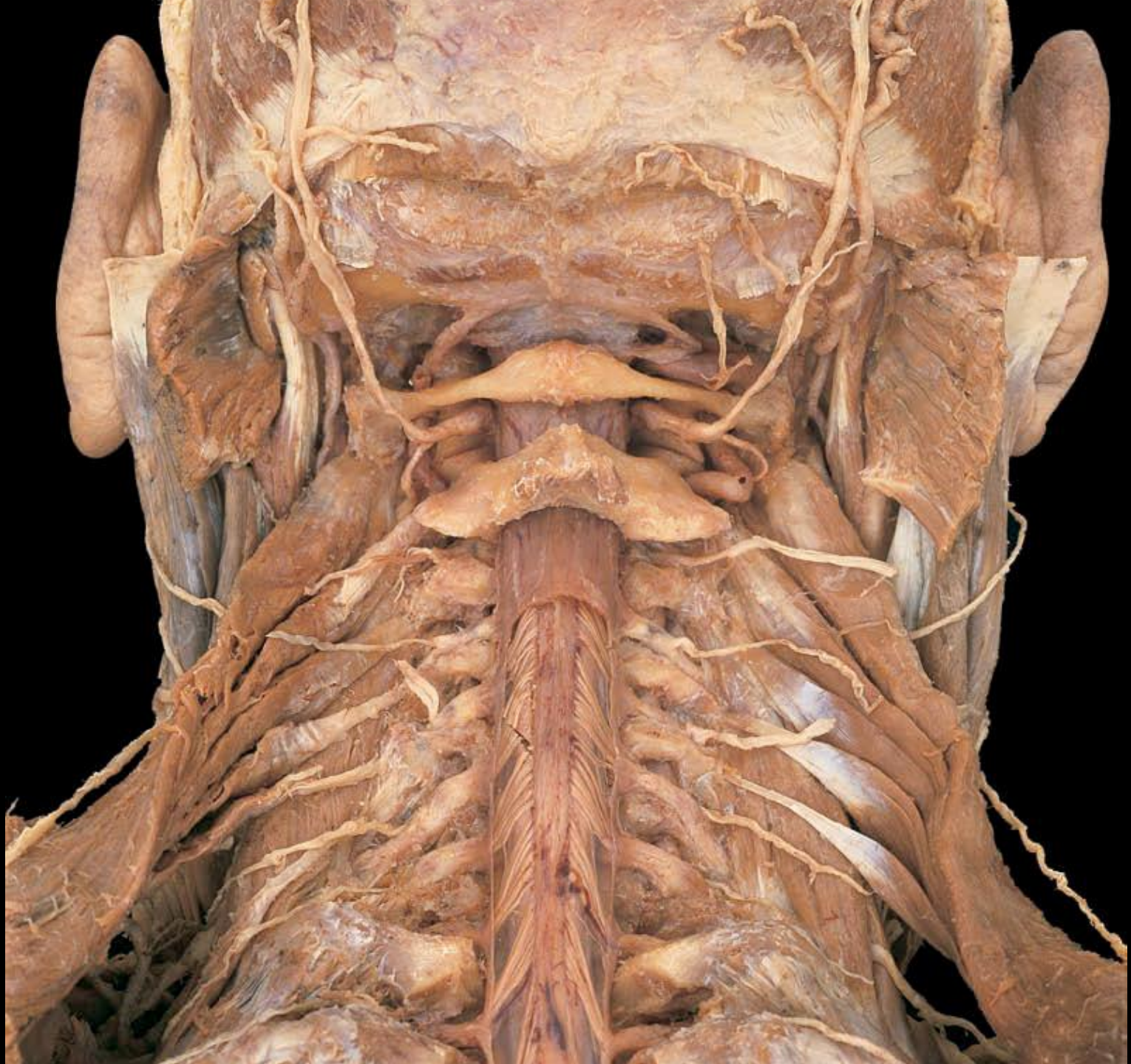


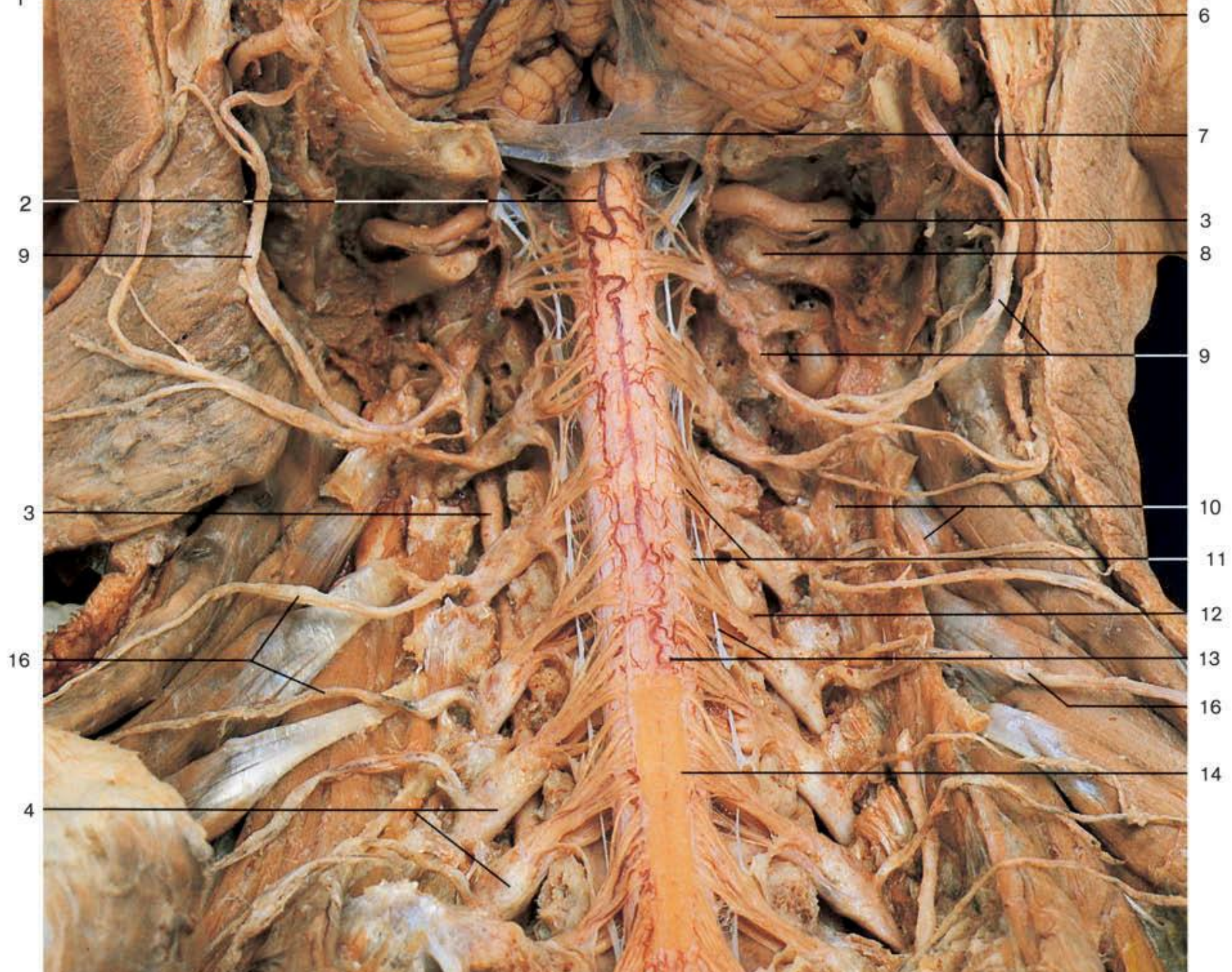
spinal cord is 42–45 cm long and extends from the foramen magnum in the occipital bone to the level of the L1 or L2 vertebra (Fig. 2.39). However, its tapering inferior end, the **conus medullaris**, may terminate as high as T12 vertebra or as low as L3 vertebra. Thus, the spinal cord occupies only the superior two thirds of the vertebral canal.









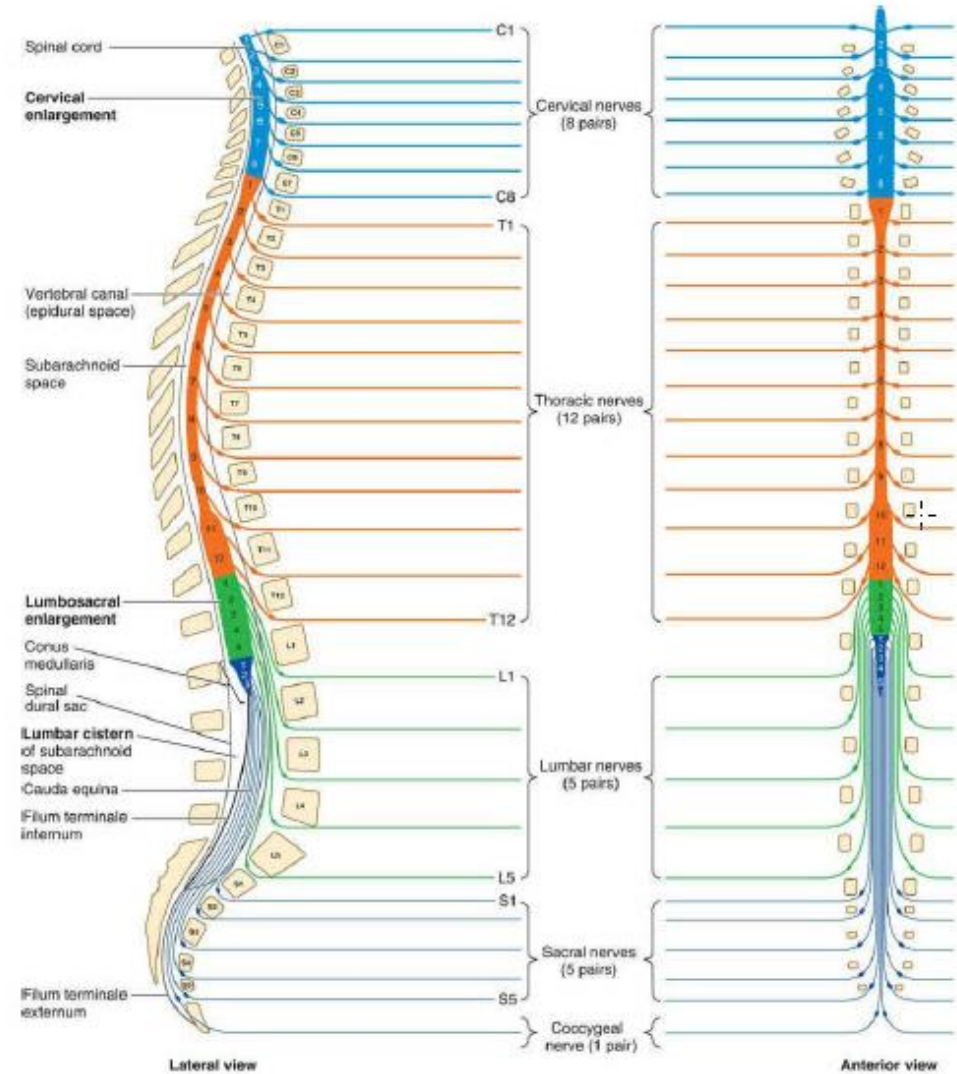




Spinal Cord Segments

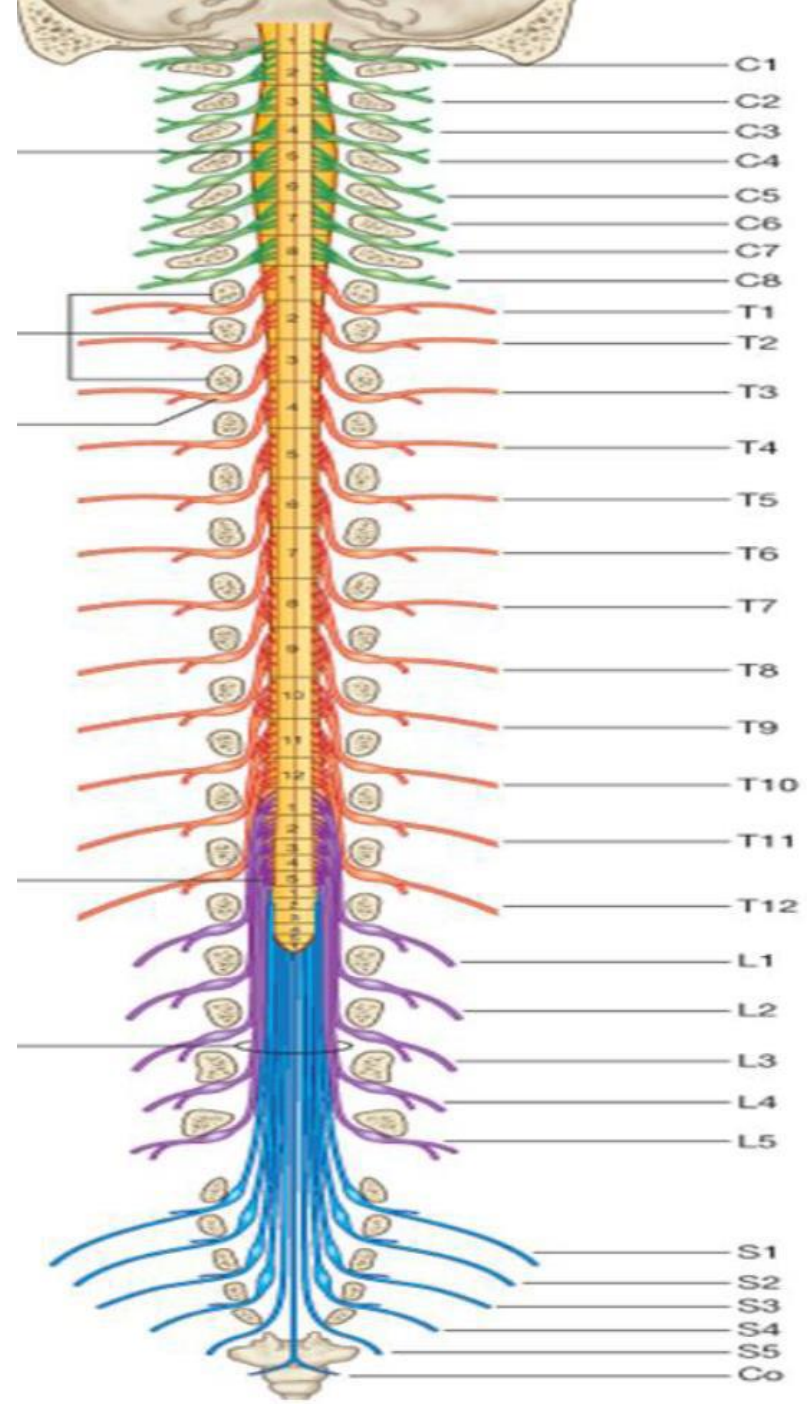
- The spinal cord formed of **31 segments** -> **8 cervical, 12 thoracic, 5 lumbar, 5 sacral,** and **1 coccygeal.**
- Segments are not demarcated externally but **each segment gives origin to a pair of spinal nerves.**
- Spinal cord segments **do not lie opposite the corresponding vertebrae.**

spinal cord is 42–45 cm long and extends from the foramen magnum in the occipital bone to the level of the L1 or L2 vertebra (Fig. 2.39). However, its tapering inferior end, the **conus medullaris**, may terminate as high as T12 vertebra or as low as L3 vertebra. Thus, the spinal cord occupies only the superior two thirds of the vertebral canal.



