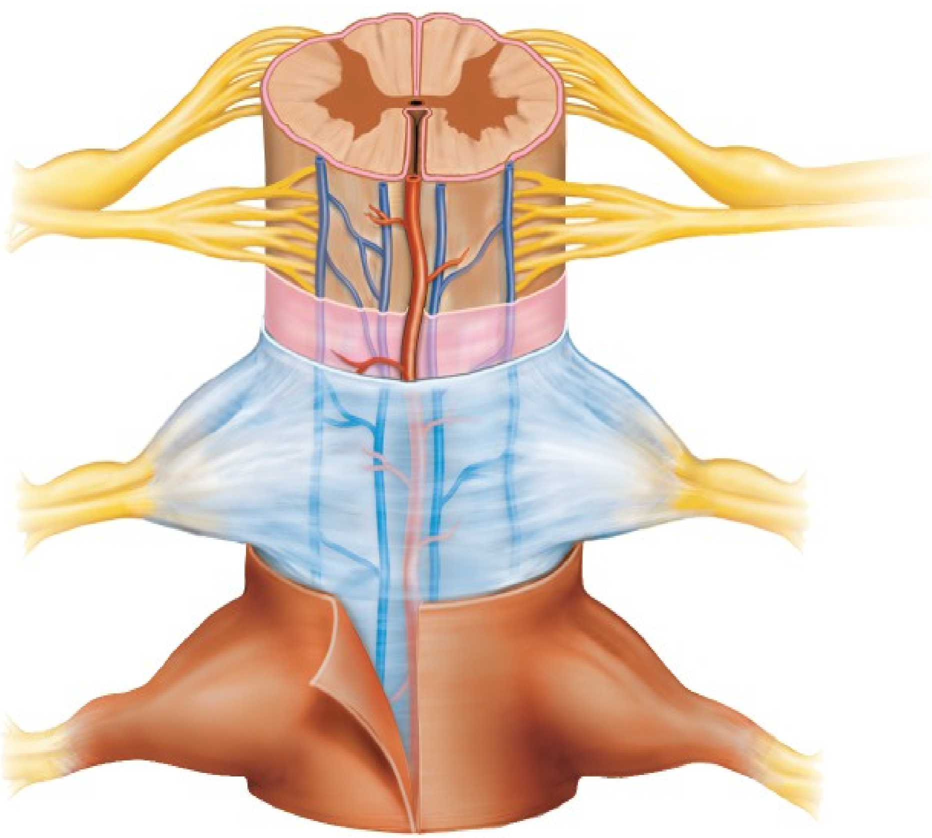
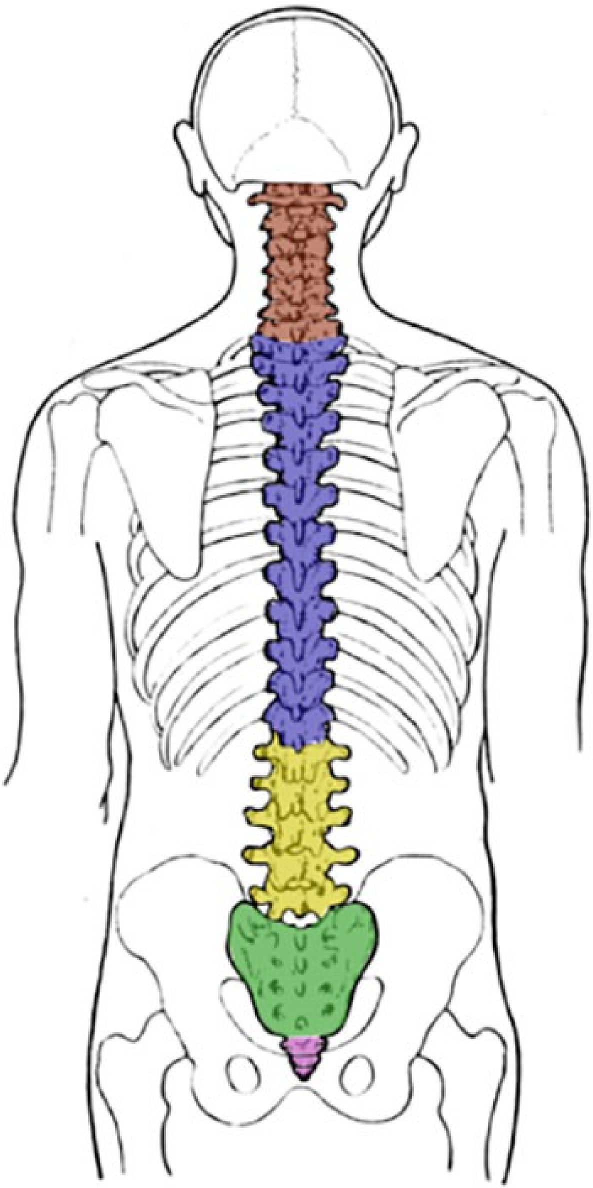
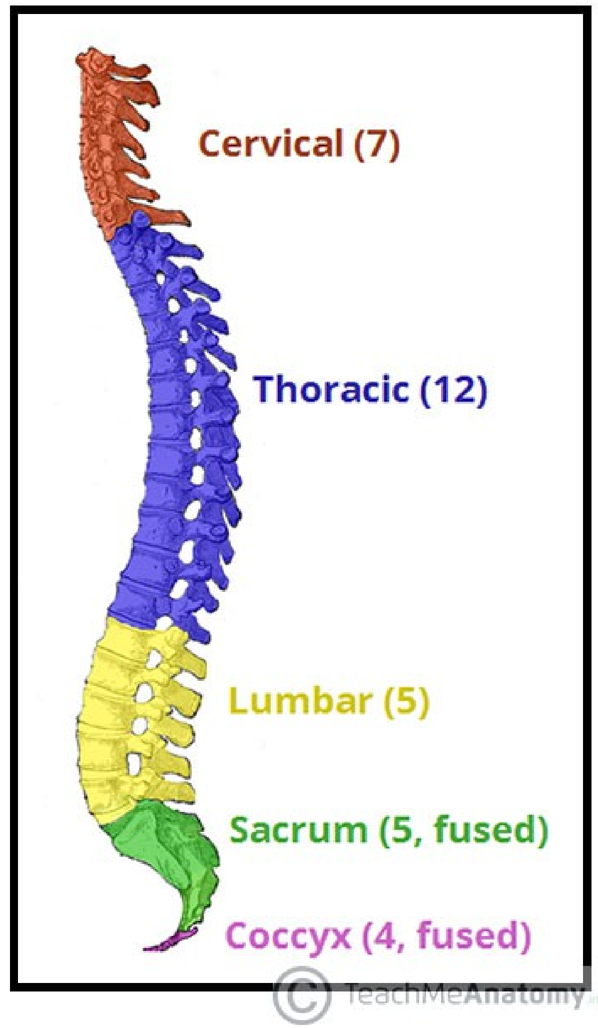
Chapter 13

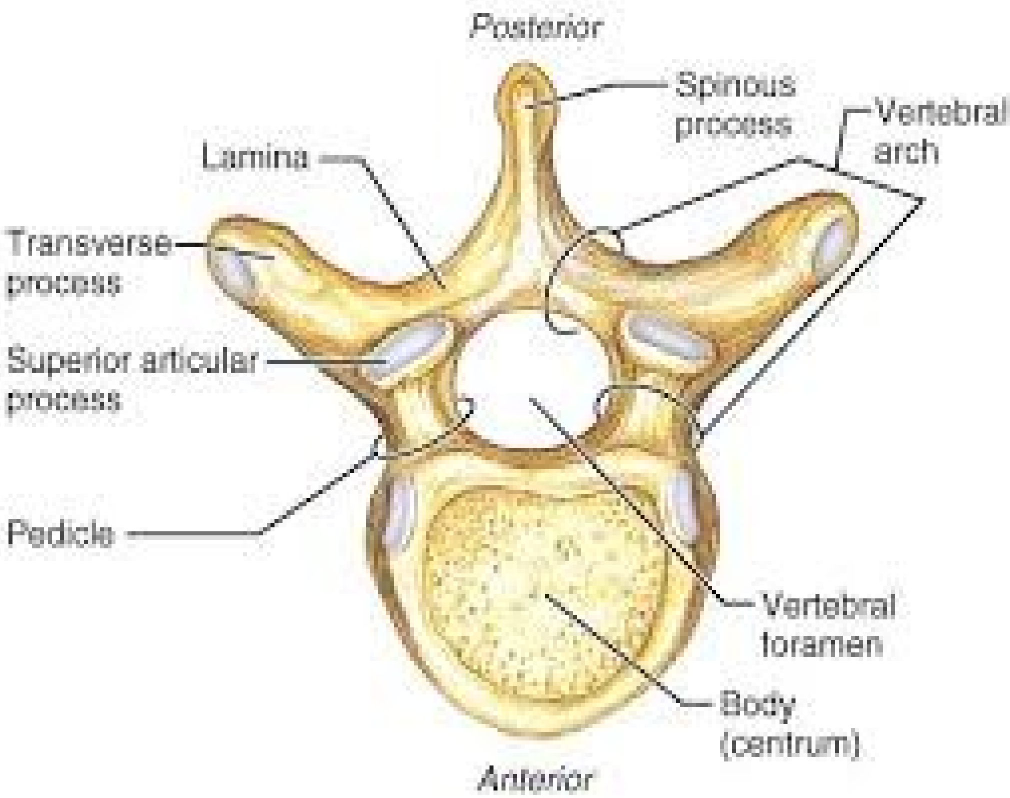
The Spinal Cord



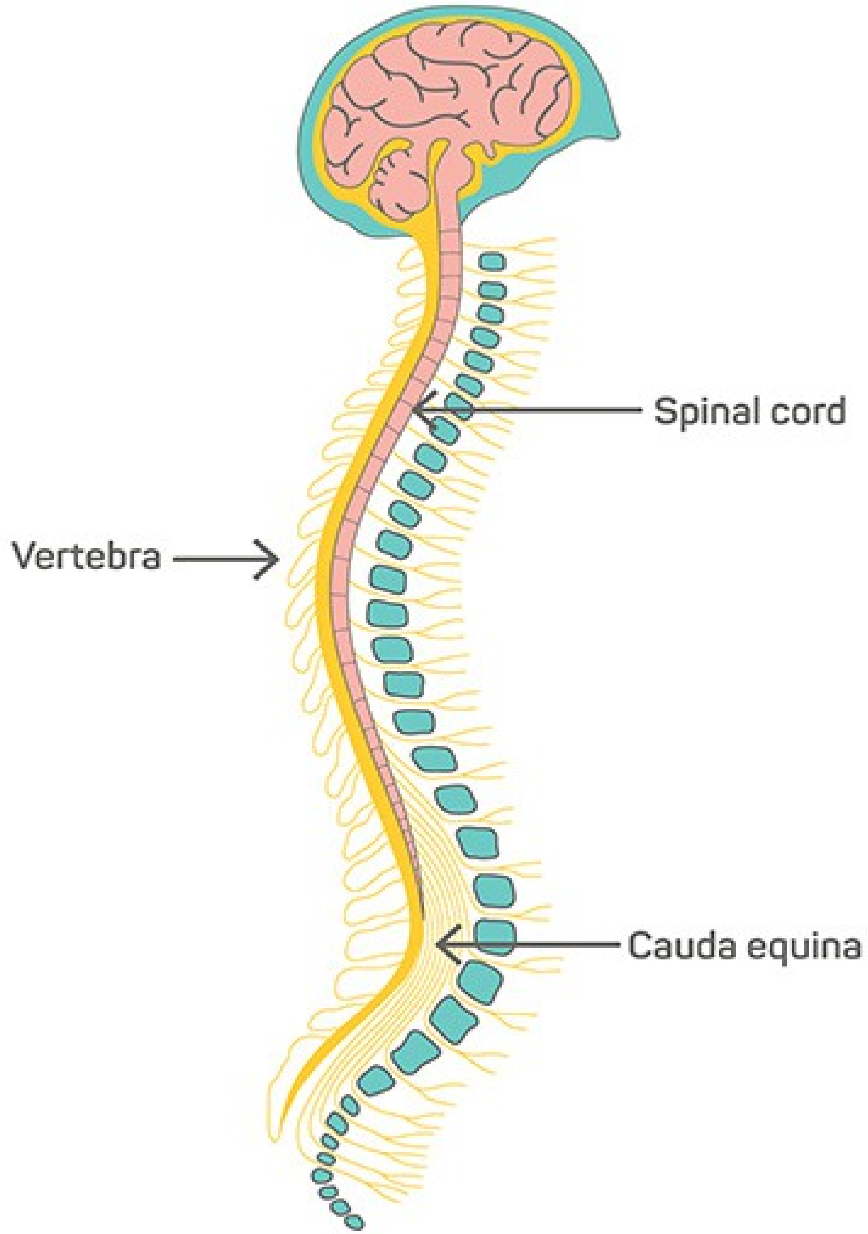
Lab Spinal Cord Orientation



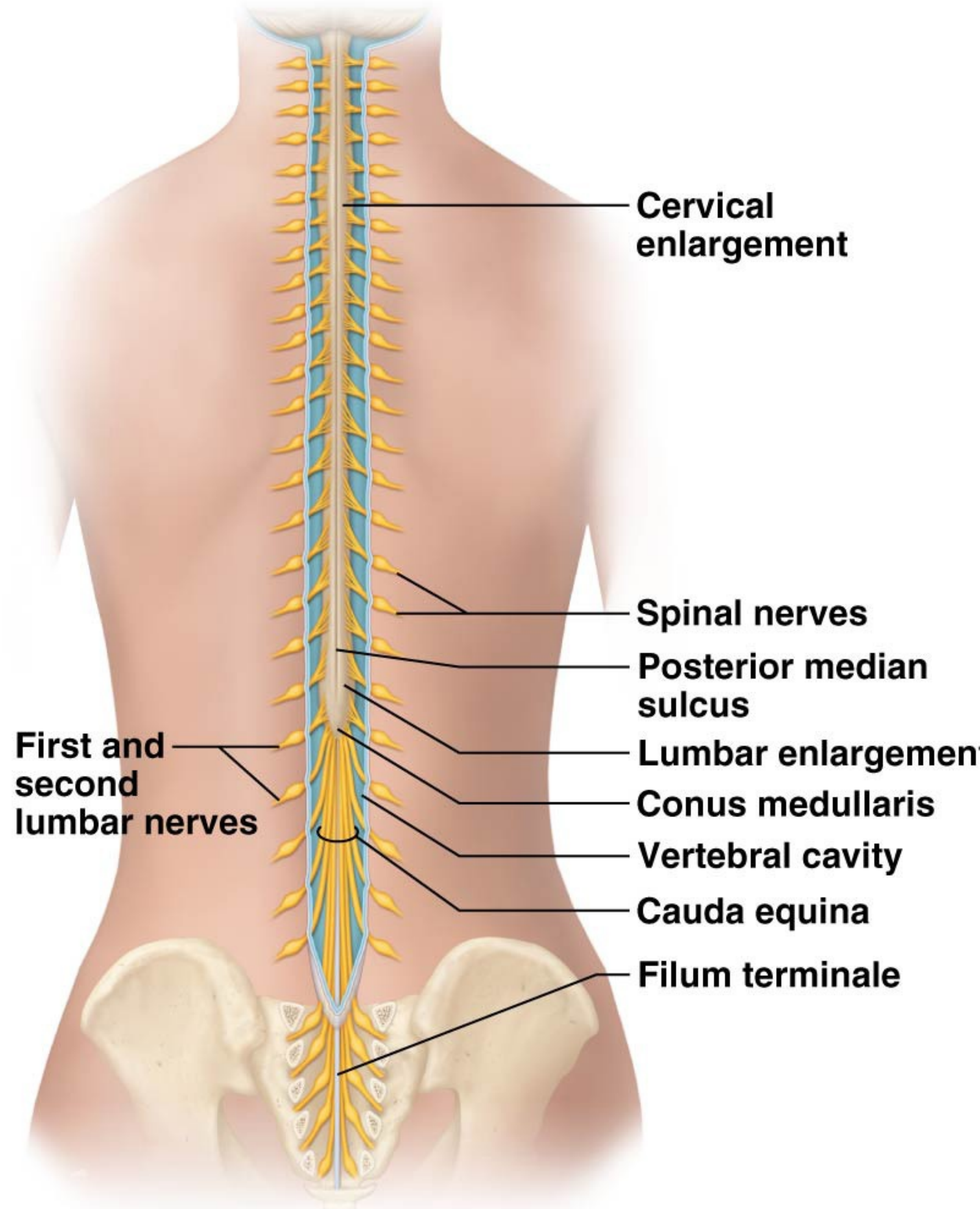




Posterior
Spinous process
Vertebral arch
Lamina
Transverse process
Superior articular process
Pedicle
Vertebral foramen
Body (centrum)
Anterior

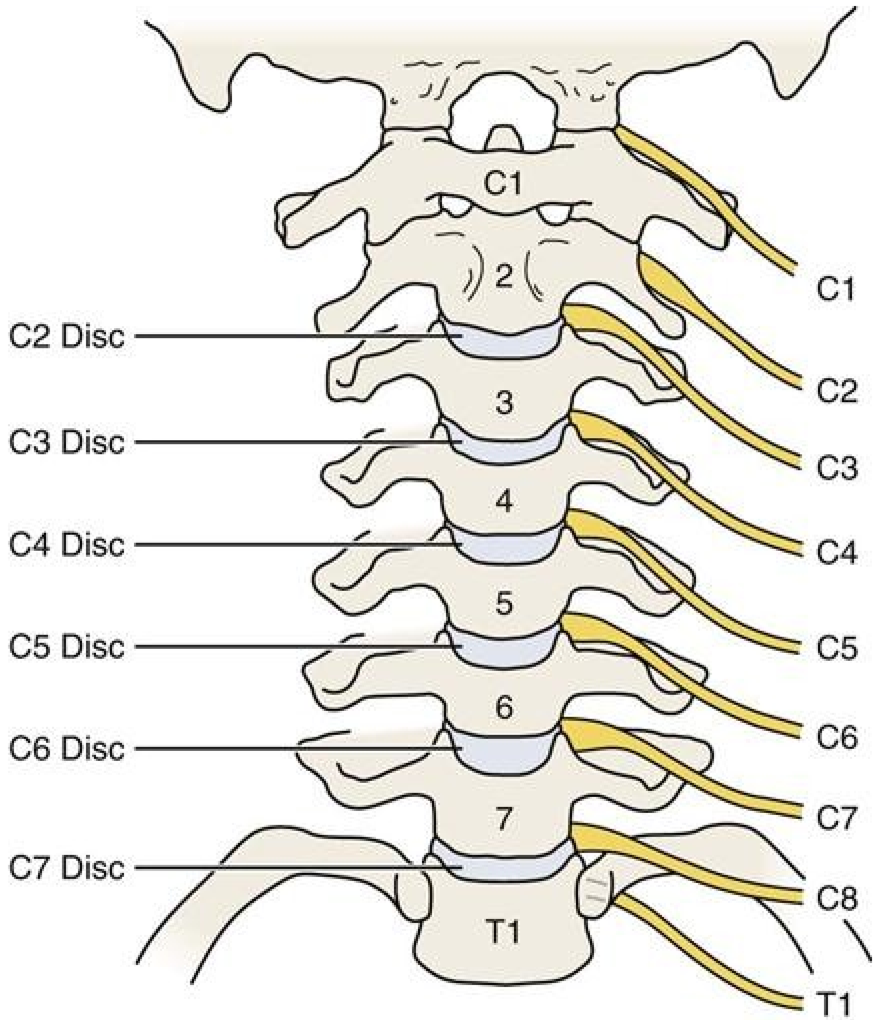

Spinal cord
Vertebra
Cauda equina

External structure of the spinal cord.



