# Spinal Cord

Steven McLoon
Department of Neuroscience
University of Minnesota

# Course News

**Review sessions with Dr. Riedl**

Tuesdays
4-5pm
in MCB 3-146
(the main lab room)

The first exam is coming soon!

# Course News

**Dr. McLoon's office hours this week:**

Wednesday (Sept 26) 2:30 – 4:30pm

In Jackson Hall 4-158

# Course News

**Midterm Exam Friday, Sept 28**

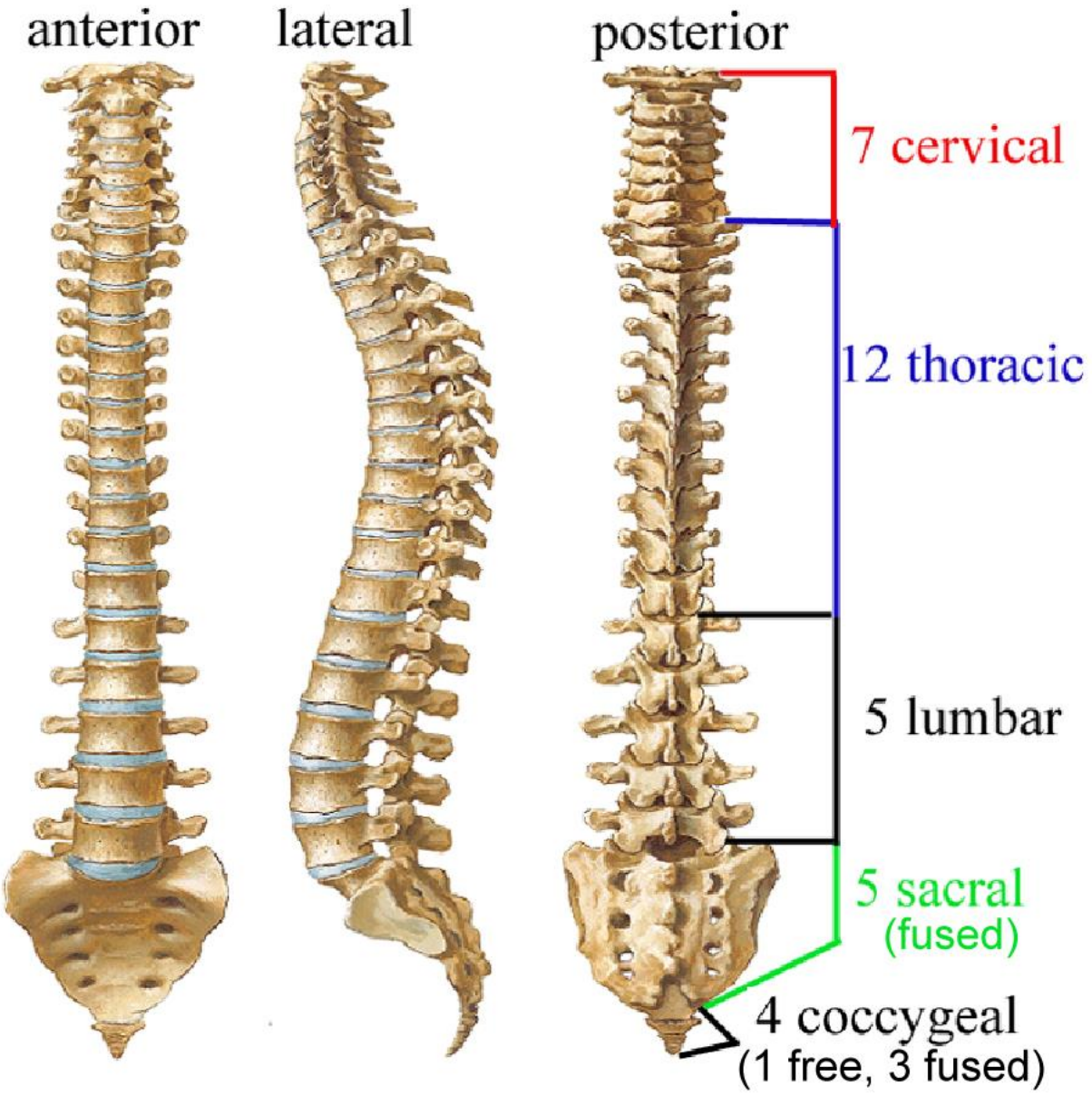
The exam will cover lectures 2-9 and labs 1-2.

A – L last names in MoosT 2-620
M – Z in MoosT 2-650

PLEASE BRING #2 PENCILS!!!

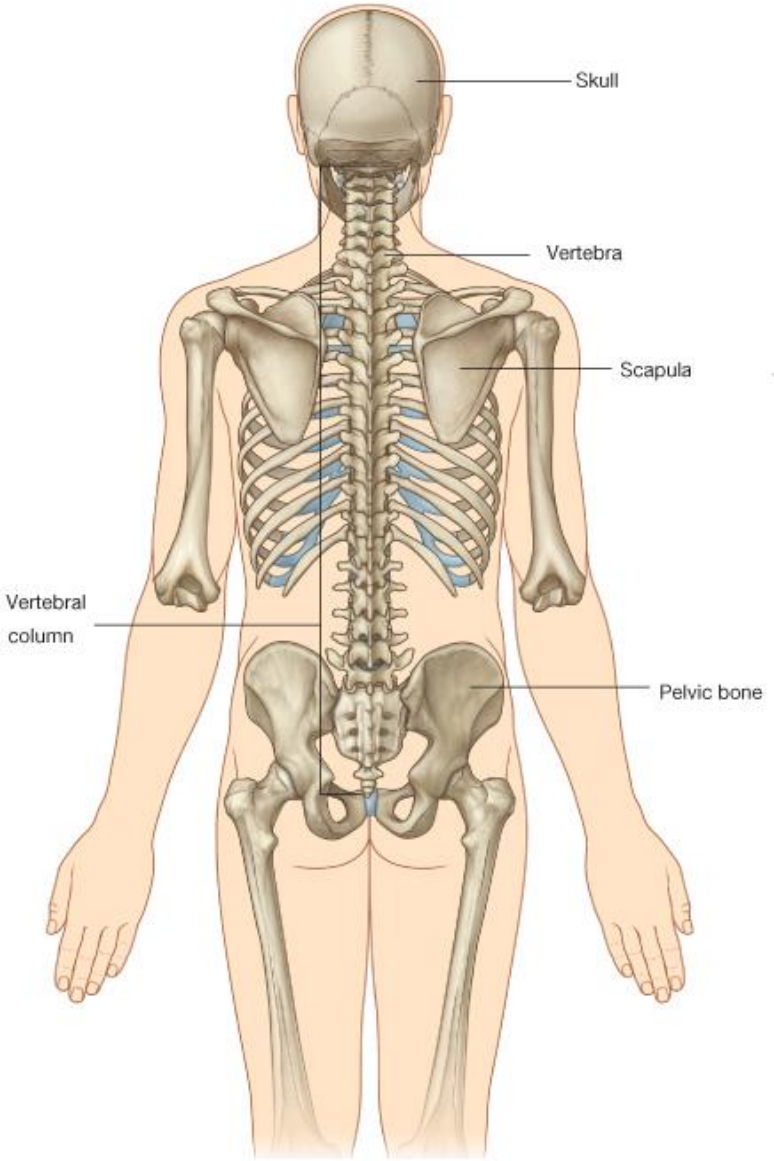
Be sure to check out last year's exam on the course website!!!

**The spine or backbone is composed of a stack of vertebrae.**



## The spine or backbone is composed of a stack of vertebrae.

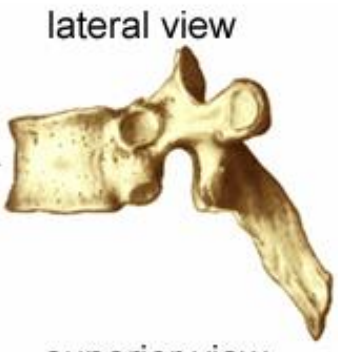
- Cervical vert. are in the neck.
- Thoracic vert. are in the thorax and each has a pair of ribs.
- Lumbar vert. are in the lower back.
- Sacrum and coccyx are part of the pelvis.



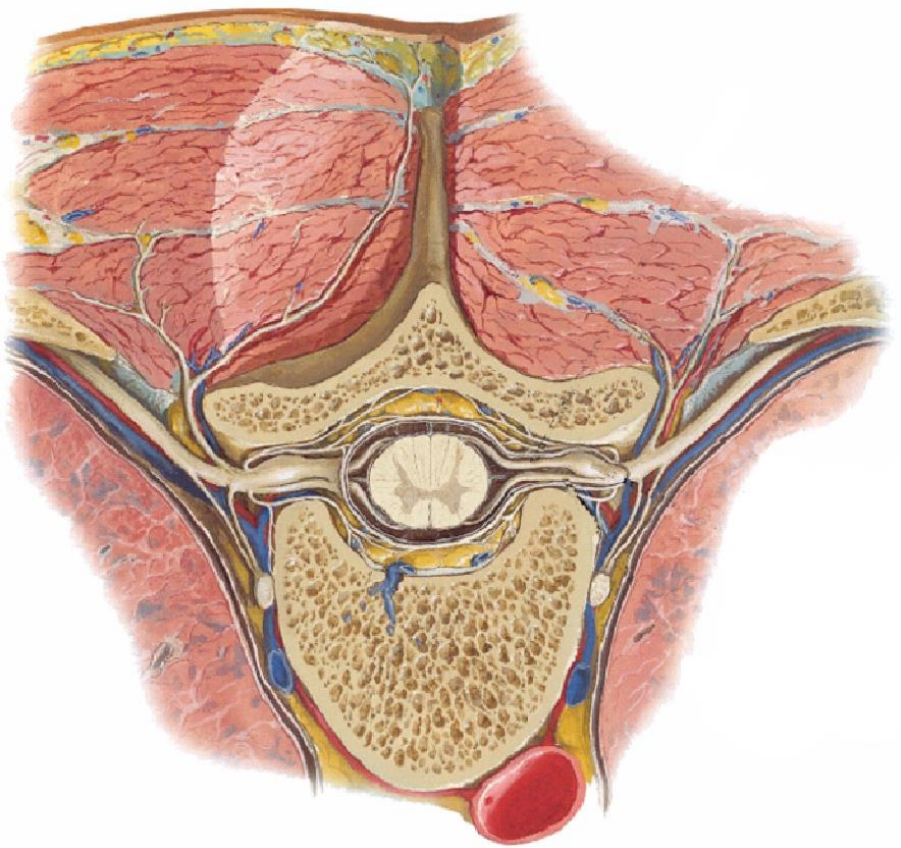
## The spine or backbone is composed of a stack of vertebrae.

- Cervical vert. are in the neck.
- Thoracic vert. are in the thorax and each has a pair of ribs.
- Lumbar vert. are in the lower back.
- Sacrum and coccyx are part of the pelvis.