Nerves and ganglia

- Cervical nerves and ganglia
- Thoracic nerves and ganglia
- Lumbar nerves and ganglia
- Sacral and coccygeal nerves and ganglia





Spinal Cord Segments

Exit of spinal nerves from the vertebral canal:

1. C1-7 pass above corresponding vertebrae.
2. C8 passes below C7 vertebra.
3. All other spinal nerves pass below corresponding vertebra.
4. The collection of nerve roots (of L2 to S5) that surround the film terminale below the termination of the spinal cord is called **cauda equina** because it resembles a horse tail. They occupy the lower 1/3 of the vertebral canal.

NUMBERING OF CERVICAL SPINAL NERVES

LEVELS OF SPINAL NERVES

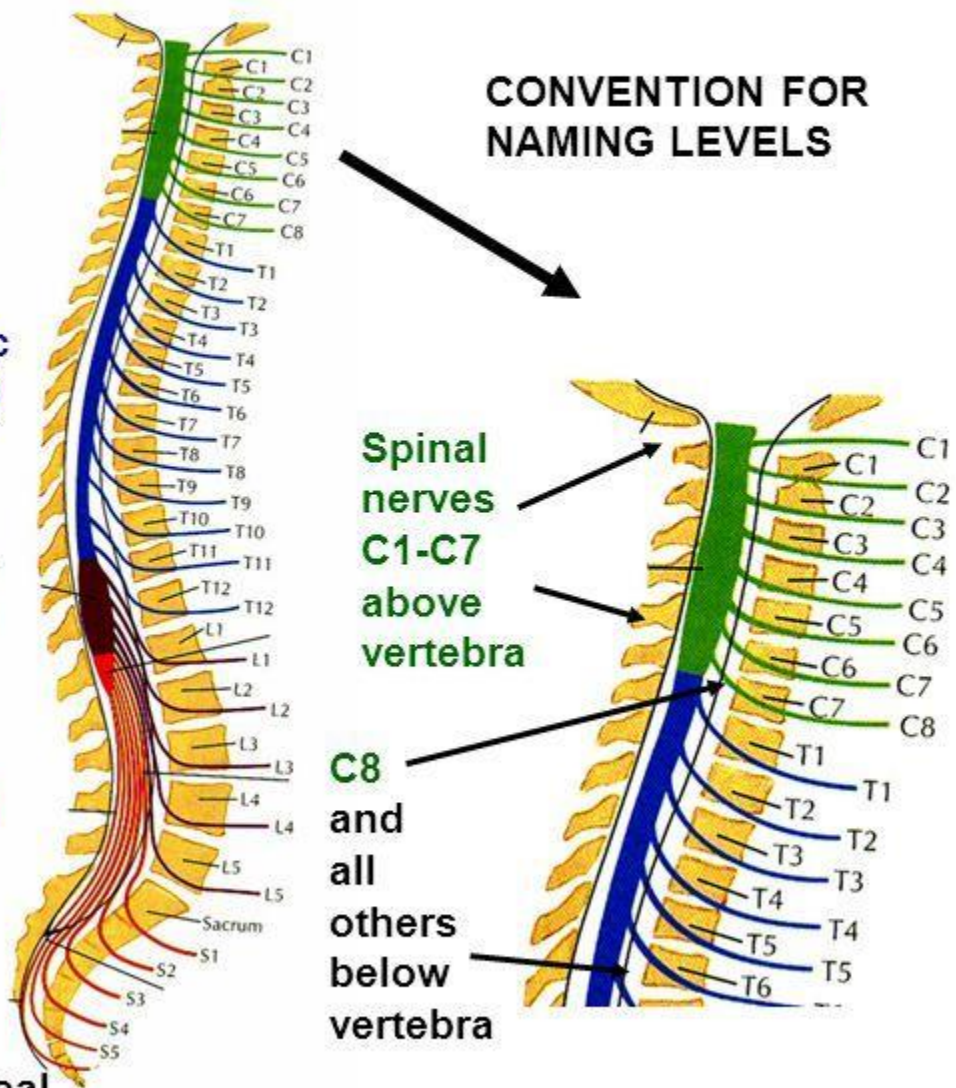
Cervical (C1-C8)

Thoracic (T1-T12)

Lumbar (L1-L5)

Sacral (S1-S5)

Coccygeal (Co1)



CONVENTION FOR NAMING LEVELS

Spinal nerves C1-C7 exit above vertebra

C8 and all others exit below vertebra

Spinal nerves - arise from/project to spinal cord; there are 31 spinal nerves (8 cervical, 12 thoracic, 5 lumbar, 5 sacral and 1 coccygeal).

Note: Cervical spinal nerves 1-7 (C1-C7) exit above corresponding vertebrae; Spinal nerve C8 exits below vertebra C7; All other spinal nerves exit below corresponding vertebrae.

SPINAL NERVE C6 ARISES ABOVE VERTEBRA C6



Segments of the Spinal Cord

Each segment of the spinal cord is located at the level higher than its corresponding vertebra:

The upper cervical segments -> Same level

The lower cervical segments -> +1 (e.g., C6 segment is opposite C5 vertebra).



Segments of the Spinal Cord

The upper 6 thoracic segments -> +2 (e.g., T6 segment is opposite T4 vertebra).

The lower 6 thoracic segments -> +3 (e.g., T12 segment is opposite T9 vertebra).

The lumbar segments -> +4 (e.g., L5 is opposite L1 vertebra).

All sacral and coccygeal segments -> opposite L1-L2 vertebrae.

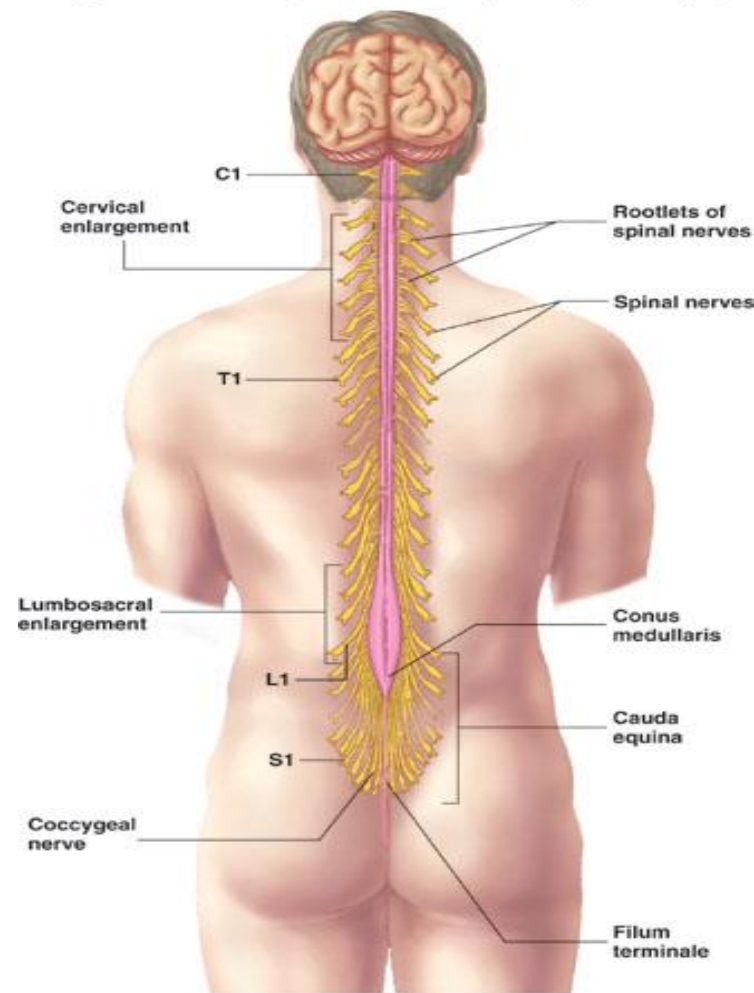
Spinal Cord

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Conus medullaris-
tapered inferior end

Ends between L1 and L2

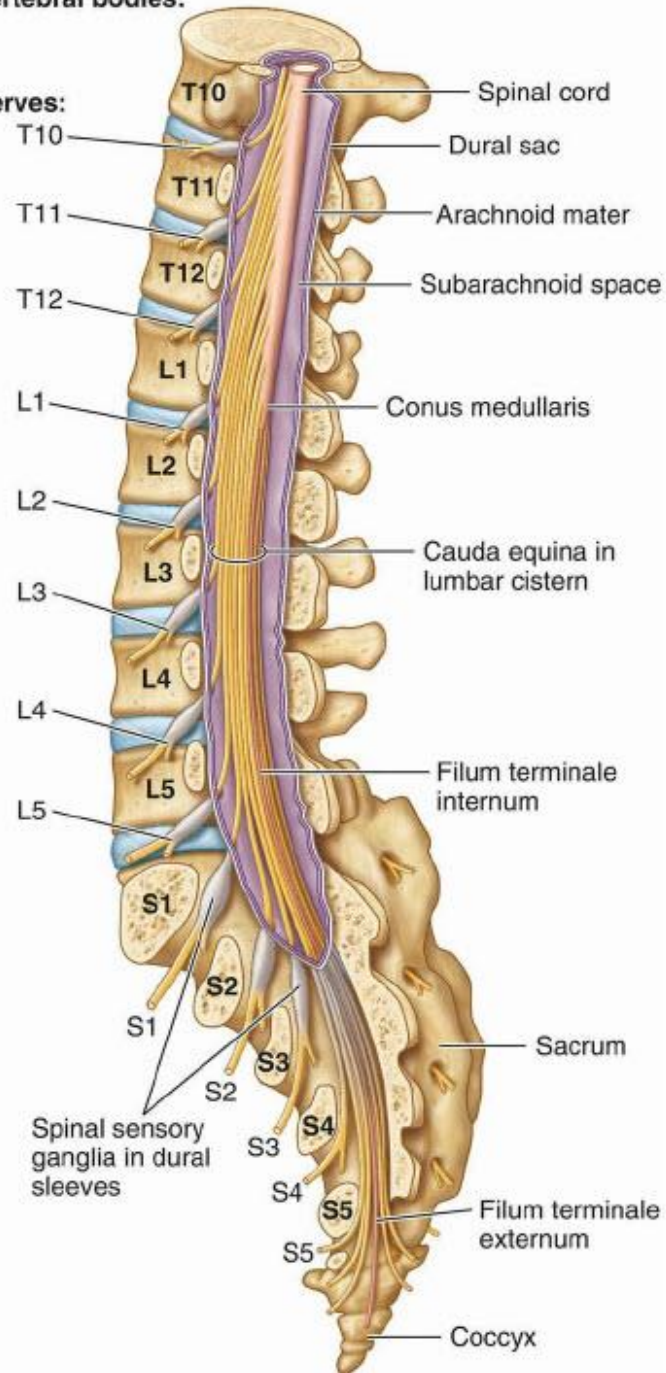
Cauda equina - origin of
spinal nerves extending
inferiorly from conus
medullaris.