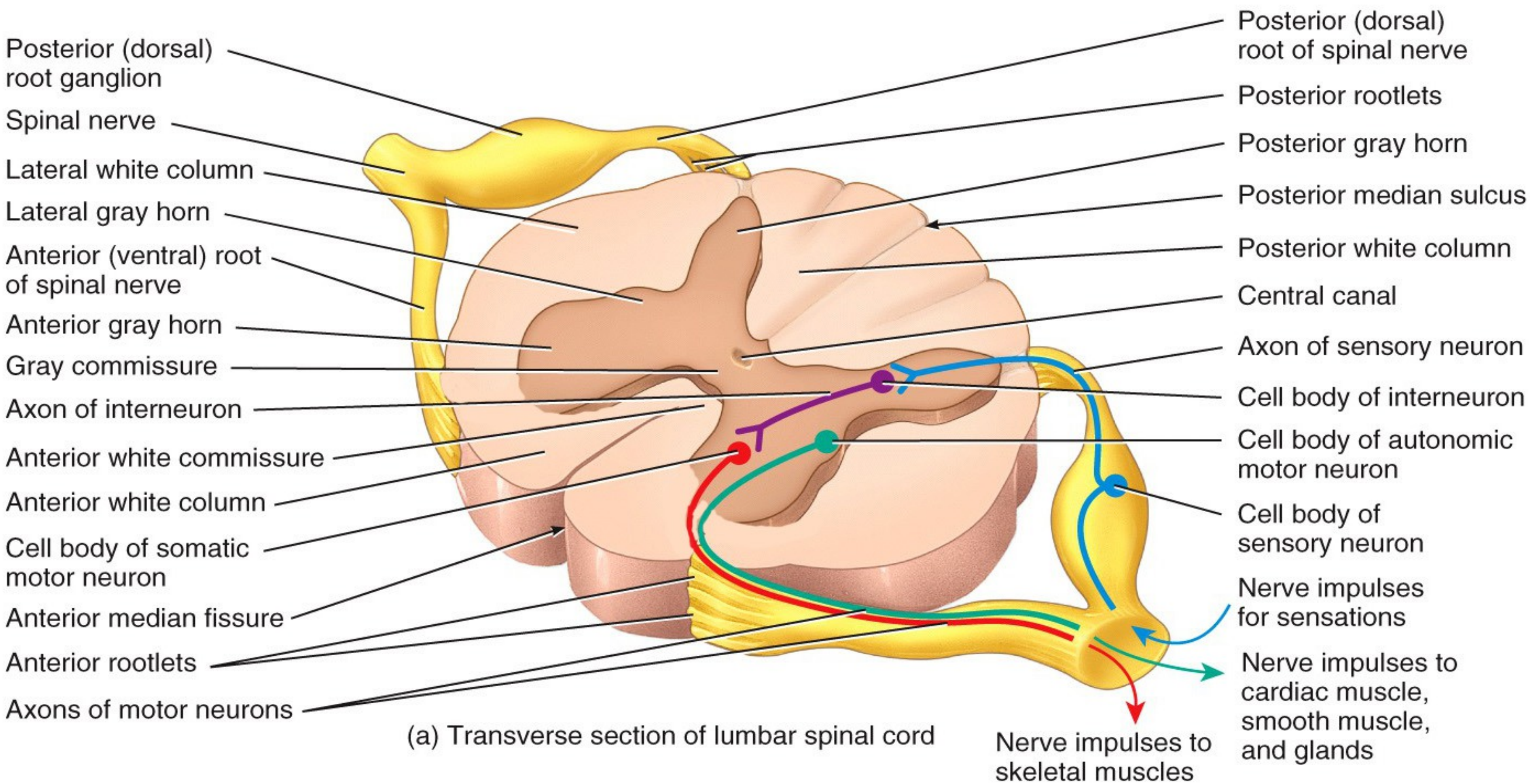
(a) Spinal cord, posterior view

Spinal Nerves

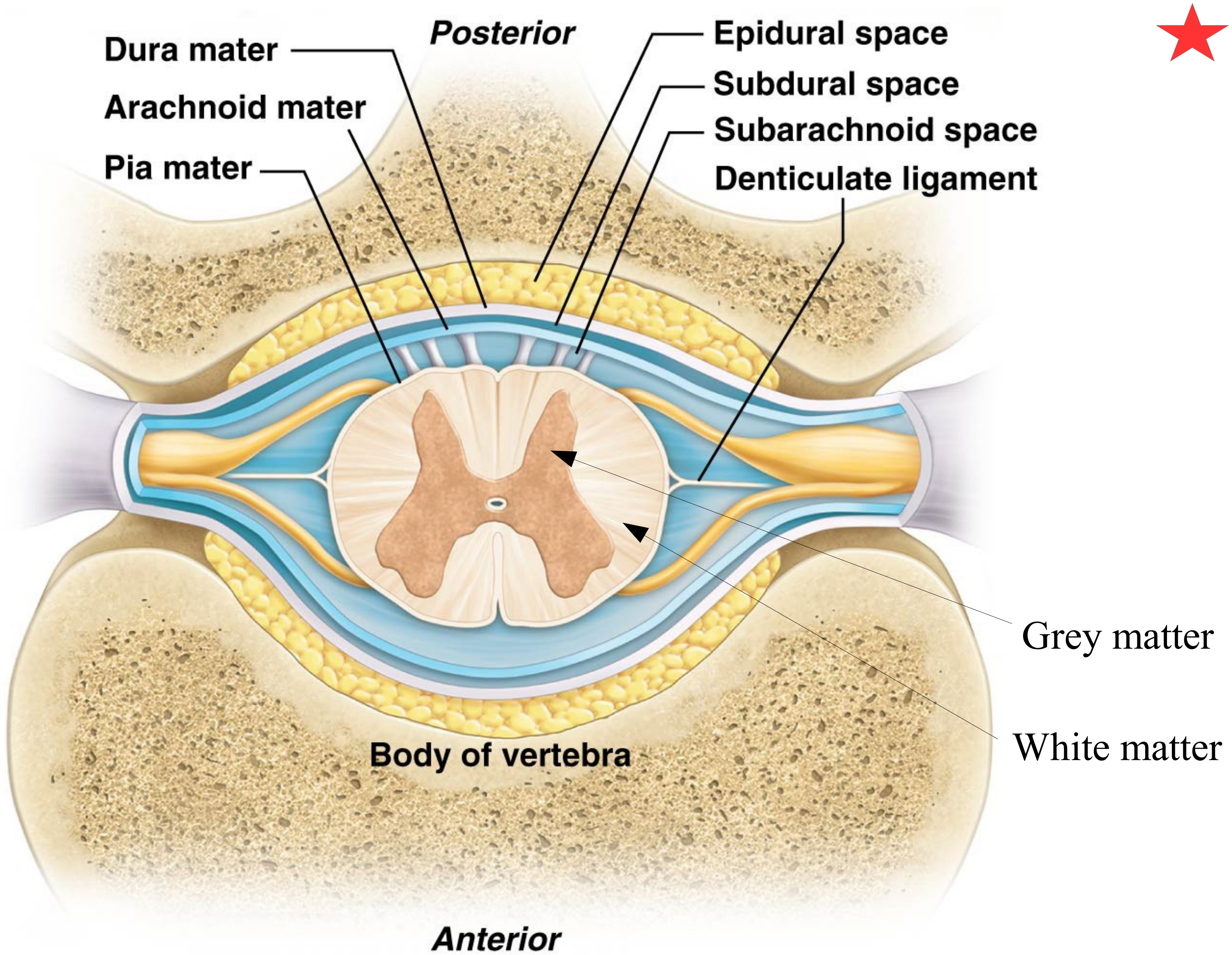


Spinal Cord Horns

Posterior, Anterior, and Lateral

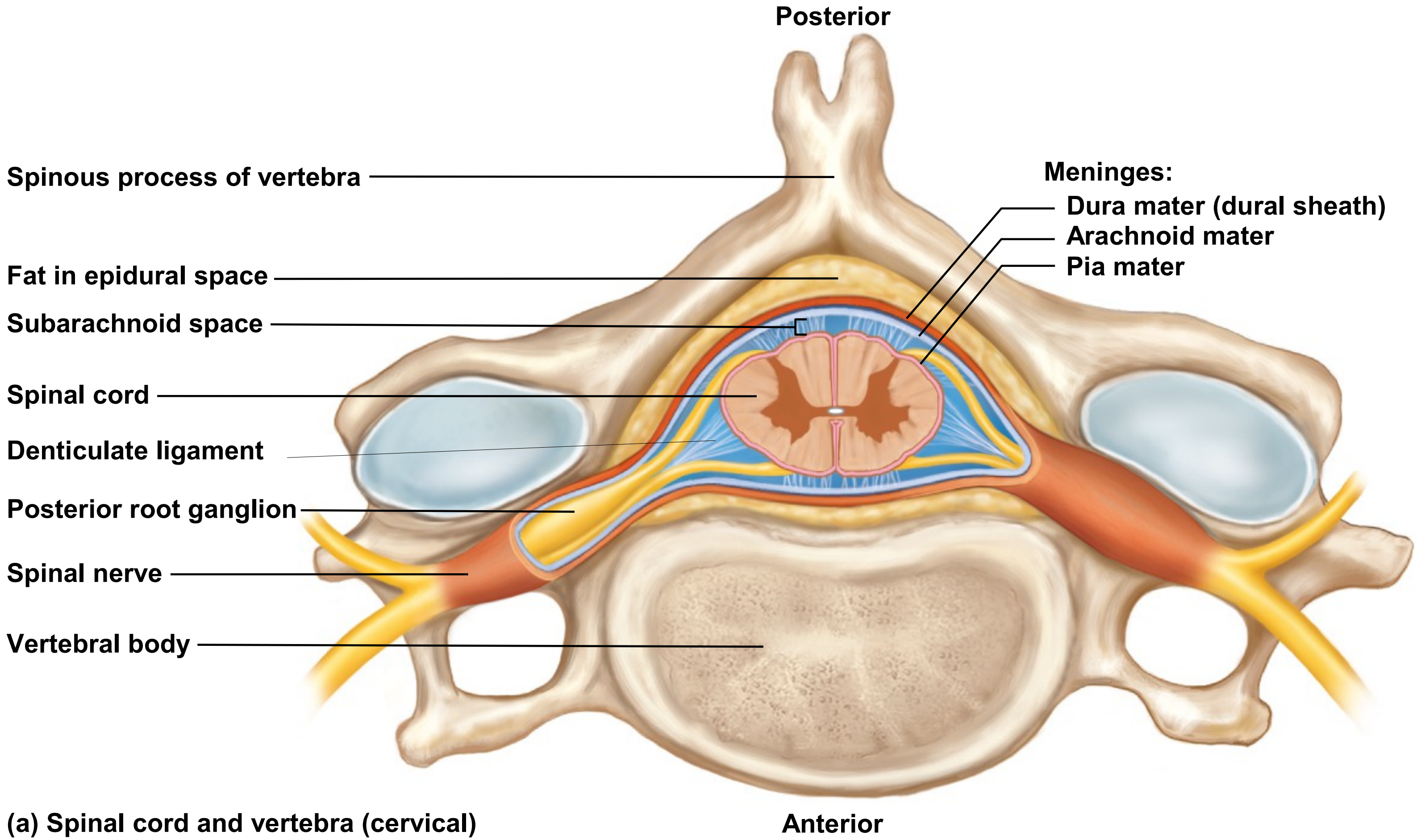


(a) Transverse section of lumbar spinal cord



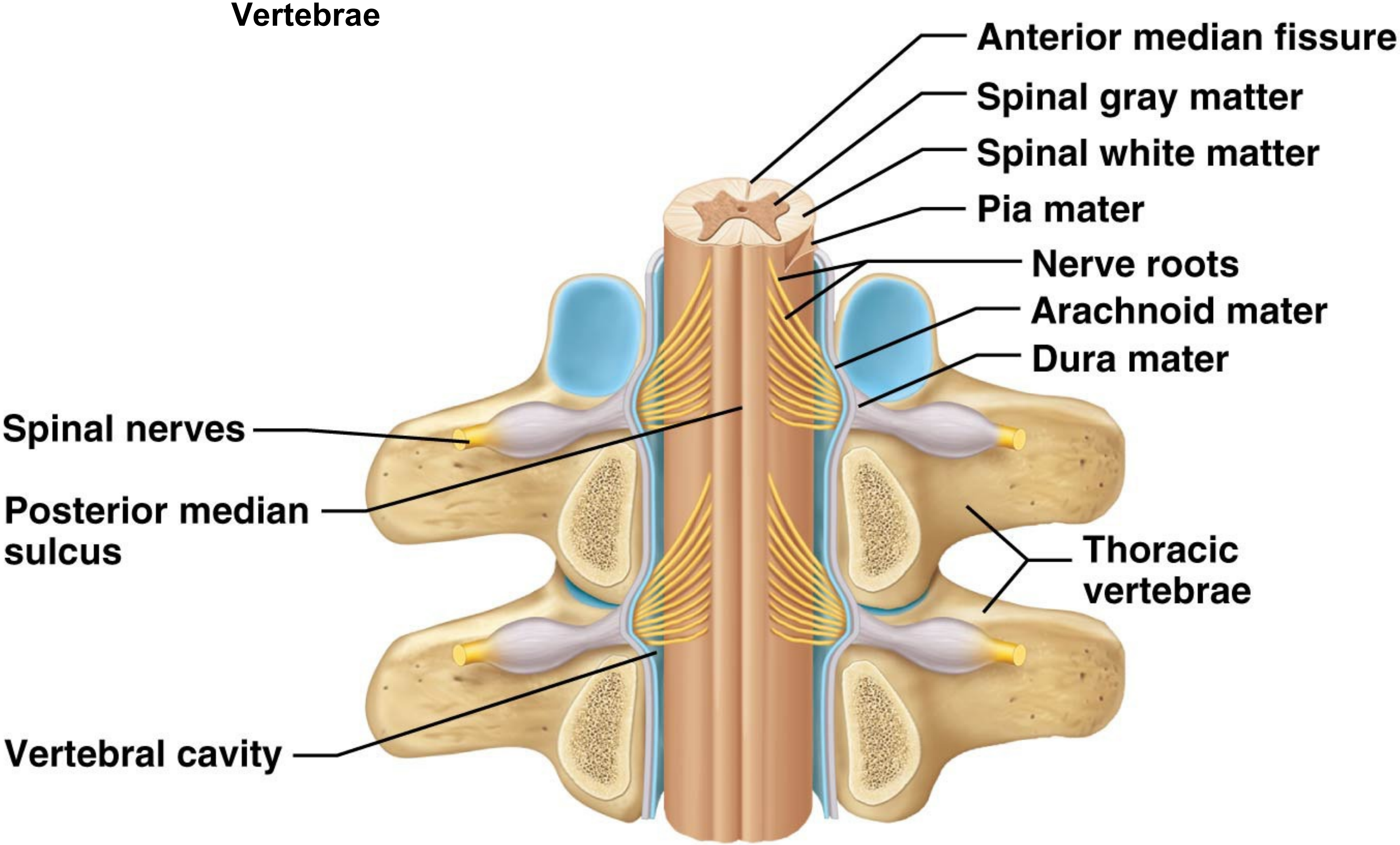
(b) Spinal meninges and spinal cord, transverse section

Spinal Cord Meninges



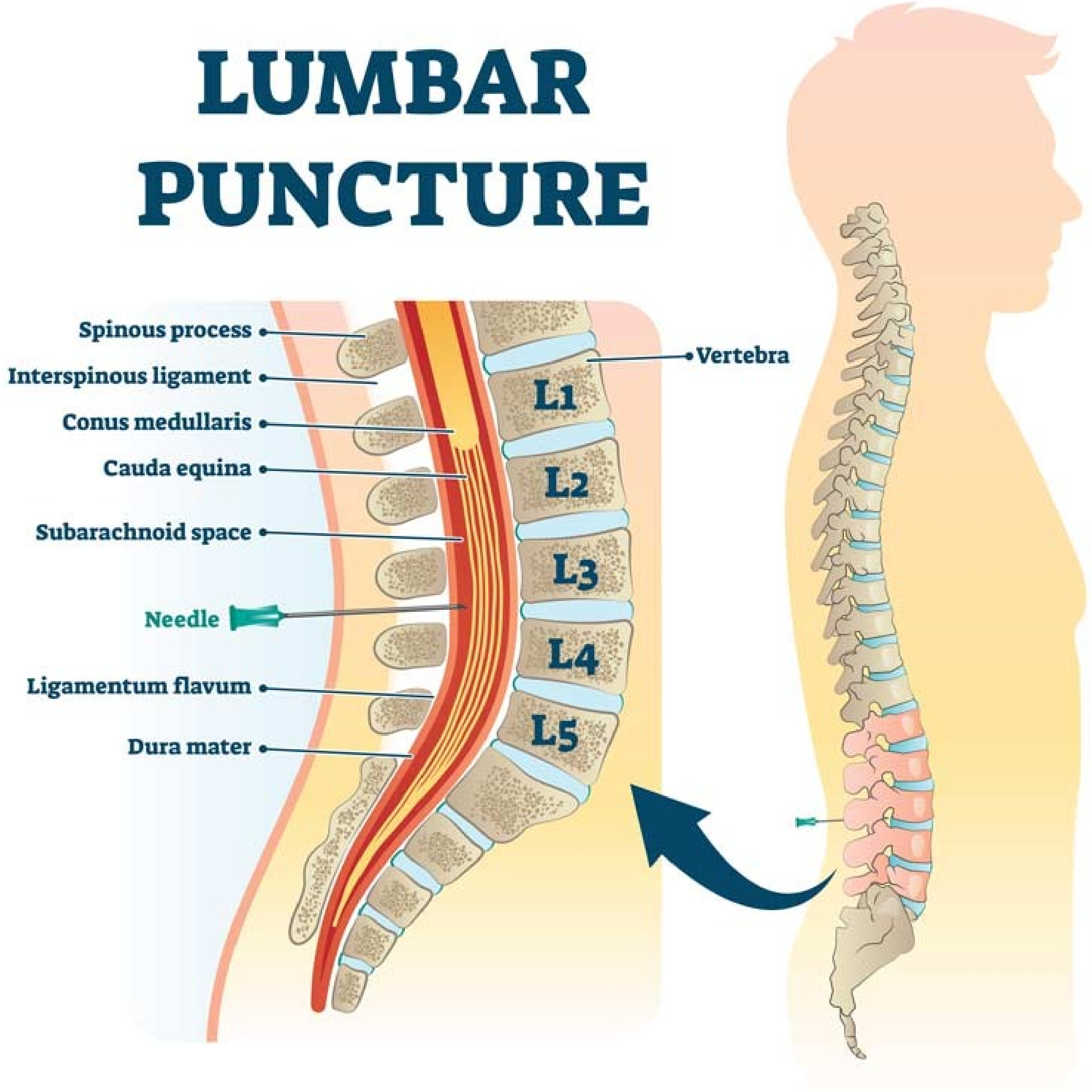
(a) Spinal cord and vertebra (cervical)

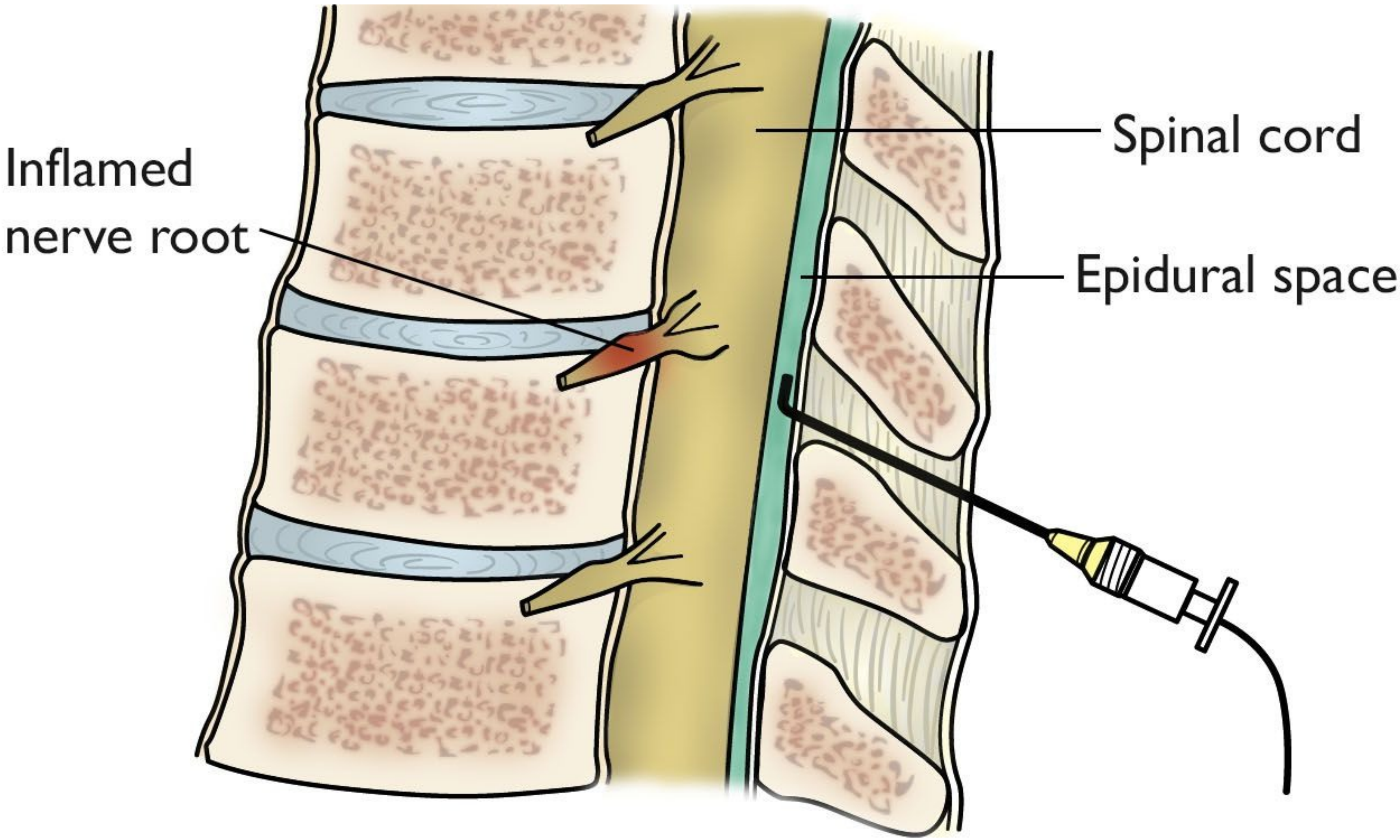
The Spinal Nerve and Vertebrae

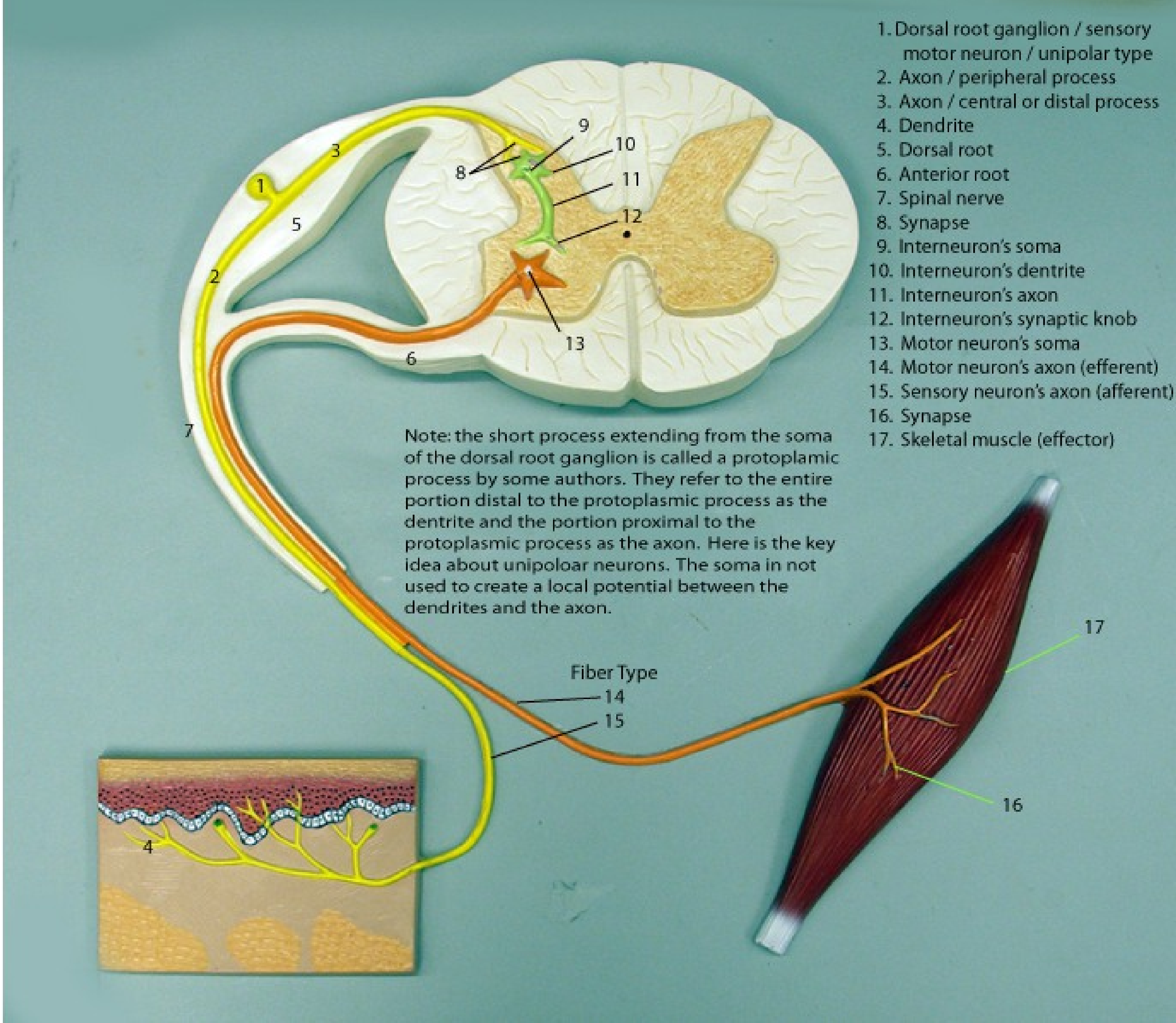


(b) Section of spinal cord and associated structures, posterior view

Clinical Significance
Taking Sample of Cerebral Spinal Fluiid




Inflamed
nerve root
Spinal cord
Epidural space

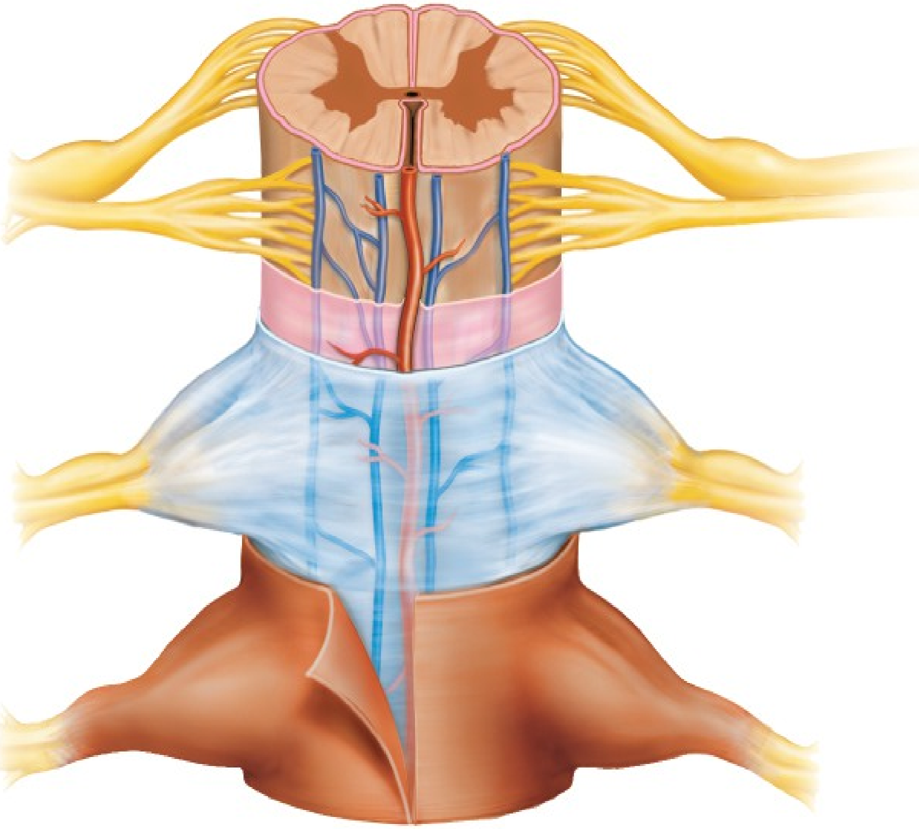


1. Dorsal root ganglion / sensory motor neuron / unipolar type
2. Axon / peripheral process
3. Axon / central or distal process
4. Dendrite
5. Dorsal root
6. Anterior root
7. Spinal nerve
8. Synapse
9. Interneuron's soma
10. Interneuron's dentrite
11. Interneuron's axon
12. Interneuron's synaptic knob
13. Motor neuron's soma
14. Motor neuron's axon (efferent)
15. Sensory neuron's axon (afferent)
16. Synapse
17. Skeletal muscle (effector)

Note: the short process extending from the soma of the dorsal root ganglion is called a protoplamic process by some authors. They refer to the entire portion distal to the protoplasmic process as the dentrite and the portion proximal to the protoplasmic process as the axon. Here is the key idea about unipoloar neurons. The soma in not used to create a local potential between the dendrites and the axon.

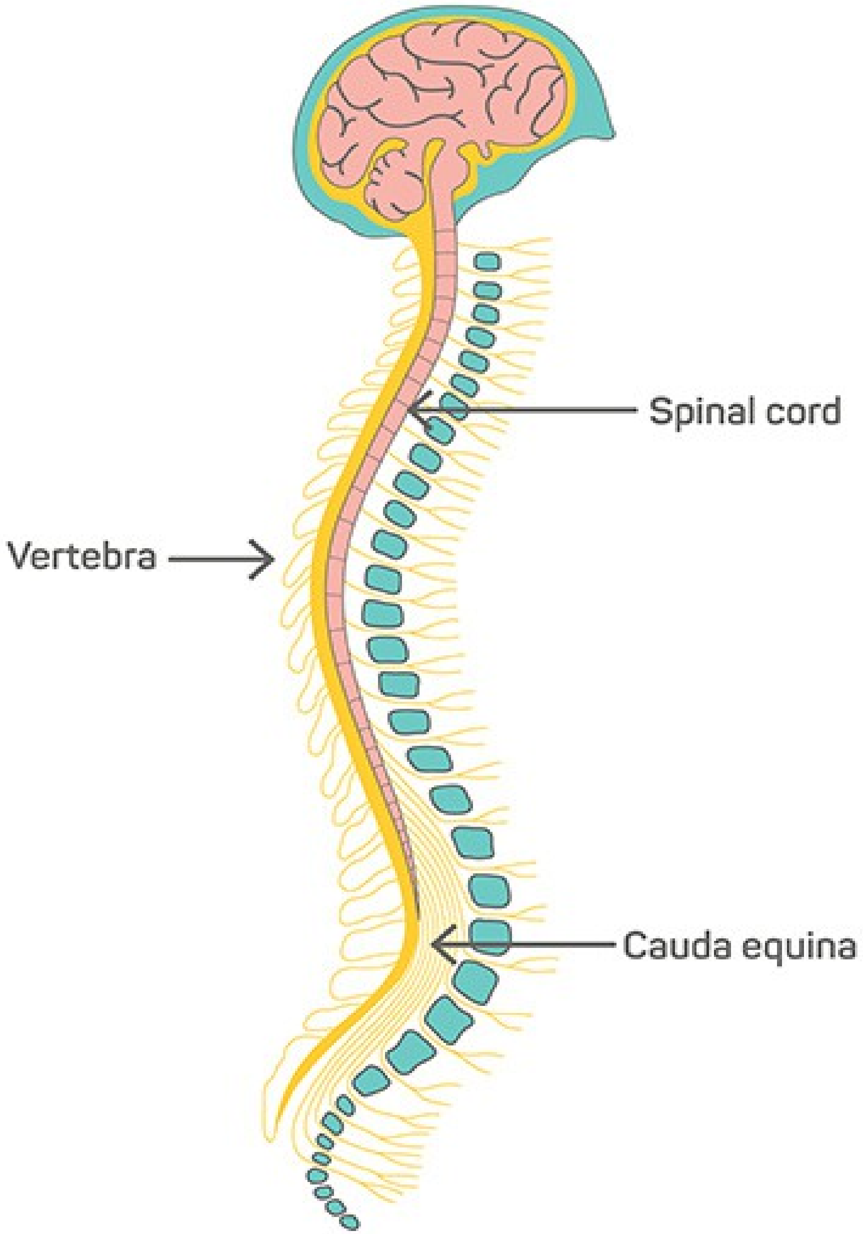
Chapter 13

The Spinal Cord



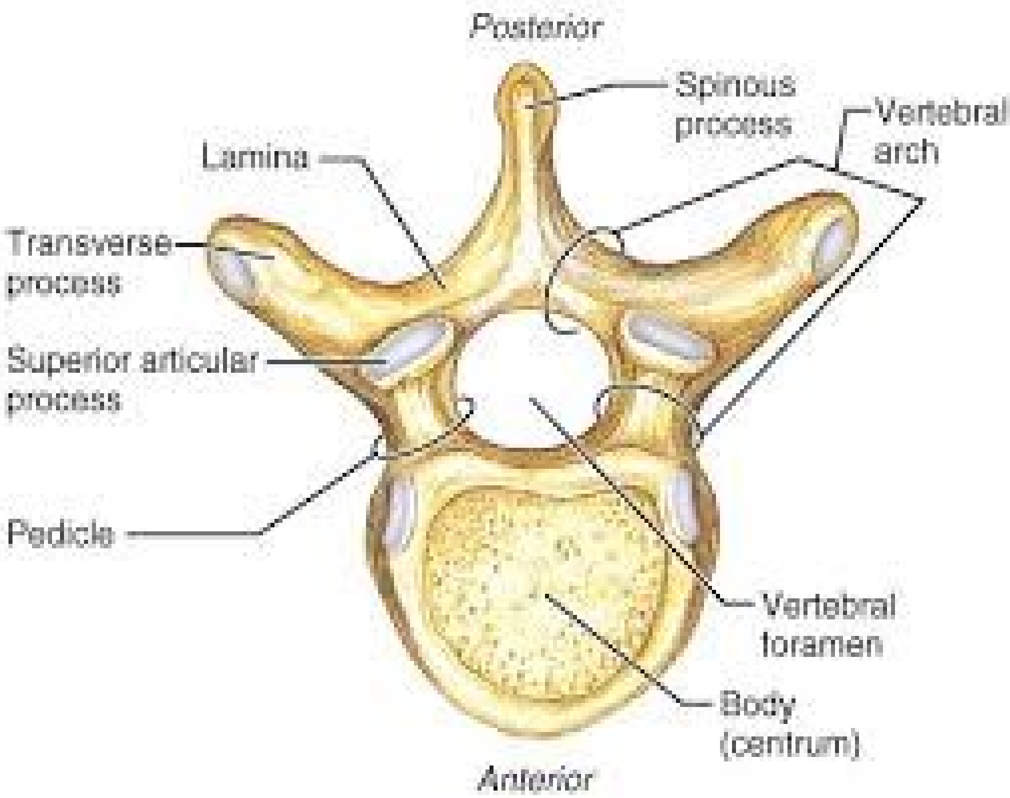
Functions of the Spinal Cord

- Conduction
  - bundles of axons transmit action potentials (information) up and down the spinal cord, connecting different levels of the trunk with each other and to the brain
- Locomotion
  - walking involves repetitive, coordinated actions of several muscle groups
  - local neural circuits (central pattern generators) are pools of neurons located at each segment of the spinal column that help to control of flexors and extensors which cause alternating movements of the lower limbs // brain sends command but local neural circuits carry out the actual movements
- Reflexes
  - involuntary, stereotyped responses to stimuli // e.g. withdrawal of hand from something hot
  - involves spinal cord and peripheral nerves (i.e. brain finds out about the event after the event occurred)

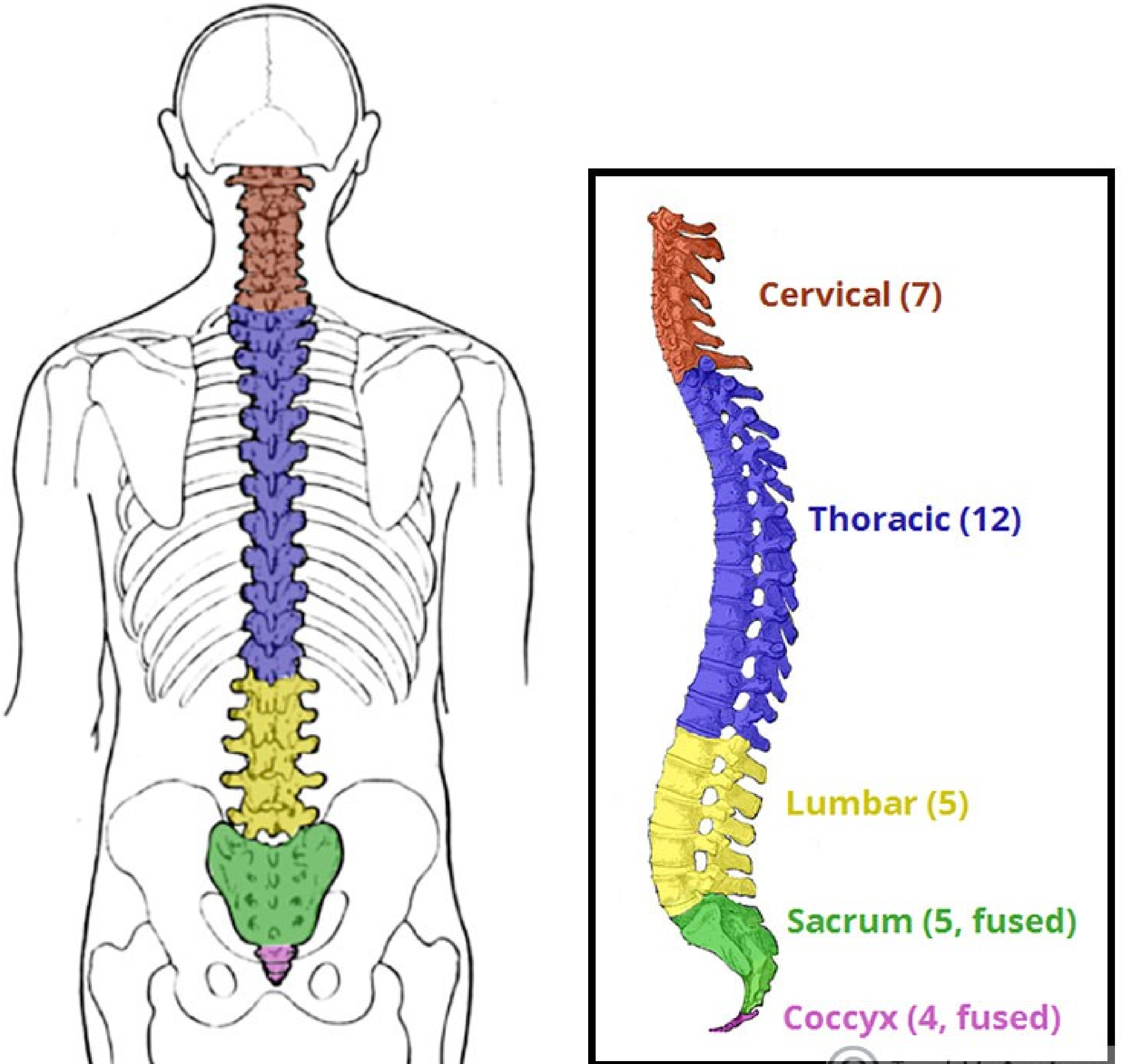

Spinal cord
Vertebra
Cauda equina

Surface Anatomy

- **Spinal cord** – cylinder of nervous tissue that starts at the end of the brainstem and passes through the foramen magnum of the skull
  - pass through the **vertebral foramen**
  - inferior margin **ends at L1** or a little beyond
  - averages 1.8 cm thick and 45 cm long
  - occupies the **upper two-thirds of the vertebral canal**



Posterior
Spinous process
Vertebral arch
Lamina
Transverse process
Superior articular process
Pedicle
Vertebral foramen
Body (centrum)
Anterior


Cervical (7)
Thoracic (12)
Lumbar (5)
Sacrum (5, fused)
Coccyx (4, fused)
TeachMeAnatomy

Spinal Nerves

At each segment of the bony spinal column, a pair of axon exit the spinal cord. These are the spinal nerves that connect the cord to muscles and other organs..