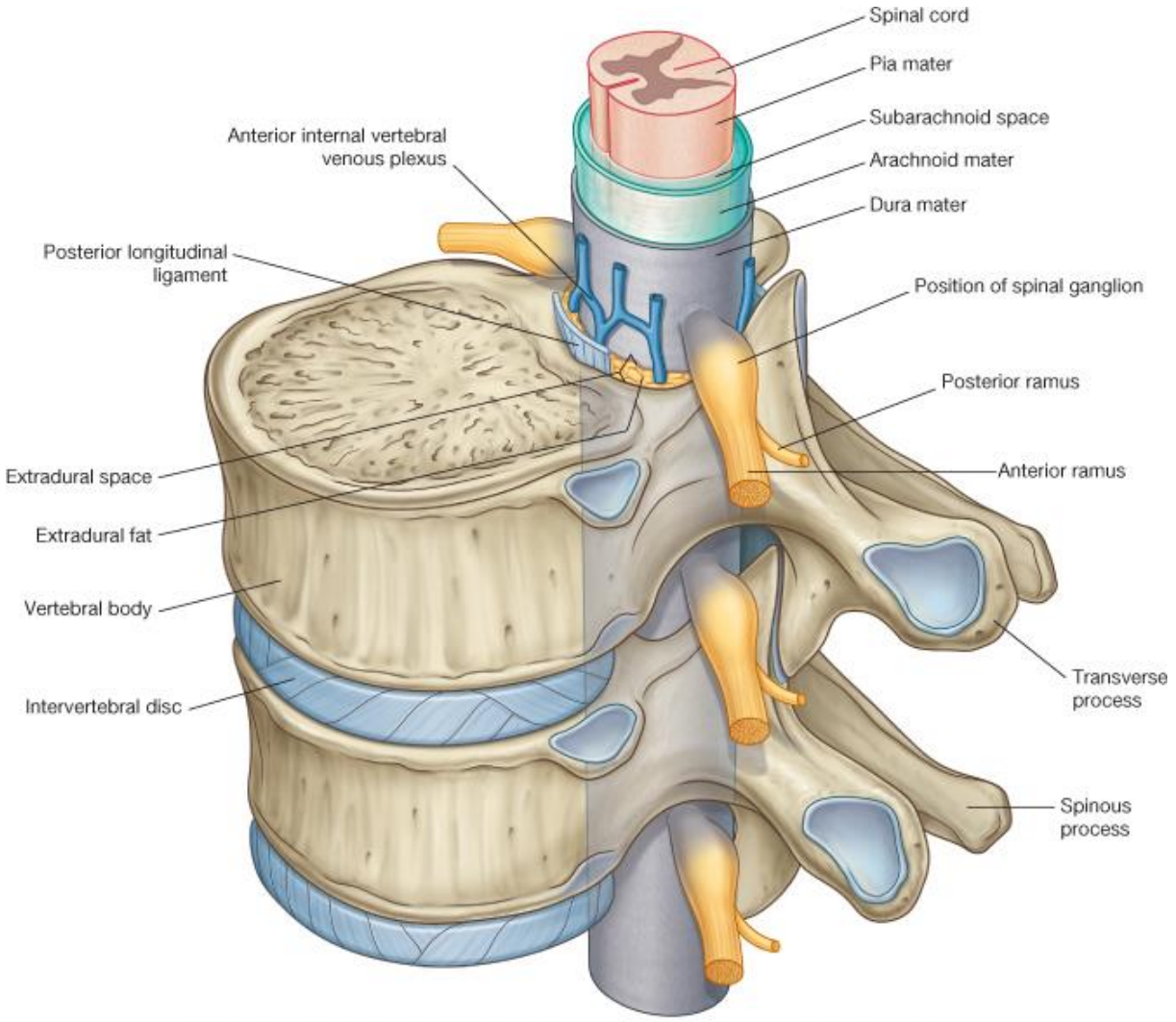
**Each vertebrae has a spinal (vertebral) canal for the spinal cord.**



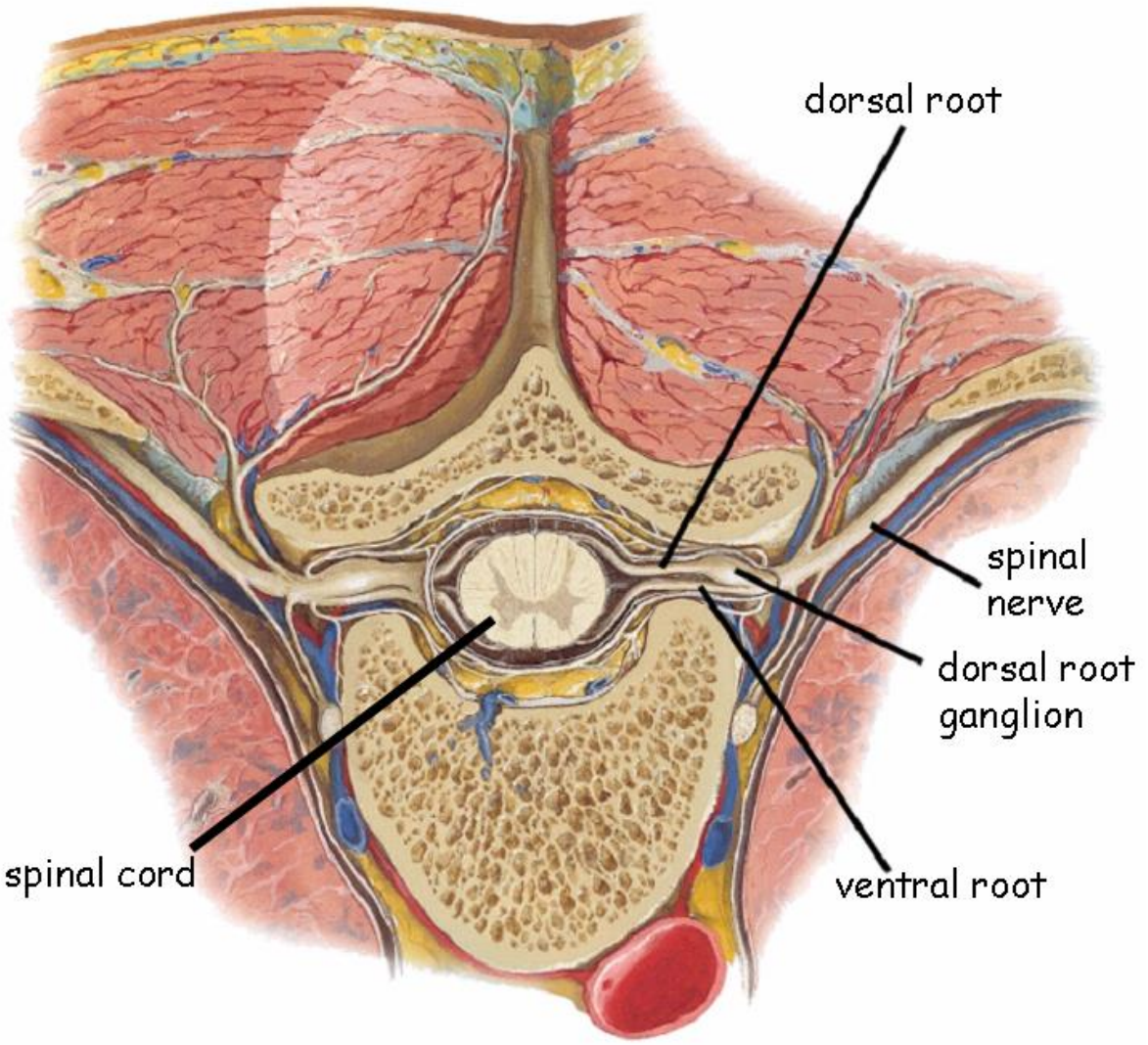


**A pair of spinal nerves pass between each adjacent vertebrae in the <u>intervertebral foramen</u>.**



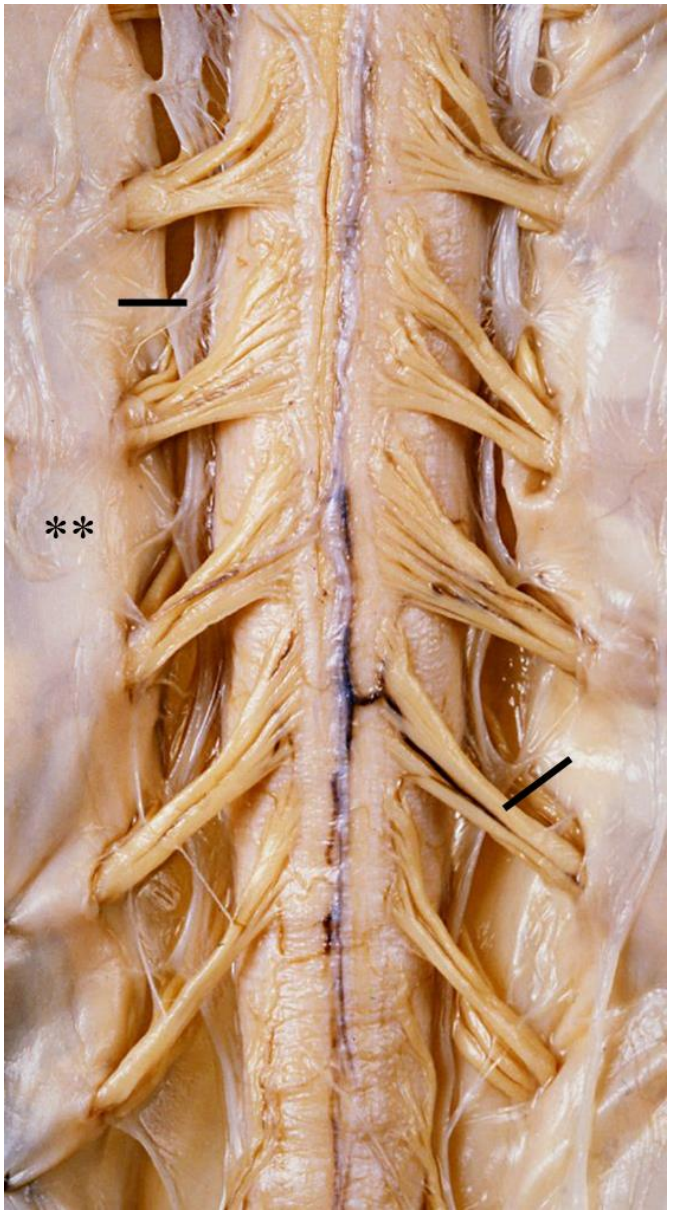
**A pair of spinal nerves pass between each adjacent vertebrae in the intervertebral foramen.**