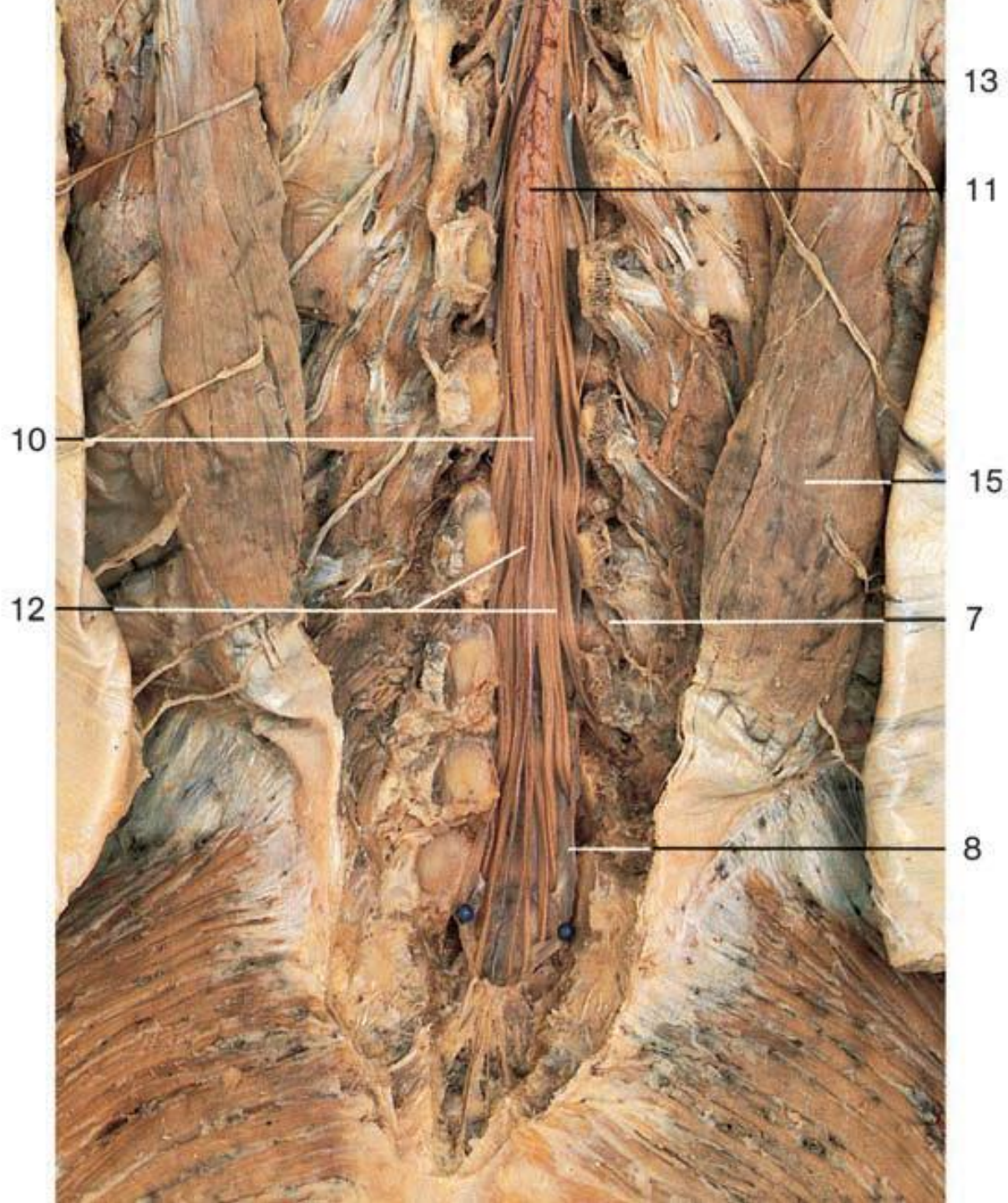


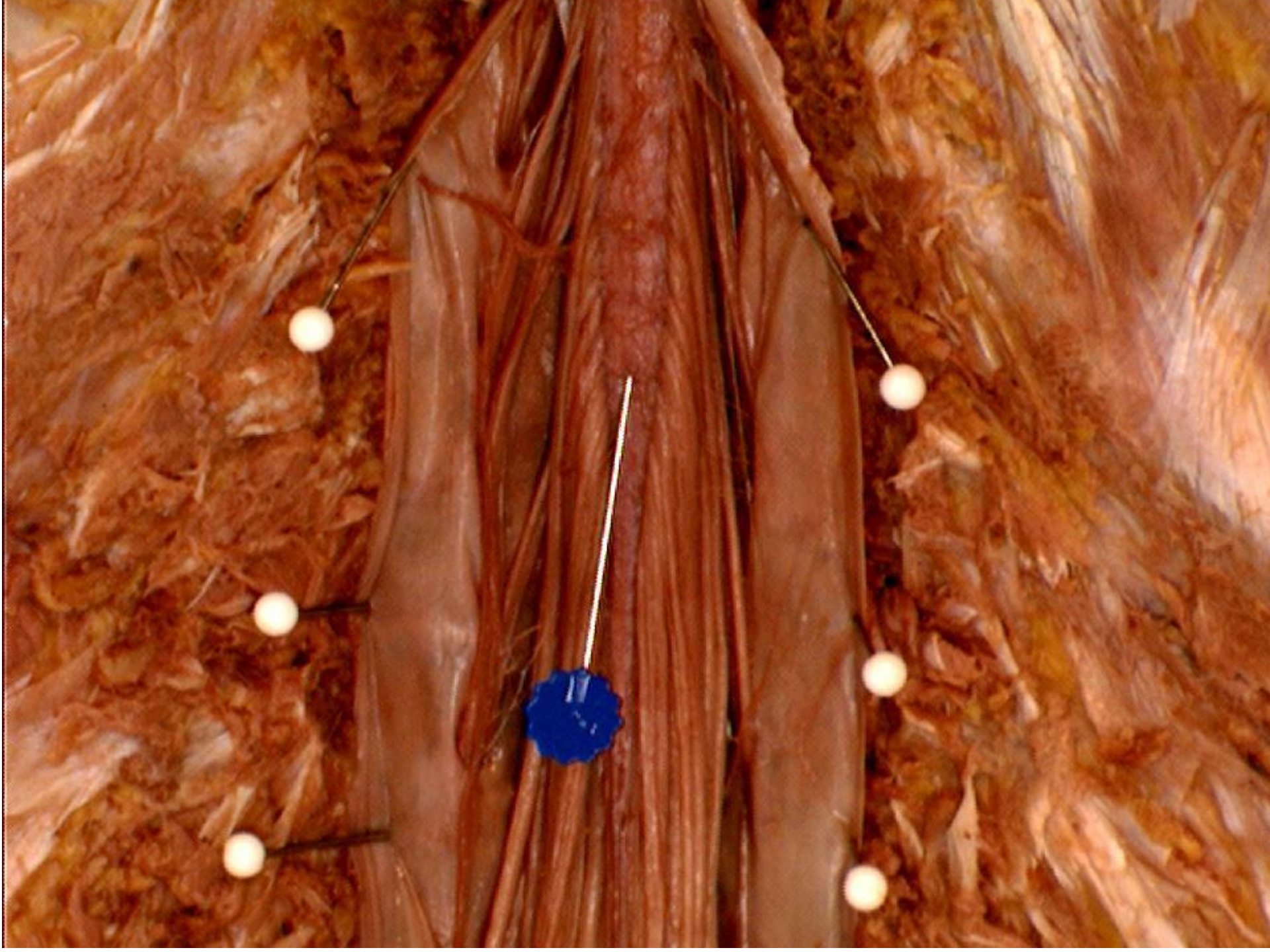
Posterior view

Vertebral bodies:

Nerves:







Regions of the Spinal Cord

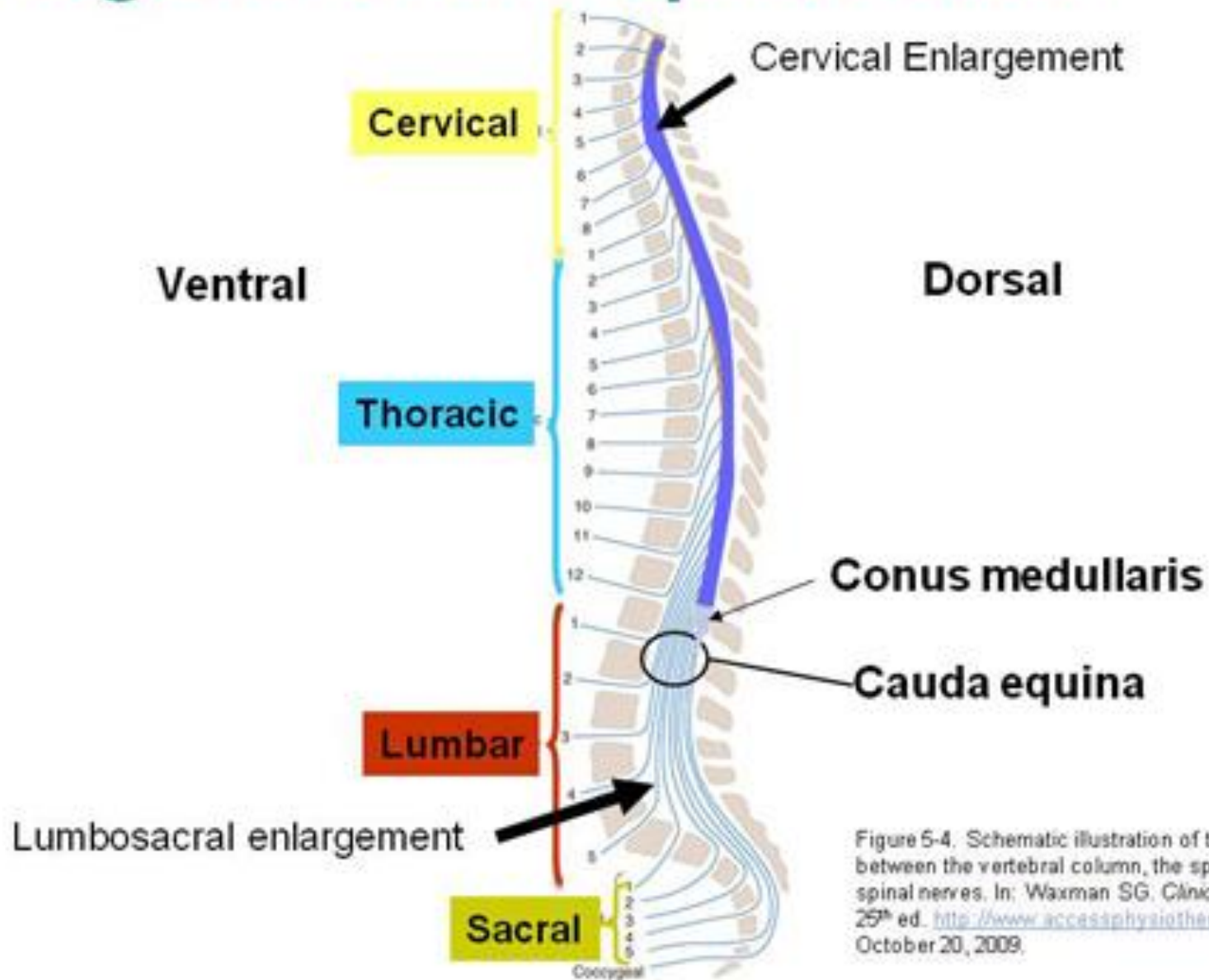


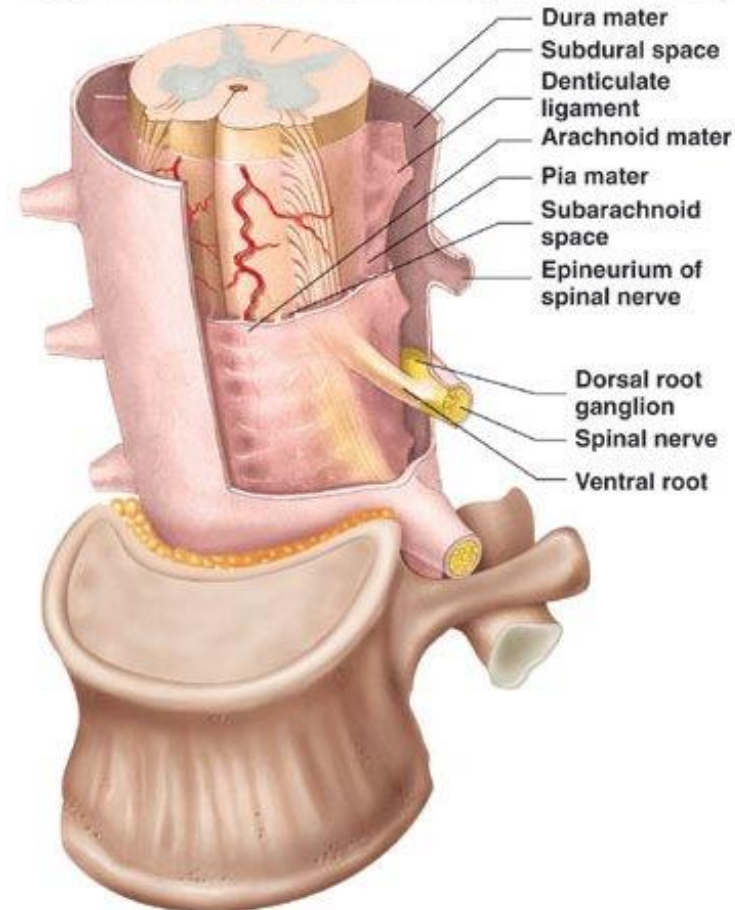
Figure 5-4. Schematic illustration of the relationship between the vertebral column, the spinal cord, and the spinal nerves. In: Waxman SG. *Clinical Neuroanatomy*. 25th ed. <http://www.accessphysiotherapy.com>. Accessed October 20, 2009.

Meninges

Connective tissue membranes

- **Dura mater:** outermost layer; continuous with epineurium of the spinal nerves
- **Arachnoid mater:** thin and wispy
- **Pia mater:** bound tightly to surface
 - Forms the ***filum terminale***
 - Anchors spinal cord to coccyx
 - Forms the denticulate ligaments that attach the spinal cord to the dura

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(a) Anterolateral view

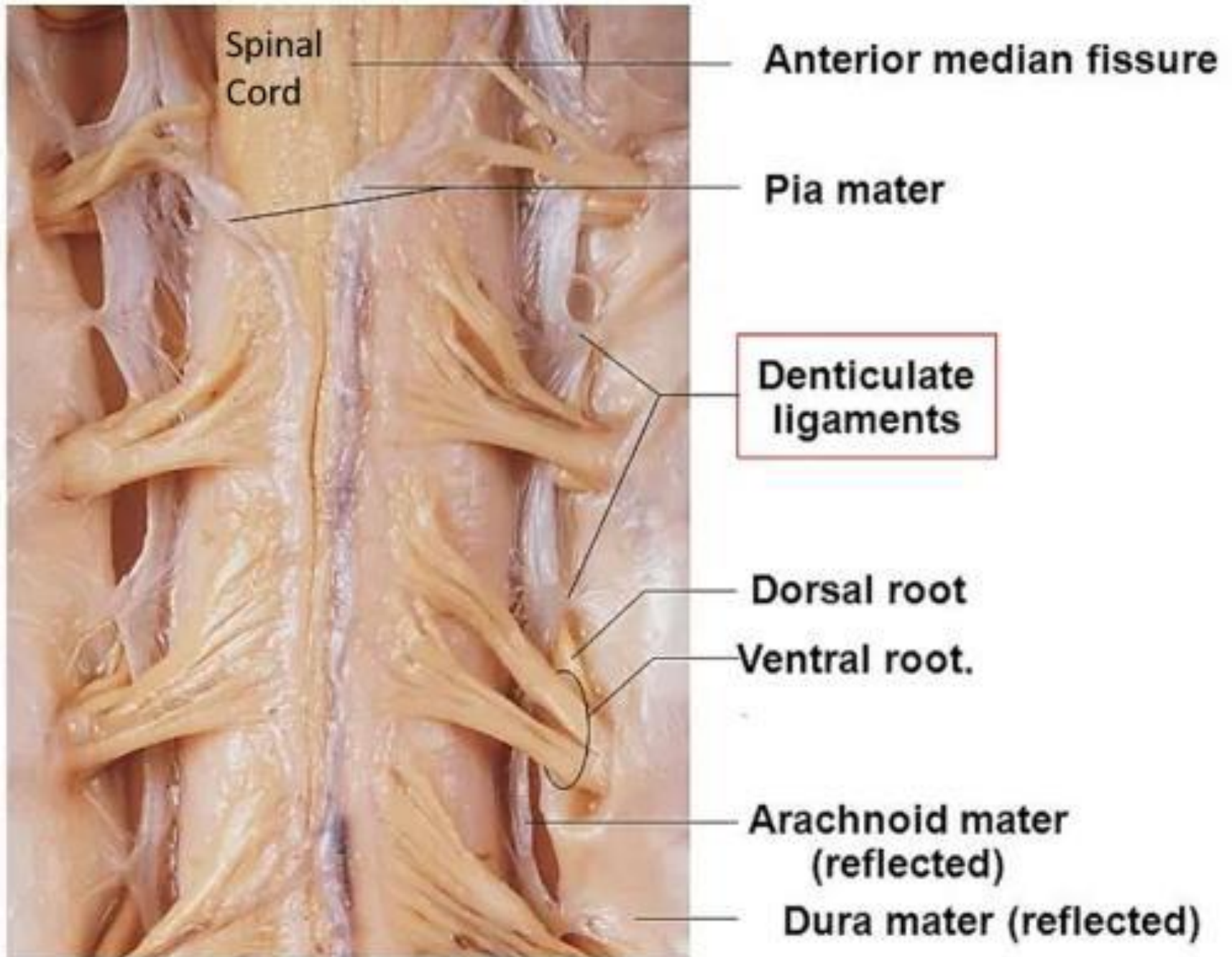


Meninges

Denticulate Ligaments:

One on each side of the cord, extending laterally between the anterior and posterior roots of spinal nerves.