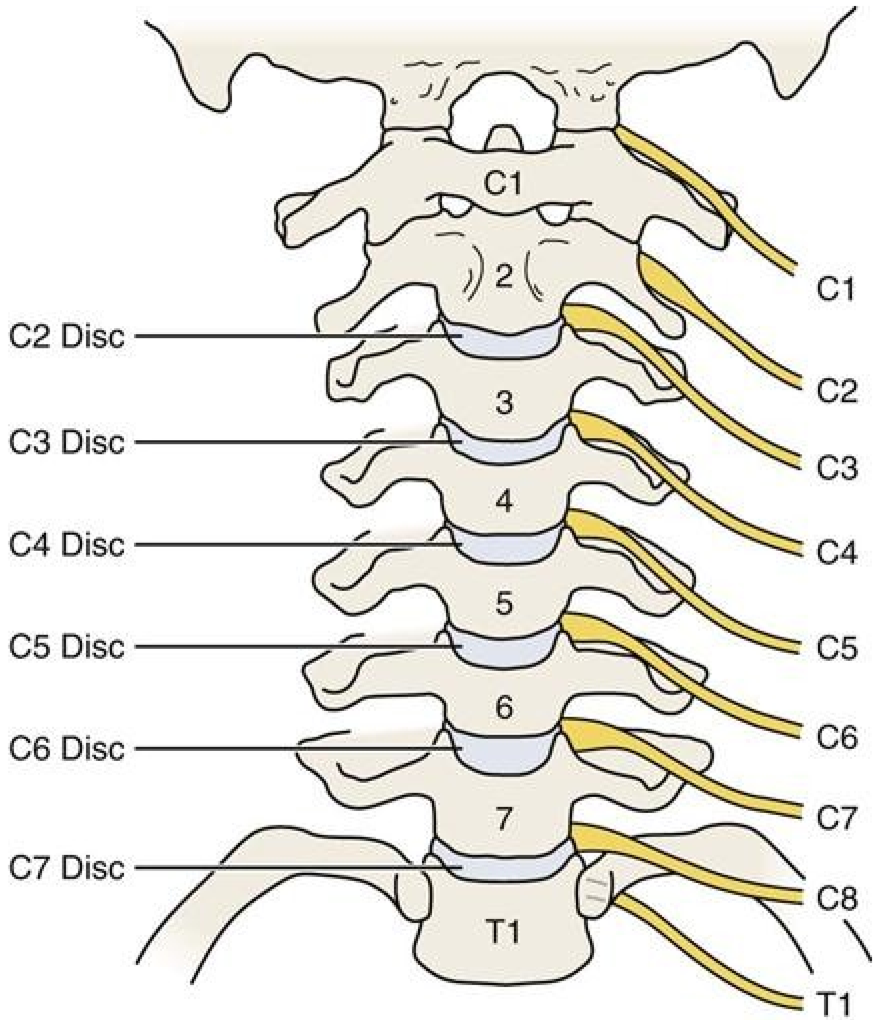
The spinal cord gives rise to 31 pair of **spinal nerves**

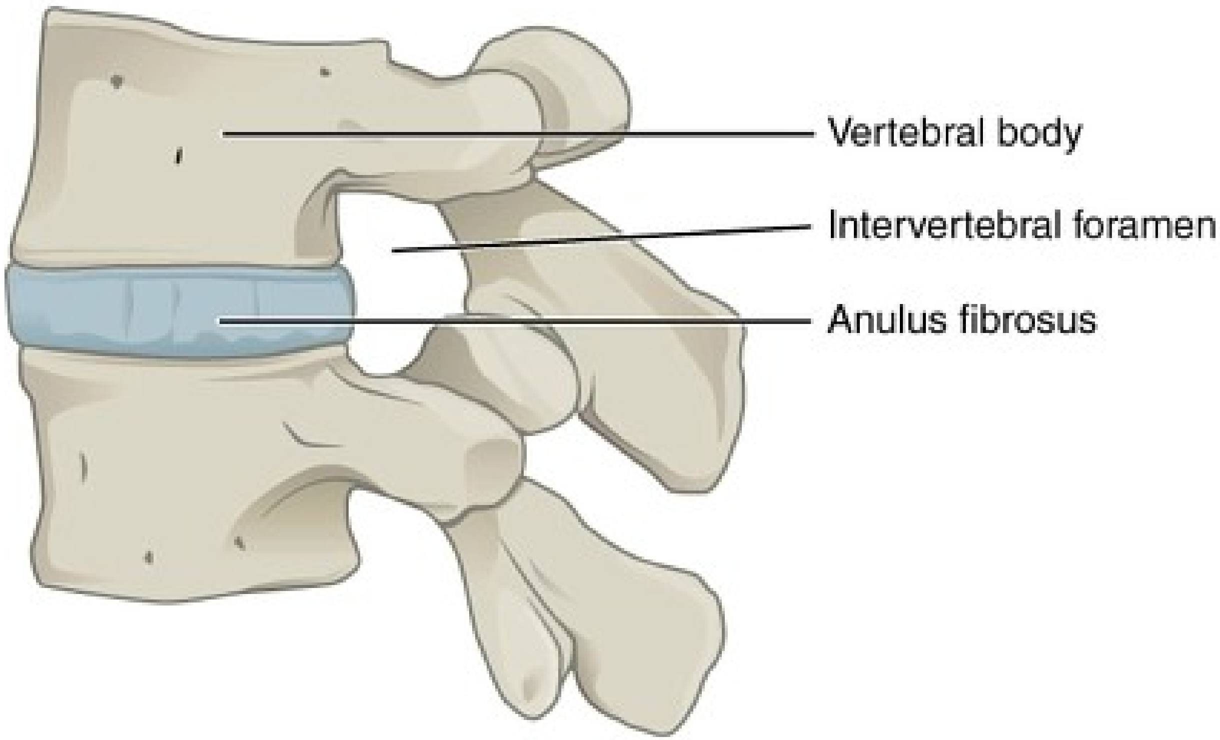
First pair passes between the skull and C1

All other pass through the intervertebral foramen

Note: a segment in the spinal cord refers to the part of the spinal cord where a a pair of spinal nerves originate

Spinal Nerves





Lateral view

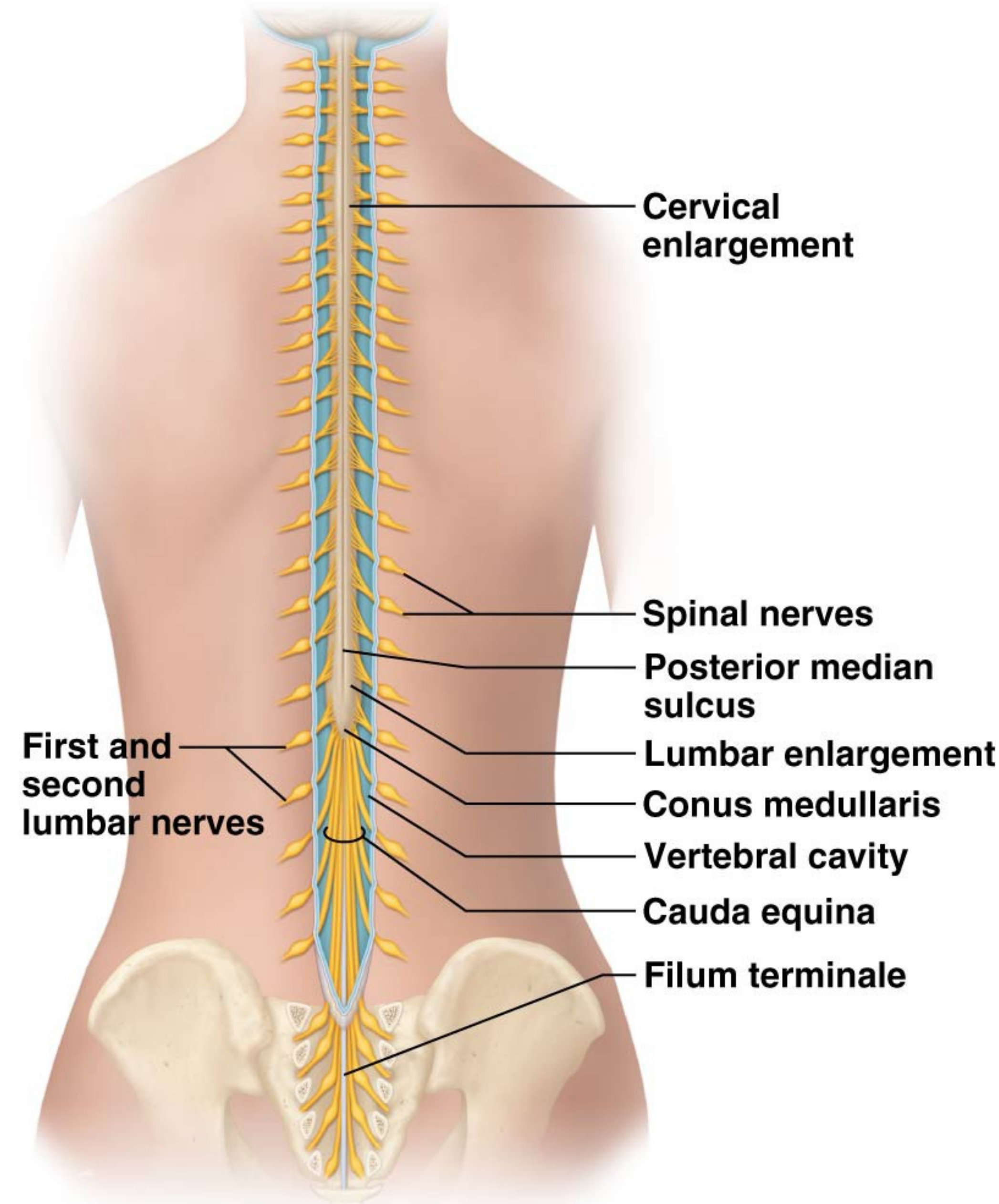
Surface Anatomy of Spinal Cord

medullary cone (conus medullaris) – cord tapers to a point inferior to lumbar enlargement

cauda equina – bundle of nerve roots that occupy the vertebral canal from L2 to S5

terminal filum – extension of pia matter from medullary cone which anchors spinal cord to inferiorly to coccyx

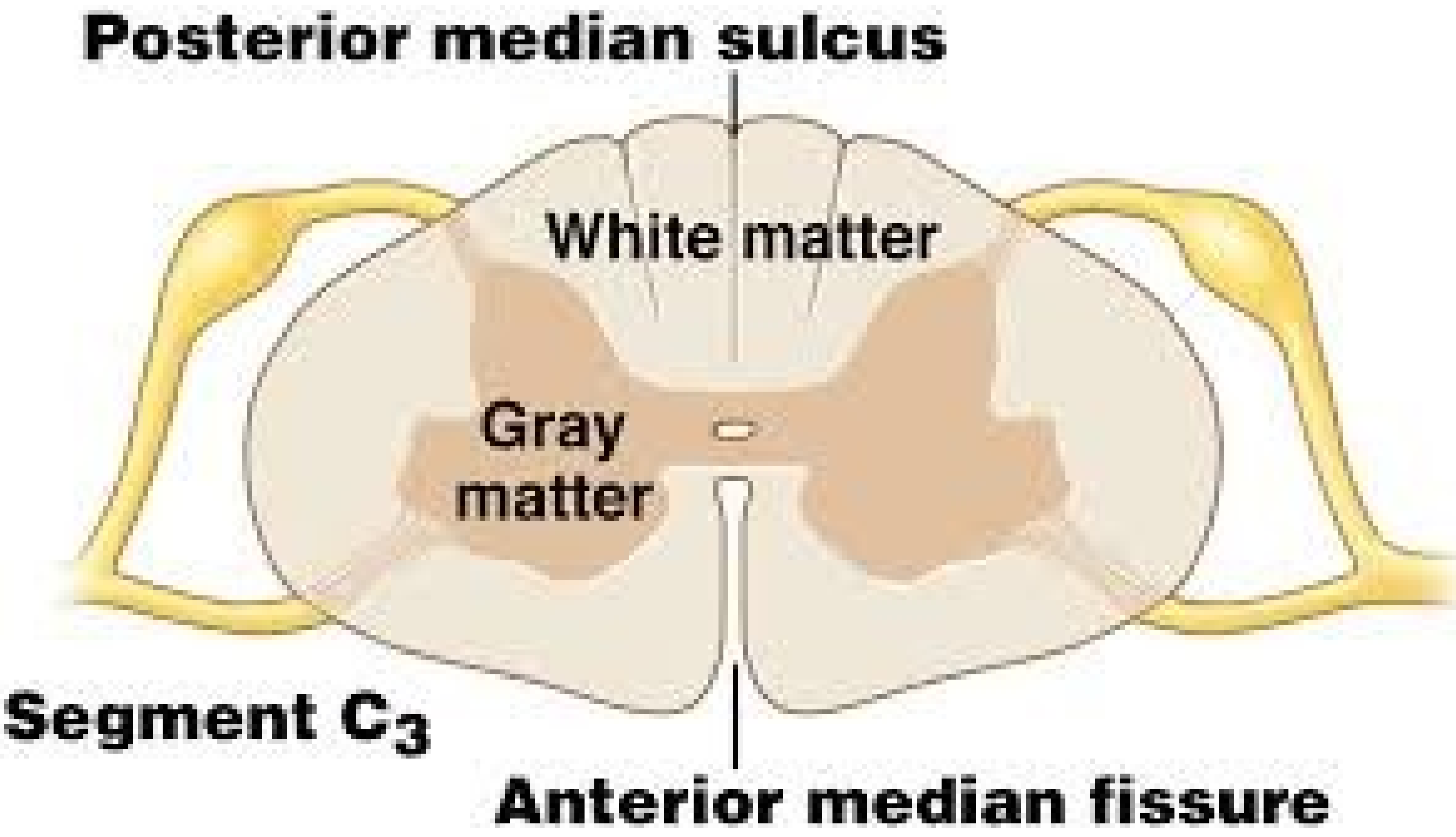
External structure of the spinal cord.



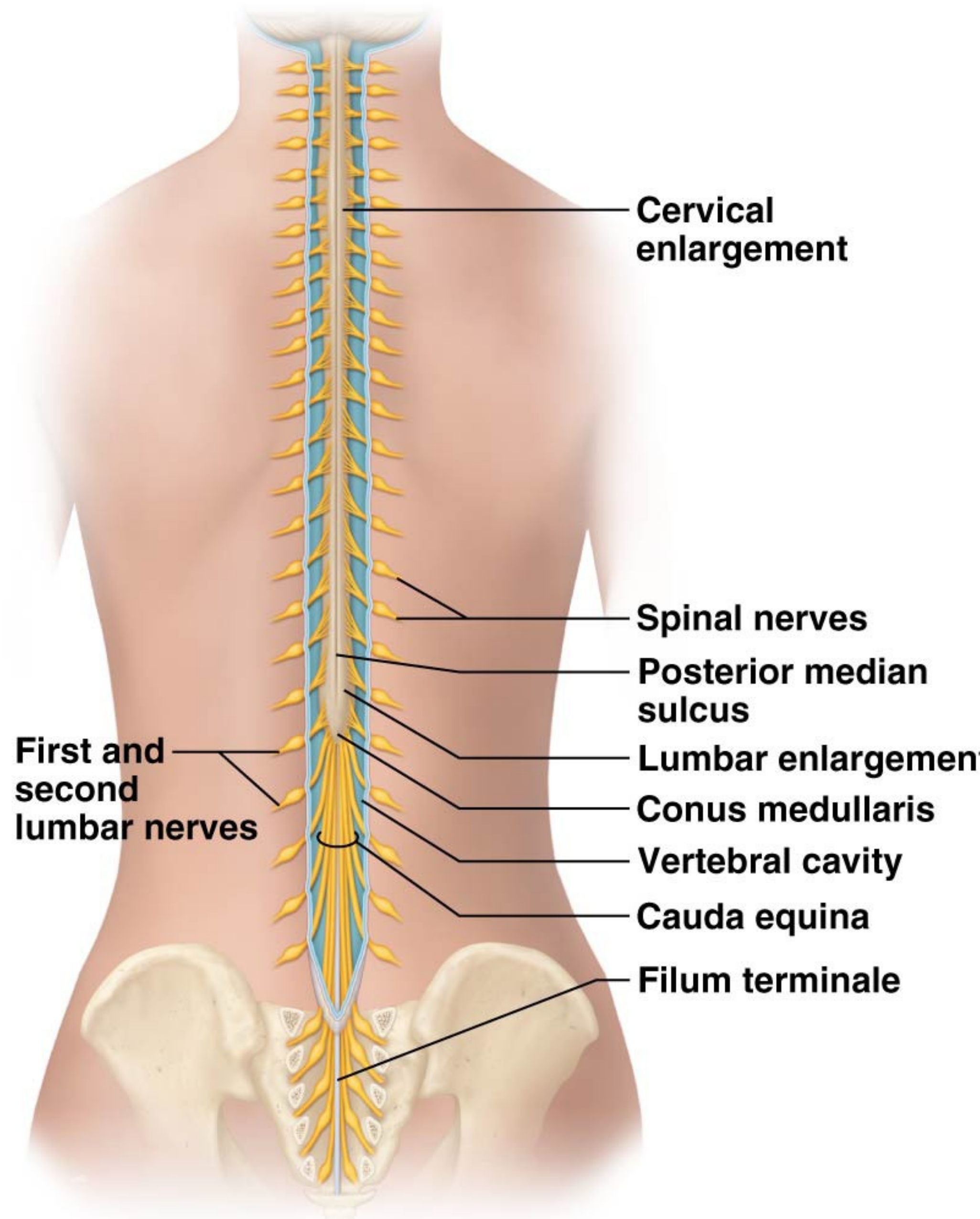
(a) Spinal cord, posterior view

Surface Anatomy of Spinal Cord

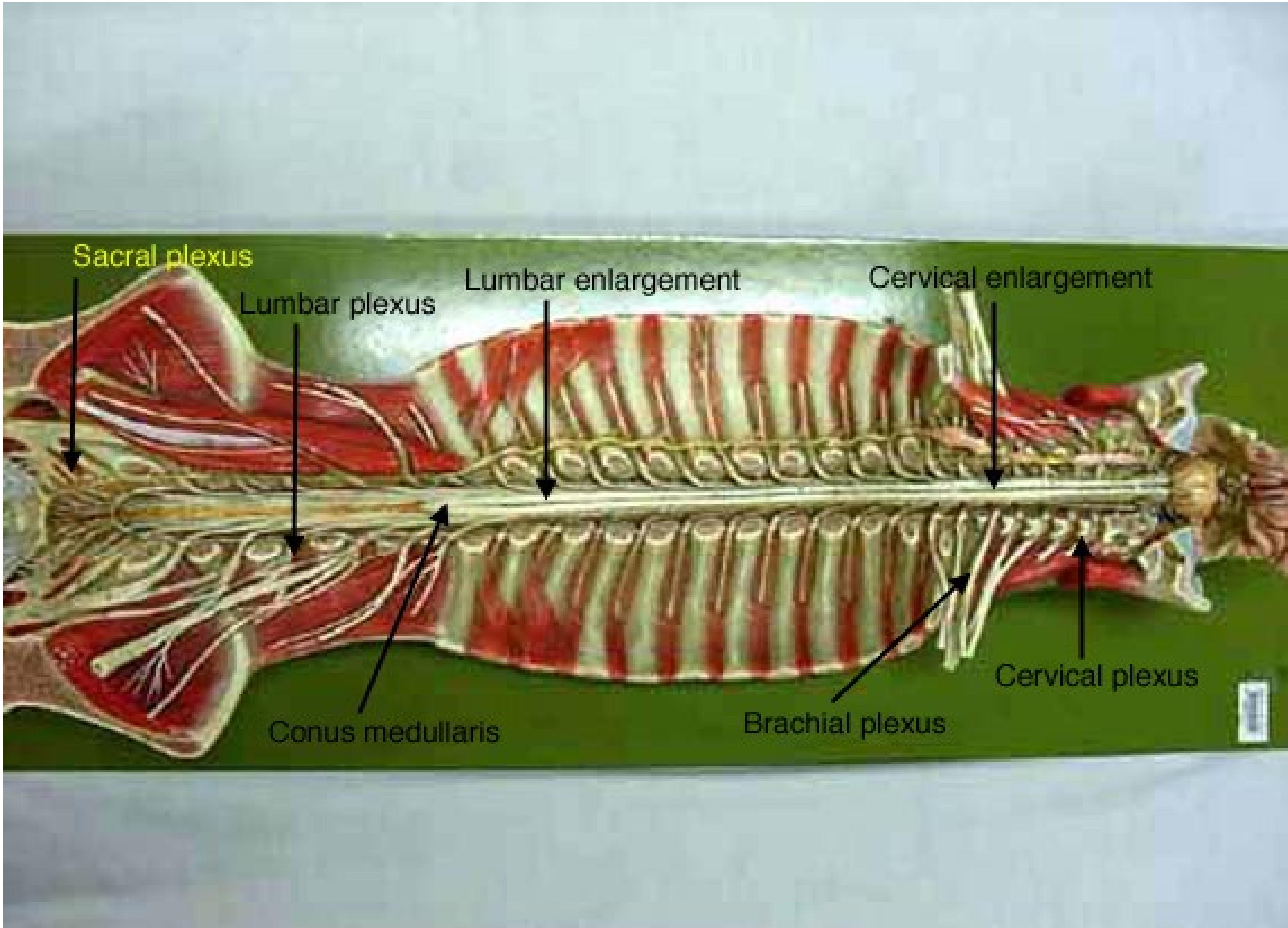
- Longitudinal grooves on anterior and posterior surface of spinal cord
  - anterior median fissure
  - posterior median sulcus
- Spinal cord divided into the cervical, thoracic, lumbar, and sacral regions
- Two areas of the cord are thicker than elsewhere
  - cervical enlargement – nerves to upper limb
  - lumbar enlargement – nerves to pelvic region and lower limbs


Posterior median sulcus
White matter
Gray matter
Segment C_3
Anterior median fissure

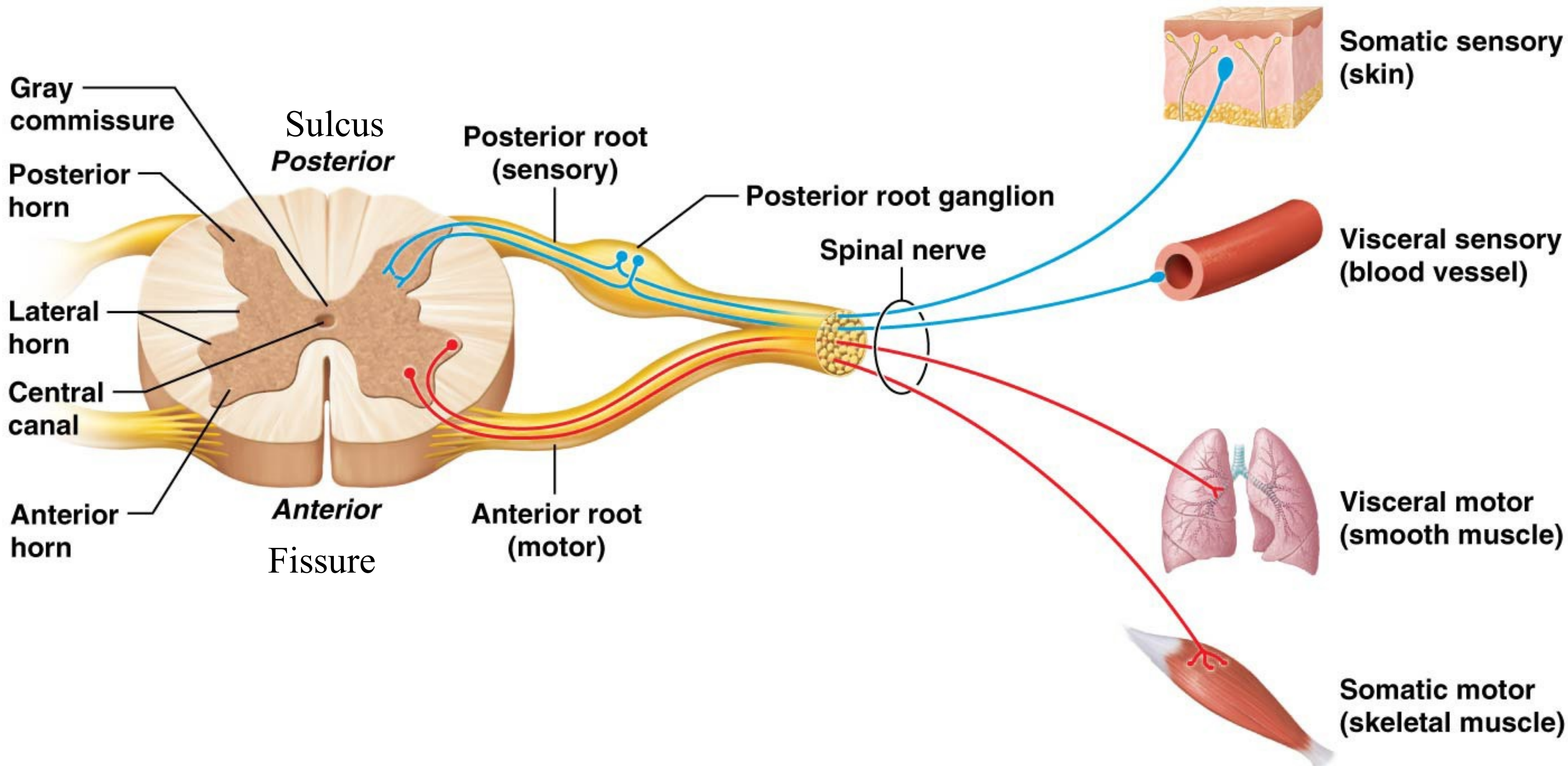
External structure of the spinal cord.