- spinal nerve
- dorsal root ganglion
- dorsal root
- ventral root



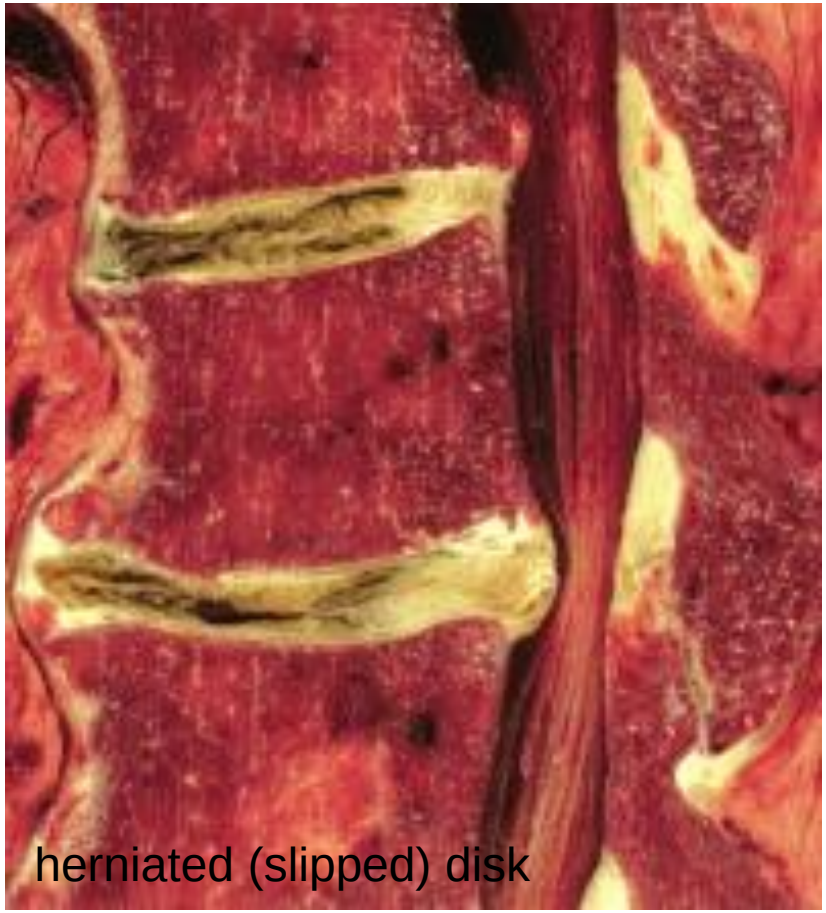
**A pair of spinal nerves pass between each adjacent vertebrae in the intervertebral foramen.**

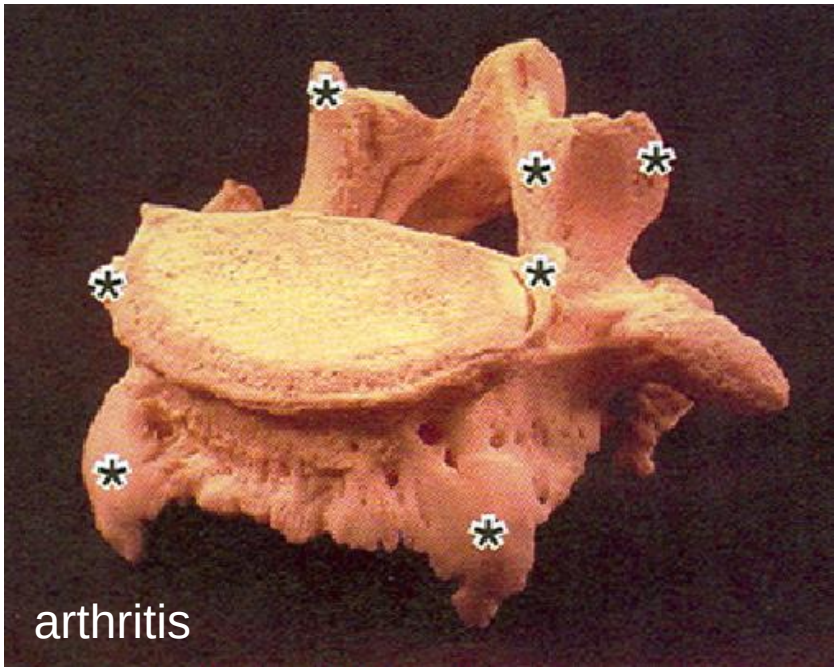
- spinal nerve
- dorsal root ganglion
- dorsal root
- ventral root

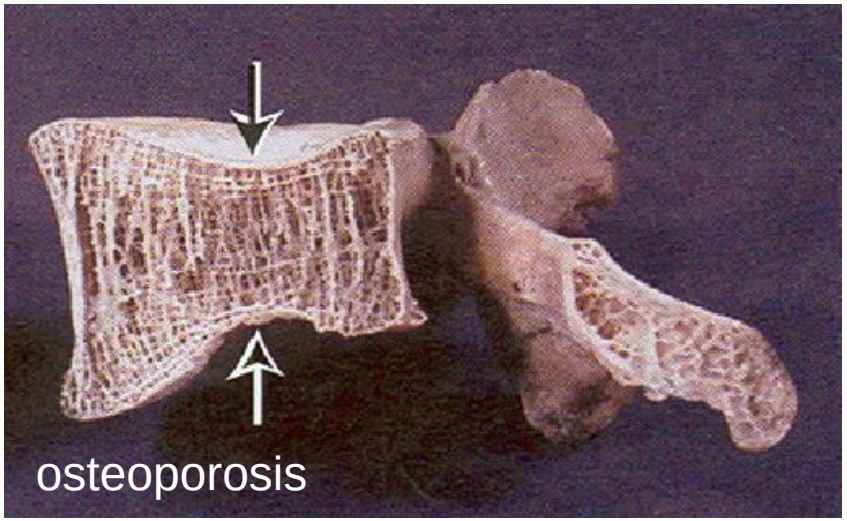


**A pair of spinal nerves pass between each adjacent vertebrae in the <u>intervertebral foramen</u>.**

- Diseases, particularly those associated with aging, can result in pressure on a spinal nerve in a foramen and cause pain and muscle weakness.

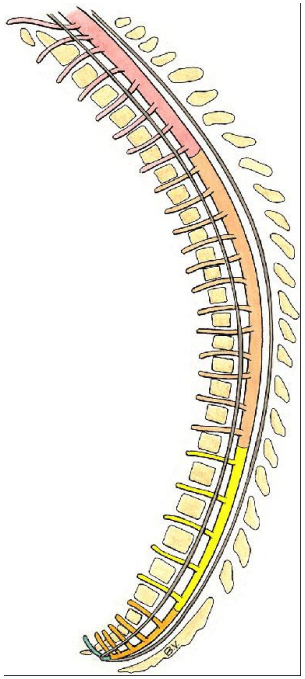

herniated (slipped) disk

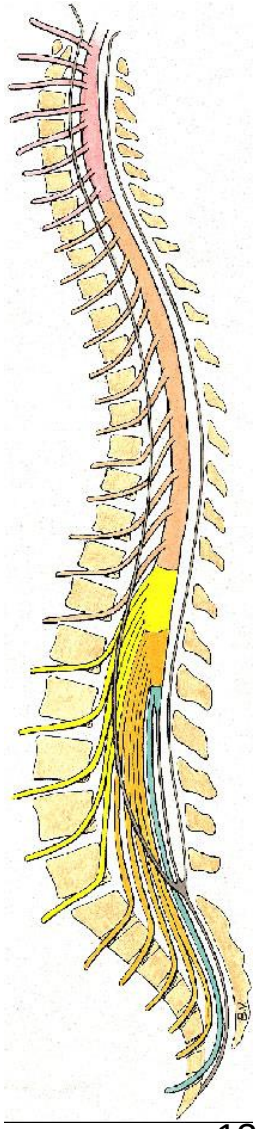

arthritis


osteoporosis

# Spinal Cord Anatomy

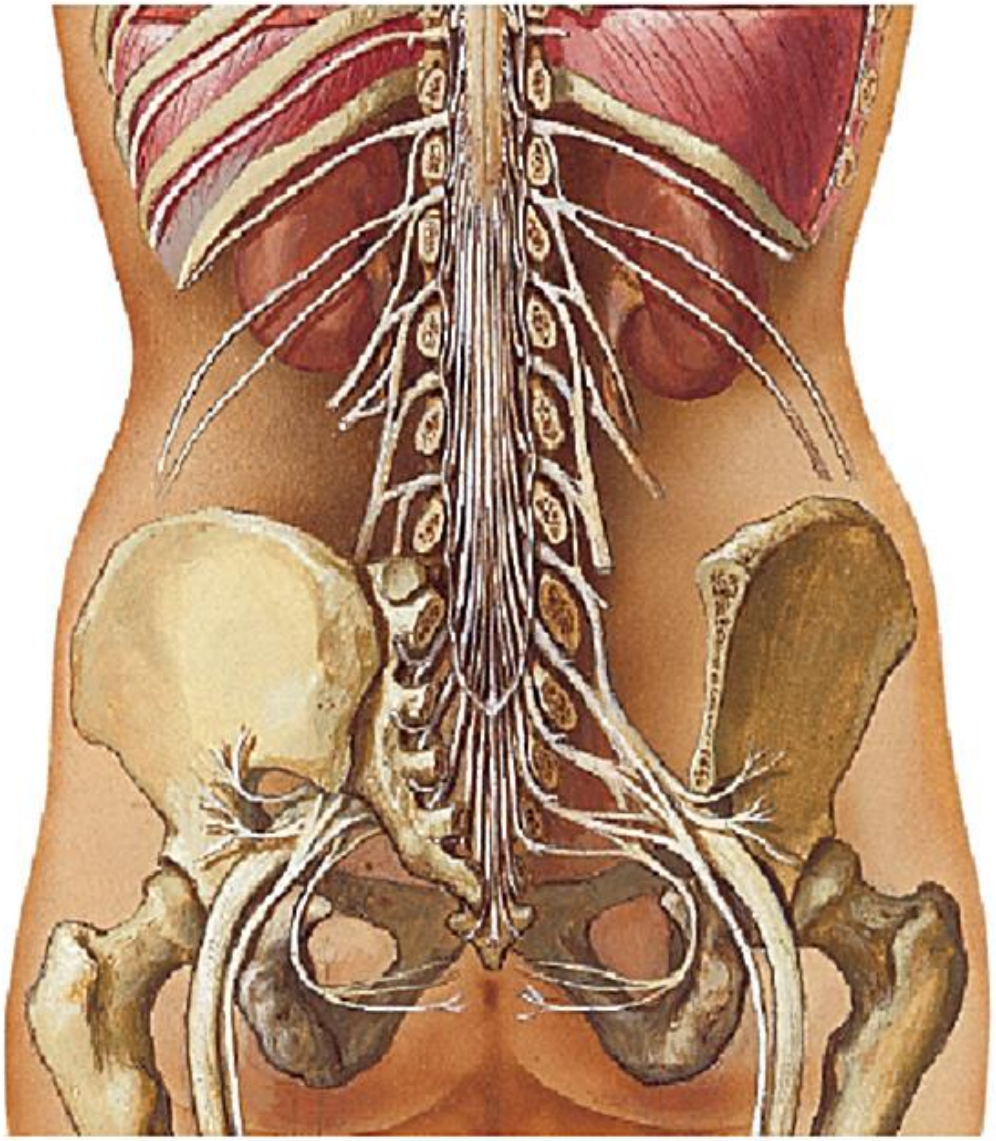
- At birth, the spinal cord goes the entire length of the spine.
- The spinal cord stops growing before the spine stops.
- In the adult, the spinal cord ends between the first and second lumber vertebrae.