Laterally, it has 21 teeth connecting the pia (on one side) to the arachnoid and dura (on the other side) to stabilize the cord within the vertebral canal.

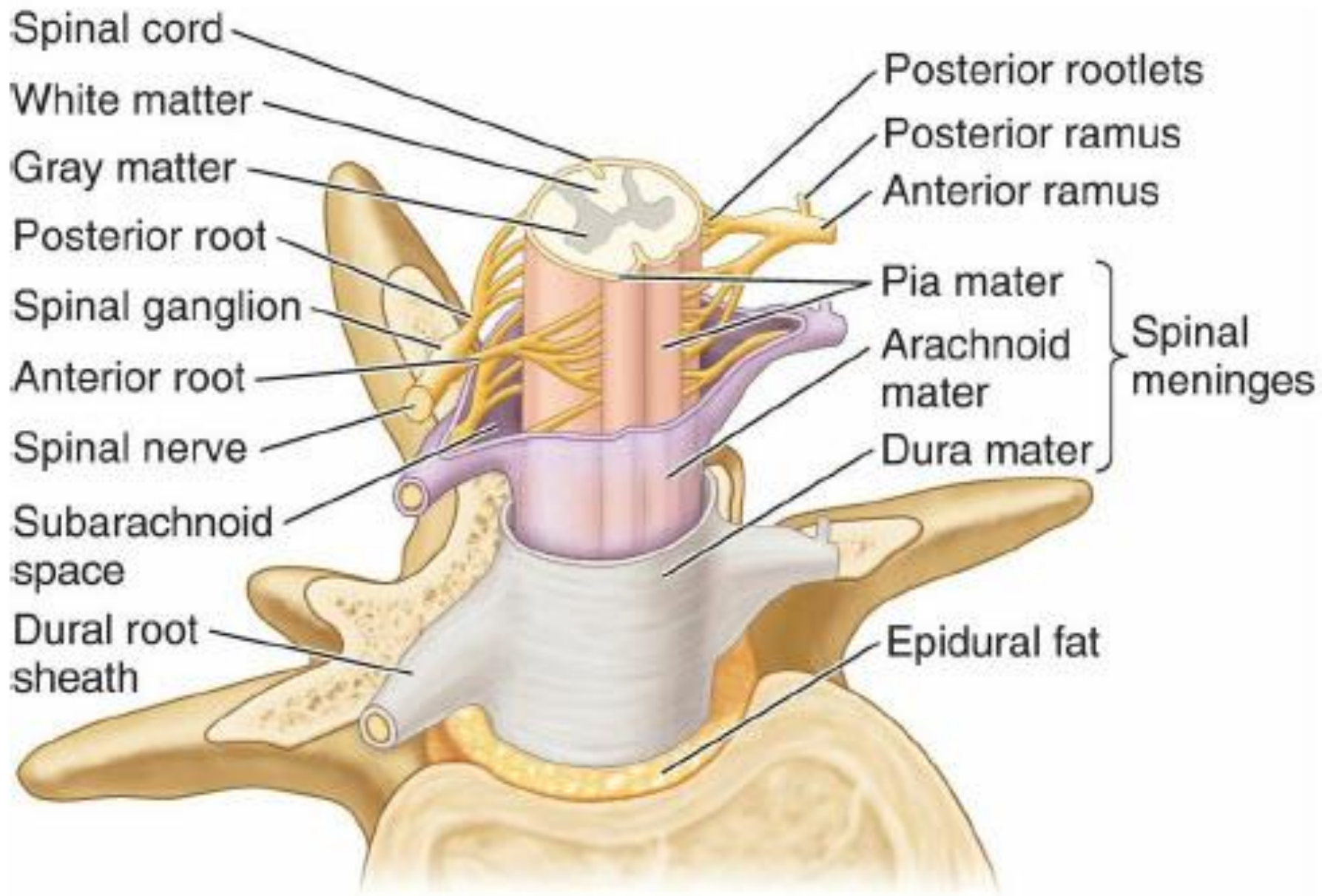




Arachnoid Mater of Spinal Cord

Continuous with the cerebral arachnoid above, it traverses the foramen magnum and descends to about the ***S2 vertebral level***

The subarachnoid space, which contains cerebrospinal fluid (C.S.F.), is a wide interval between the arachnoid and pia



Meninges

Spaces

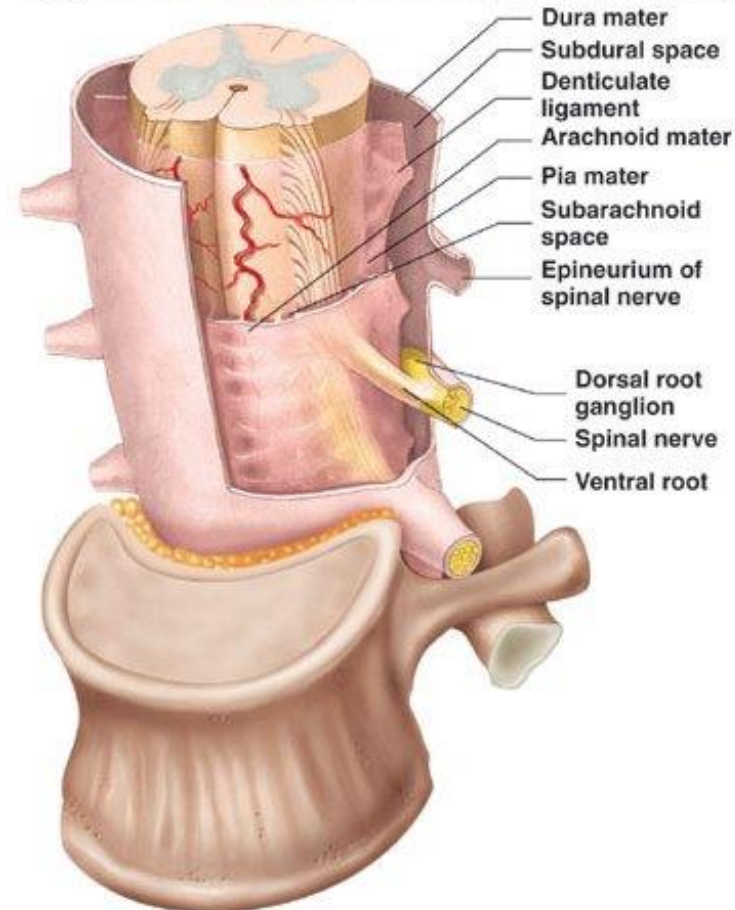
- **Epidural:** external to the dura, contains fat, small arteries, venous plexus and lymphatics

Anesthetics are injected here

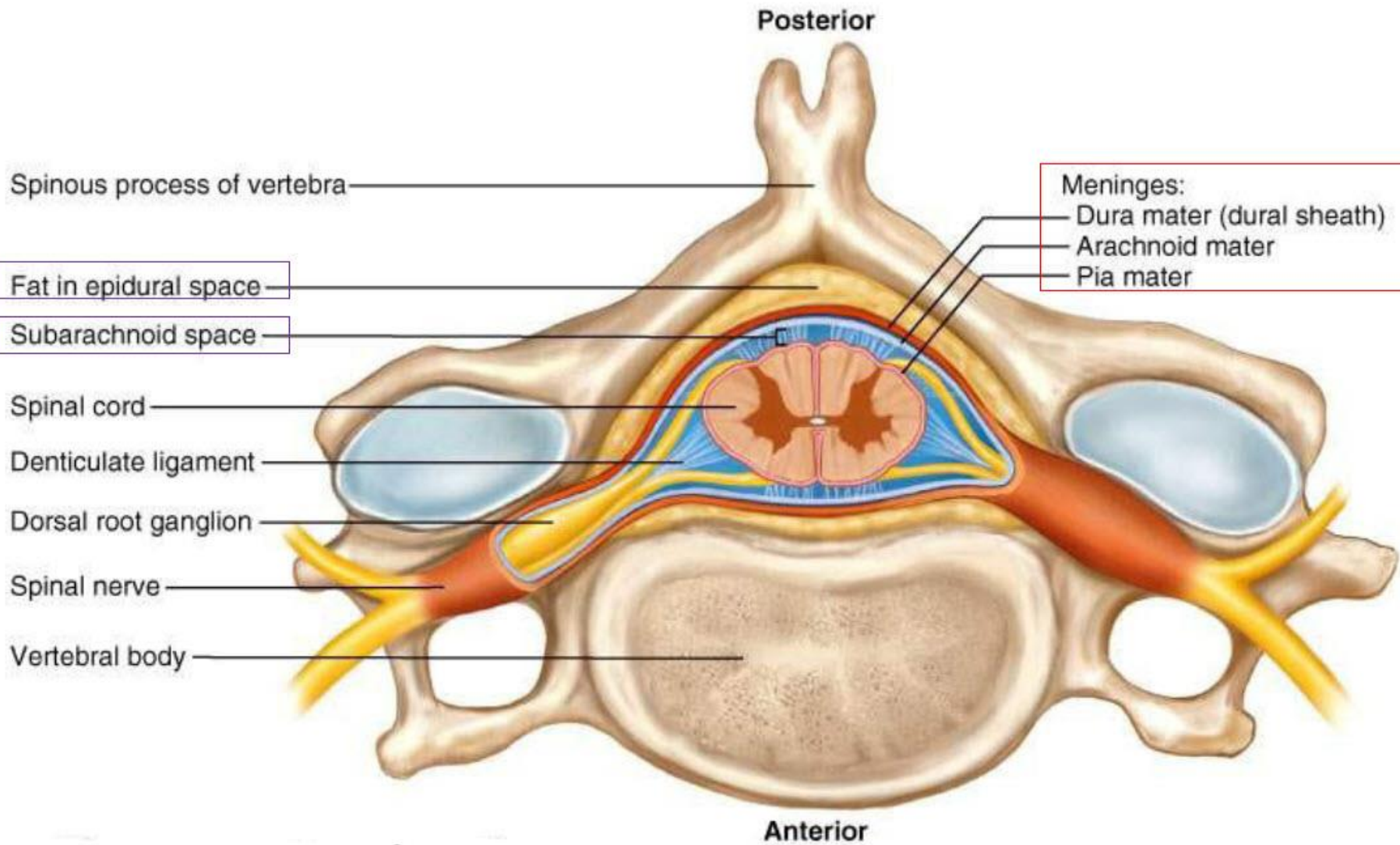
Subdural space: serous fluid

- **Subarachnoid:** between pia and arachnoid, filled with CSF along with 3 ligaments supporting the spinal cord: filum terminale, ligamentum denticulatum, subarachnoid septum

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(a) Anterolateral view



Spinous process of vertebra

Fat in epidural space

Subarachnoid space

Spinal cord

Denticulate ligament

Dorsal root ganglion

Spinal nerve

Vertebral body

Meninges:
Dura mater (dural sheath)
Arachnoid mater
Pia mater

Posterior

Anterior



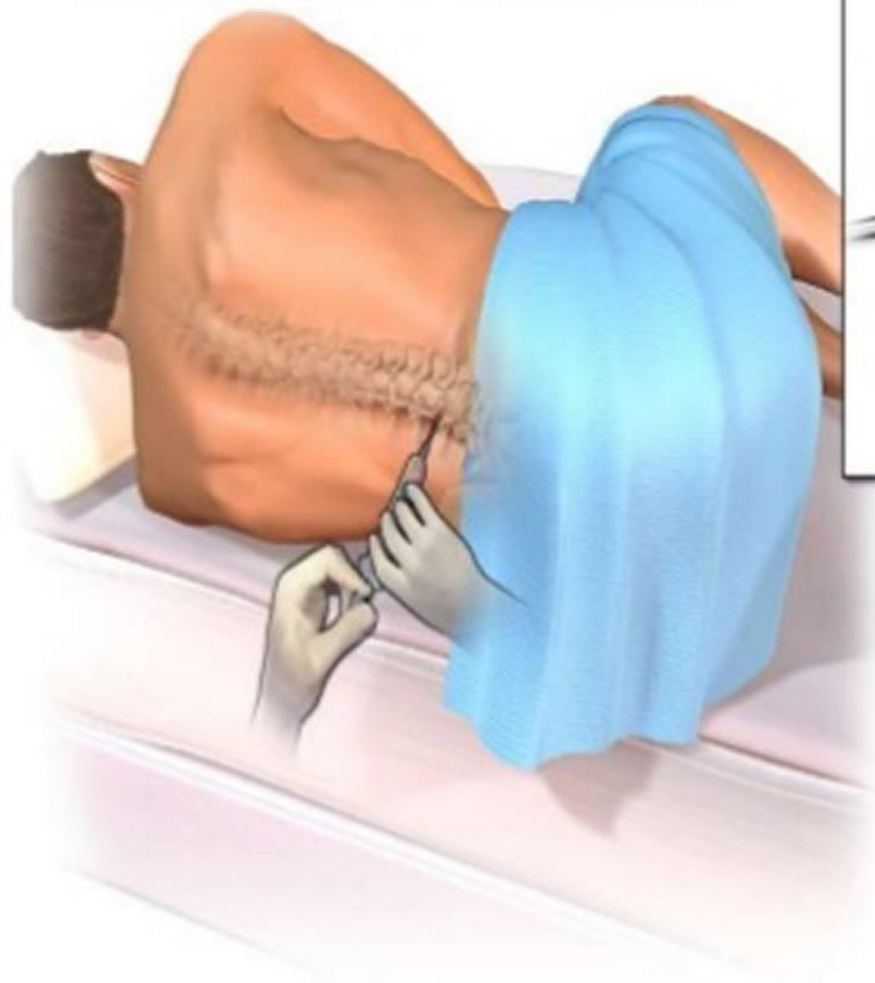
Arachnoid Mater of Spinal Cord

As the subarachnoid space continues to S2, access can be gained to the C.S.F. by inserting a needle between the vertebral lamina (***lumbar puncture***)

By this means, the ***pressure of C.S.F.*** can be ***measured***, the ***fluid*** can be ***analyzed***, a spinal ***anesthetic*** can be ***introduced***, or ***fluid*** can be ***replaced*** by a ***contrast medium*** for radiography (myelography) (***i.e: diagnostic or therapeutic purposes***)