(a) Spinal cord, posterior view


Sacral plexus
Lumbar plexus
Lumbar enlargement
Cervical enlargement
Conus medullaris
Brachial plexus
Cervical plexus

Overview of the spinal cord structure and function.

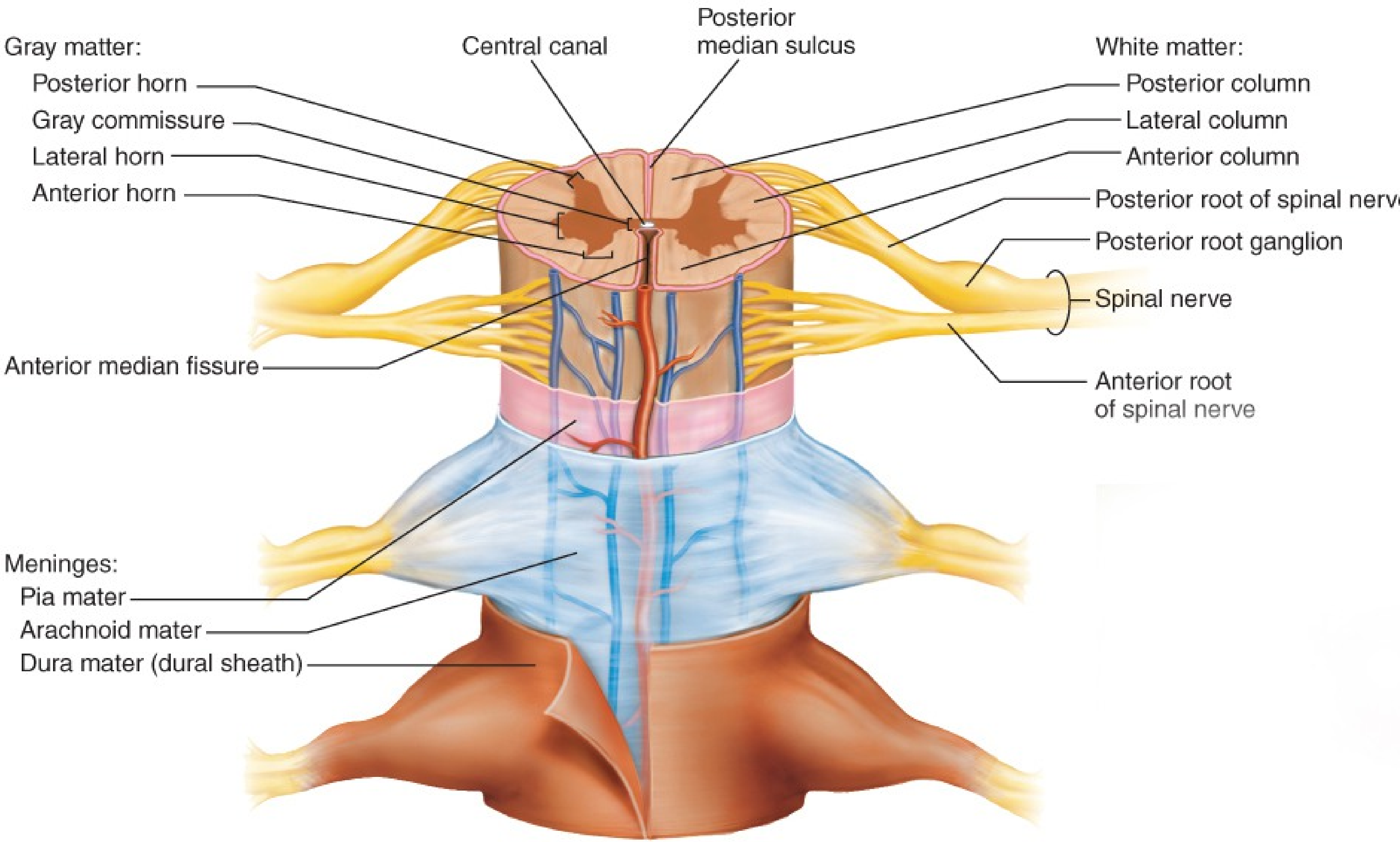


- Lateral horns located only at thoracic and lumbar segments

The Meninges of the Spinal Cord

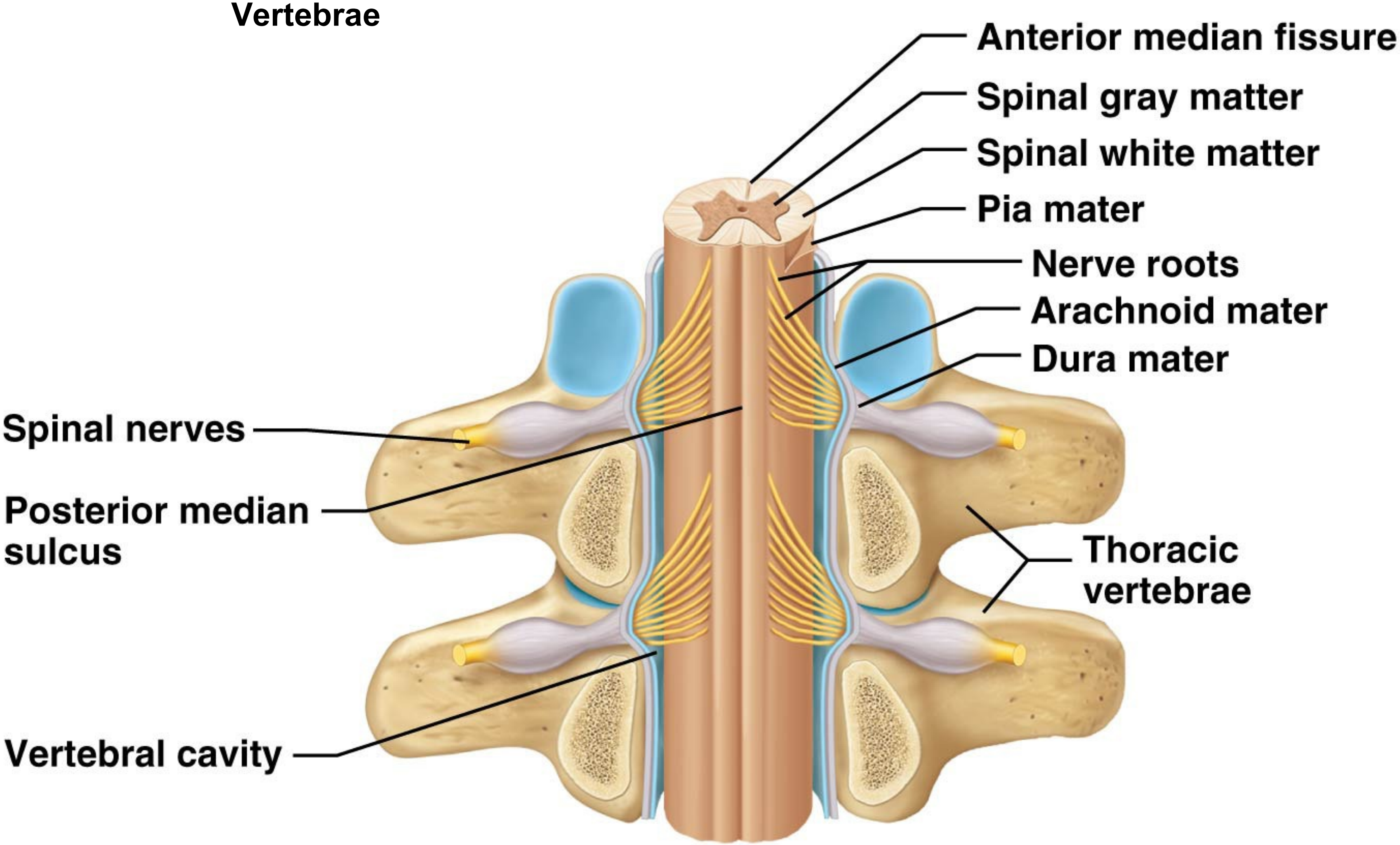
- Three fibrous connective tissue membranes that enclose the brain and spinal cord
  - separate soft tissue of central nervous system from bones of cranium and vertebral canal
  - from superficial to deep
    - dura mater
    - arachnoid mater
    - pia mater

Spinal Nerves and Spinal Roots



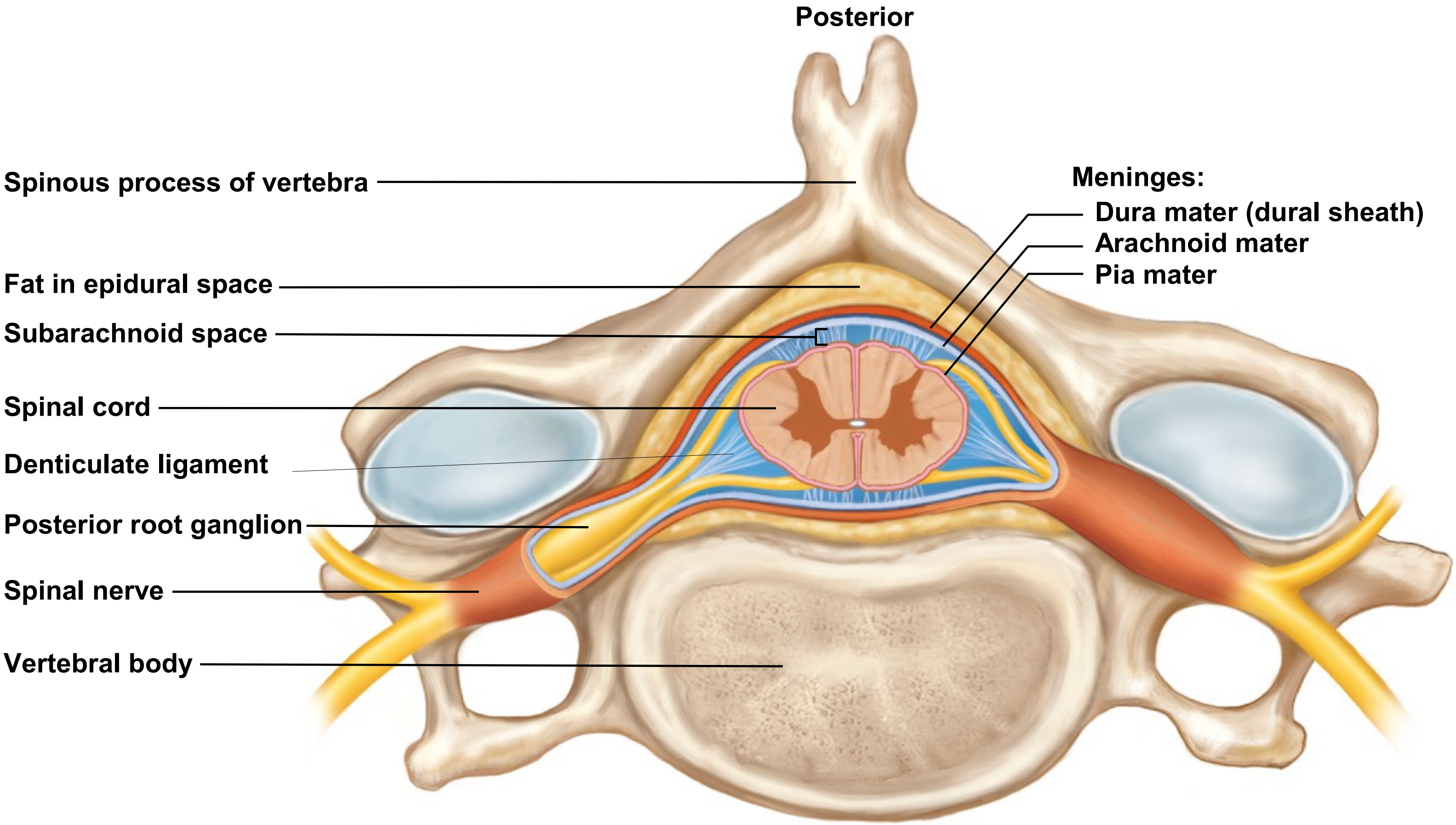
(b) Spinal cord and meninges (thoracic)

The Spinal Nerve and Vertebrae



(b) Section of spinal cord and associated structures, posterior view

Spinal Cord Meninges



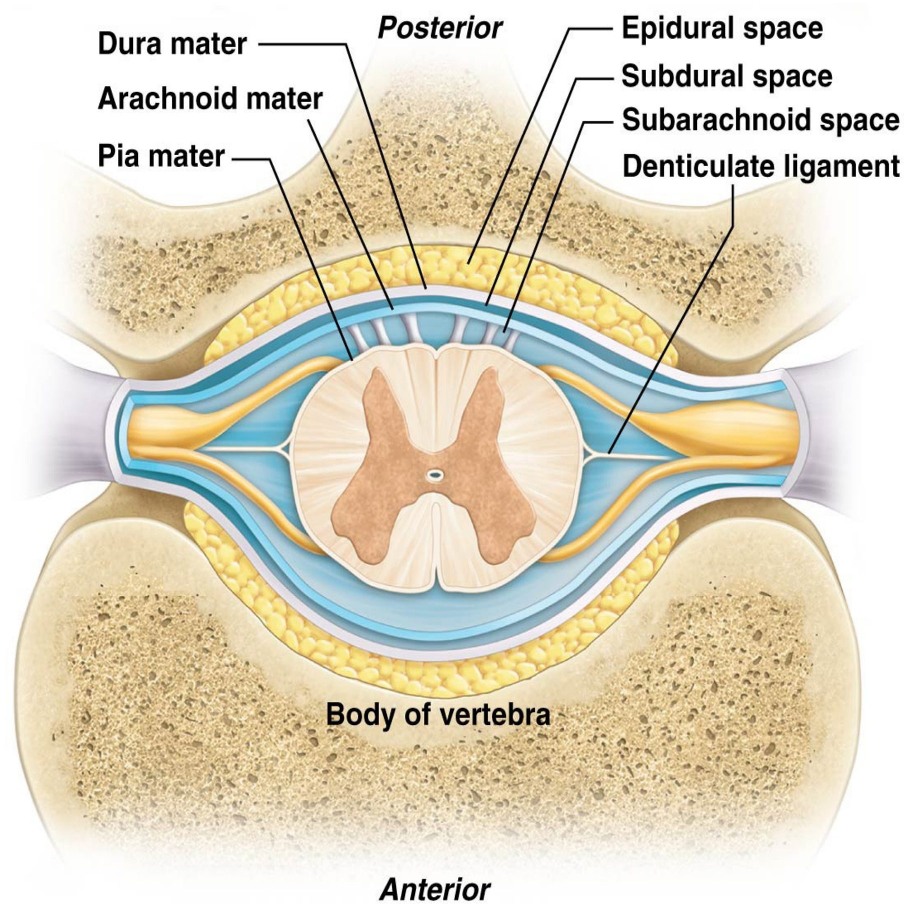
(a) Spinal cord and vertebra (cervical)

Dura Mater

Forms loose fitting sleeve around spinal cord // dura mater around brain is fused to periosteum

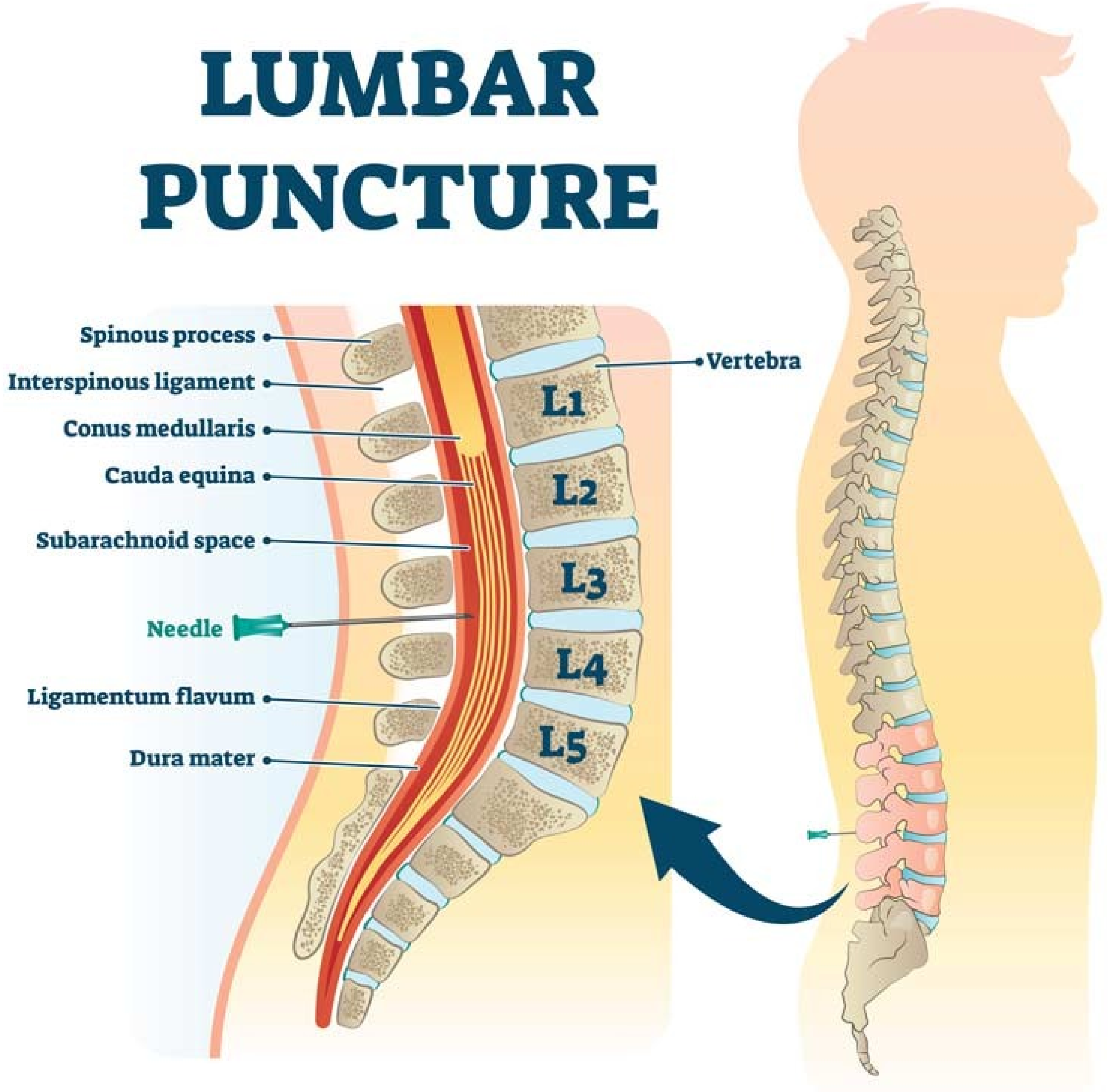
Dura mater is tough, collagenous membrane with an epidural space between dura mater and periosteum. This space is filled with adipocytes.

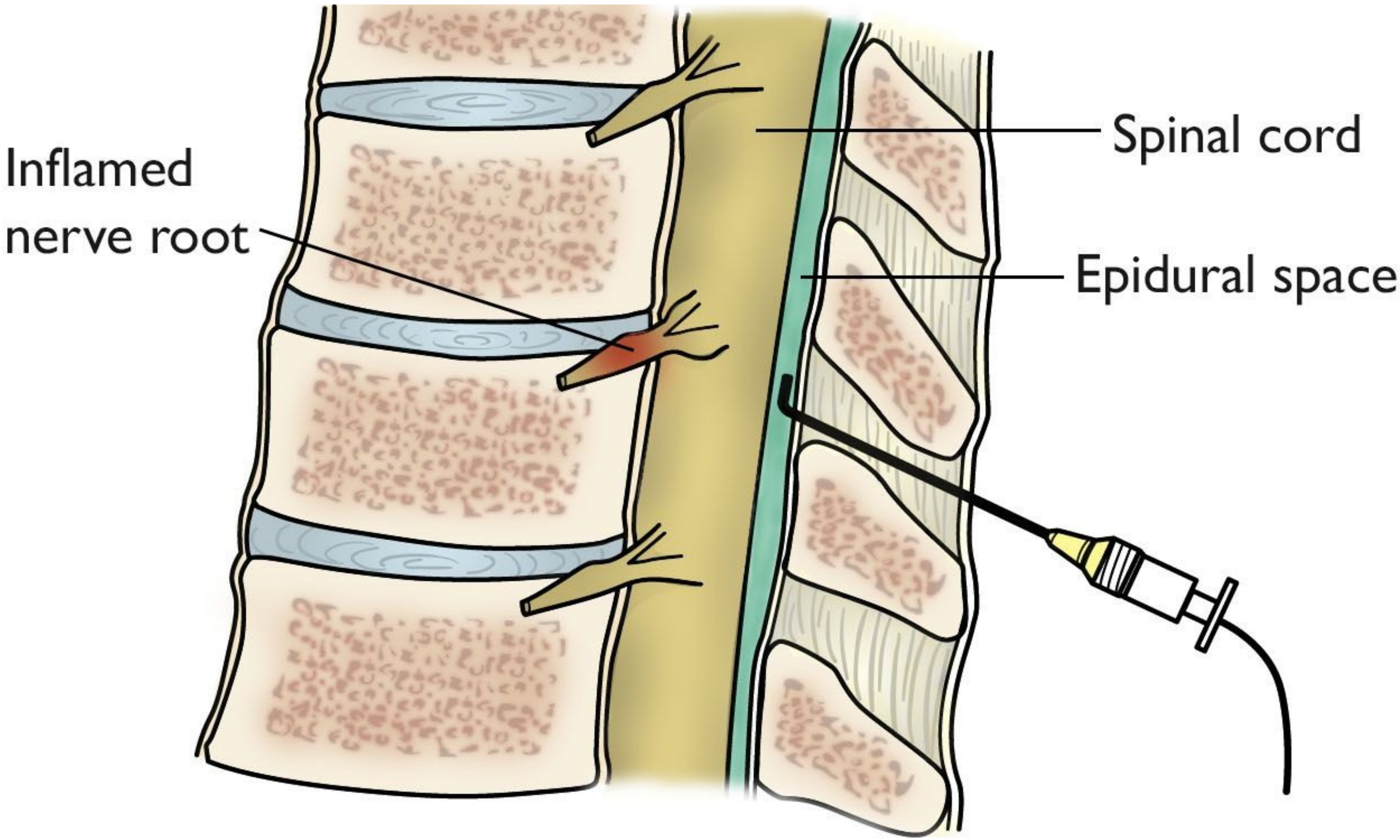
An epidural anesthesia is often injected into the epidural space during childbirth.

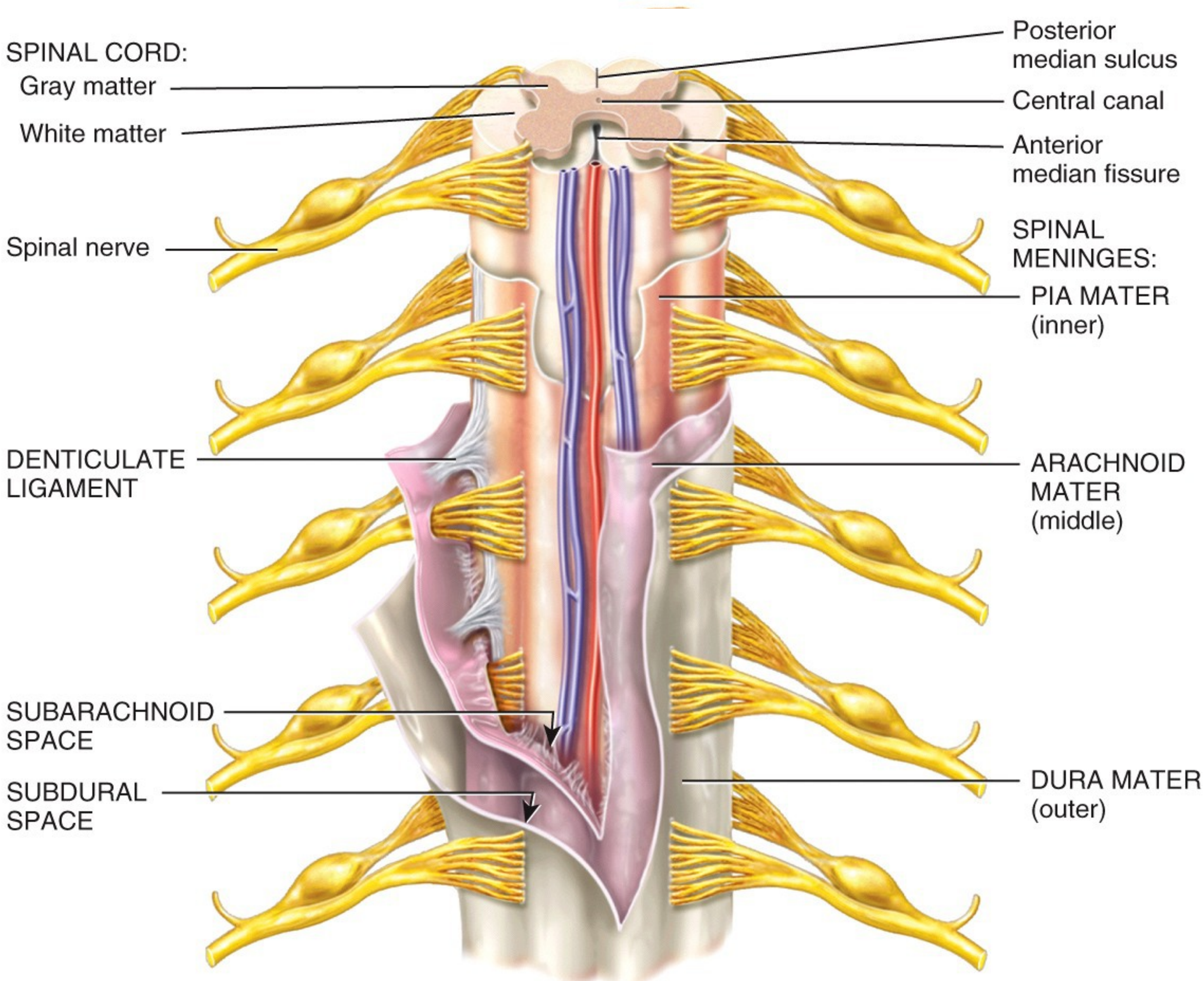


(b) Spinal meninges and spinal cord, transverse section

Clinical Significance
Taking Sample of Cerebral Spinal Fluiid




Inflamed
nerve root
Spinal cord
Epidural space



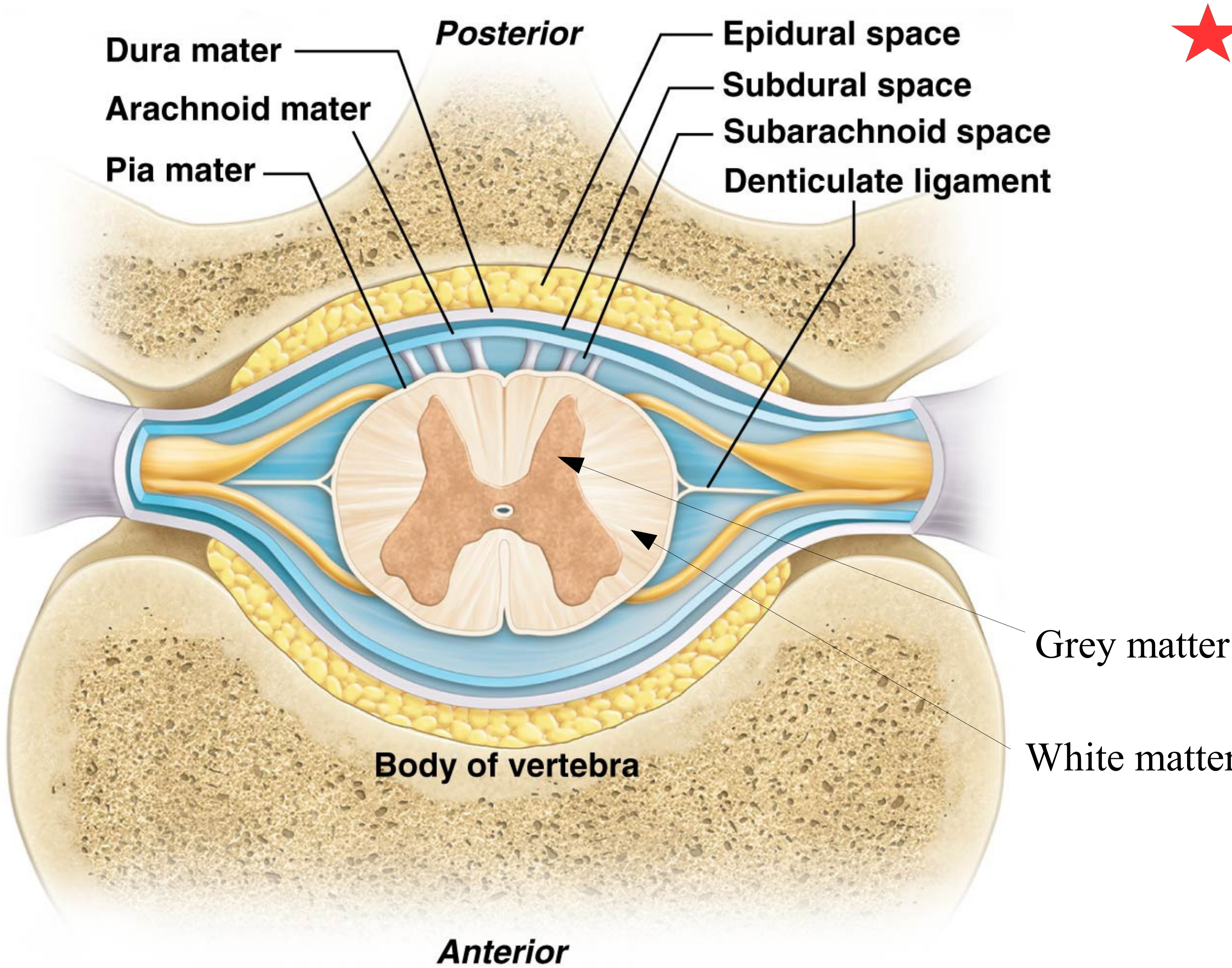
(a) Anterior view and transverse section through spinal cord