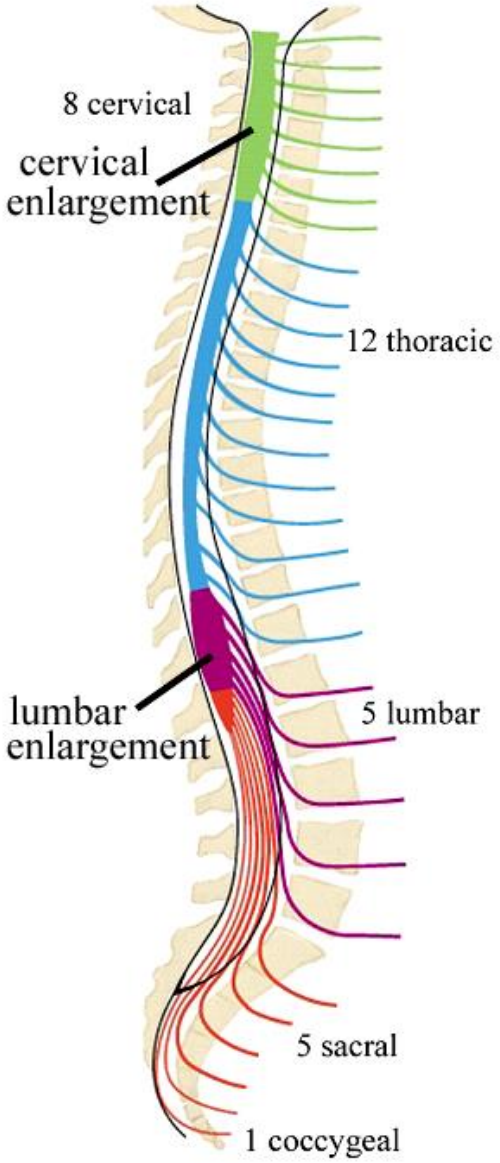
# Spinal Cord Anatomy

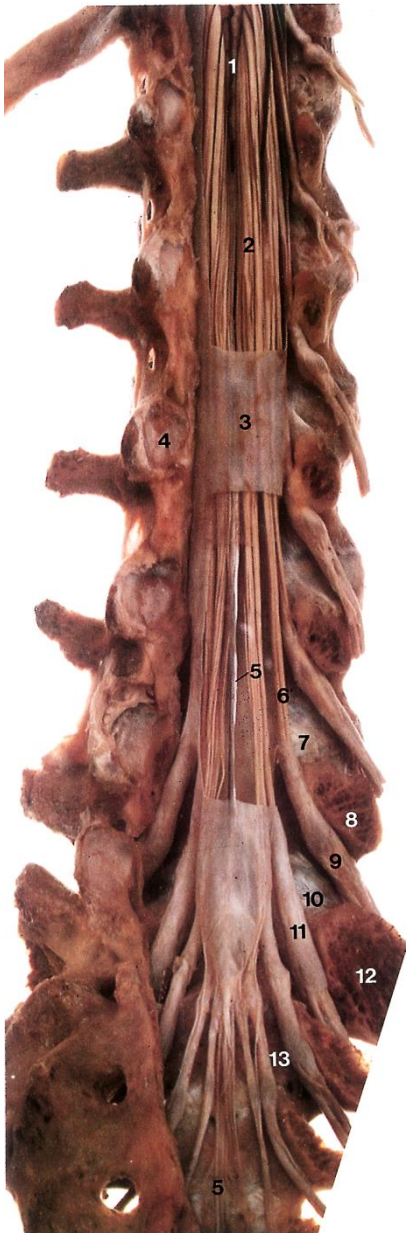
- In the adult, the spinal cord ends at the conus medullaris between the first and second lumber vertebrae.



# Spinal Cord Anatomy

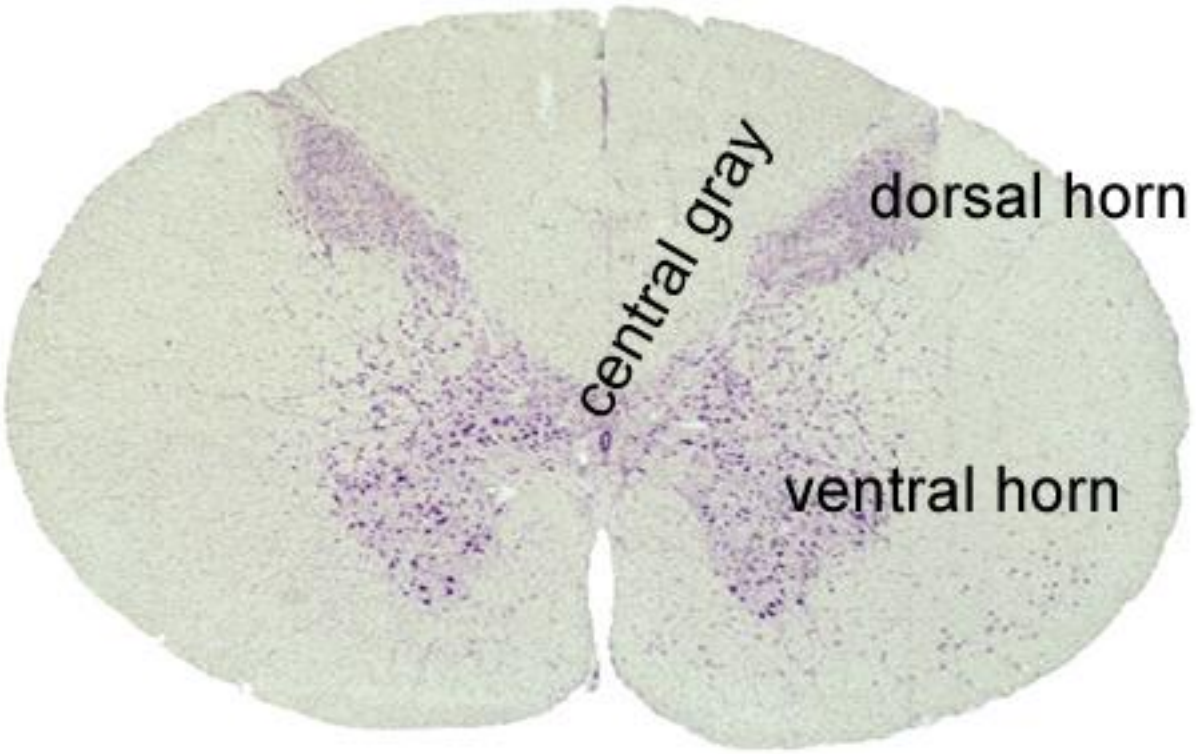
- The dorsal and ventral roots for the vertebrae below the conus medullaris form the cauda equina.