Patient Position

Lumbar Puncture



Lying Position



Sitting Position

Ligamentum flavum

Skin

Supraspinous ligament

Interspinous ligament

Epidural space

Lumbar spinal puncture for spinal anesthesia

Lumbar injection for epidural anesthesia

Sacrum

Filum terminale externum

Sacral hiatus

Subarachnoid space

Conus medullaris

L2

CSF in lumbar cistern

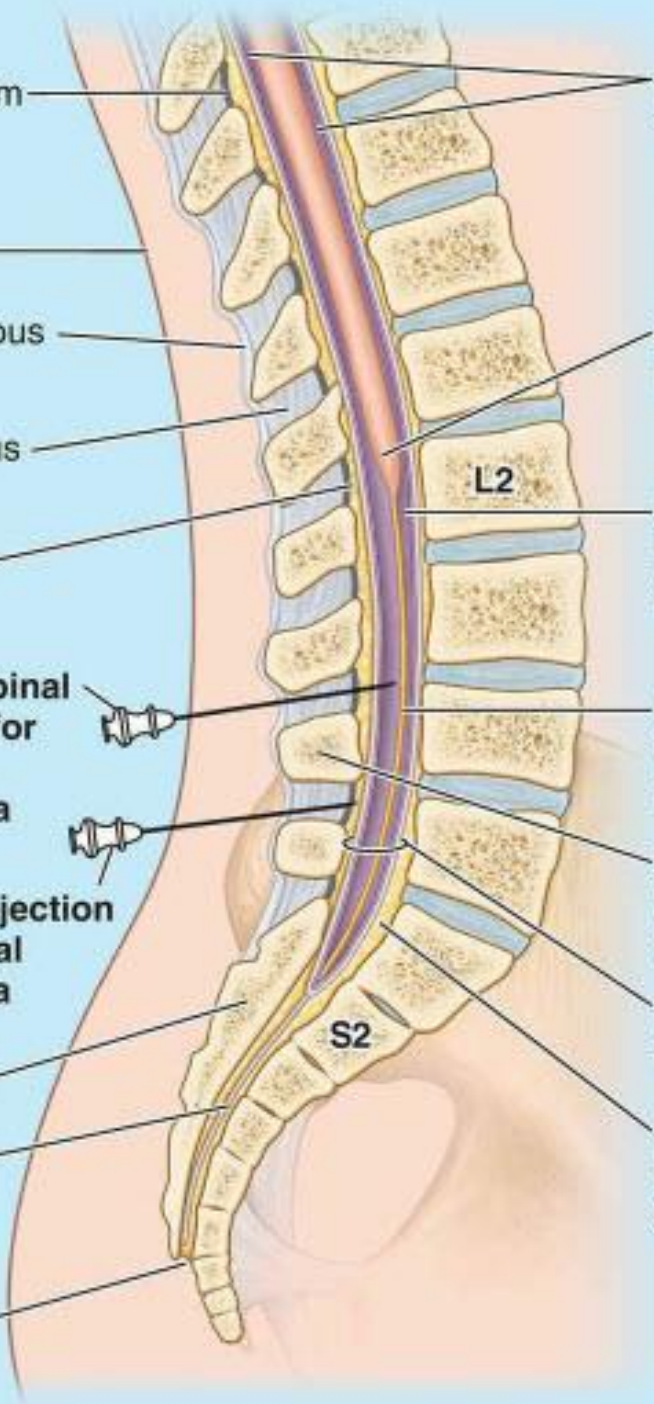
Filum terminale internum

Spinous process of L4

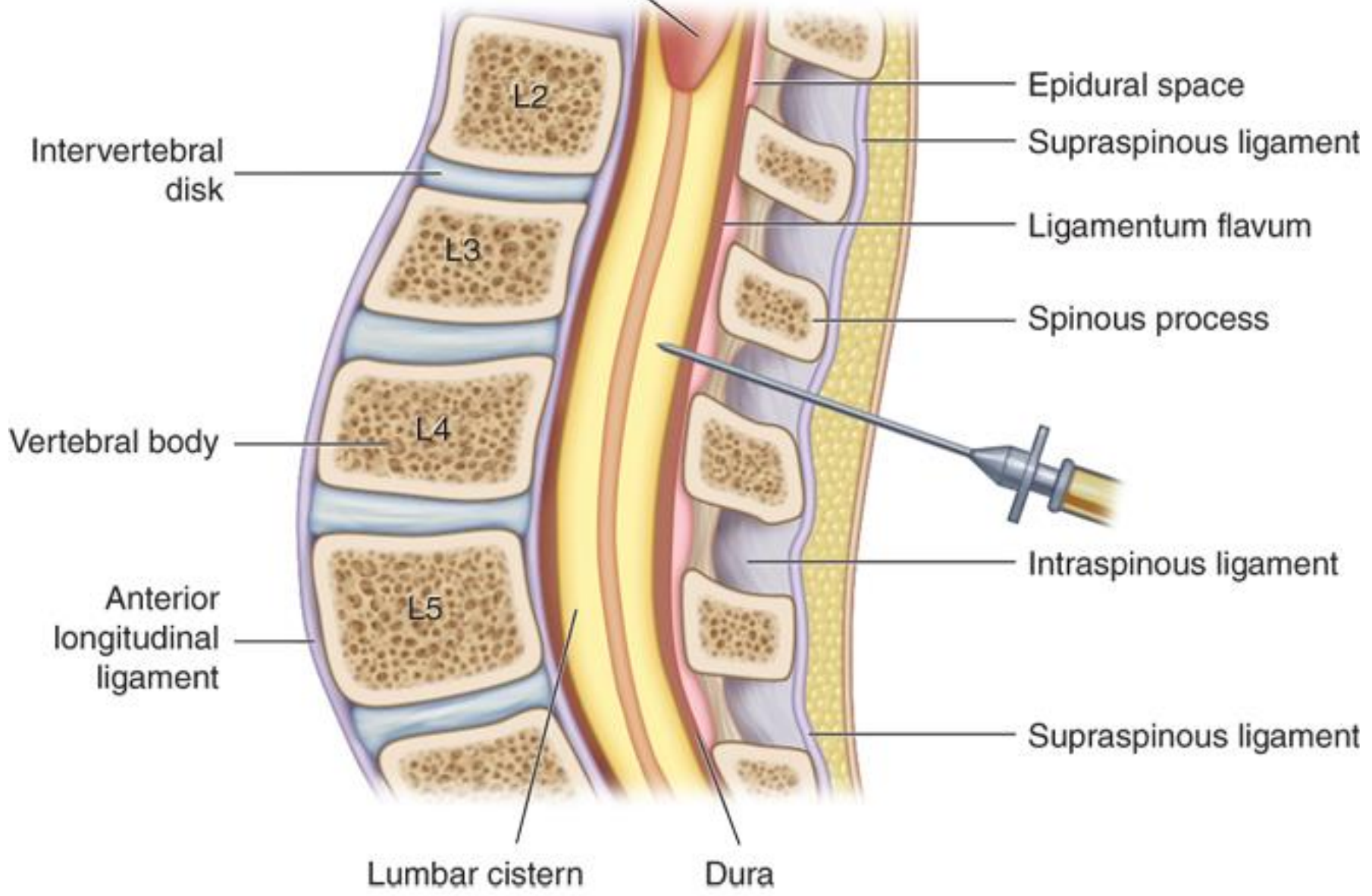
Spinal dural sac

Epidural space in sacral canal

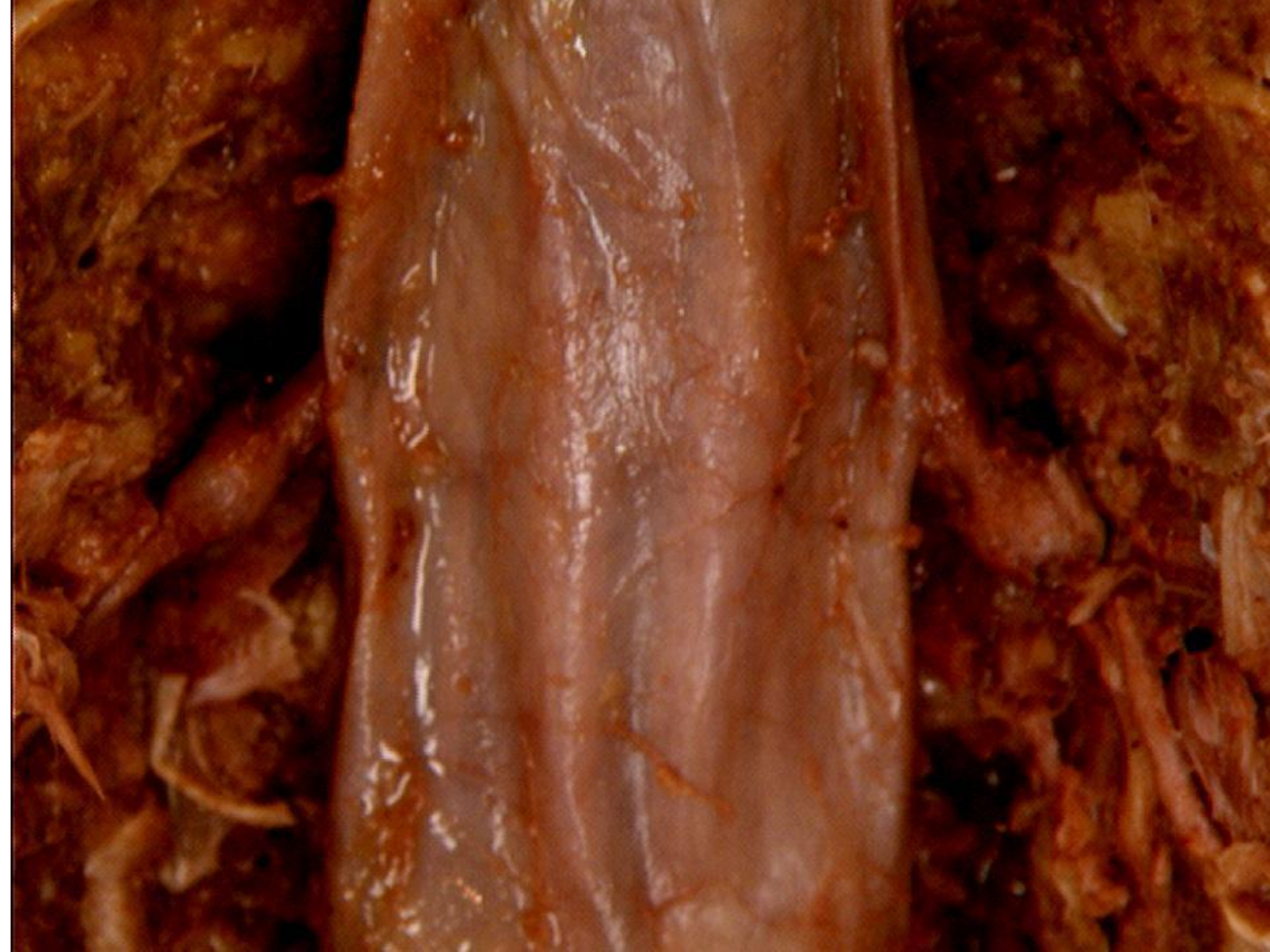
S2

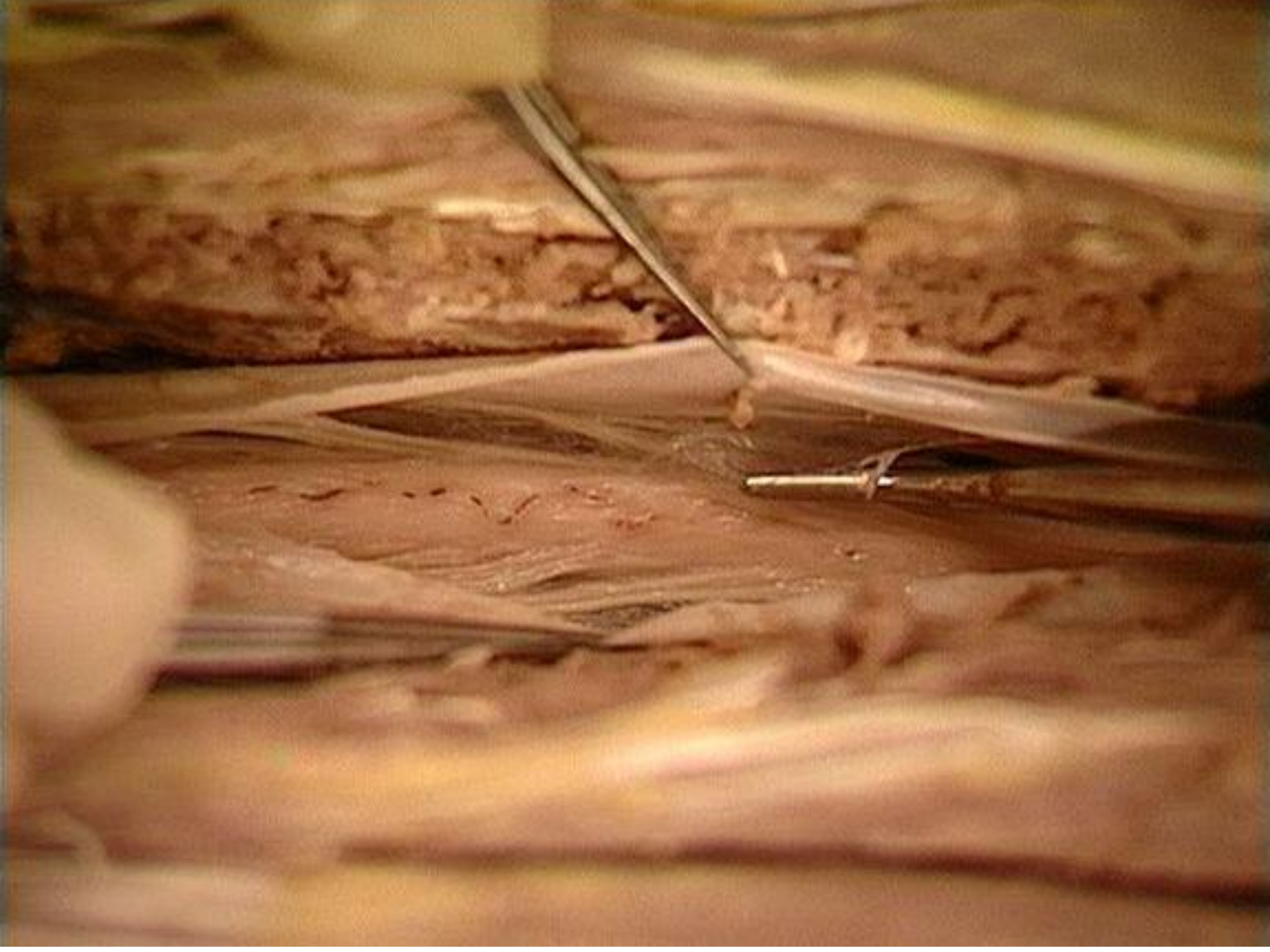


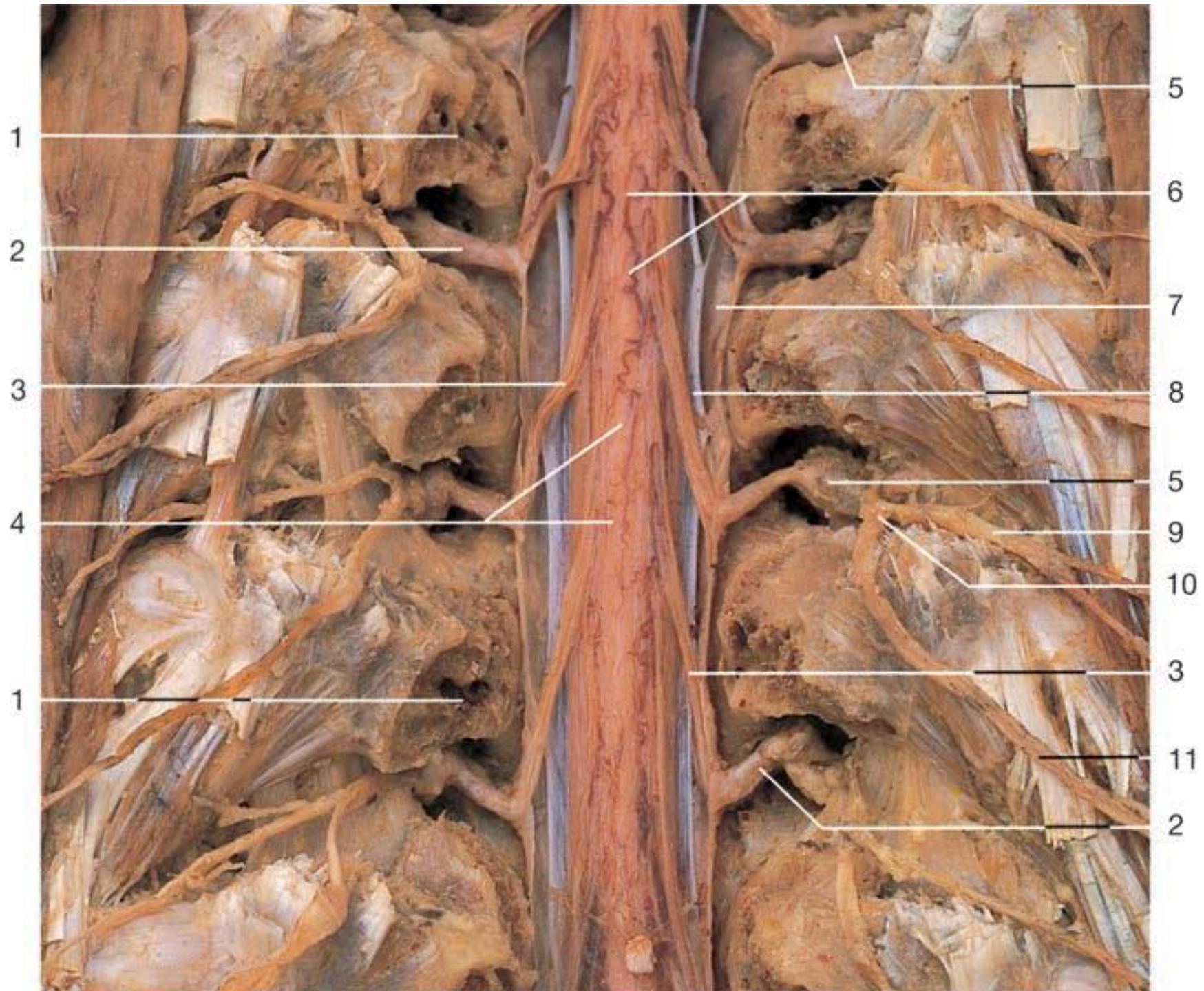
Spinal cord

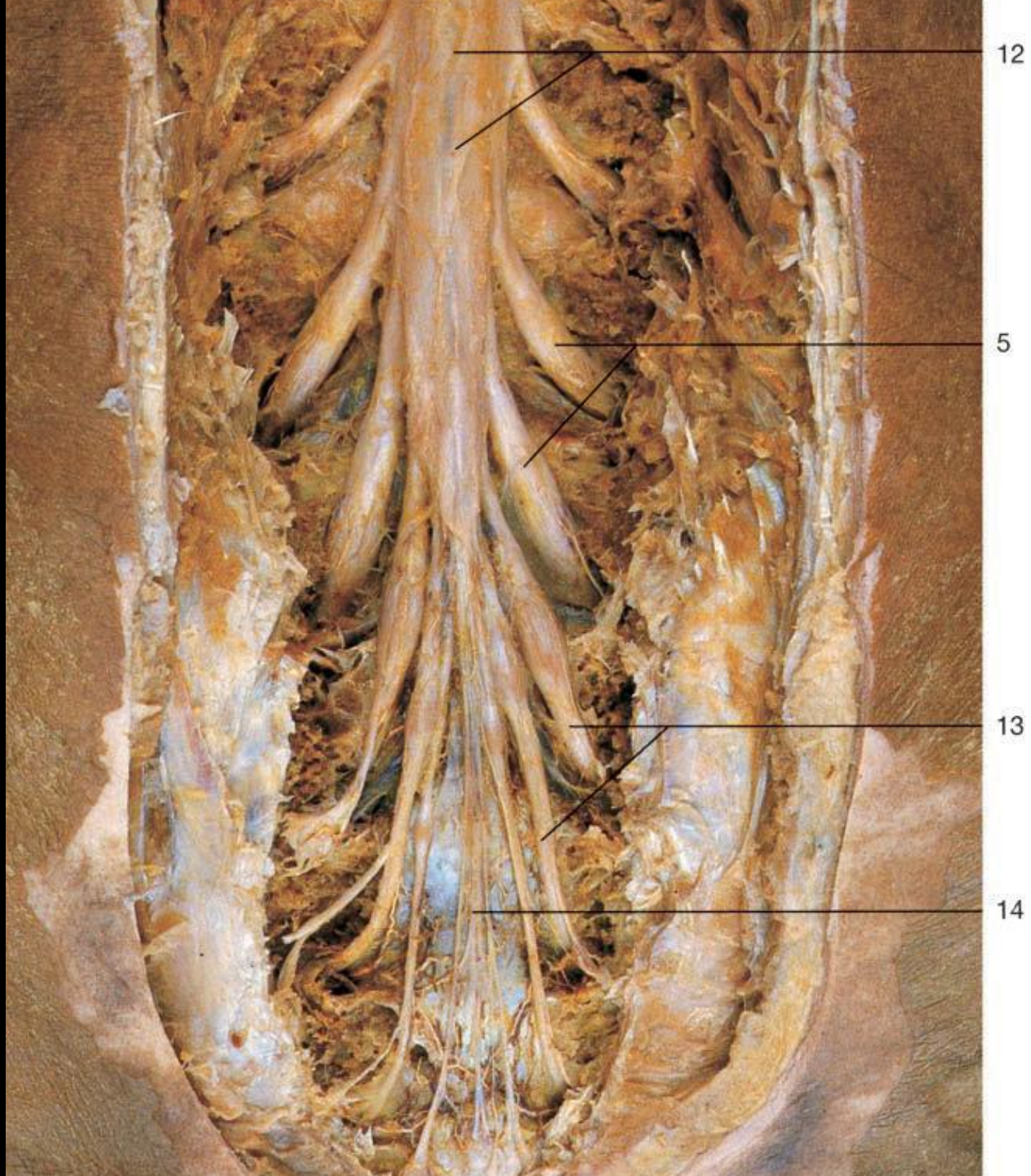


Source: John M. Oropello, Stephen M. Pastores, Vladimir Kvetan: Critical Care
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12

5

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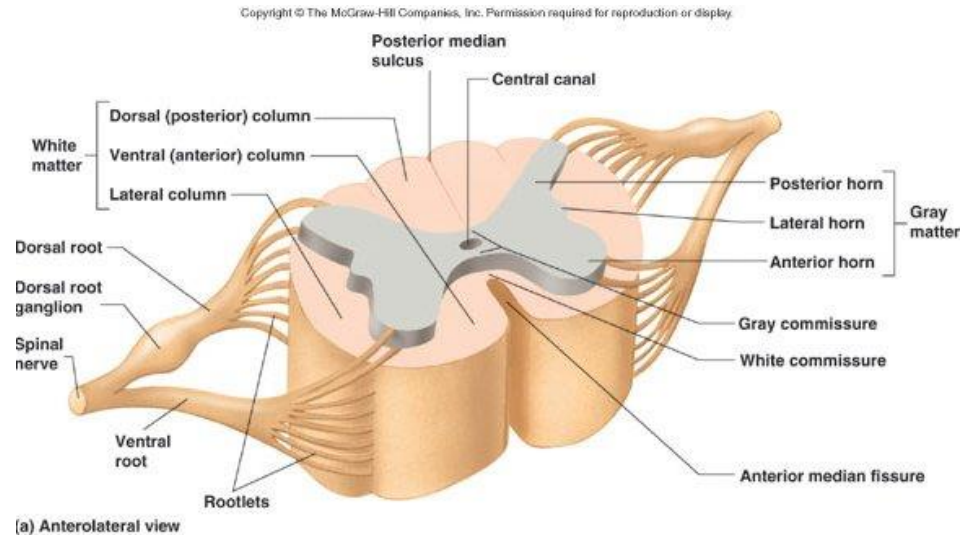