Arachnoid Mater

arachnoid membrane - layer of simple squamous epithelium lining dura mater and a loose mesh of collagenous and elastic fibers spanning the gap between the arachnoid membrane and the pia mater

subarachnoid space – gap between arachnoid membrane and the pia mater /// filled with cerebrospinal fluid (CSF)

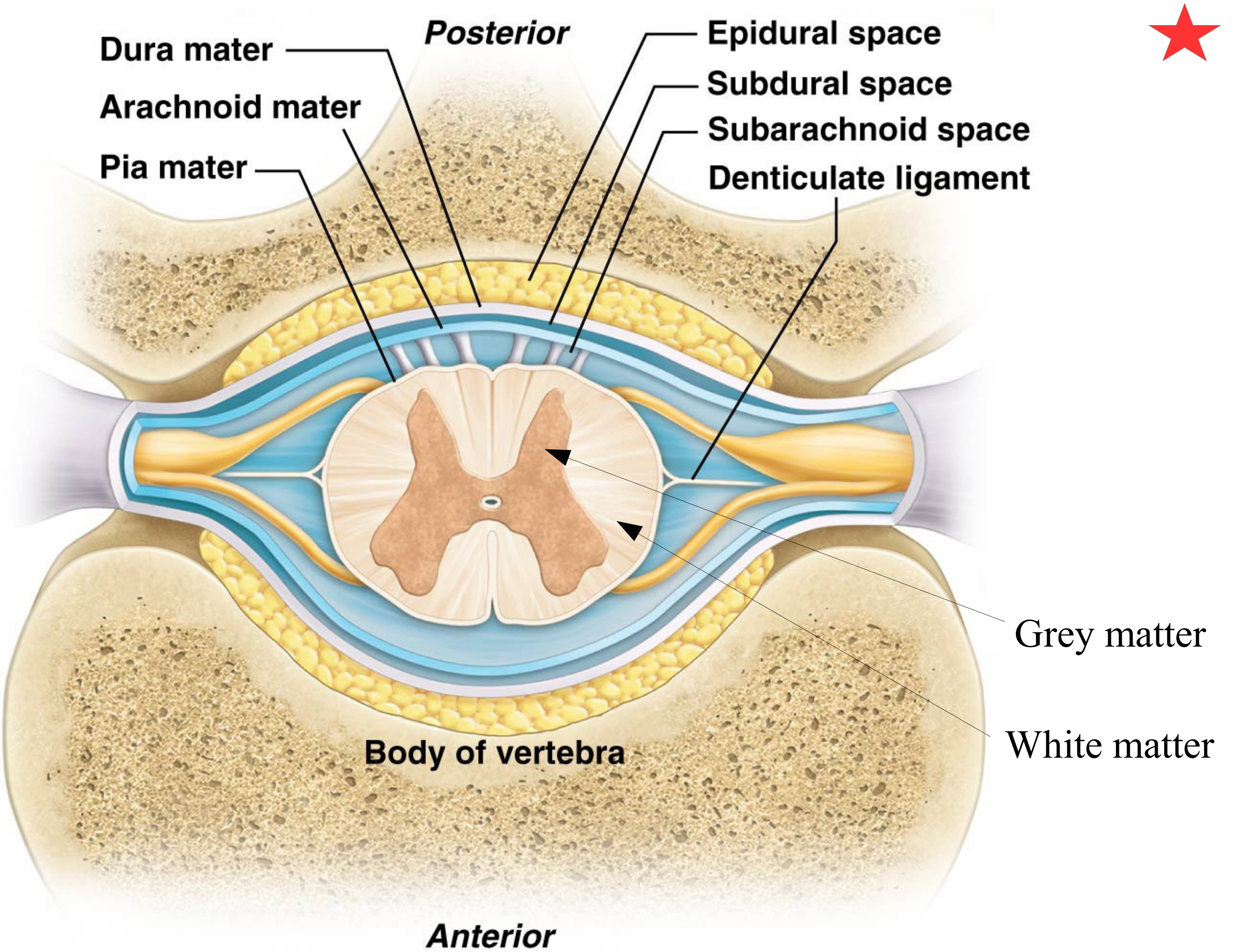
lumbar cistern – subarachnoid space inferior to medullary cone that contains cauda equina and CSF



(b) Spinal meninges and spinal cord, transverse section

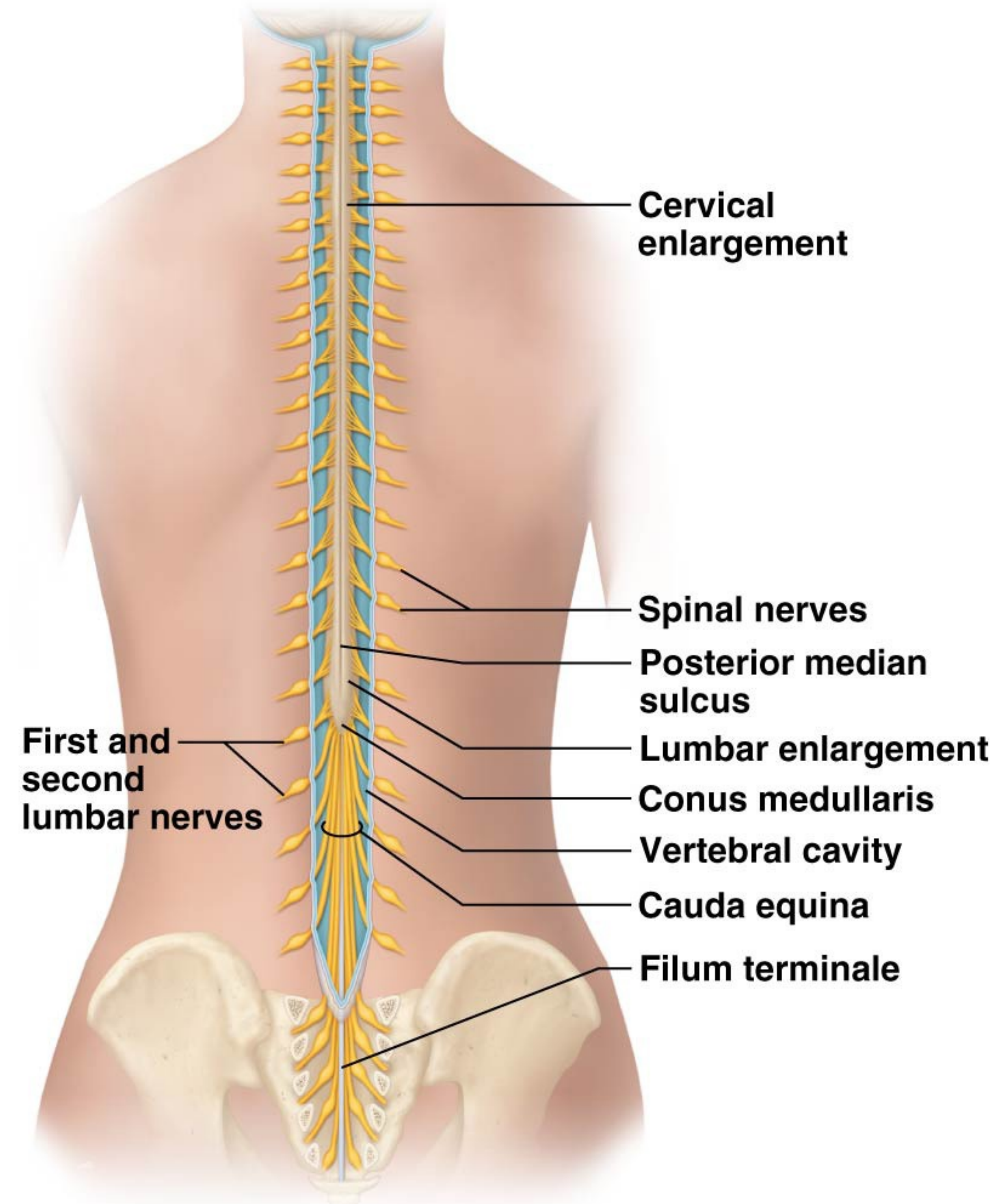
Pia Mater

- delicate, translucent membrane that follows the contours of the spinal cord
- terminal filum – fibrous strand of pia mater that extends beyond the medullary cone within the lumbar cistern
- coccygeal ligament – formed from fusion of terminal filum and dura mater // anchors the cord and meninges to vertebra Co1
- denticulate ligaments – pia mater extends through the arachnoid mater to the dura mater // anchors spinal cord to limit side to side movement

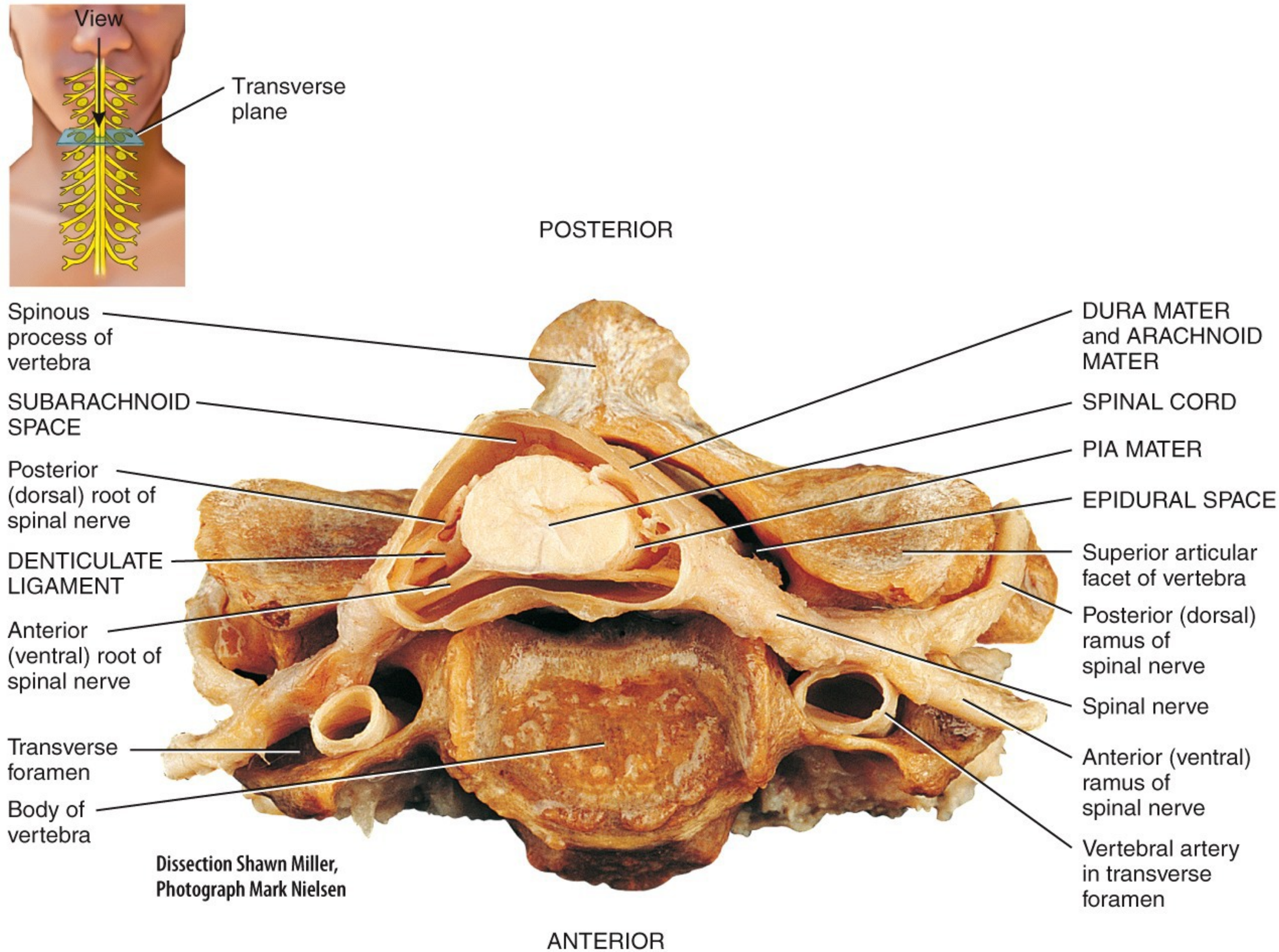


(b) Spinal meninges and spinal cord, transverse section

External structure of the spinal cord.

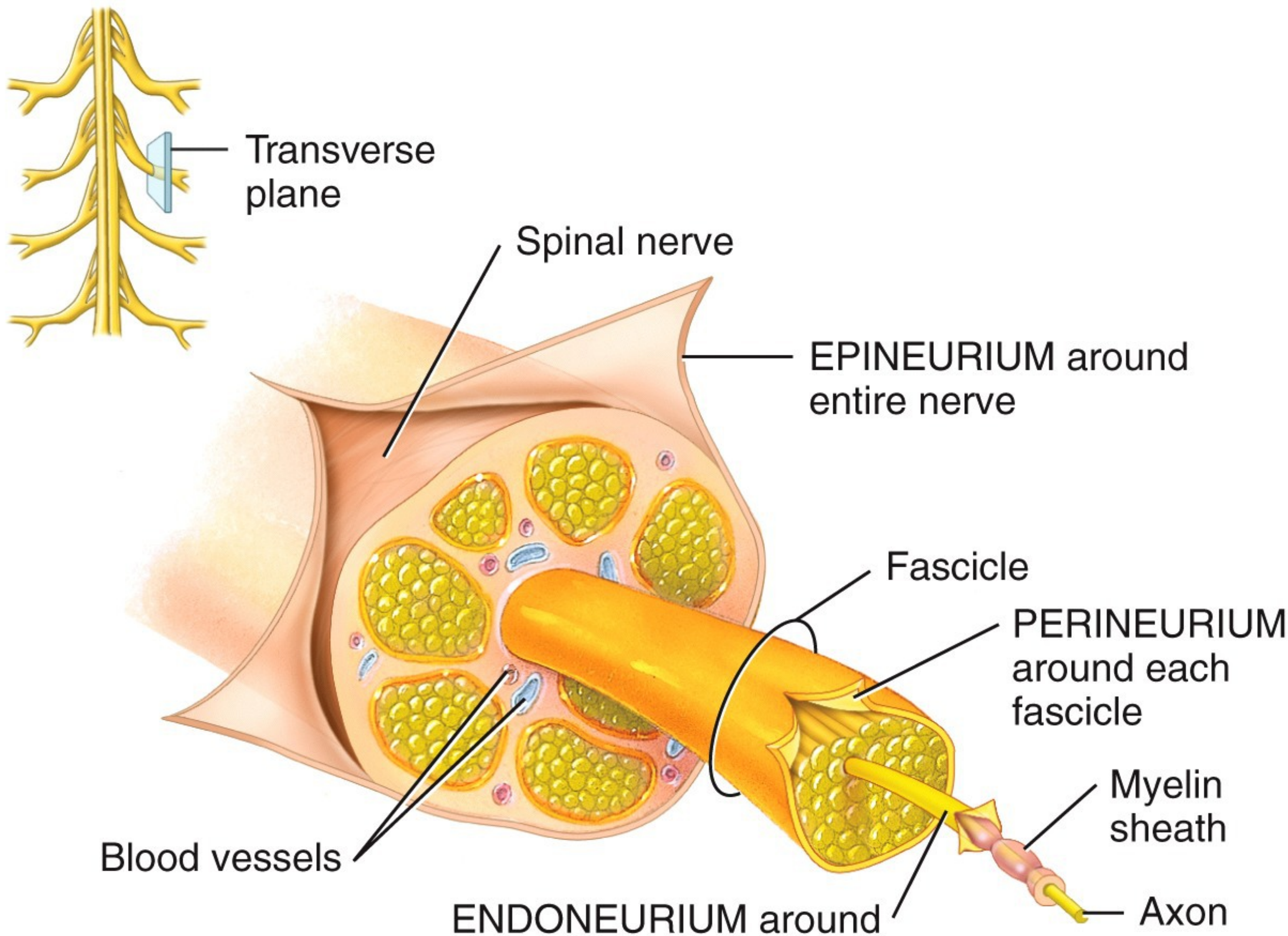


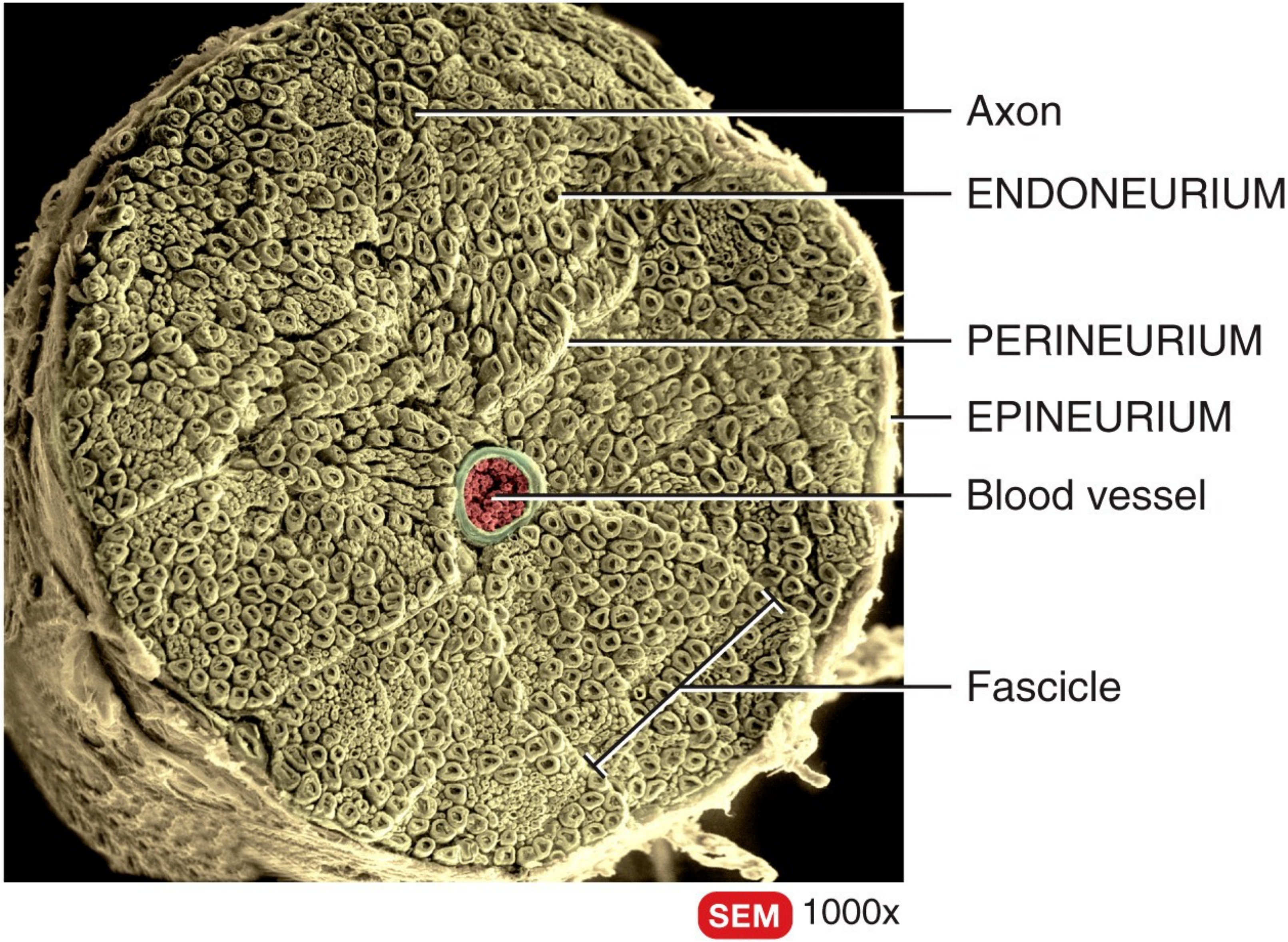
(a) Spinal cord, posterior view



(b) Transverse section of the spinal cord within a cervical vertebra

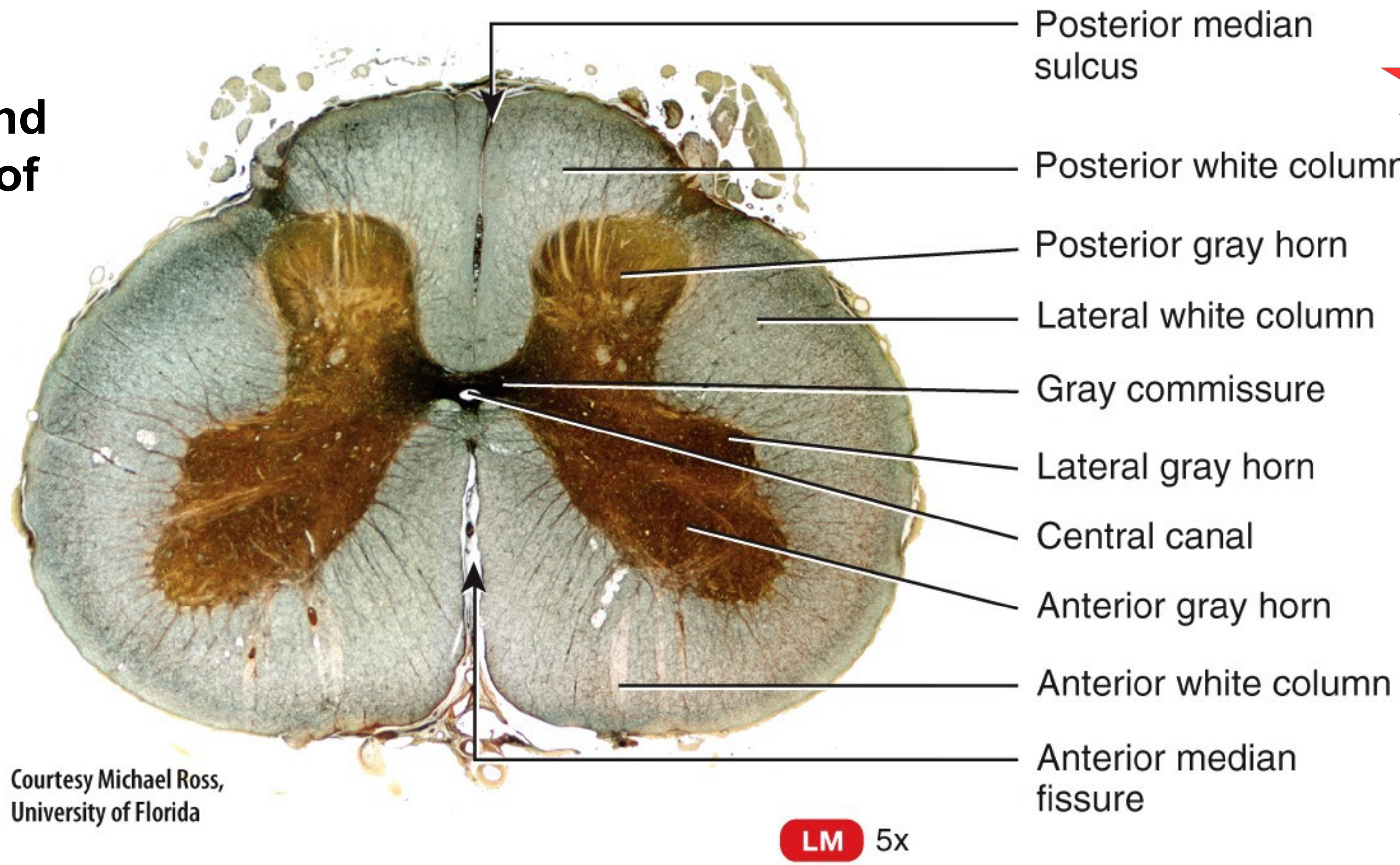
Connective Tissue Surrounding Spinal Nerve





(b) Transverse section of several nerve fascicles

Grey Matter and White Matter of Spinal Cord



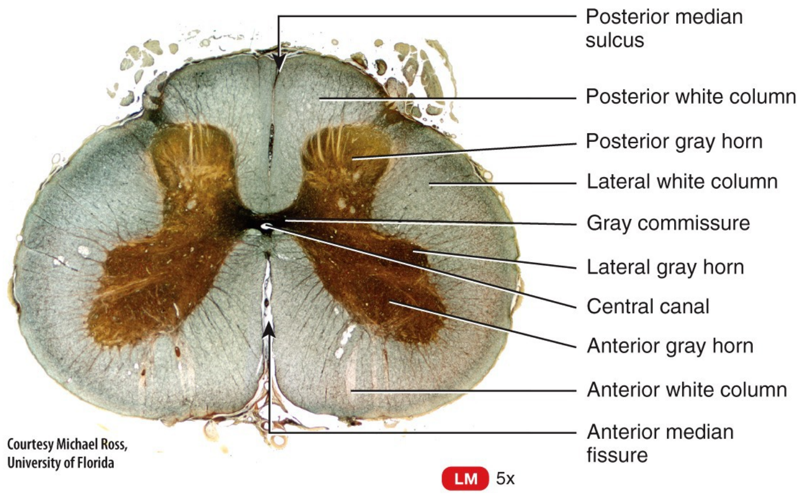
(b) Transverse section of lumbar spinal cord

central area of gray matter shaped like a butterfly and surrounded by white matter in 3 columns // white areas = tracts

gray matter - neuron cell bodies with little myelin // site of information processing – synaptic integration // grey matter = horns

white matter – abundantly myelinated axons // carry signals from one part of the CNS to another

Functions of the Spinal Cord Horns



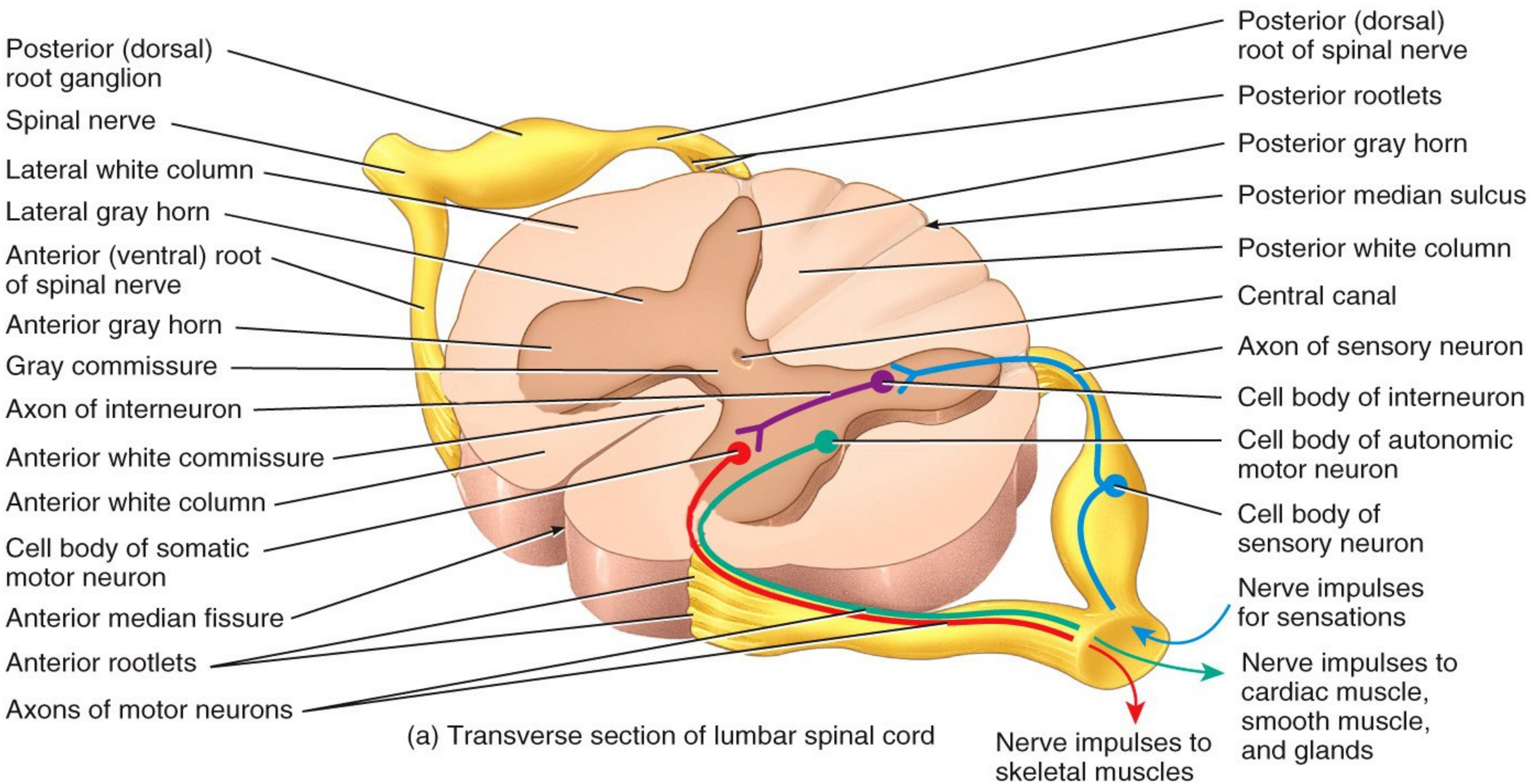
(b) Transverse section of lumbar spinal cord