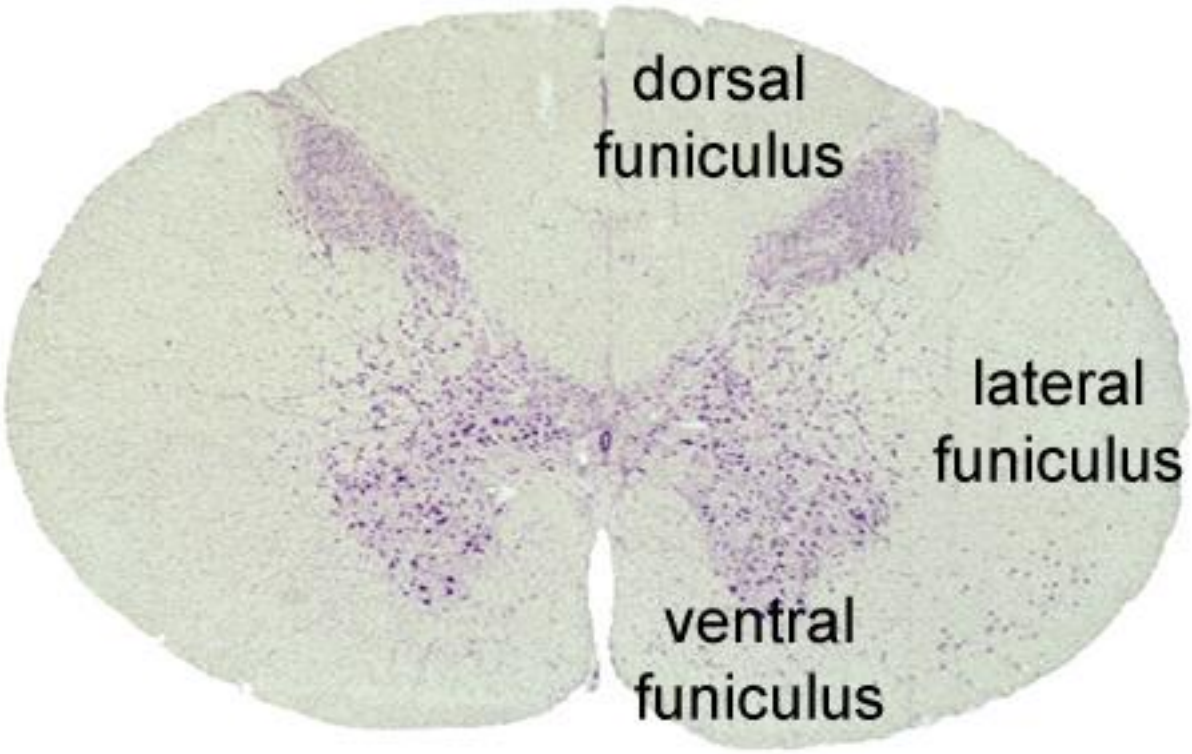
## Spinal Cord Anatomy

- grey matter



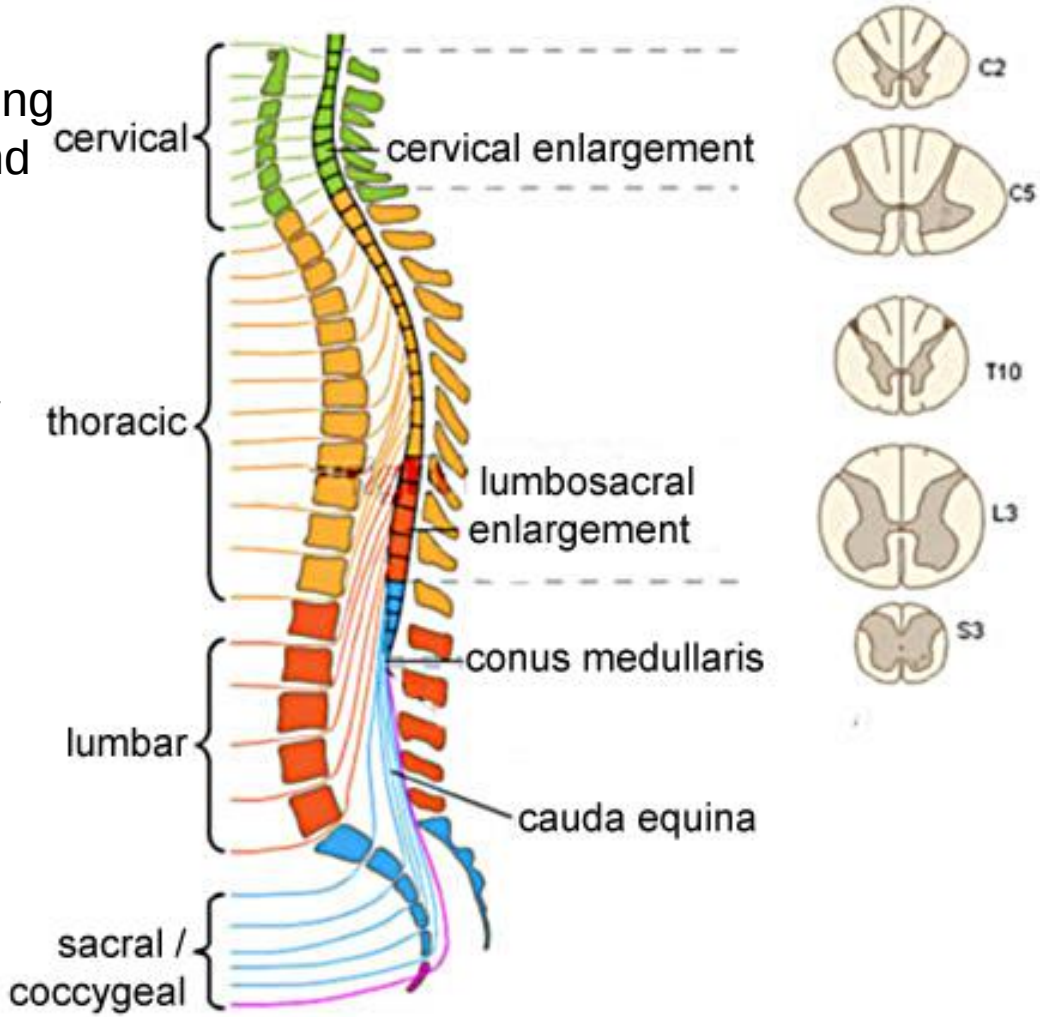
# Spinal Cord Anatomy

- white matter



# Spinal Cord Anatomy

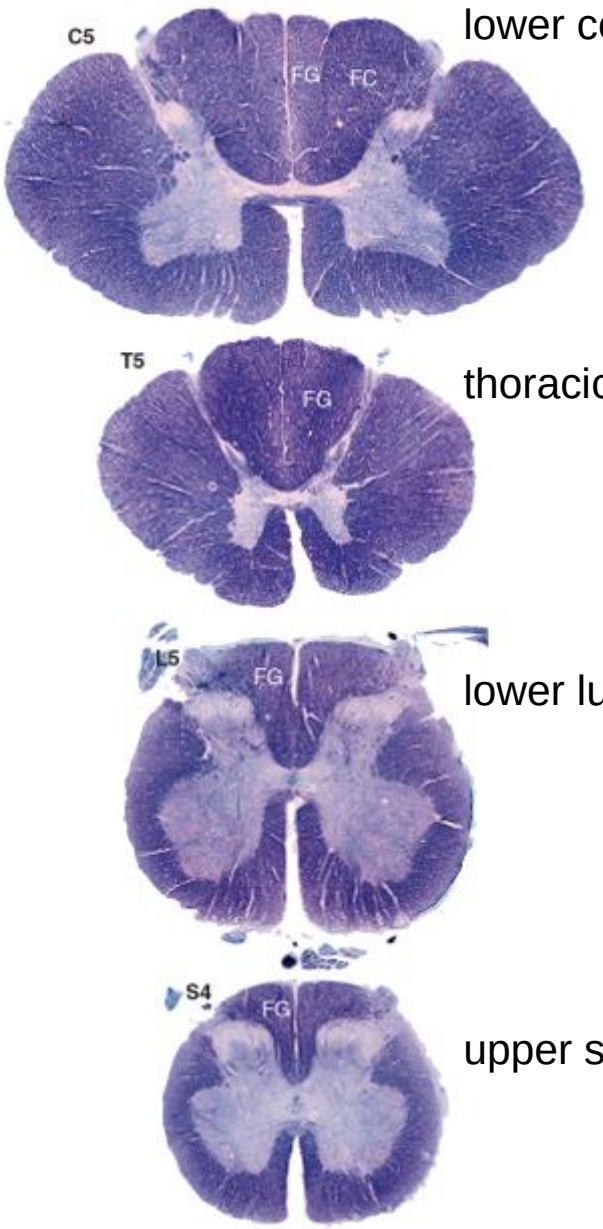
- More grey matter is in levels serving the arms and legs, the cervical and lumbosacral enlargements respectively.
- The spinal cord has progressively more white matter from caudal to rostral.



# Spinal Cord Anatomy

- More grey matter is in levels serving the arms and legs, the cervical and lumbosacral enlargements respectively.

- The spinal cord has progressively more white matter from caudal to rostral.



## Systems

- Sensory systems
  - Somatosensory
  - Visceral sensory
  - Special sensory
    - Vision
    - Auditory
    - Vestibular
    - Gustatory (taste)
    - Olfactory (smell)
- Motor systems
  - Somatic motor
  - Autonomic motor
    - Sympathetic
    - Parasympathetic

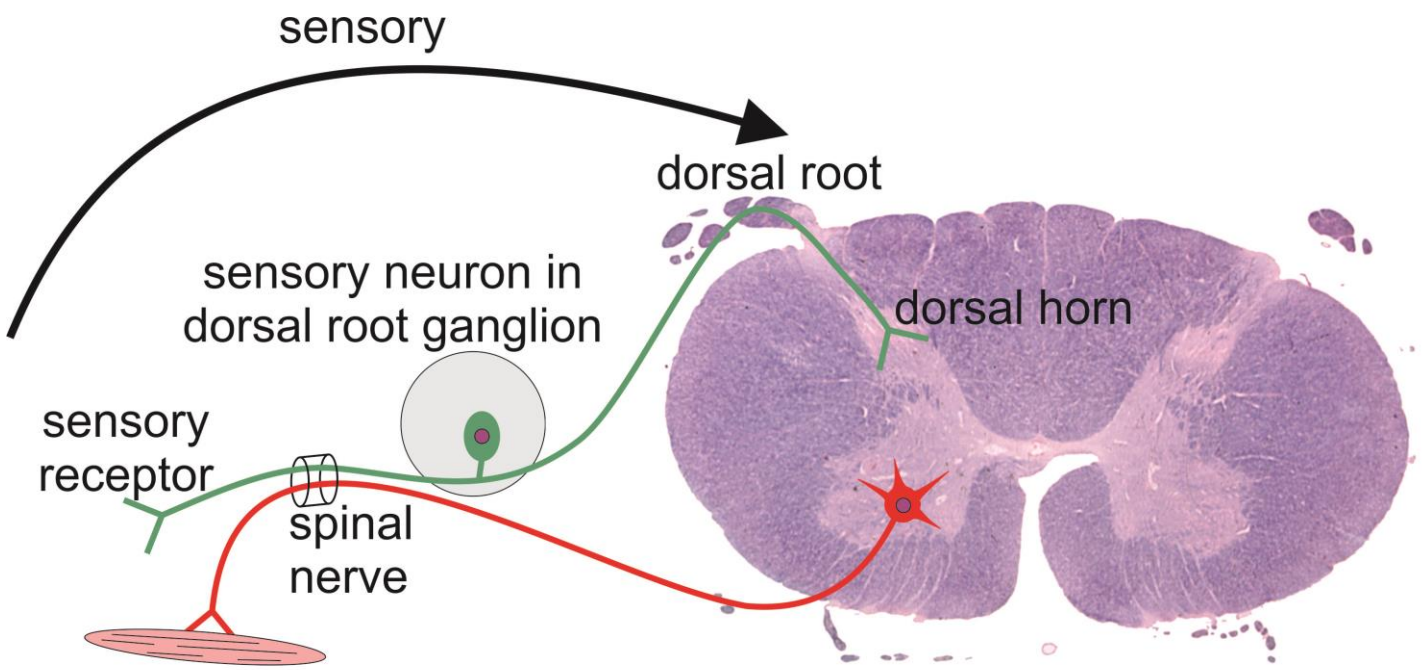
Special senses are carried by cranial nerves.
The other systems are carried by cranial and spinal nerves.

## Somatosensory system detects multiple sensations.

- Mechanosensation
  - Fine touch
  - Pressure
  - Vibration
  - Movement against the skin
- Proprioception (limb & trunk position, movement & load)
- Thermoception (temperature)
  - Heat
  - Cold
- Nociception (pain – tissue damage)

# Somatosensory Pathways

- Sensory information enters the spinal cord via dorsal roots.