Cross Section of Spinal Cord

- **Anterior median fissure and posterior median sulcus**

- Deep clefts partially separating left and right halves

- **Gray matter: neuron cell bodies, dendrites, axons**

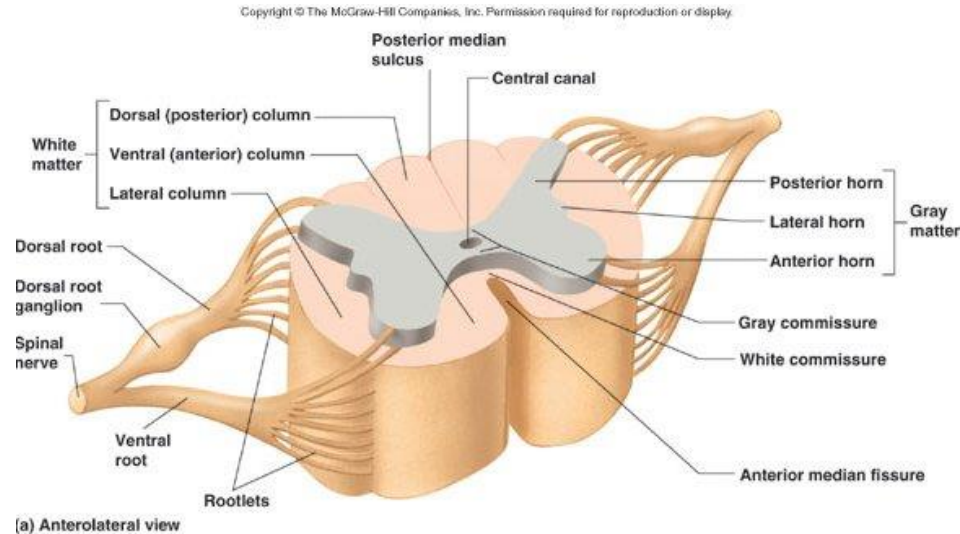
- Divided into *horns*
 - Posterior (dorsal) horn
 - Anterior (ventral) horn
 - ± Lateral horn (autonomic at T1-T12)



Cross Section of Spinal Cord

■ **White matter**

- Myelinated axons
- Divided into three *columns* (funiculi)
 - **Ventral**
 - **Dorsal**
 - **Lateral**
- Each of these divided into sensory or motor tracts





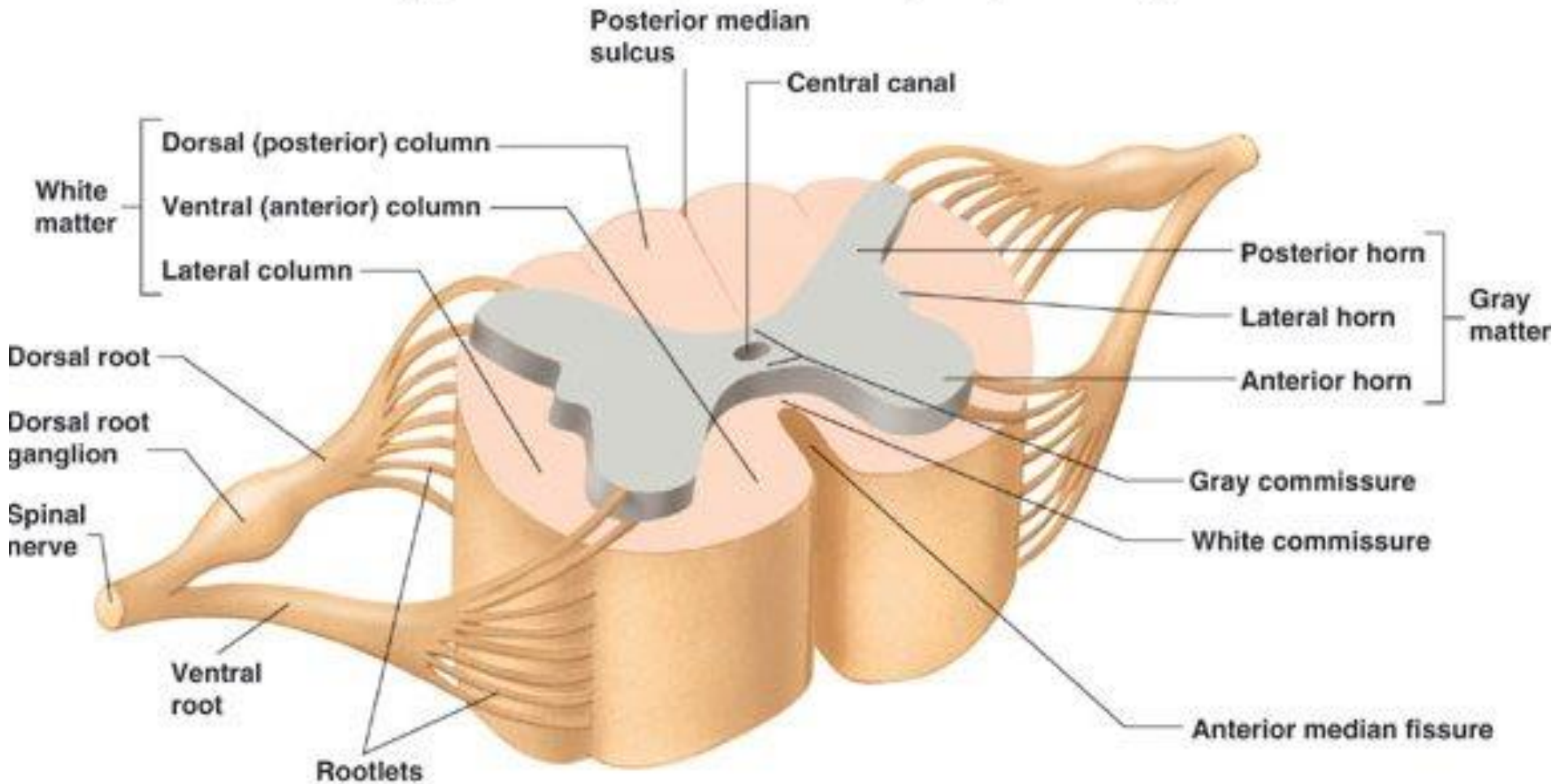
Cross Section of Spinal Cord

- Its center contains a narrow **central canal** extending throughout the length of spinal cord.
- The cord is divided into **right** and **left halves** by an **anterior median sulcus** and **a posterior median septum**.