Grey commissure connects right and left sides // punctured by a central canal lined with ependymal cells and filled with CSF

- **Posterior grey horns / cell bodies and axons of interneurons + incoming sensory neurons form dorsal root ganglion**
- **Anterior grey horns / somatic motor nuclei to skeletal muscles (LMN /// local motor neurons)**
- **Lateral grey horns / only in thoracic and upper lumbar / contain autonomic motor nuclei / regulate smooth muscle – cardiac muscle - glands**

Spinal Cord Horns

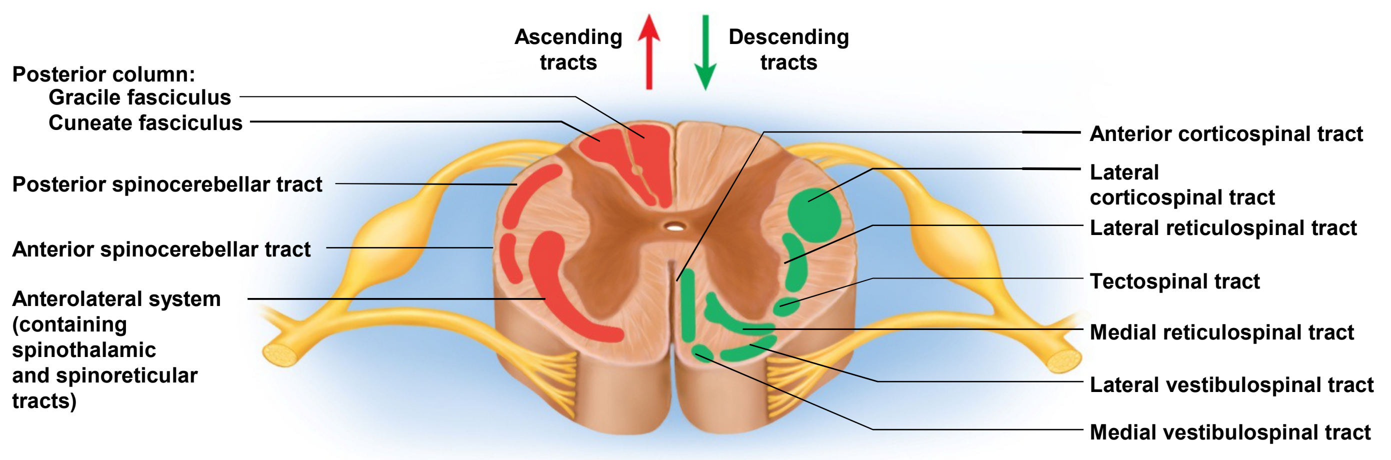
Posterior, Anterior, and Lateral



(a) Transverse section of lumbar spinal cord

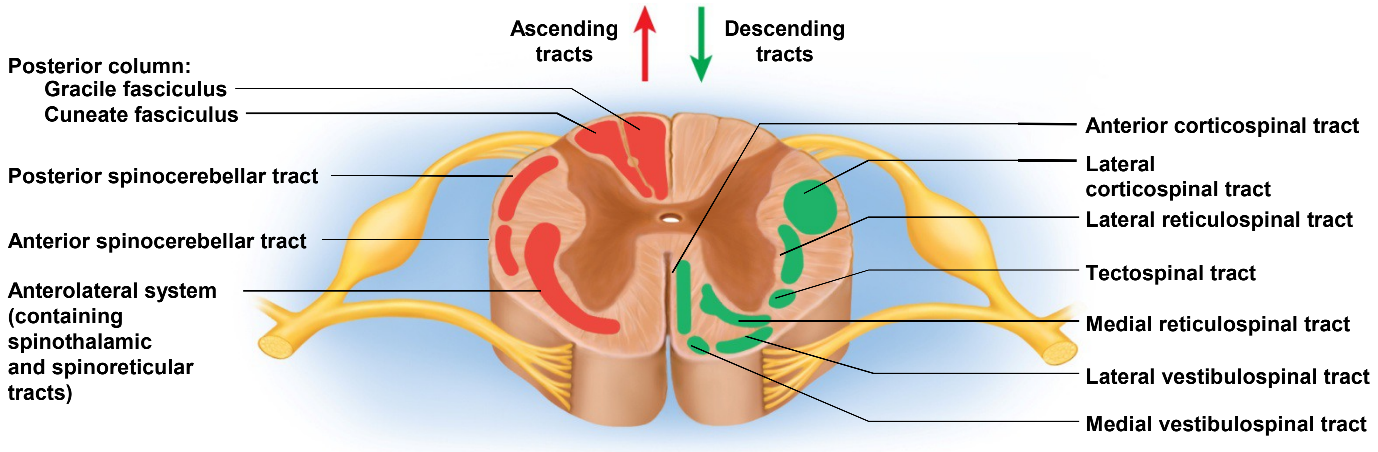
White Matter "Tracts" of the Spinal Cord

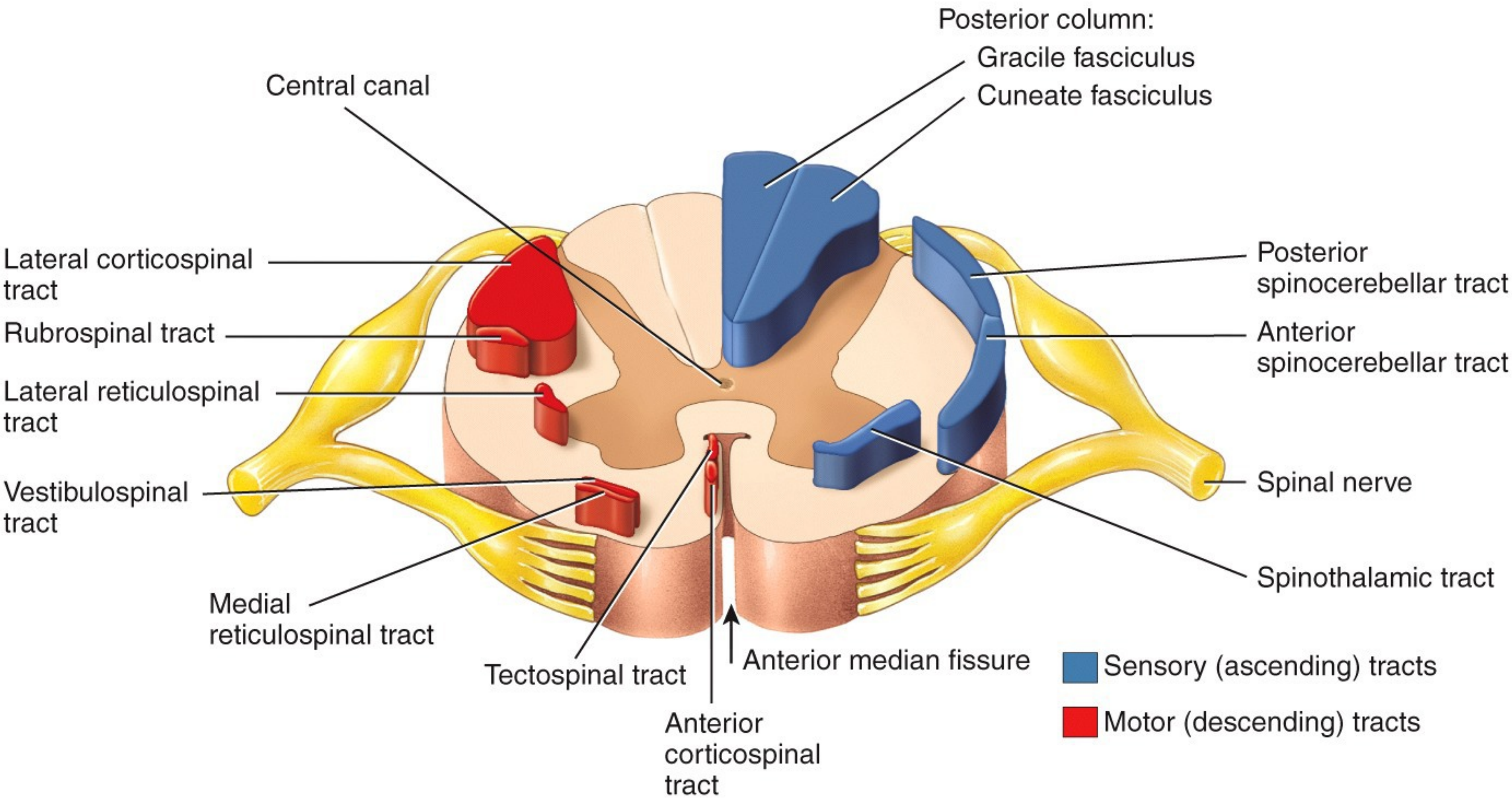
- White matter surrounds the gray matter in spinal cord
- White matter is bundles of axons that course up and down the cord (i.e. arranged in fasicles)
- Provide pathway of communication between CNS and PNS target tissues



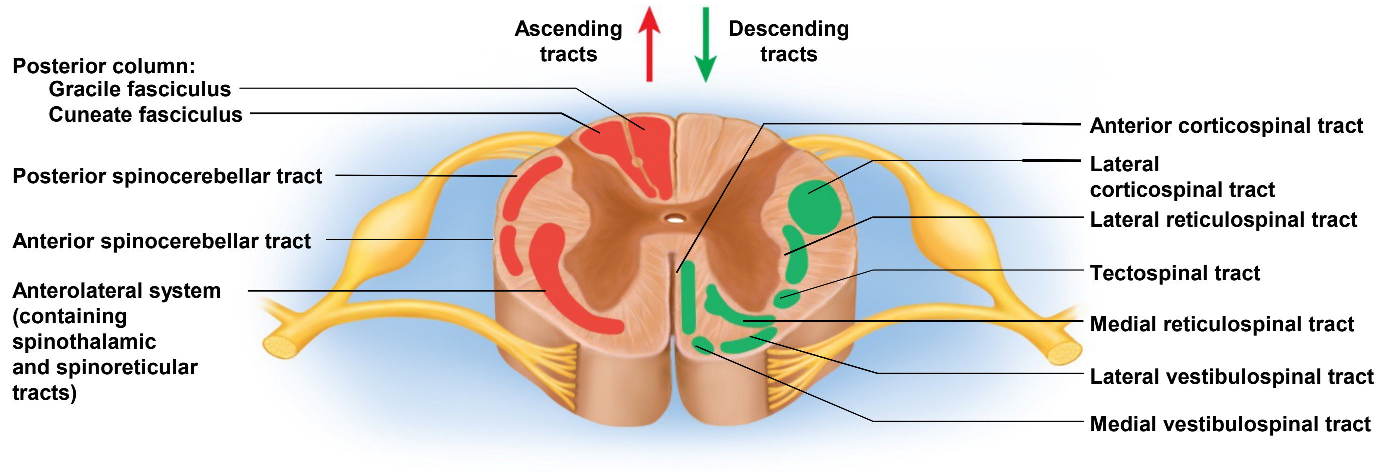
White Matter in the Spinal Cord

- columns or funiculi – three pair of these white matter bundles
  - Posterior columns (dorsal)
  - Lateral columnsl
  - Anterior columns (ventral)
- tracts or fasciculi – subdivisions of each column



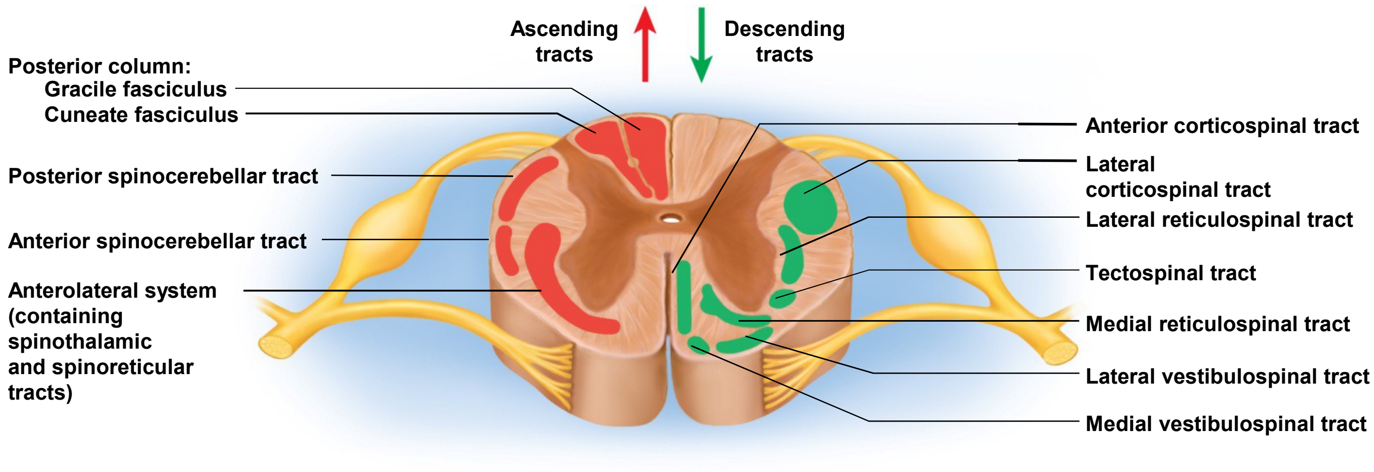

Posterior column:
Gracile fasciculus
Cuneate fasciculus
Central canal
Lateral corticospinal tract
Rubrospinal tract
Lateral reticulospinal tract
Vestibulospinal tract
Medial reticulospinal tract
Tectospinal tract
Anterior corticospinal tract
Anterior median fissure
Posterior spinocerebellar tract
Anterior spinocerebellar tract
Spinal nerve
Spinothalamic tract
Sensory (ascending) tracts
Motor (descending) tracts

Spinal Tracts



- ascending tracts – carry sensory information up the spinal cord
- descending tracts – carry motor information down the spinal cord // all nerve fibers in a given tract have a similar origin, destination, and function
- decussation – as the fibers pass up or down the brain stem and spinal cord they cross over from the left to the right side and vise versa

Spinal Tracts



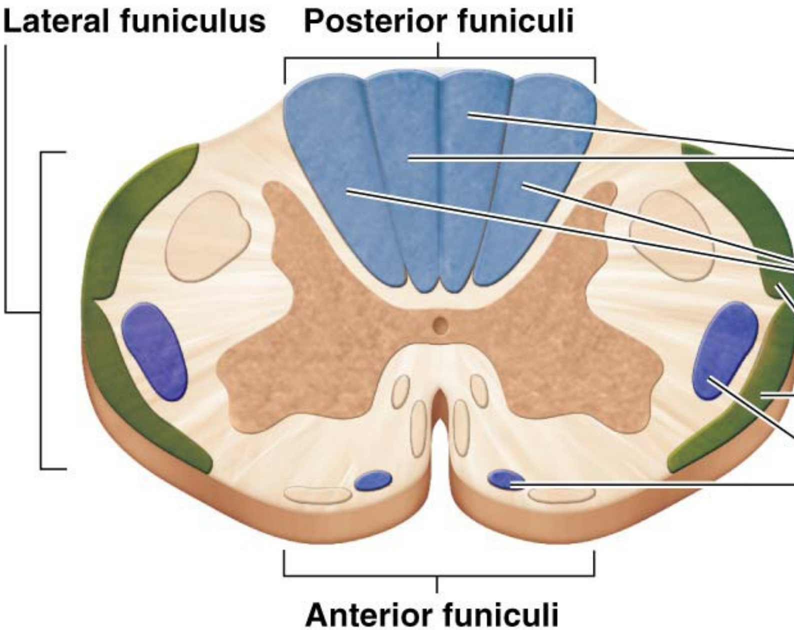
- contralateral – when the origin and destination of a tract are on opposite sides of the body
- ipsilateral – when the origin and destination of a tract are on the same side of the body // does not decussate

Ascending Tracts

- ascending tracts carry sensory signals up the spinal cord // sensory to the brain
- sensory signals travel across three neurons from origin in receptors to the destination in the sensory areas of the brain // typical pattern
  - first order neurons – detect stimulus and transmit signal to spinal cord or brain-stem
  - second order neurons – continues to the thalamus at the upper end of the brain-stem
  - third order neurons – carries the signal the rest of the way to the sensory region of the cerebral cortex

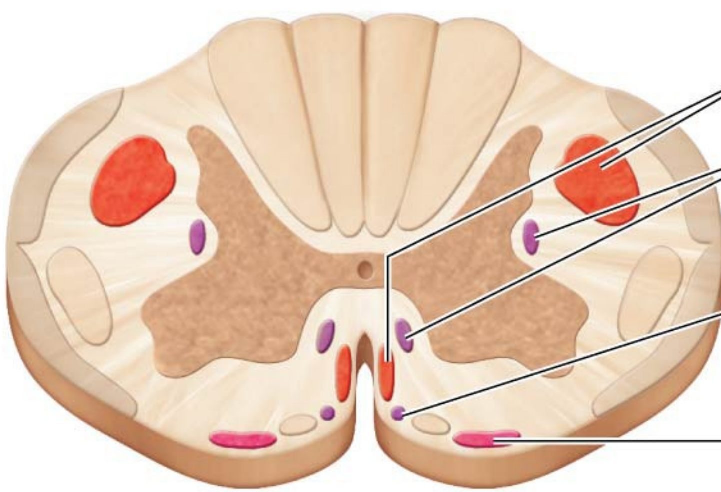
Major Ascending Tracts

- cuneate fasciculus (above T6)
- gracile fasciculus (below T6)
- spinothalamic tract
- spinoreticular tract
- spinocerebellar tracts - posterior and anterior



ASCENDING TRACT	FUNCTION
Posterior columns—fasciculus gracilis	• Carry somatosensory information including fine touch, vibration, and proprioception from the lower limbs
Posterior columns—fasciculus cuneatus	• Carry somatosensory information including fine touch, vibration, and proprioception from the trunk, neck, and upper limbs
Spinocerebellar tracts	• Carry proprioceptive information to the cerebellum
Anterolateral system—spinothalamic tracts	• Carry information about pain, temperature, and certain types of touch

(a) Ascending tracts (sensory)

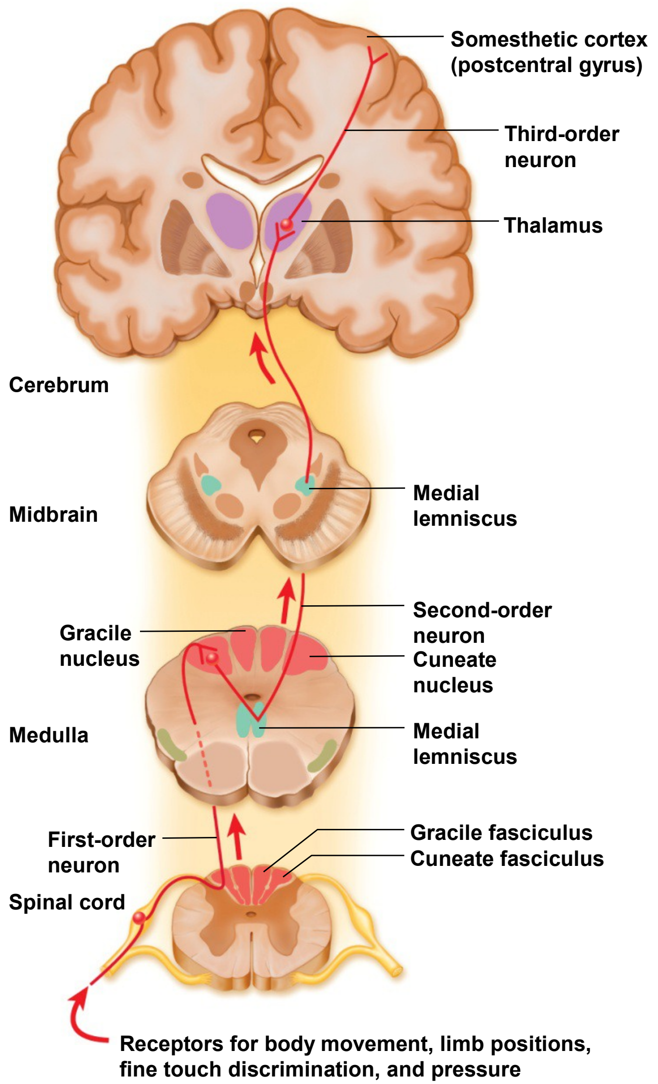


DESCENDING TRACT	FUNCTION
Corticospinal tracts	• Carry motor information from the motor areas of the cerebral cortex
Reticulospinal tracts	• Carry motor information from the brainstem • Important for the maintenance of posture and proper orientation of the limbs during movement
Tectospinal tract	• Carries motor information from the superior colliculus of the brainstem • Important for reflexive movement of the head and eyes
Vestibulospinal tract	• Carries motor information from vestibular nuclei in the brainstem • Important for the maintenance of posture and balance

(b) Descending tracts (motor)

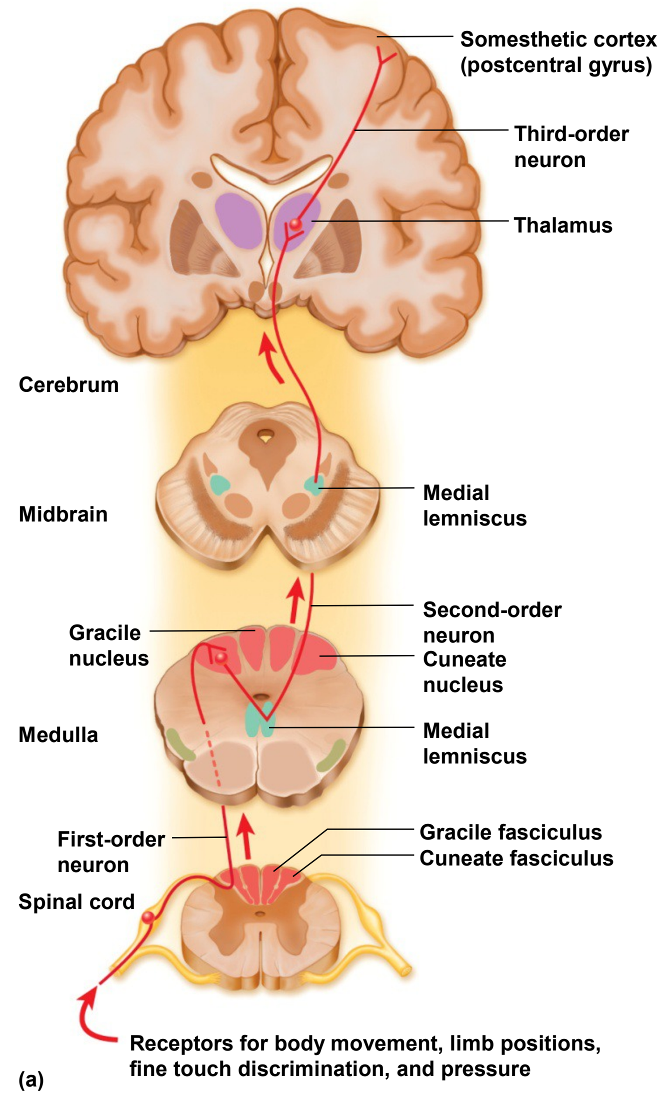
Cuneate Fasciculus // Ascending

- originate at the level of T6 and above // upper limb and chest
- joins gracile fasciculus at T6
- occupies lateral portion of the posterior column // forces gracile fasciculus medially
- these are somatosensory (somesthetic) which are conscious signals
- carries signals for vibration, visceral pain, deep and discriminating touch, and proprioception from upper limbs, upper truck and and neck
- fibers end in the cuneate nucleus on the ipsilateral side of the medulla oblongata
- What is proprioception? Called the forgotten sensation // non-visual sensation for the position and movement of the body from receptors located in skeletal muscles / CF is a conscious pathway



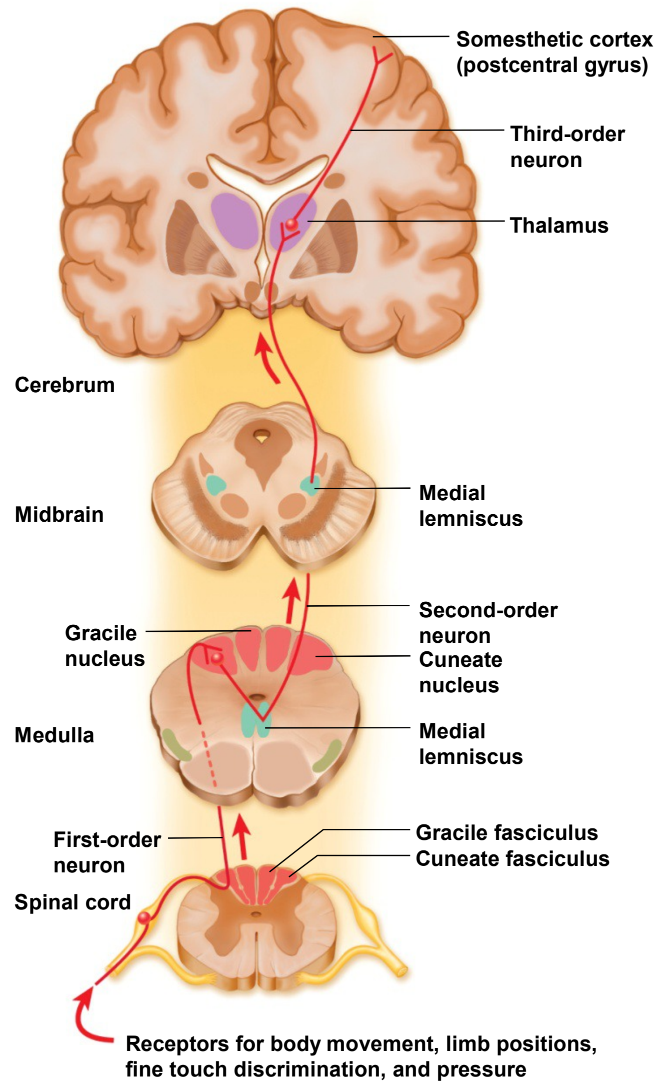
Gracile Fasciculus // Ascending

- carries signals from midthoracic and lower parts of the body
- below T6, it composes the entire posterior column // at T6 joins cuneate fasciculus
- consists of first-order nerve fibers that travel up the ipsilateral side of the spinal cord
- terminates at the gracile nucleus of the medulla oblongata
- carries signals for vibration, visceral pain, deep and discriminating touch, and proprioception from lower limbs and lower trunk



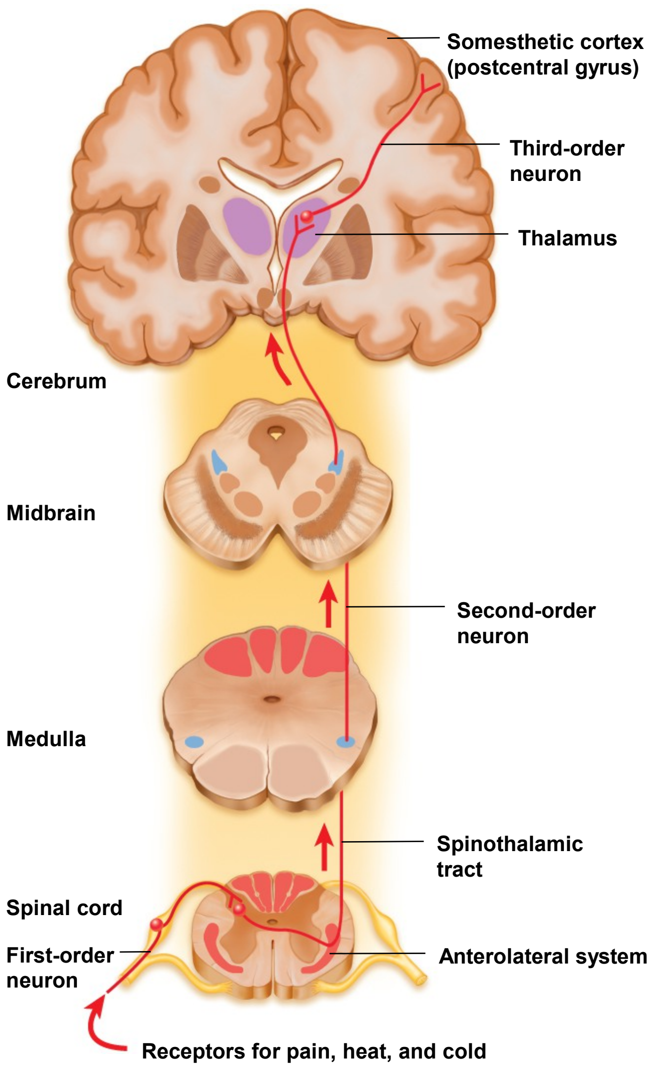
Medial Lemniscus

- medial lemniscus // formed from the second-order neurons of gracile and cuneate systems that decussate in the medulla
  - tracts of these nerve fibers lead the rest of the way to the thalamus
  - third-order neurons go from thalamus to cerebral cortex
  - carry signals to contralateral cerebral hemisphere



Spinothalamic Pathway // Ascending

- one of the smaller tracts of the anterolateral system /// passes up the anterior and lateral columns of the spinal cord
- carry signals for pain, pressure, temperature, light touch, tickle, and itch
- first-order neurons end in posterior horn of spinal cord
- synapse with second-order neurons which decussate to other side of spinal cord and form the ascending spinothalamic tract that goes to the thalamus
- third-order neurons continue from there to cerebral cortex
- sends signals to the contralateral cerebral hemisphere
- these are also conscious signals



(b)

Spinoreticular Tract // Ascending

- travel up the anterolateral system
- carries pain signals resulting from tissue injury
- first-order neurons enter posterior horn and immediately synapse with second-order neurons
- decussate to opposite anterolateral system
  - ascends the cord // end in reticular formation – loosely organized core of gray matter in the medulla and pons
- *third-order neurons* continue from the pons to the thalamus
- *fourth-order neurons* complete the path to the cerebral cortex (Note: exception to the rule!)