## Somatosensory Pathways

Somatosensory information is processed via three main pathways:

- local spinal circuits for reflex responses
- to cerebellum and other brainstem centers for maintaining balance and coordinating movements
- to cerebral cortex for conscious perception and other responses

# Reflexes

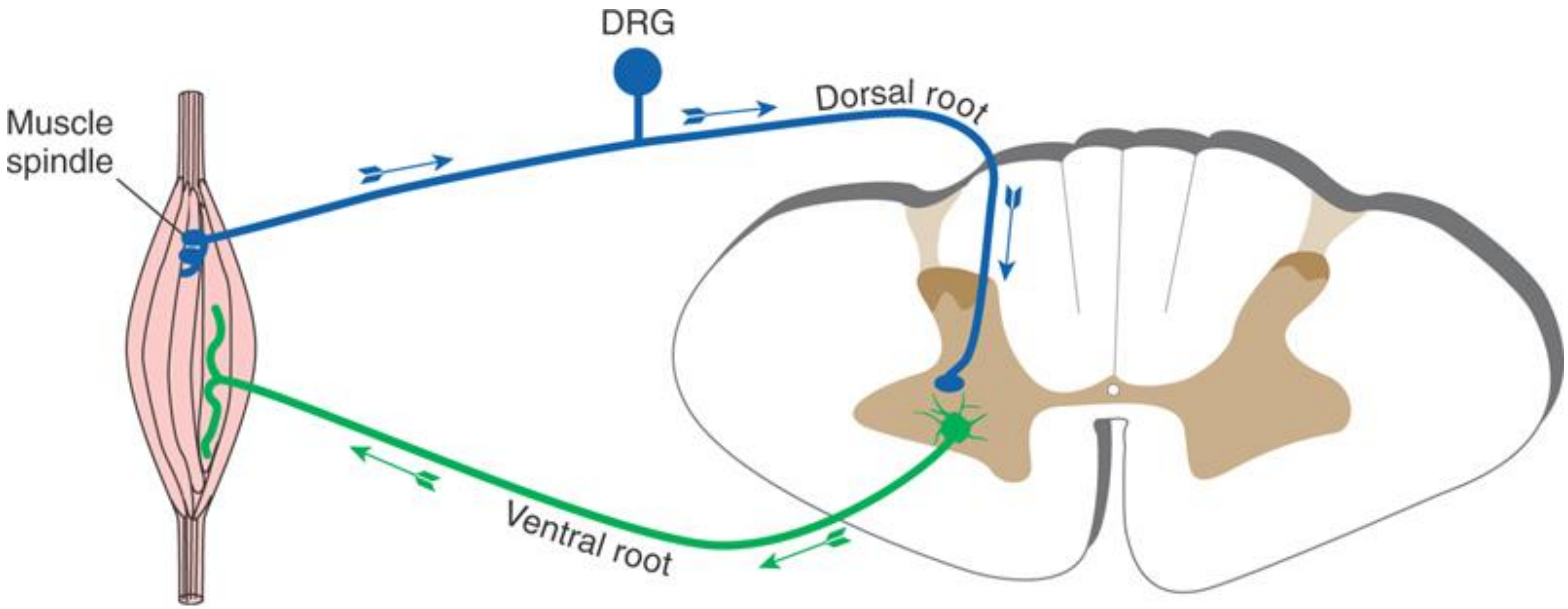
- Reflexes are rapid, preprogrammed, stereotypic responses to specific stimuli.
- Reflexes are processed locally in the spinal cord or brainstem, but can be modulated by input from higher brain centers.
- All somatosensory modalities are involved in reflexes.

# Reflexes

The stretch reflex is monosynaptic:

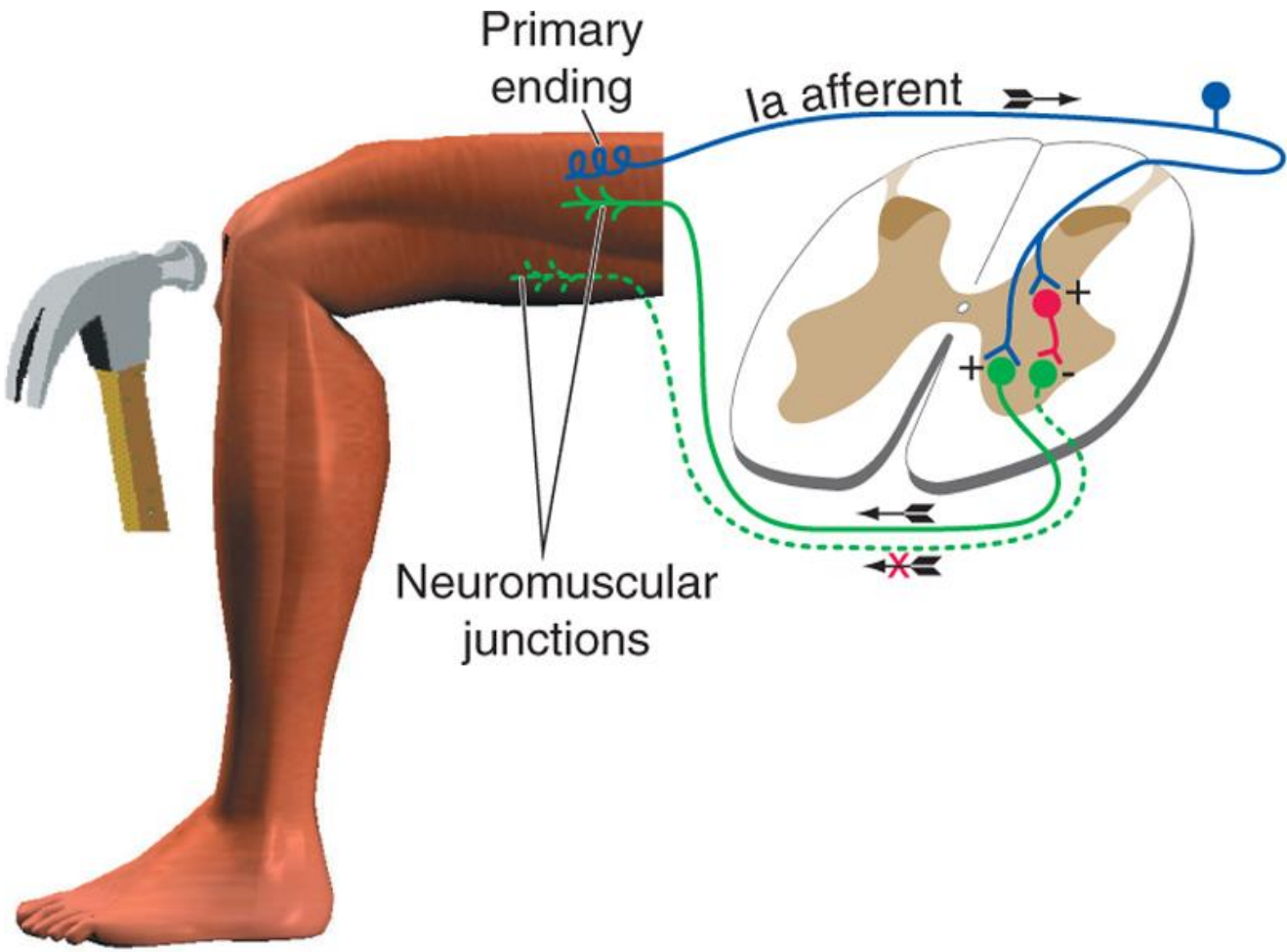
- It is initiated by stretch of muscle spindles, which activates the sensory axons to the spindles.

- It involves a monosynaptic circuit between the sensory neuron and primary motor neuron, which initiates contraction of the stretched muscle.



# Reflexes

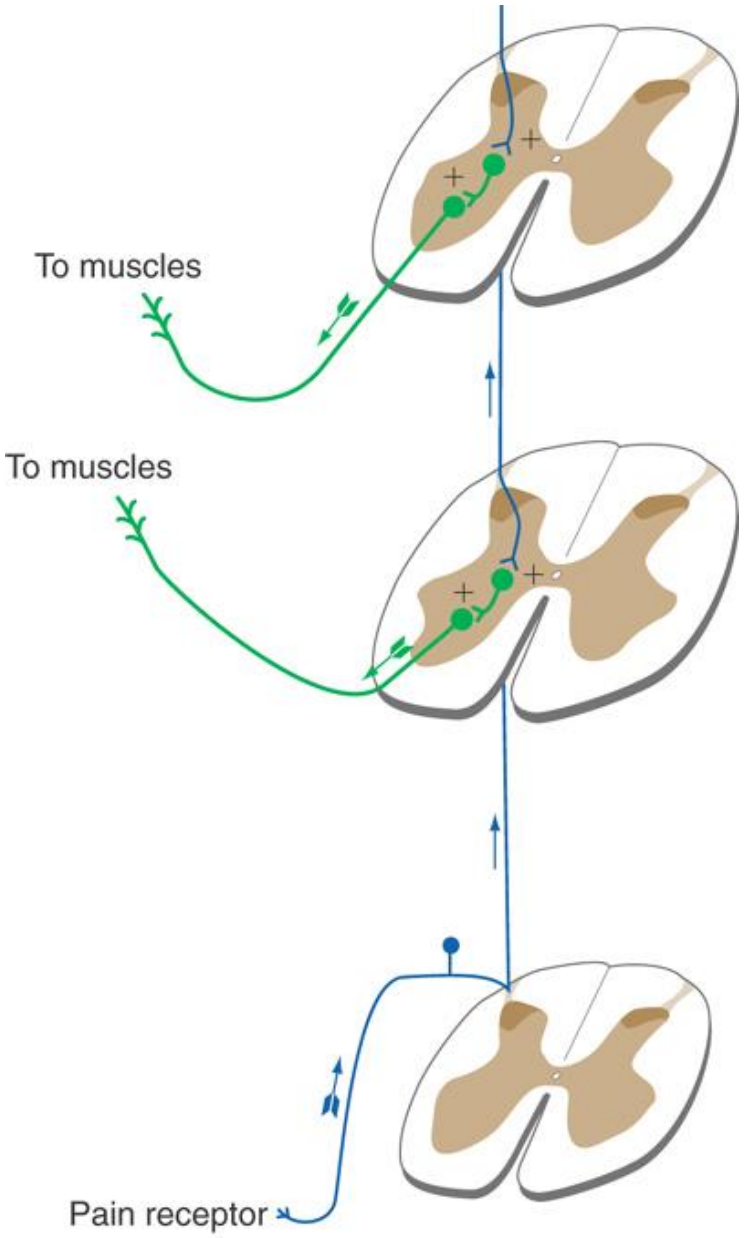
- The stretch reflex also includes inhibition of antagonistic muscles via activation of an inhibitory interneuron.



# Reflexes

The withdrawal reflex activates motor neurons at multiple spinal levels:

- It is initiated by activation of pain receptors in a limb.
- The primary sensory neuron activates interneurons in multiple spinal levels.
- The interneurons activate motor neurons that in turn activate flexor muscles in the affected limb.
- Contraction of flexor muscles withdraws the limb.



# Reflexes

- Primary afferents ascend and descend in Lissauer's tract.