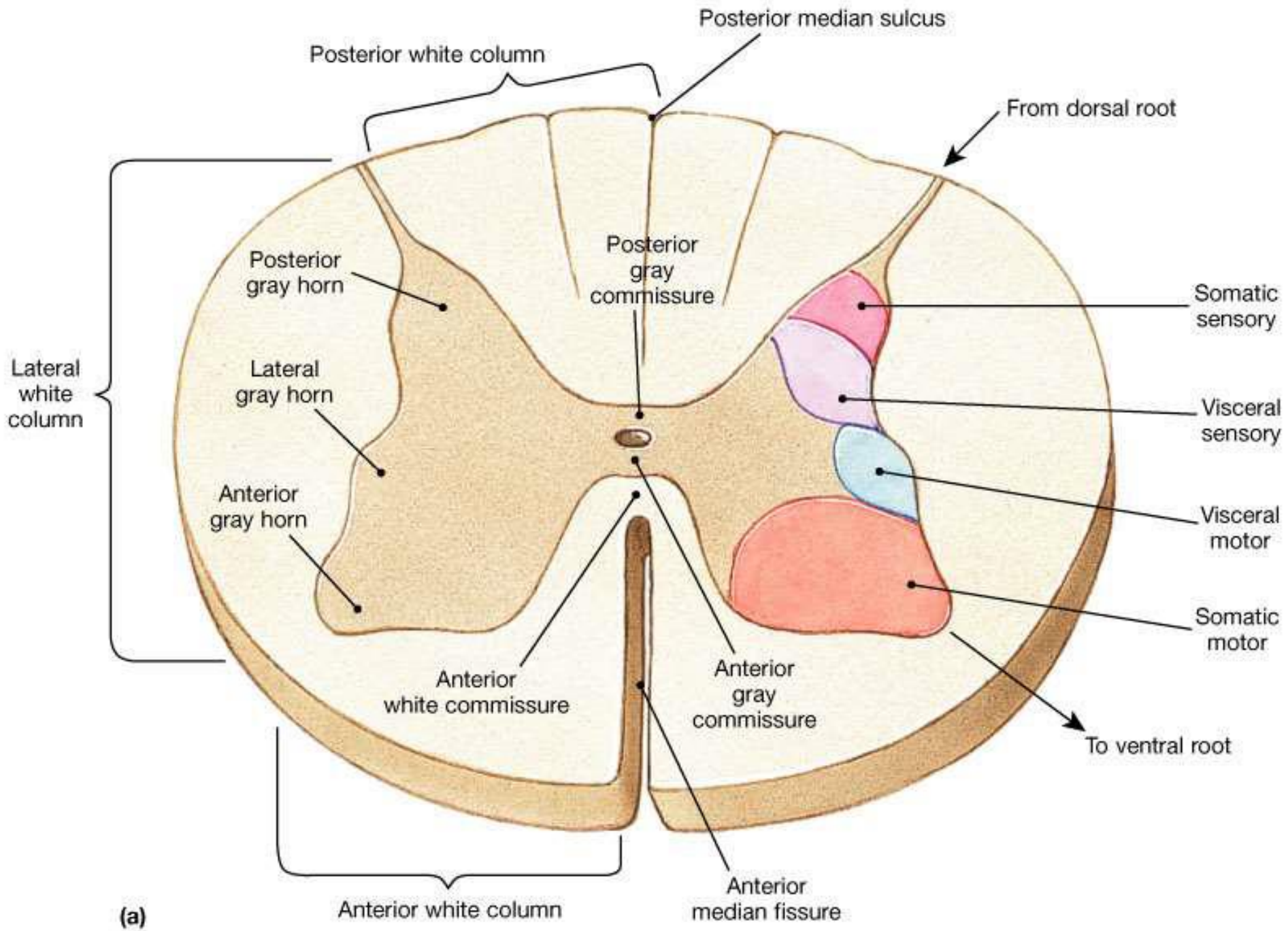
The two halves are connected by 3 commissures:

1. **White commissure:** behind the anterior median sulcus.
2. **Anterior grey commissure:** in front of the central canal.
3. **Posterior grey commissure:** behind the central canal.

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(a) Anterolateral view



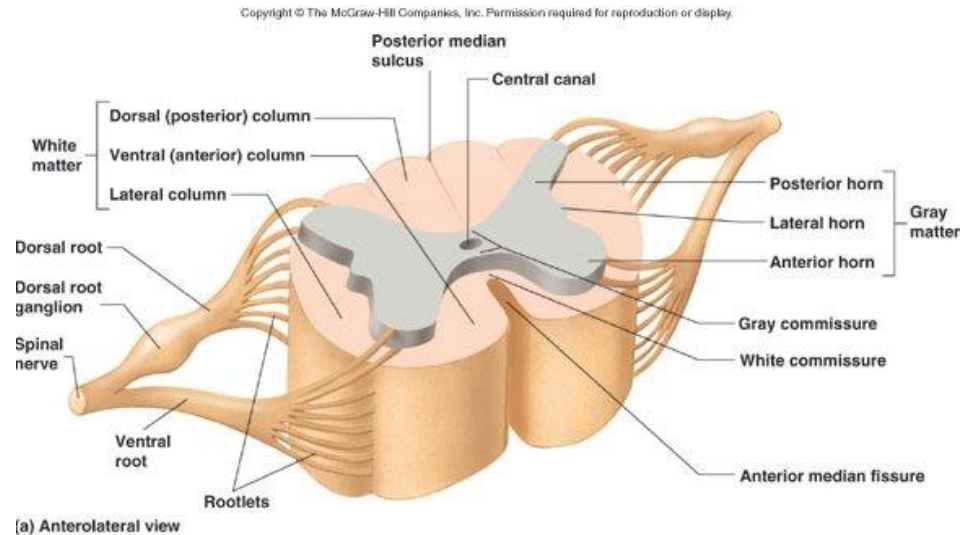
(a)

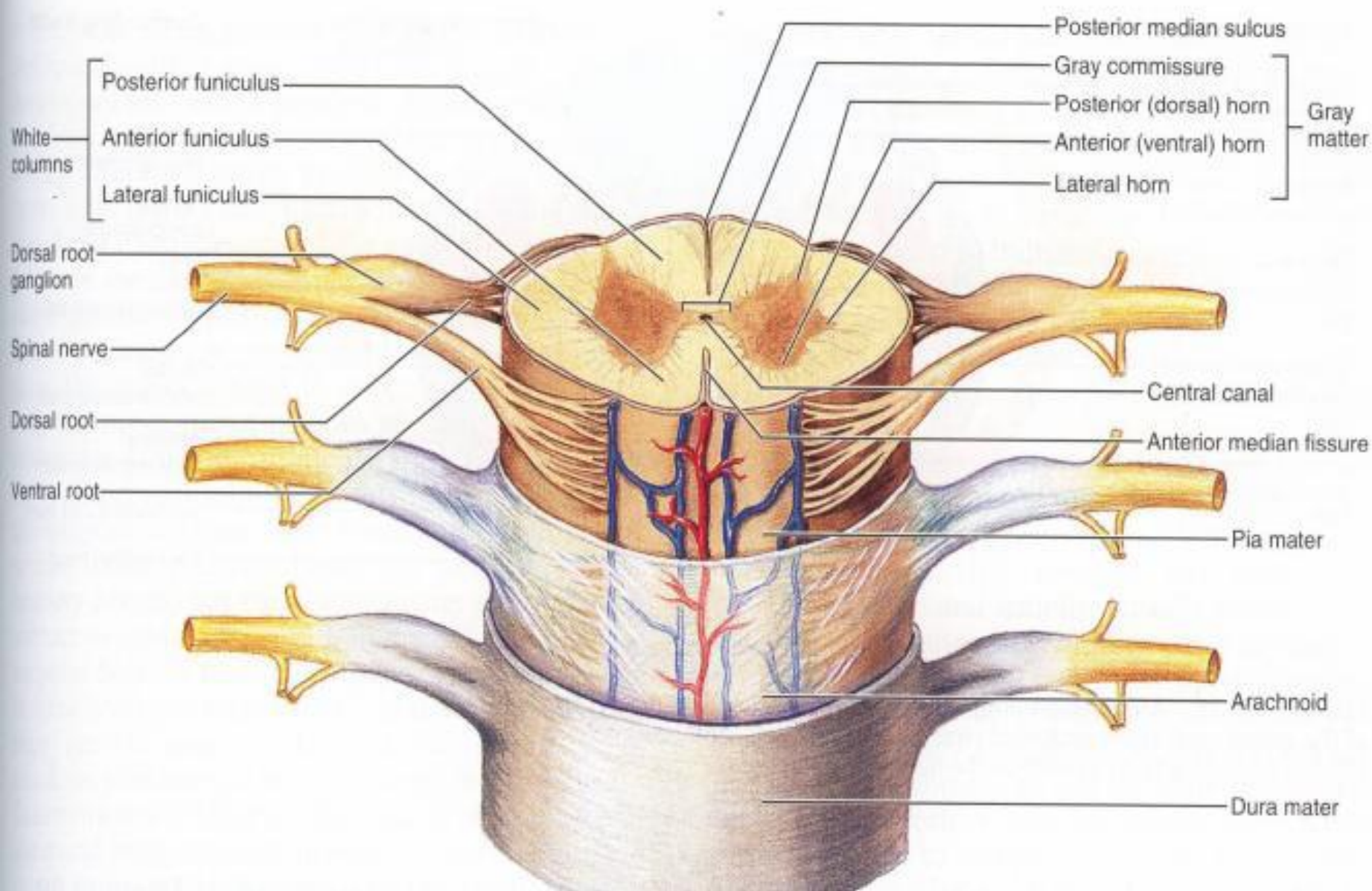
Cross Section of Spinal Cord

Roots

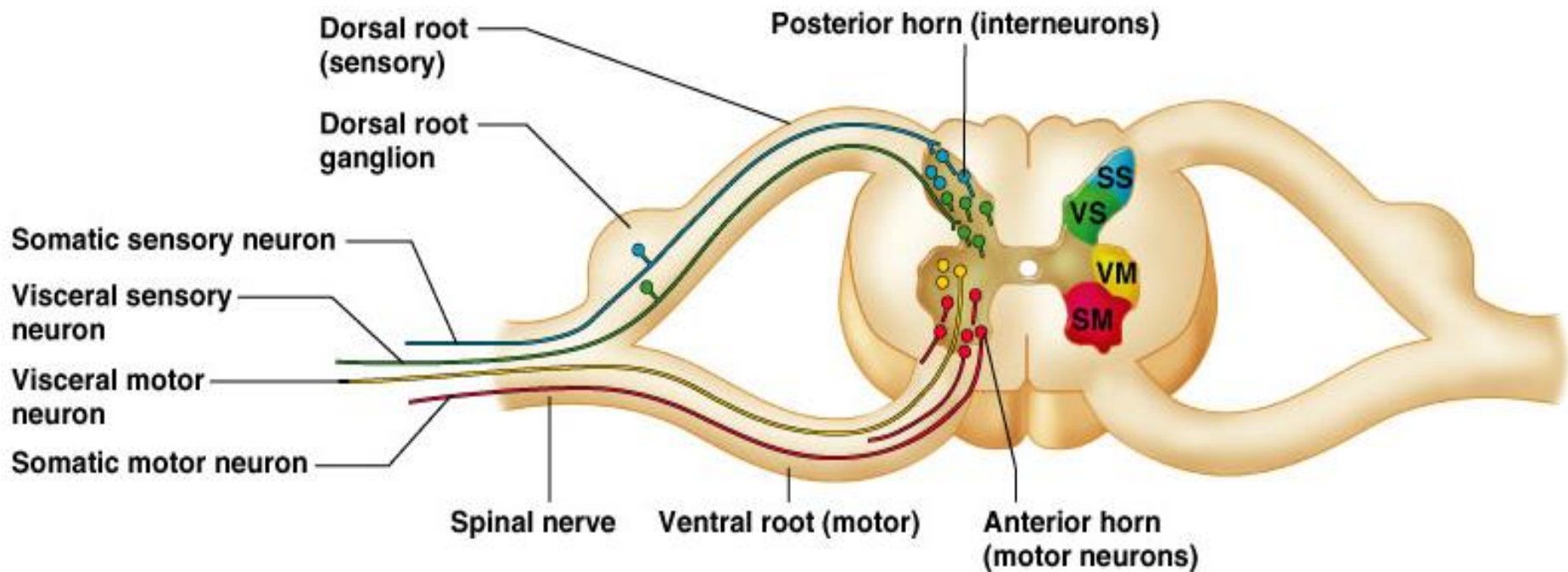
Spinal nerves arise as rootlets then combine to form dorsal and ventral roots

Dorsal (Sensory) and *Ventral (Motor, ±autonomic)* roots merge laterally and form the spinal nerve





Reflex Arc





Nuclei of Grey Matter of Spinal Cord

- **In Dorsal Horn: Nuclei are mainly sensory.**
 1. ***Substantia Gelatinosa of Rolandi:*** Present at tip of dorsal horn in all segments of spinal cord.
Function: relays pain and temperature.
 2. ***Nucleus Proprius:*** Present anterior to Substantia Gelatinosa in all segments of spinal cord.
Function: relays light touch, as well as pain and temperature.