Spinocerebellar Tracts // Ascending

- travel through lateral column
- carry proprioceptive signals from limbs and trunk to the cerebellum
- first-order neurons originate in the muscles and tendons // end in posterior horn of the spinal cord
- second-order nerves ascend spinocerebellar tracts and end in cerebellum
  - fibers of the posterior tract travel up the ipsilateral side of the spinal cord
  - fibers of the anterior tract cross over and travel up the contralateral side // cross back in the brainstem to enter the ipsilateral side of the cerebellum
- provide cerebellum with feedback needed to coordinate muscle actions // **subconscious knowledge** of muscle's actual performance

Corticospinal Tracts = Descending or Motor Tracts

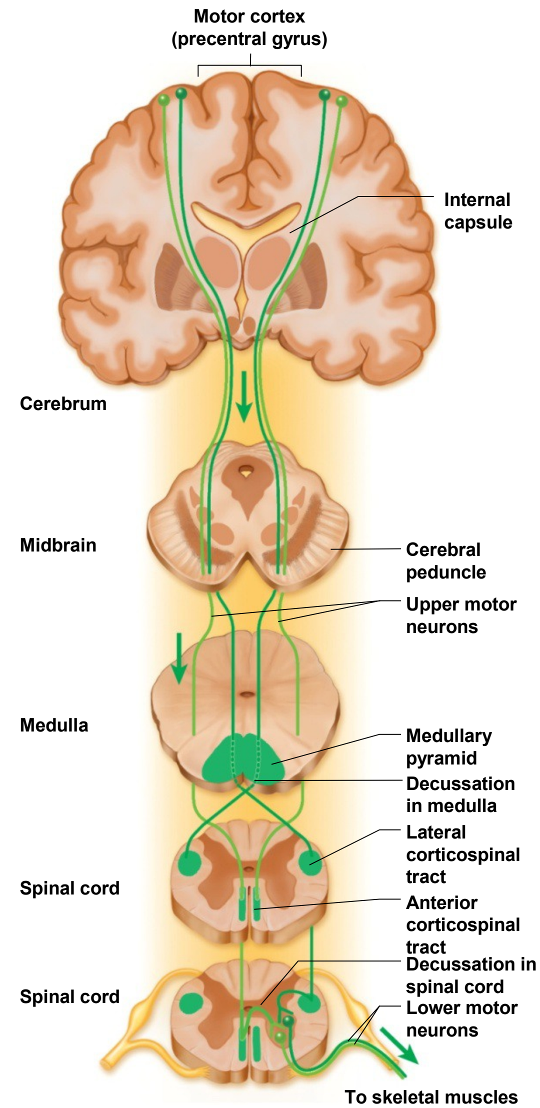
- from cerebral cortex to innervate skeletal muscles // lateral corticospinal tract for finely coordinated movement of our skeletal muscles in **arms and legs**

- Travel down medulla to form the pyramids – ridges on anterior surface of the medulla oblongata formed from fibers of this system

- decussate in lower medulla

- lateral corticospinal tract on contralateral side of spinal cord

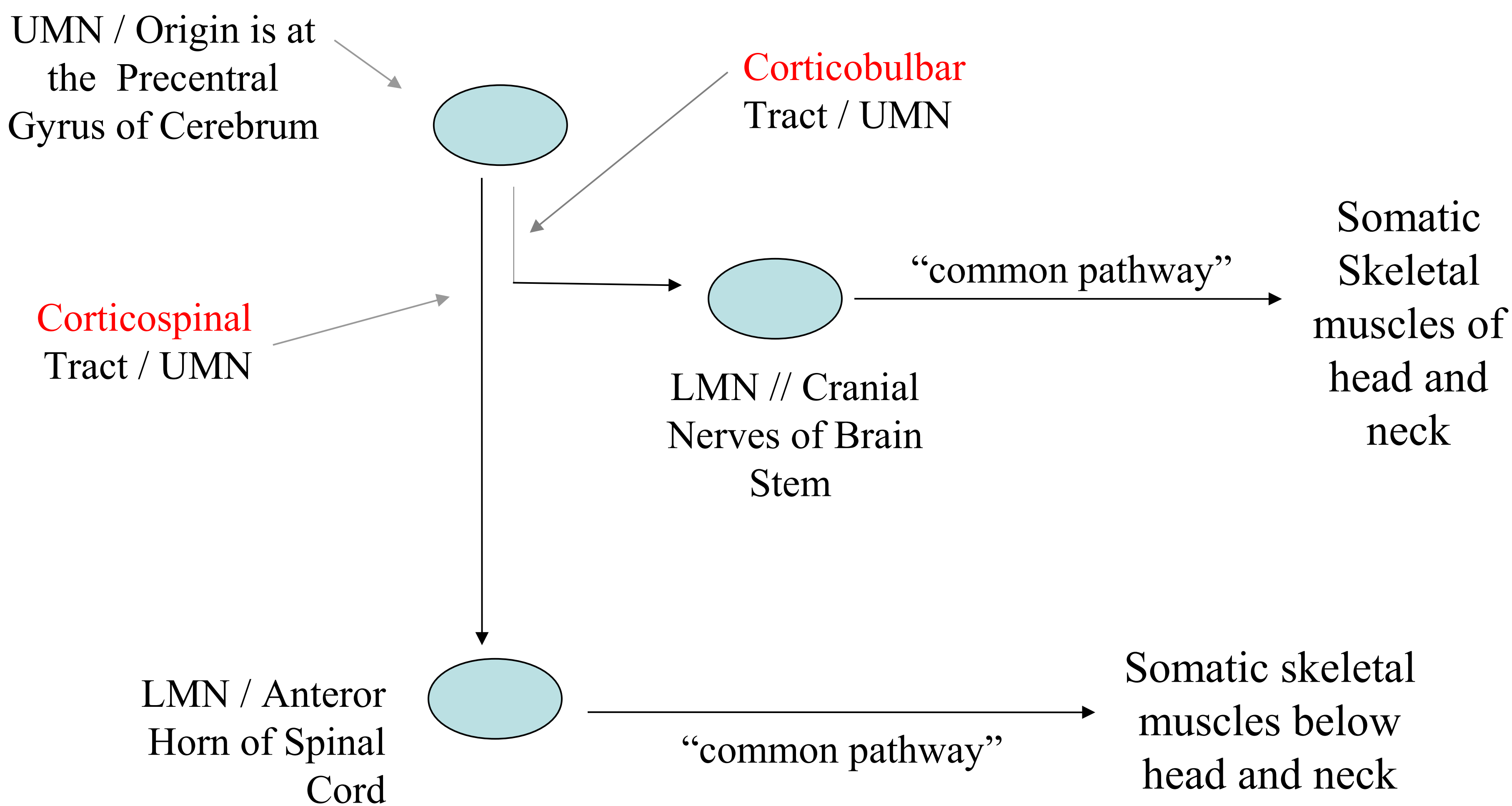
- anterior (ventral) corticospinal tract on ipsilateral side of spinal cord



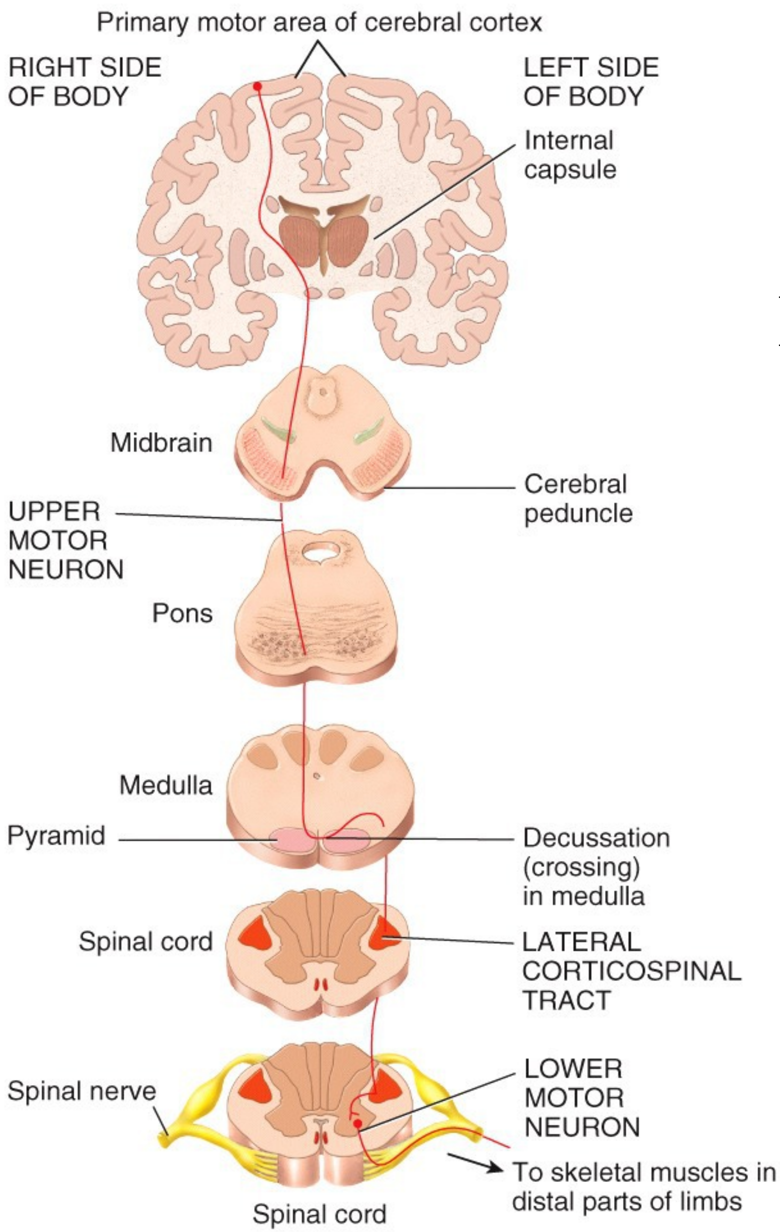
The Descending Motor Pathway From the Precentral Gyrus to Skeletal Muscles

(Upper and Lower Motor Neurons)

Pathways = Axon Tracts

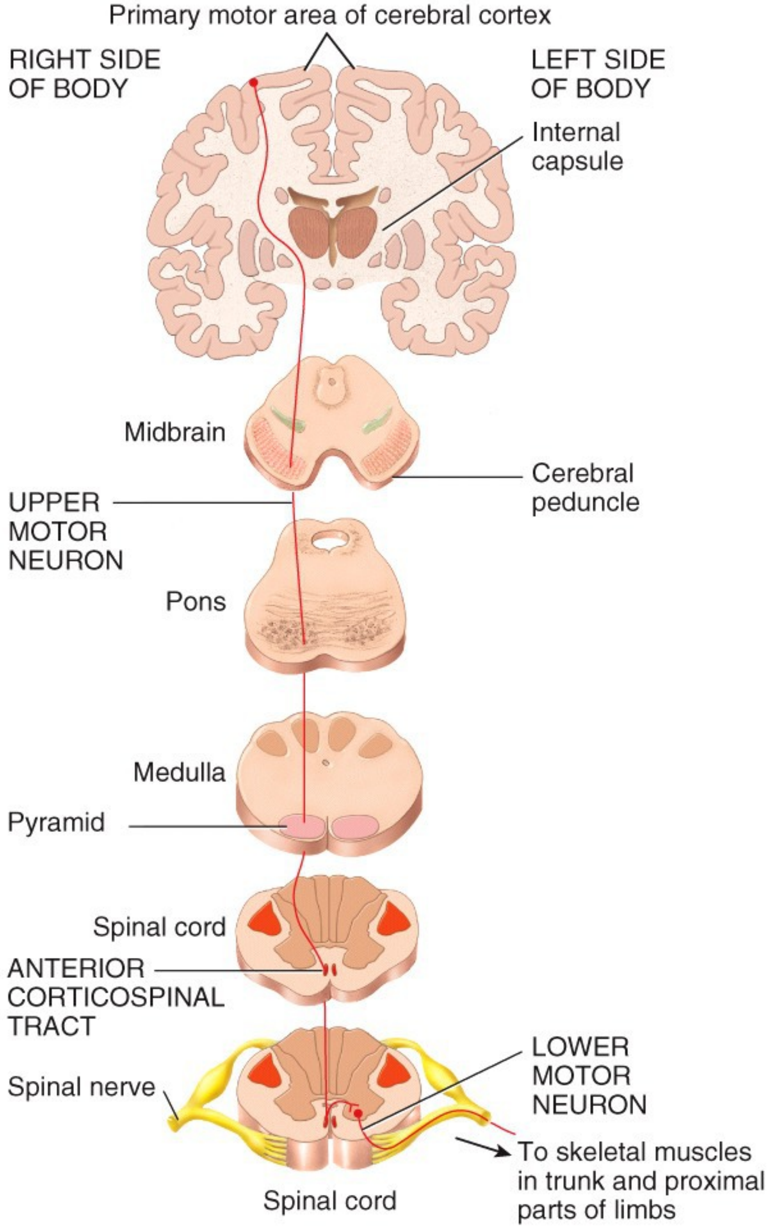


Lateral Corticospinal Pathway



(a) The lateral corticospinal pathway

Anterior Corticospinal Pathway



(b) The anterior corticospinal pathway

Descending “Pyramidal Tract”

- Tracts from precentral gyrus (motor strip) carry action potentials down through the brainstem and spinal cord

- Pathways from precentral gyrus are voluntary pathways used to control skeletal muscles in arms and legs /// consist of upper and lower motor neurons

- Two different upper motor neuron tracts // synapse on their lower motor neurons

  - Corticospinal = upper motor neuron /// synapse with anterior horn neurons = lower motor neuron // innervate skeletal muscles

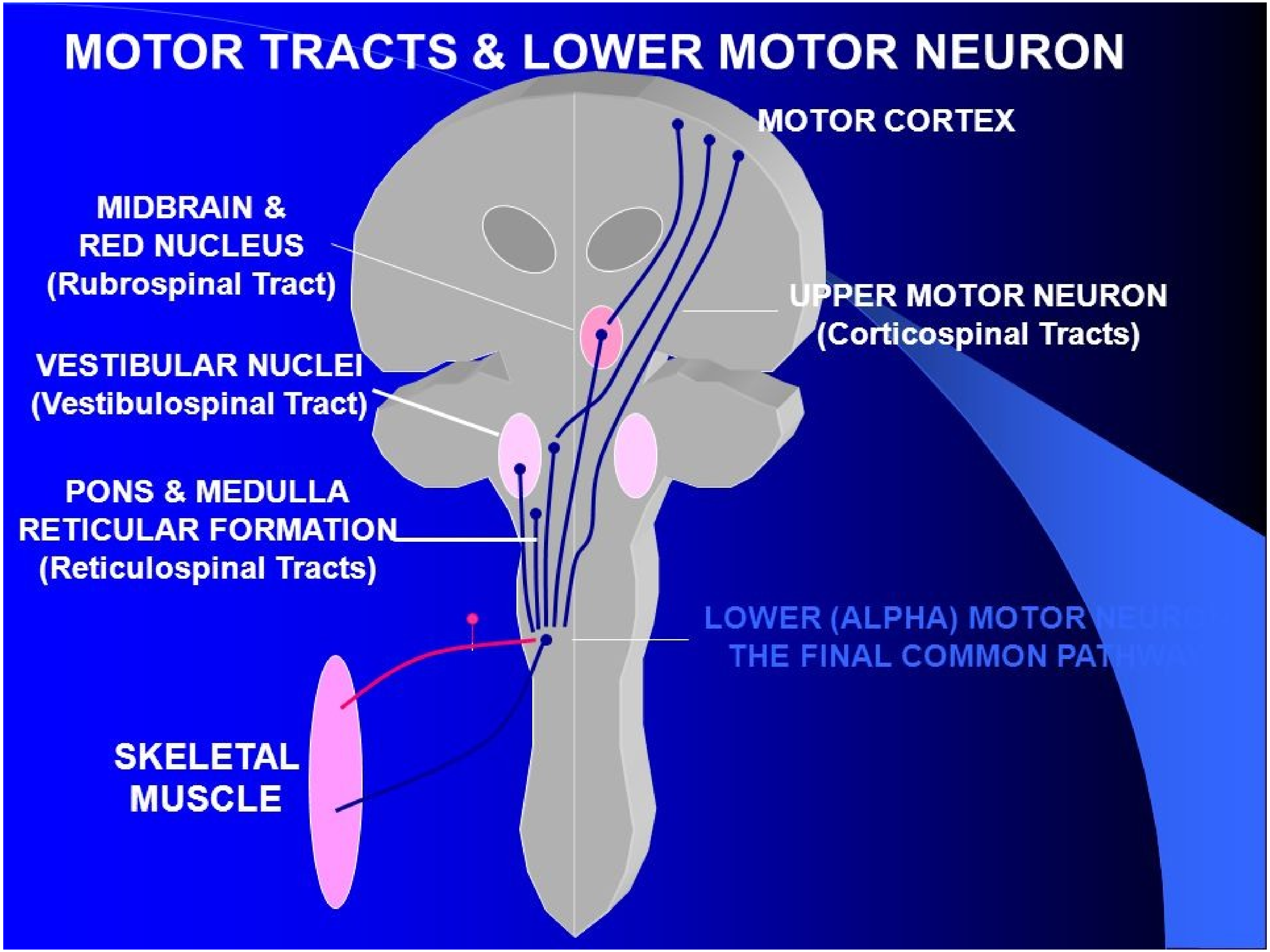
  - Corticobulbar = upper motor neuron / synapse with cranial nerves = lower motor neuron /// innervate skeletal muscles in head and neck

- About lower motor neurons for corticospinal tract /// LMN soma in the anterior horn // LMN called common pathway

- About lower motor neurons for corticobulbar tract /// LMN soma are cranial nerves' nuclei in brainstem // LMN called common pathway

Descending Extrapyramidal Motor Tracts (Pyramidal VS Extrapyramidal)

- Both carry motor signals down the brain-stem and spinal cord
- Pyramidal = voluntary // origin = precentral gyrus also called the motor strip
- Extrapyramidal = involuntary (plus influence voluntary) // origin = subcortical nuclei
  - Modify descending signals from pyramidal tracks
  - These subcortical nuclei also function as reflex centers sensitive to different stimuli
  - May cause involuntary skeletal muscle contractions from various stimuli.
  - (Tectospinal / vestibulospinal / rubriospinal / reticularspinal tracts)/



Pyramidal = voluntary // origin = precentral gyrus also called the motor strip

Extrapyramidal = involuntary + influence voluntary // origin = subcortical nuclei

Extrapyramidal Motor Tracts

- Tectospinal tract – begins in midbrain region (tectum)
  - crosses to contralateral side of midbrain
  - reflex turning of head in response to sights and sounds
- Reticulospinal tract
  - originate in the reticular formation of brainstem
  - controls muscles of upper and lower limbs // especially those for posture and balance //
  - send signals to "gama fibers" of the muscle spindle to adjust "sensitivity" of the muscle spindle in the "stretch reflex" - how the CNS can influence the "stretch reflex"
  - contain descending analgesic pathways // reduce the transmission of pain signals to brain

Extrapyramidal Motor Tracts

Rubiospinal tract /// It is one of the pathways for the mediation of voluntary movement. The tract is responsible for large muscle movement as well as fine motor control, and it terminates primarily in the cervical spinal cord, suggesting that it functions in upper limb but not in lower limb control. It primarily facilitates flexion in the upper extremities

Vestibulospinal tract /// begins in brainstem vestibular nuclei

<u>receives impulses form vestibular organs of balance from inner ear</u>

<u>controls extensor muscles of limbs for balance control</u>

Responsible for the trip response // activates extensor muscles in the arms and legs.

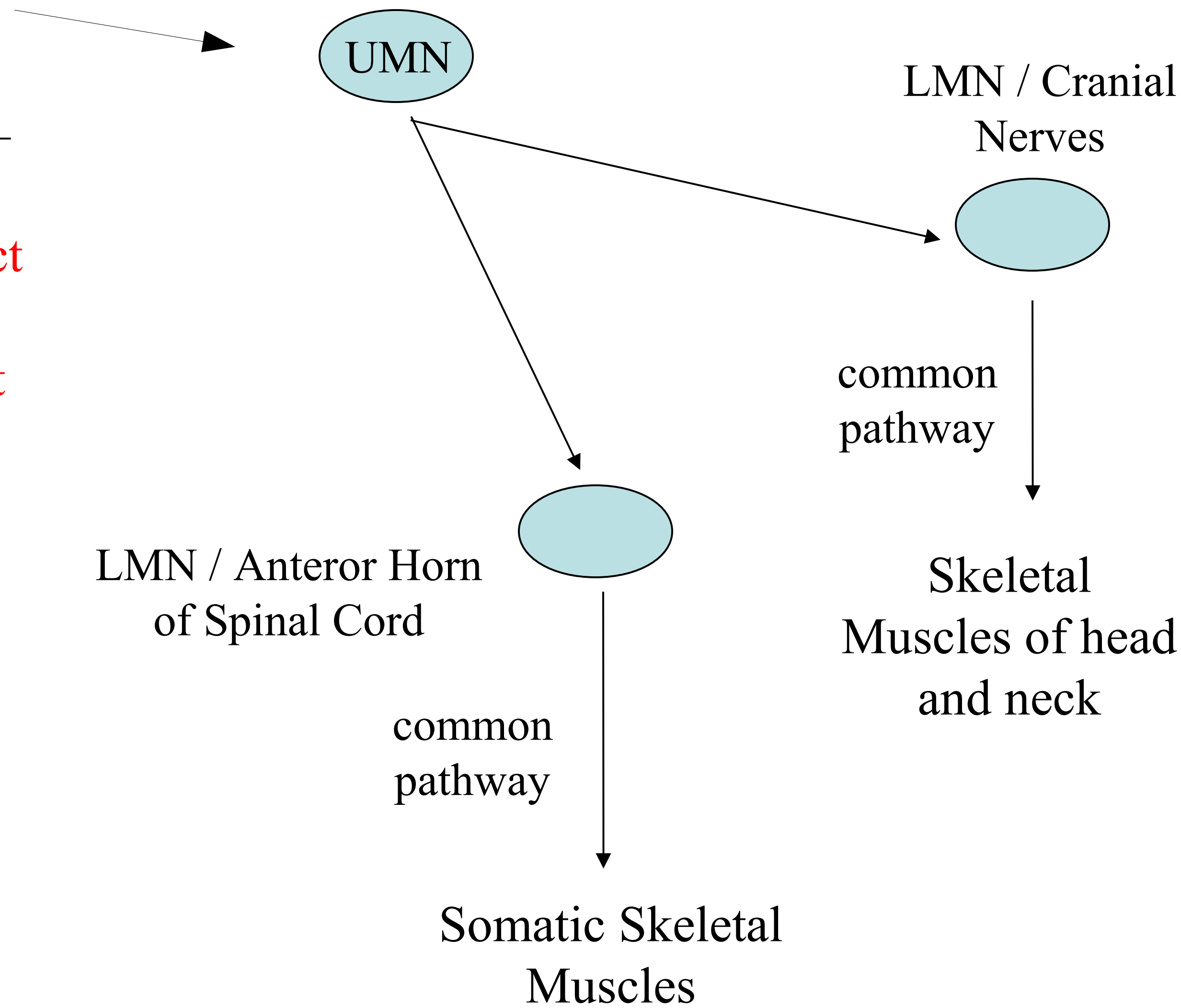
Note: the role of the basal nuclei in motor control will be covered in C14

Descending Extrapyramidal Pathways

Pathways = Axon Tracts

UMN // These **nuclei originate in medulla oblongata**

1. tectospinal tract
2. vestibulospinal tract
3. rubriospinal tract
4. reticularspinal tract



The Descending Extra-Pyramidal Motor Pathways to Skeletal Muscles

- The extrapyramidal system is an important part of the motor system of the body whose fibers pass through the tegmentum rather than the medullary pyramid, therefore distinguishing it from the pyramidal motor system.

- The extrapyramidal system is actively involved in the initiation and selective activation of voluntary movements, along with their coordination.

- This system also regulates the involuntary movements (reflexes), as opposed to the pyramidal system which controls the voluntary movements only.

- Other structures which are involved include the nuclei of the cerebellum and brain stem, as well as the mesencephalic reticular formation.

- All these structures share intricate connections that modulate the motor activity of the body, which is why the extrapyramidal system is also often described as the **motor-modulation system**

The Descending Extra-Pyramidal Motor Pathways to Skeletal Muscles

- Extrapyramidal tracts are chiefly found in the reticular formation of the pons and medulla, and target lower motor neurons in the spinal cord that are involved in reflexes, locomotion, complex movements, and postural control.

- *These tracts are in turn modulated by various parts of the central nervous system, including the nigrostriatal pathway, the basal ganglia, the cerebellum, the vestibular nuclei, and different sensory areas of the cerebral cortex.*

- All of these regulatory components can be considered part of the extrapyramidal system, in that they modulate motor activity without directly innervating motor neurons.

The Basal Nuclei Functions

- The basal nuclei are a group of subcortical nuclei.
- The basal nuclei (use to be called the basal ganglia) is part of the pyramidal system.
    - Consist of the following nuclei: cadate nuclei, putamen, globus pallidus, subthalamic nuclei, substantia nigra
    - Basal ganglia regulate a broad range of functions
    - Basal ganglia acts like a "consultant" to provide either inhibitory or excitation stimulus for the skeletal muscle pathway
    - Positioned between the prefrontal cortex (i.e. executive function) and motor strip // determines if signal will be able to pass through the thalamus
    - Coordinates and smooths out **voluntary skeletal muscle contraction and limits extraneous skeletal muscle contractions** // also functions in cognition – addiction – vision // these and other topic about basal ganglia to be covered in C14

The Cortico-Basal Nuclei-Thalamo-Cortical Loop

The two major input structures of the circuit are the striatum and the subthalamic nucleus (STN).

> The striatum receives inputs from both the cortex and the pars compacta of the substantia nigra (Snc)

> While the STN only receives cortical inputs.

Two pathways emerge from the striatum: Indirect and Direct.

Indirect > One pathway is called the indirect (or NoGo) pathway and is **inhibitory**. This projects to and inhibits the globus pallidus externus (GPe), resulting in the dis-inhibition of the globus pallidus internus (GPi), leading to inhibition of the thalamus. This pathway also, as a result of inhibiting the GPe, disinhibits the subthalamic nucleus, which results in excitation of the GPi, and therefore **inhibition of the thalamus**.