# Reflexes

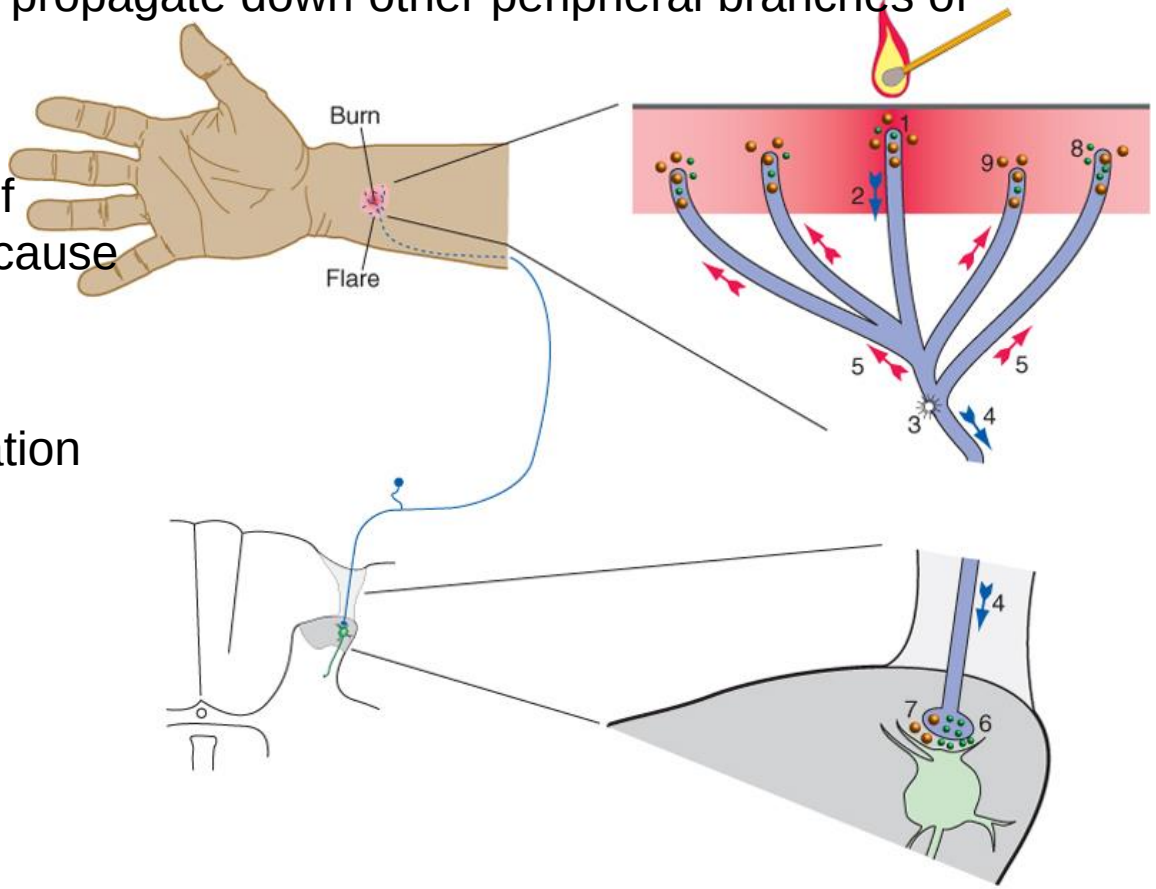
- Many reflexes involve activation or inhibition of motor neurons at multiple spinal levels and on both sides of the cord.

- Input from the brain can override or modify a reflex.

# Reflexes

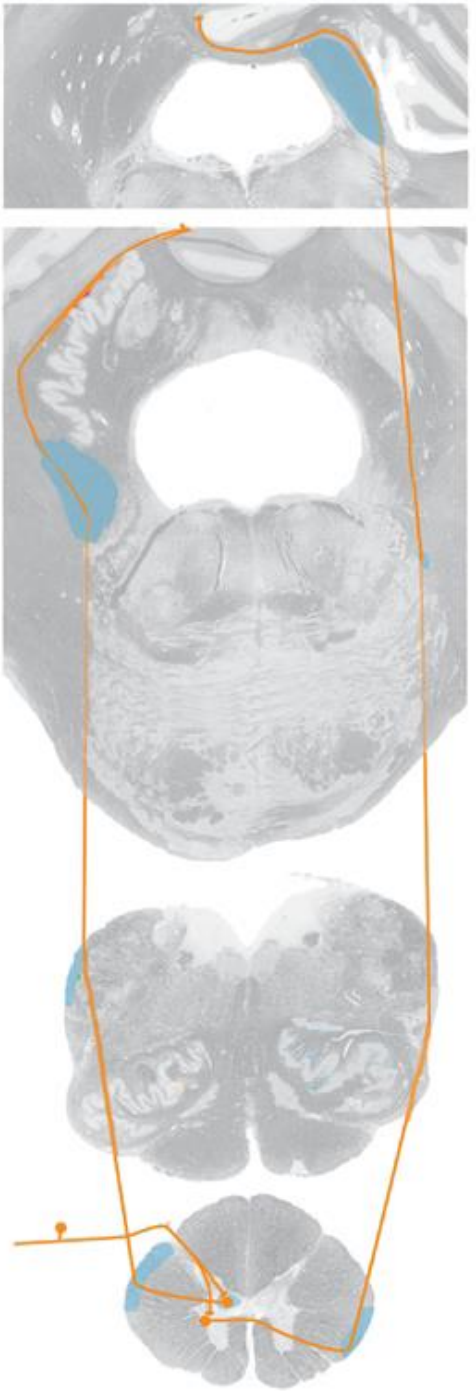
Axon reflex involves bidirectional signaling:

- Tissue damage activates pain receptors.
- The axon potential will propagate down other peripheral branches of the same neuron.
- This initiates release of neuropeptides, which cause vasodilatation.
- This leads to inflammation (reddening of the skin, edema).



## Spinocerebellar Pathway

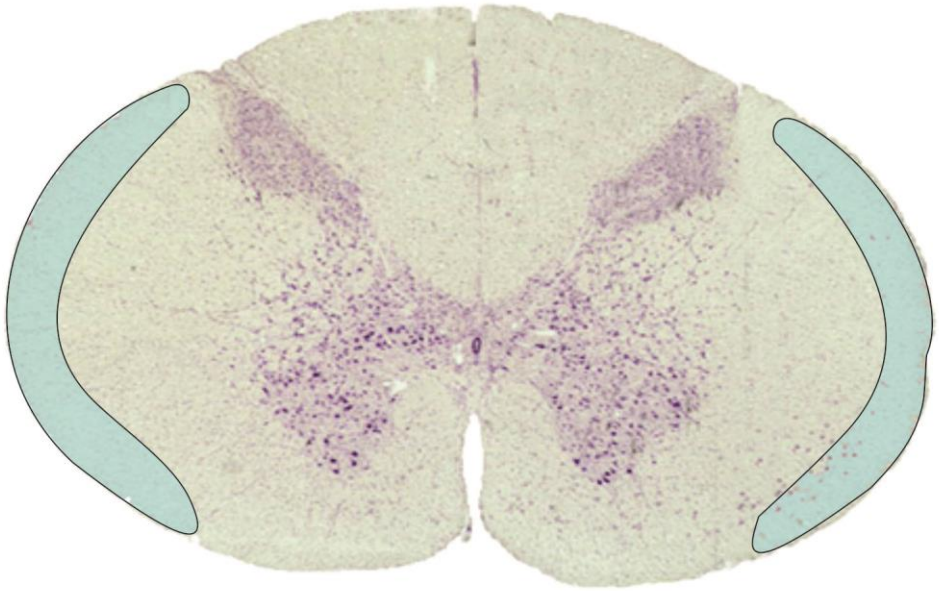
- Primary sensory neurons carrying proprioceptive information synapse deep in the dorsal horn.
- Second order neurons ascend on both sides of the spinal cord in the spinocerebellar tracts.
- The cerebellum has important roles in maintaining balance and coordinating movements.



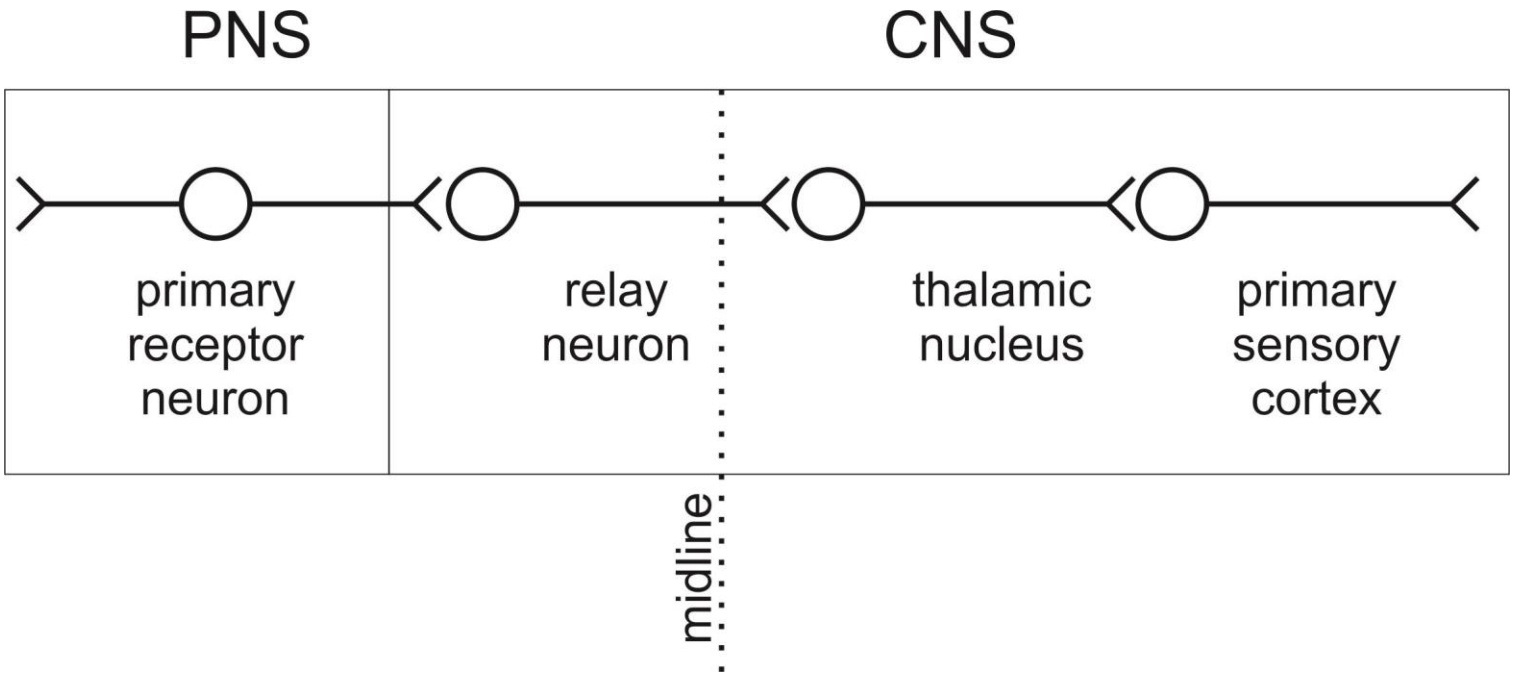
# Spinocerebellar Pathway

- The spinocerebellar tracts are in the lateral funiculus of the spinal cord.

[Note how tracts are often labeled by their origin and target.]