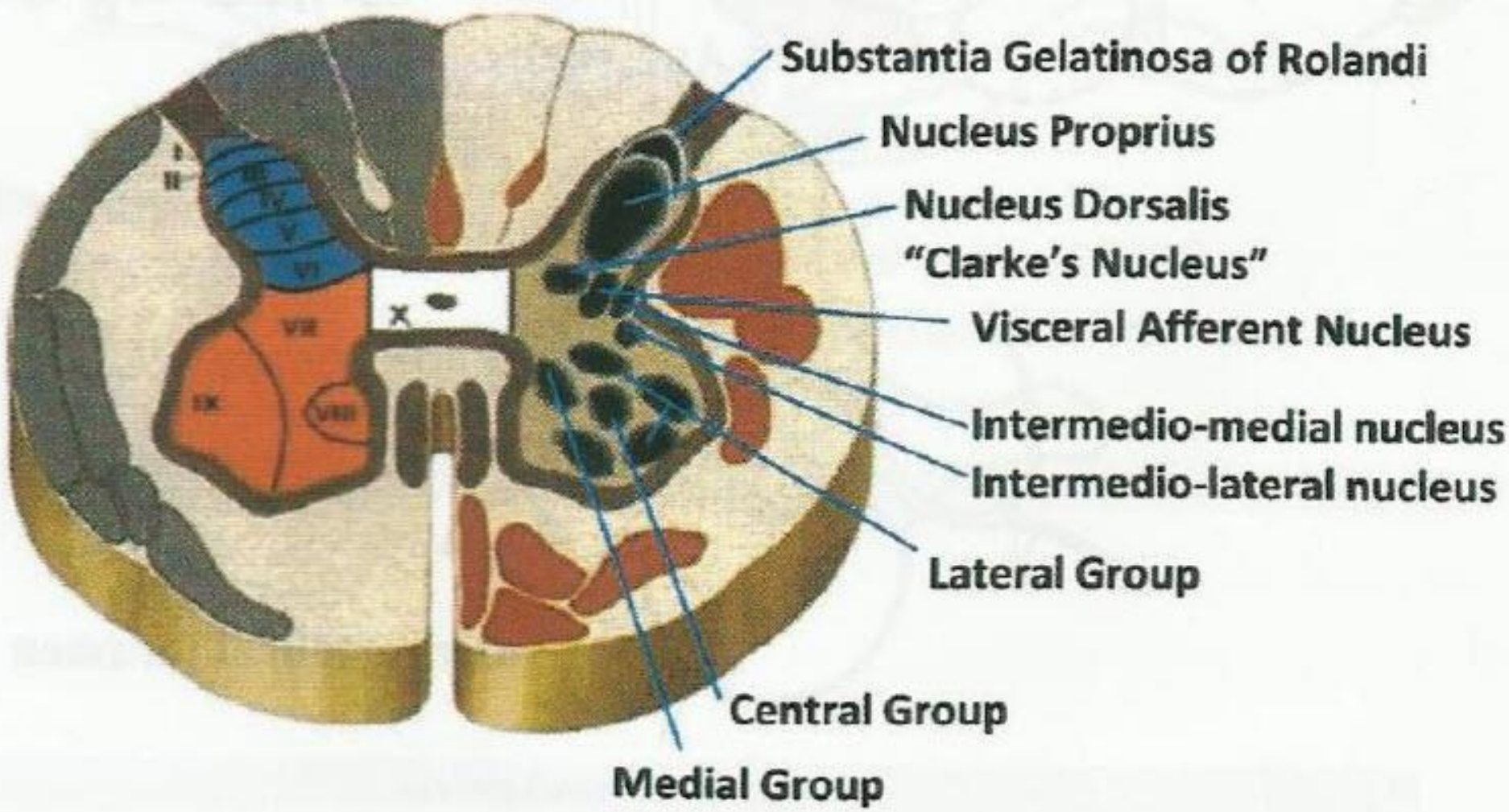
Nuclei of Grey Matter of Spinal Cord

3. ***Nucleus Dorsalis of Clarke:*** Present at the base of dorsal horn in C8 to L3 segments of the spinal cord.

Function: relays **unconscious proprioception** to the cerebellum.

4. ***Visceral Afferent Nucleus:*** Present in C8 to L3 segments of the spinal cord lies lateral to Clarke's Nucleus.

Function: relays **visceral sensations**





Nuclei of Grey Matter of Spinal Cord

In ventral Horn: Nuclei are mainly **motor** and arranged in three groups.

Medial Group: present throughout the whole length of the spinal cord and supply **trunk muscles..**

Central Group: present only in some cervical segments e.g. Phrenic Nucleus C3,4,5 (supply **diaphragm**) and spinal accessory nucleus C1-5 (supply **trapezius** and **sternocleidomastoid**).



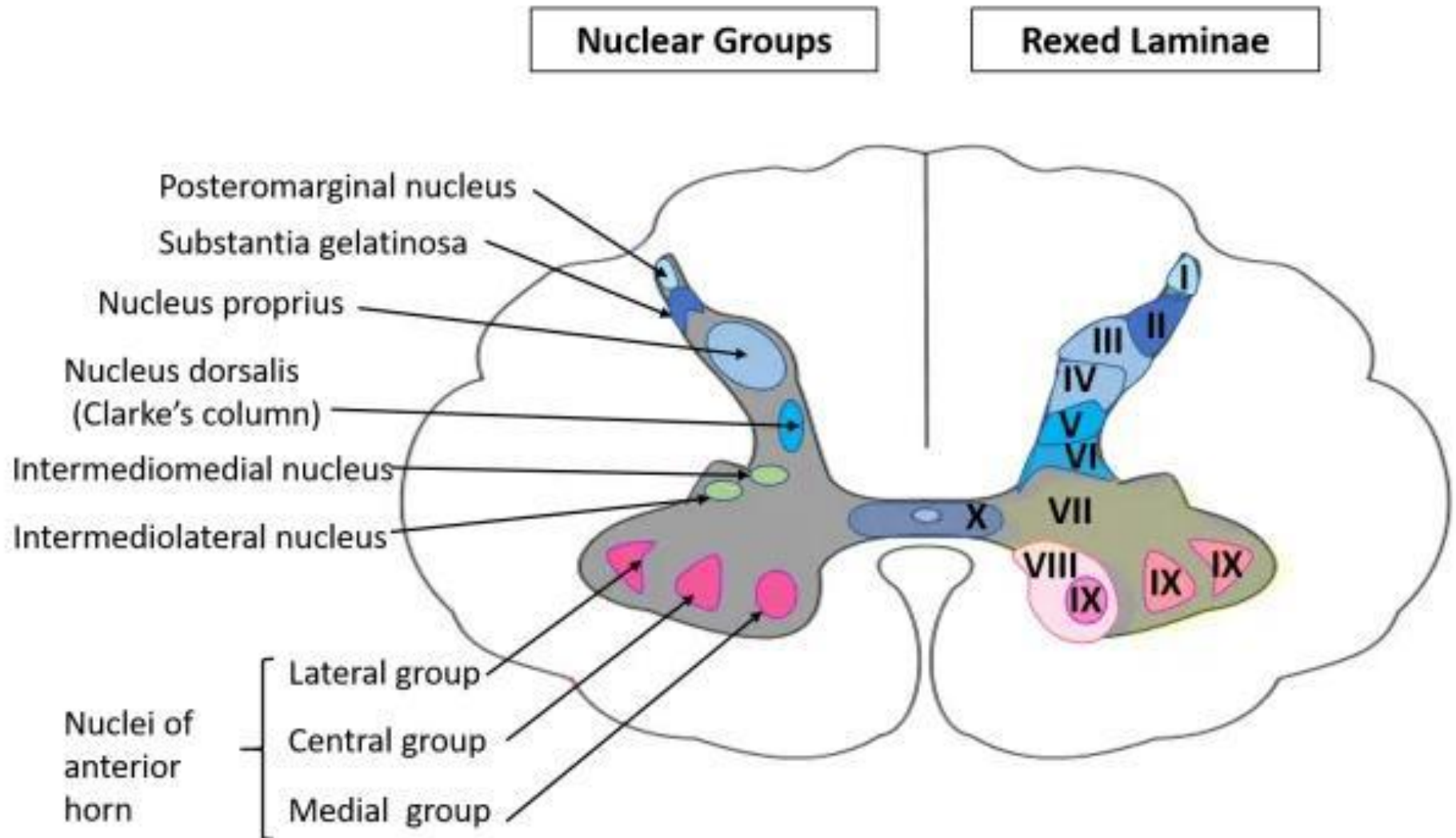
Nuclei of Grey Matter of Spinal Cord

Lateral Group: present in cervical and lumbosacral segments and supply ***limb muscles.***

The motor neurons are either:

- 1. Alpha-motor neurons:*** Large, their axons supply skeletal muscle fibers (excitatory).
- 2. Gamma-motor neurons:*** Small, their axons supply the muscle spindles (sensory receptors).

Recent studies (Rexed (1950s) have divided Gray matter into 10 laminae





Blood Supply to Spinal Cord

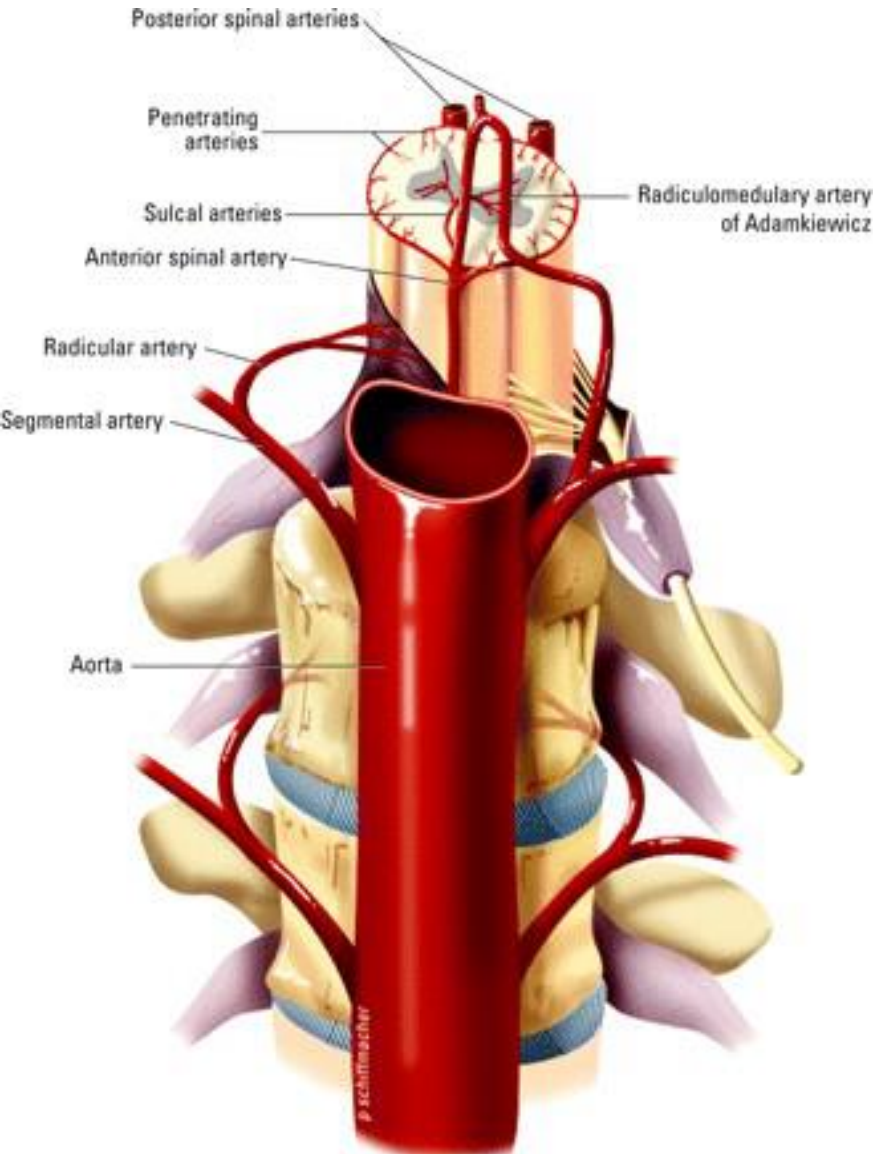
- The spinal cord is supplied with blood by three arteries that run along its length starting in the brain, and many arteries that approach it through the sides of the spinal column
- The three longitudinal arteries are called the **anterior spinal artery, and the right and left posterior spinal arteries**



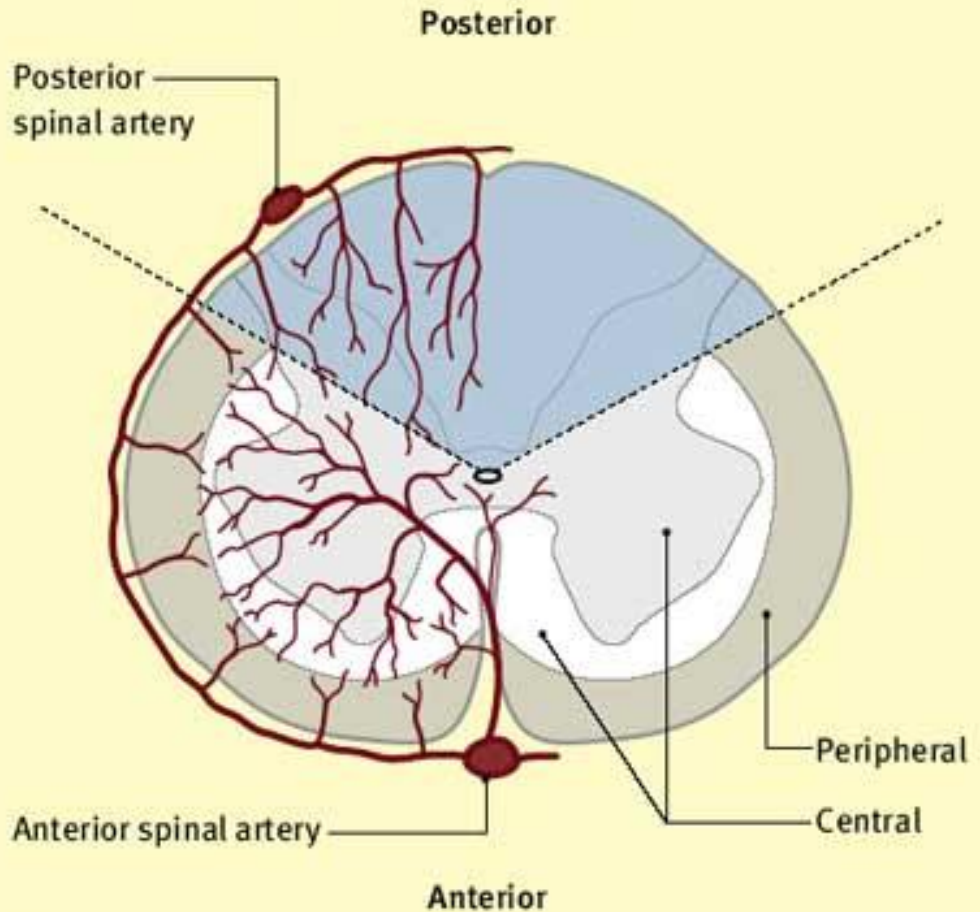
Blood Supply to Spinal Cord

- These travel in the **subarachnoid space** and send branches into the spinal cord
- They form anastomoses via the **anterior and posterior segmental arteries**, which enter the spinal cord at various points along its length
- Supply blood up to **cervical segments**

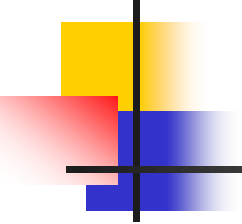
Blood Supply to Spinal Cord



Blood supply to the spinal cord: horizontal distribution

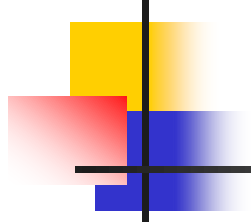


The central area supplied only by the anterior spinal artery is predominantly a motor area

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- For further inquiries **PLZ** feel free to contact at any time through email

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Thank You