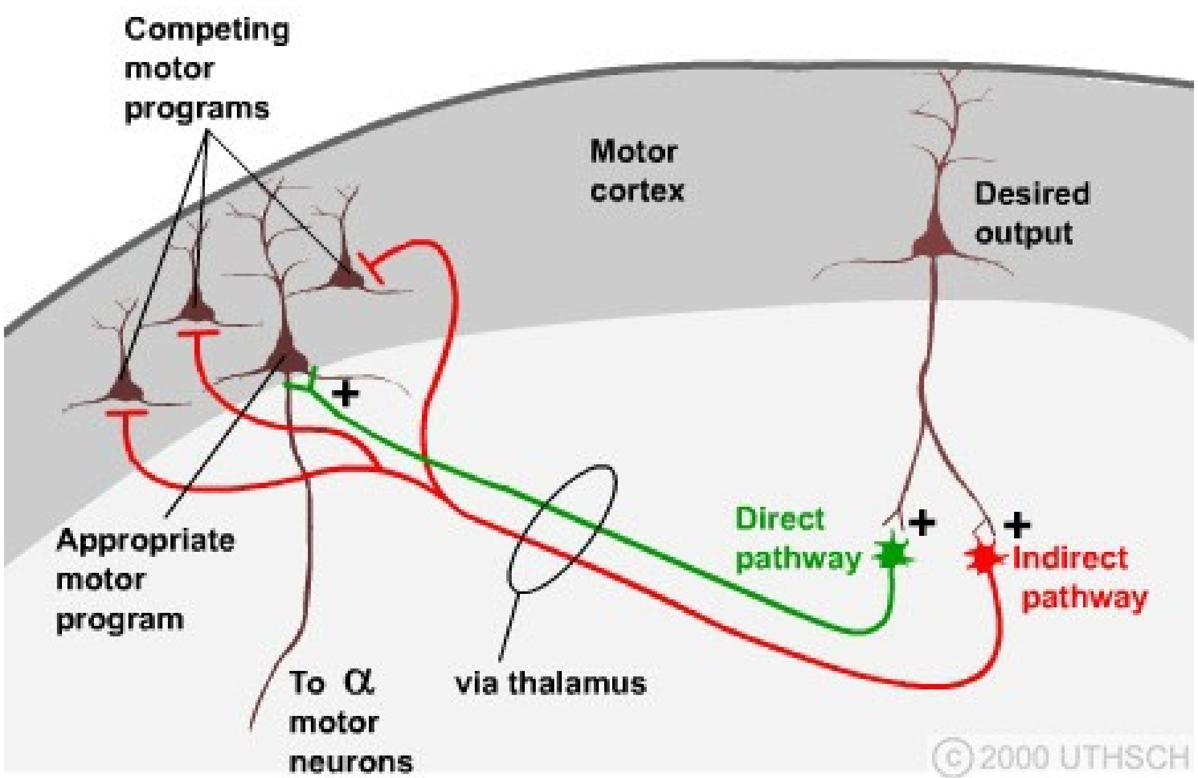
Direct > The second pathway, is called the direct (or Go) pathway and is **excitatory**. This pathway inhibits the GPi, resulting in the **disinhibition of the thalamus**. The direct pathway mostly consists of monosynaptic connections driven by dopamine receptor D1, adenosine A1 receptor, and muscarinic acetylcholine receptor M4, while the indirect pathway relies on connections driven by dopamine receptor D2, adenosine A2A receptor, and muscarinic acetylcholine receptor M1.

Difference Between Direct VS Indirect Pathways

What is the difference between a direct and indirect pathway?

Excitation of the direct pathway has the net effect of exciting thalamic neurons (which in turn make excitatory connections onto cortical neurons).

Excitation of the indirect pathway has the net effect of inhibiting thalamic neurons (rendering them unable to excite motor cortex neurons).



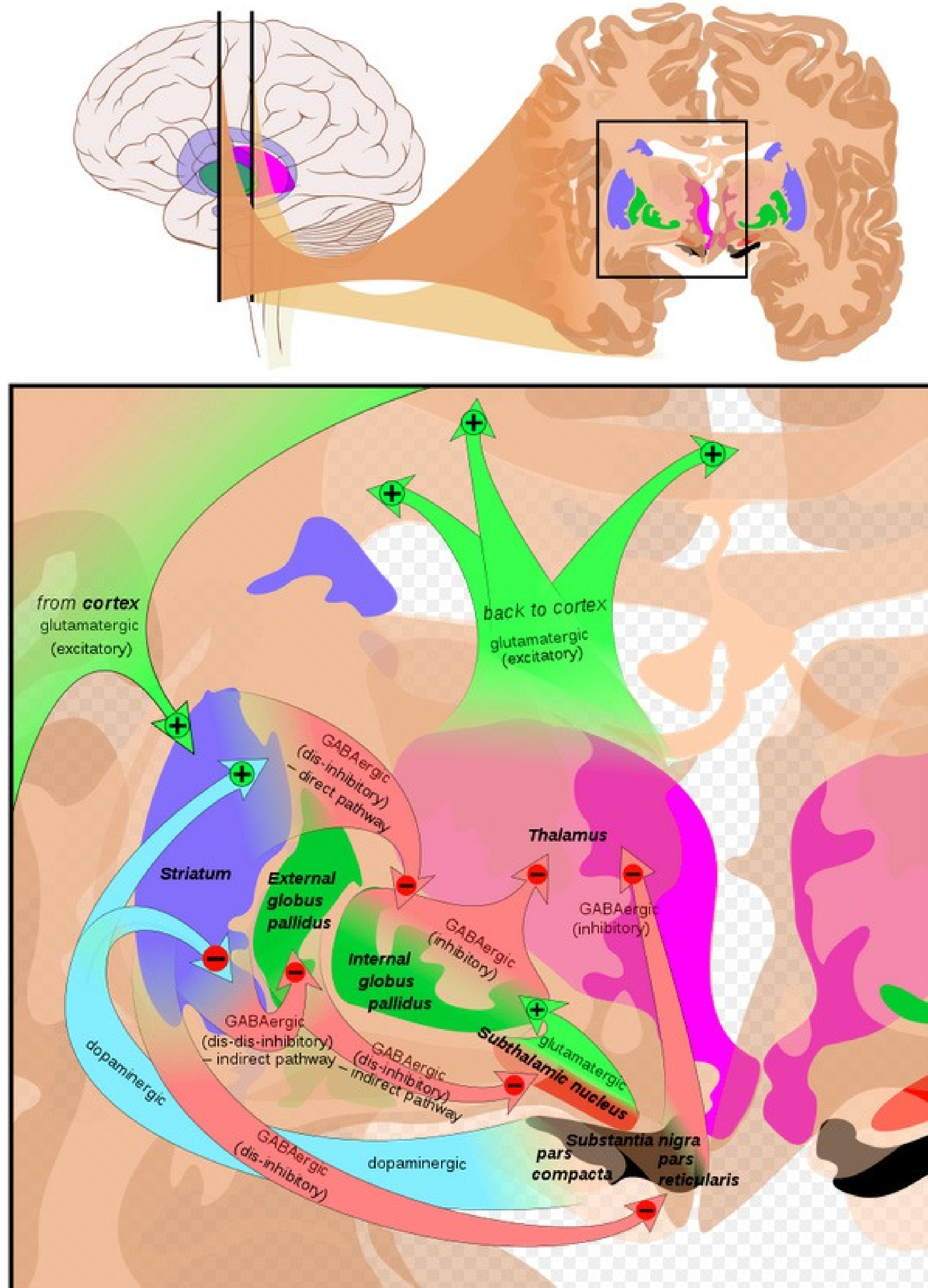
The Cortico-Basal Nuclei-Thalamo-Cortical Loop

The cortico-basal ganglia-thalamo-cortical loop (CBGTC loop) is a system of neural circuits in the brain.

The loop involves connections between the cortex, the basal ganglia, the thalamus, and back to the cortex.

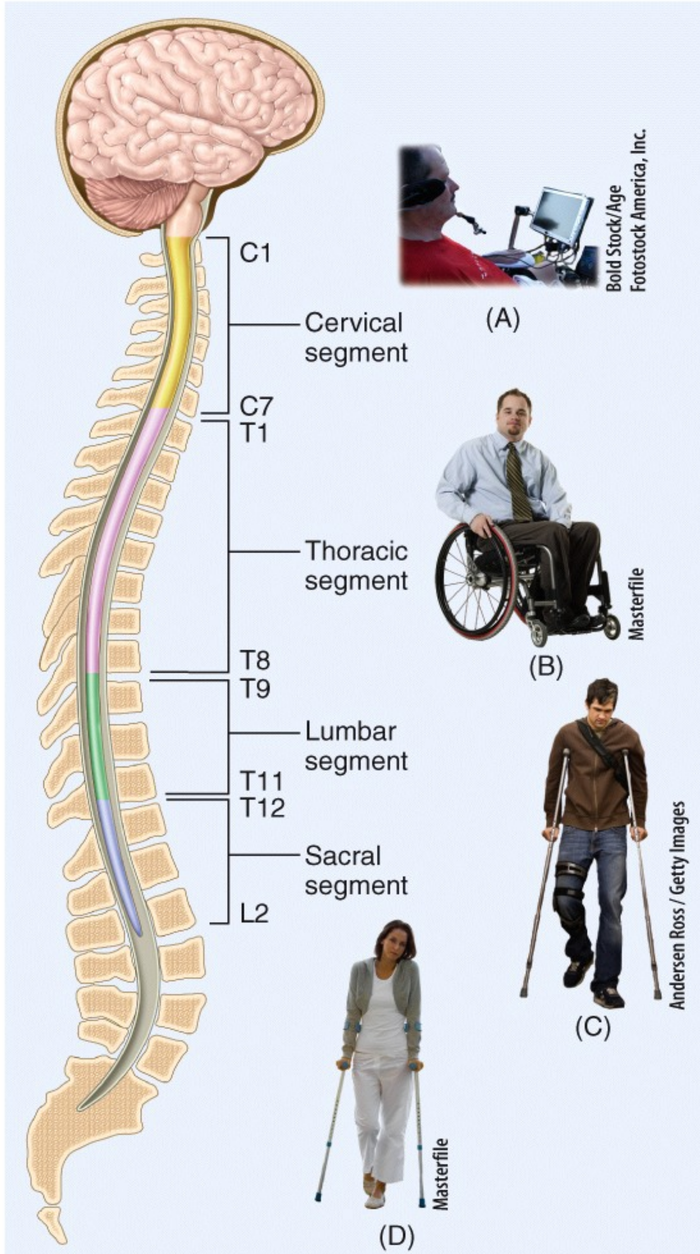
It is of particular relevance to hyperkinetic and hypokinetic movement disorders, such as Parkinson's disease and Huntington's disease,[1] as well as to mental disorders of control, such as attention deficit hyperactivity disorder (ADHD),[2] obsessive–compulsive disorder (OCD),[3] and Tourette syndrome.[4

The Cortico-Basal Nuclei-Thalamo-Cortical Loop



Damage to Spinal Cord

- accidents damage the spinal cord of thousands of people every year
  - paraplegia - paralysis of lower limbs
  - quadriplegia – paralysis of all four limbs
  - hemiplegia – paralysis of one side of the body only
  - respiratory paralysis - loss of sensation or motor control
  - disorders of bladder, bowel and sexual function
- damage to spinal cord also occur from strokes or other brain injuries

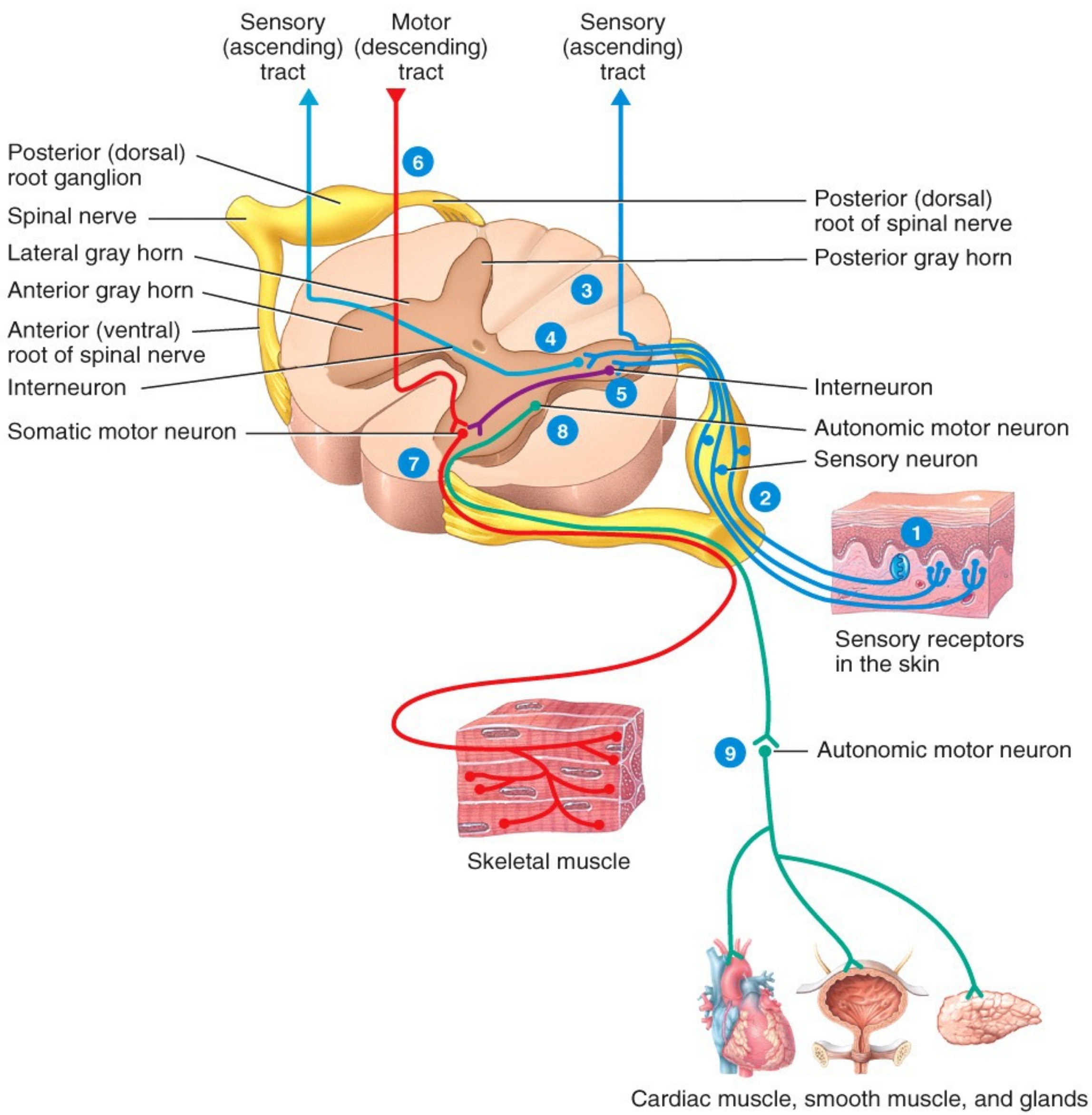


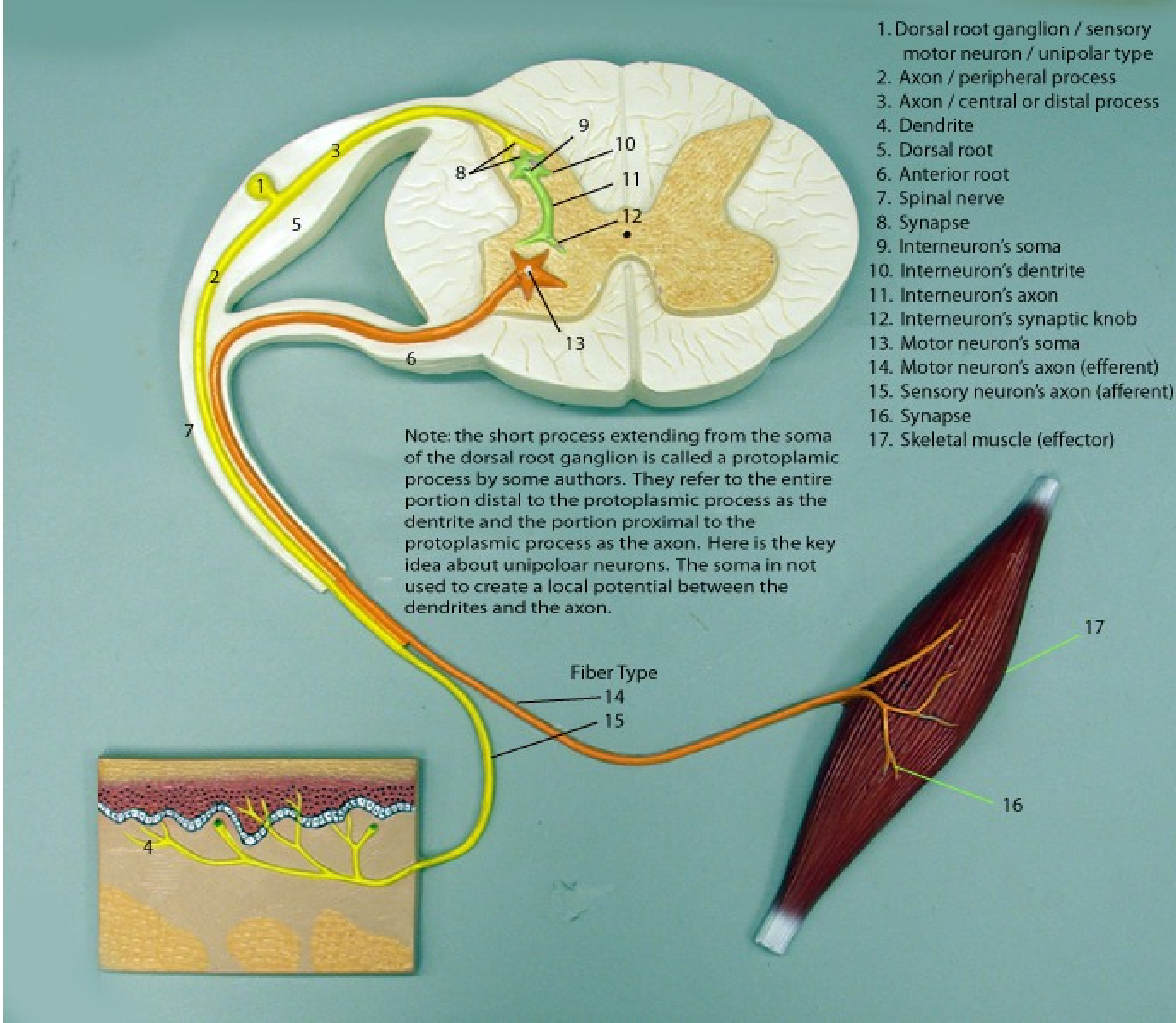
C1
Cervical segment
C7
T1
Thoracic segment
T8
T9
Lumbar segment
T11
T12
Sacral segment
L2
Bold Stock/Age Fotostock America, Inc.
(A)
Masterfile
(B)
Andersen Ross / Getty Images
(C)
Masterfile
(D)

Spina Bifida

- spina bifida – congenital defect in which one or more vertebrae fail to form a complete vertebral arch for enclosure of the spinal cord
  - in 1 baby out of 1000
  - common in lumbosacral region
  - spina bifida occulta and spina bifida cystica
- folic acid (a B vitamin) as part of a healthy diet for all women of childbearing age reduces risk
  - defect occurs during the first four weeks of development, so folic acid supplementation must begin 3 months before conception

Bi-Directional Pathways of Action Potentials Between the PNS, Spinal Cord, and Brain




1. Dorsal root ganglion / sensory motor neuron / unipolar type
2. Axon / peripheral process
3. Axon / central or distal process
4. Dendrite
5. Dorsal root
6. Anterior root
7. Spinal nerve
8. Synapse
9. Interneuron's soma
10. Interneuron's dentrite
11. Interneuron's axon
12. Interneuron's synaptic knob
13. Motor neuron's soma
14. Motor neuron's axon (efferent)
15. Sensory neuron's axon (afferent)
16. Synapse
17. Skeletal muscle (effector)
Note: the short process extending from the soma of the dorsal root ganglion is called a protoplamic process by some authors. They refer to the entire portion distal to the protoplasmic process as the dentrite and the portion proximal to the protoplasmic process as the axon. Here is the key idea about unipoloar neurons. The soma in not used to create a local potential between the dendrites and the axon.
Fiber Type
1
2
3
4
5
6
7
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9
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14
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16
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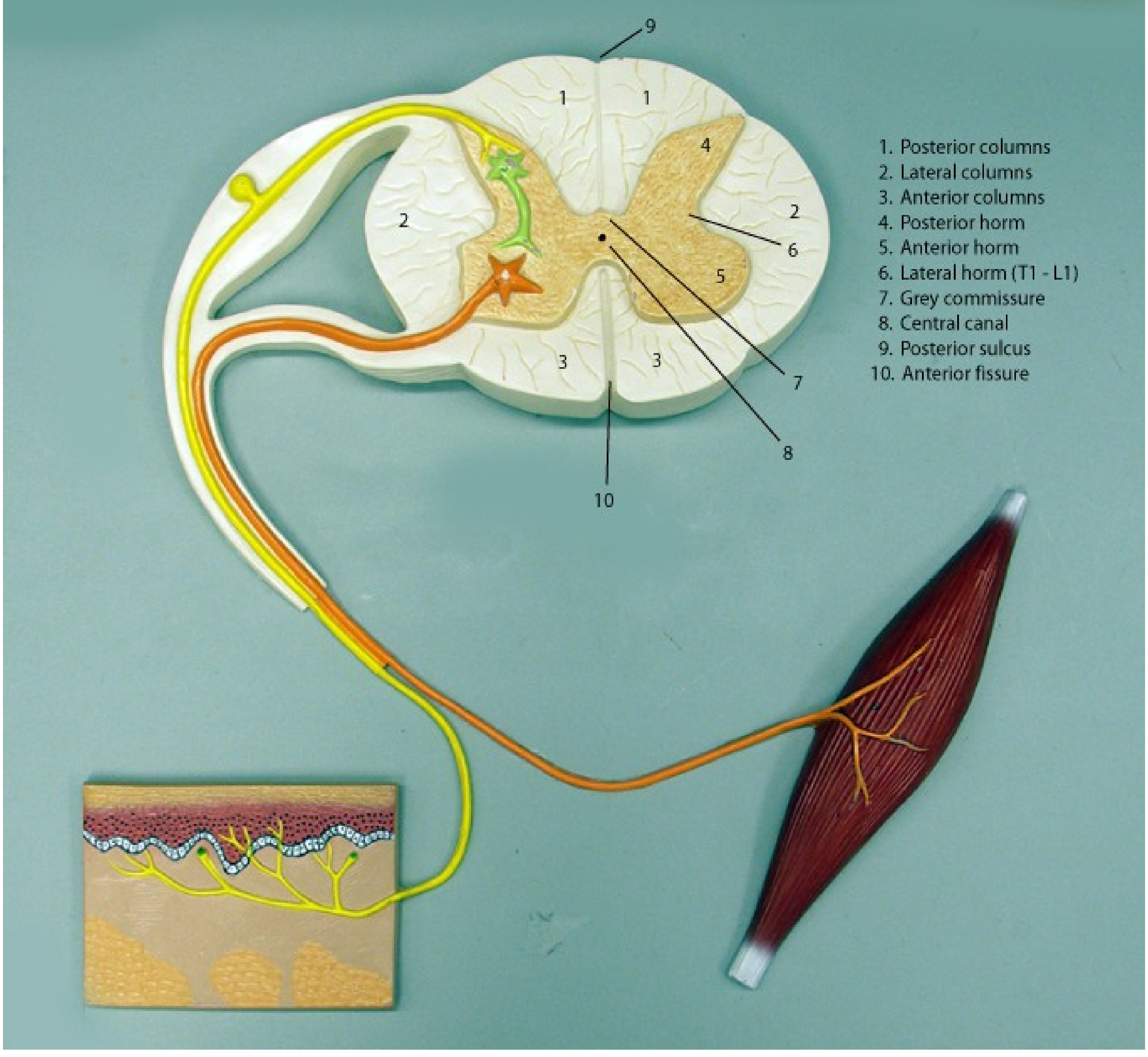
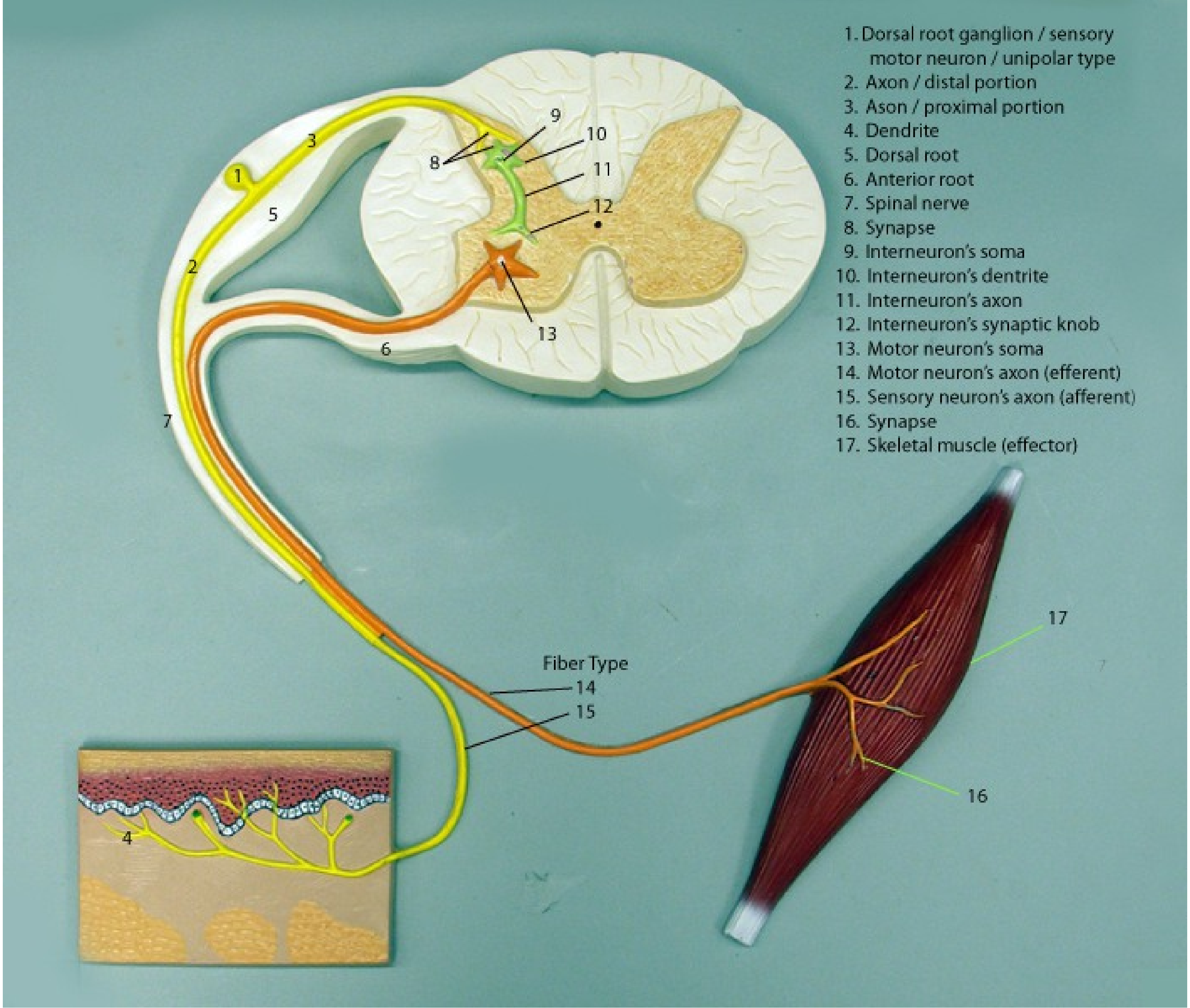

9
1
1
4
2
2
6
5
7
8
3
3
10
1. Posterior columns
2. Lateral columns
3. Anterior columns
4. Posterior horm
5. Anterior horm
6. Lateral horm (T1 - L1)
7. Grey commissure
8. Central canal
9. Posterior sulcus
10. Anterior fissure


1. Dorsal root ganglion / sensory motor neuron / unipolar type
2. Axon / distal portion
3. Ason / proximal portion
4. Dendrite
5. Dorsal root
6. Anterior root
7. Spinal nerve
8. Synapse
9. Interneuron's soma
10. Interneuron's dentrite
11. Interneuron's axon
12. Interneuron's synaptic knob
13. Motor neuron's soma
14. Motor neuron's axon (efferent)
15. Sensory neuron's axon (afferent)
16. Synapse
17. Skeletal muscle (effector)
Fiber Type