# Somatosensory Projection to Cortex



## Somatosensory Projection to Cortex

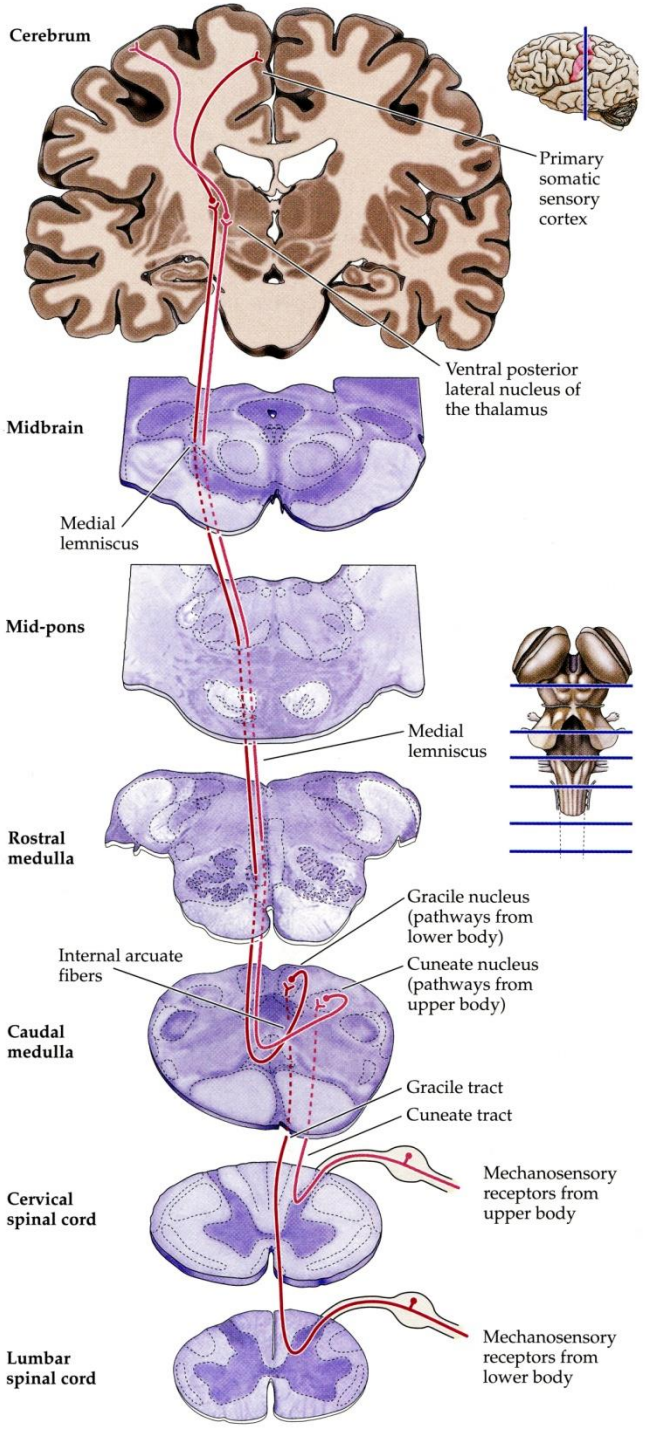
Two somatosensory pathways to cortex:

- Proprioception and deep touch via the dorsal columns.
- Pain, temperature and light touch via the spinothalamic tracts.

# Somatosensory Projection to Cortex

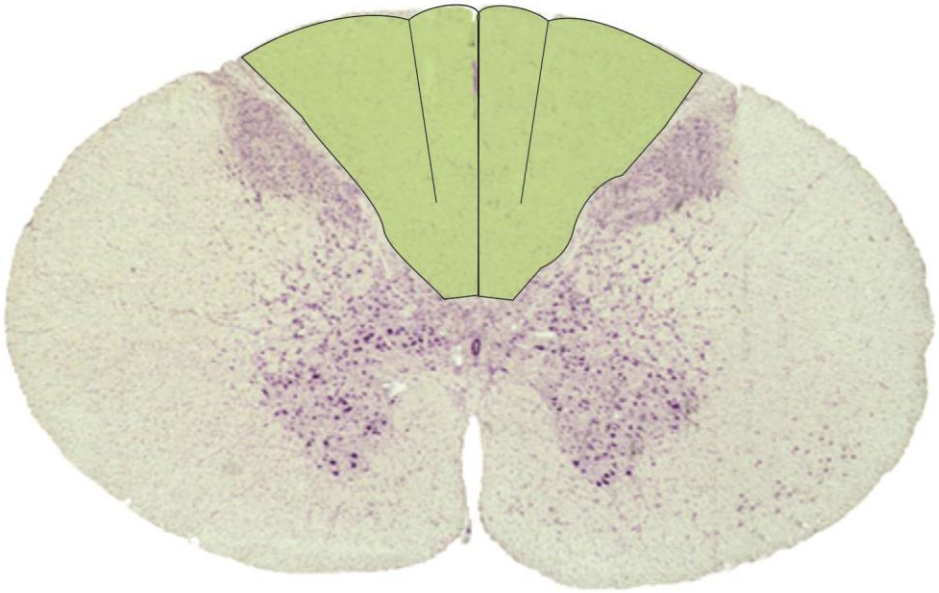
Dorsal column projection:

- Primary sensory axons for proprioception and deep touch enter the dorsal horn and ascend in the dorsal columns.
- These axons synapse in nucleus gracilis (from lower body) and nucleus cuneatus (from upper body) in the medulla.
- Axons from these nuclei cross the medulla and ascend to thalamus.
- They synapse in the ventral posterolateral nucleus (VPL) of the thalamus.
- Axons from the VPL neurons project to somatosensory cortex.



## Somatosensory Projection to Cortex

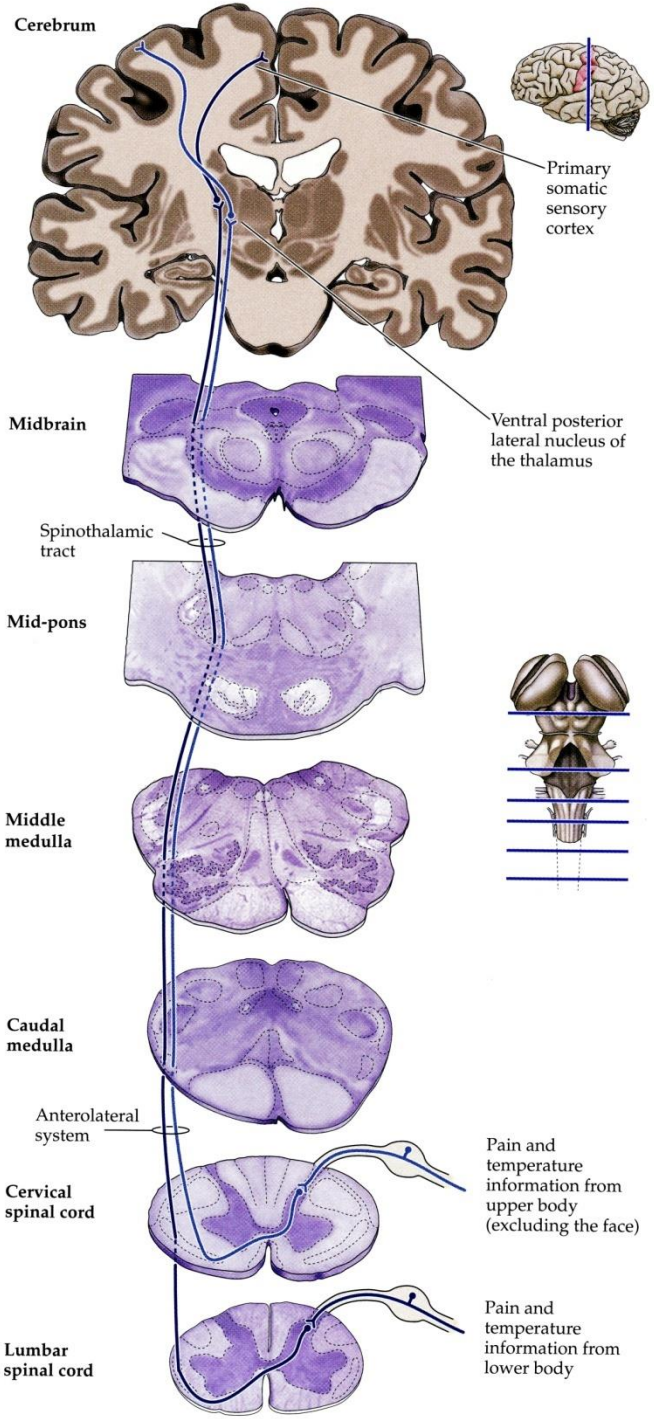
- The dorsal columns are in the dorsal funiculus of the spinal cord.



# Somatosensory Projection to Cortex

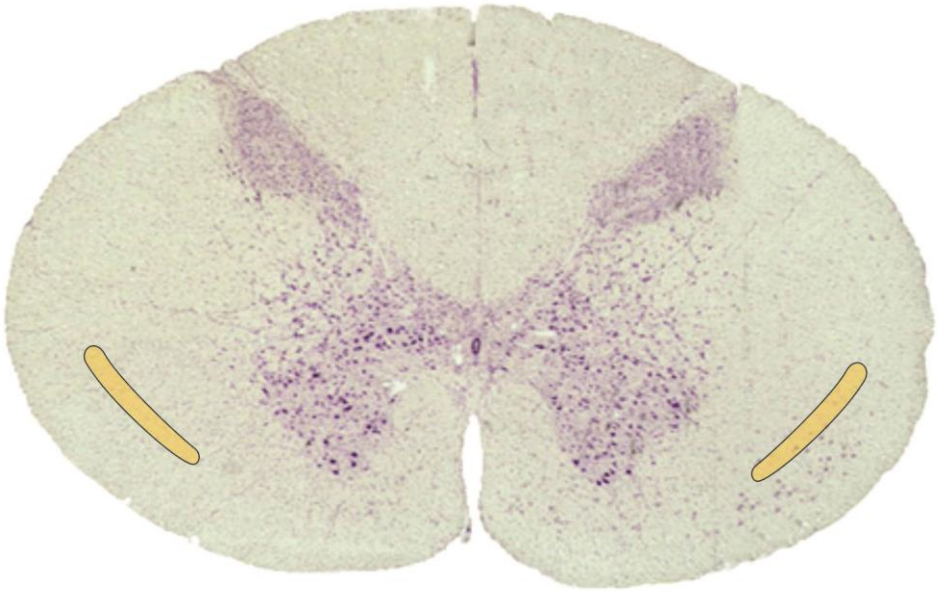
Spinothalamic projection:

- Primary sensory axons for pain, temperature and light touch synapse on neurons in the dorsal horn.
- Axons of these dorsal horn neurons cross the spinal cord and ascend in the spinothalamic tract.
- They synapse in the ventral posterolateral nucleus (VPL) of the thalamus.
- Axons from the VPL neurons project to somatosensory cortex.



## Somatosensory Projection to Cortex

- The spinothalamic tracts are in the lateral funiculus of the spinal cord.



# Motor System

- Upper motor neuron in motor cortex

  (axons cross to the opposite side of the body)

  -synapses with-

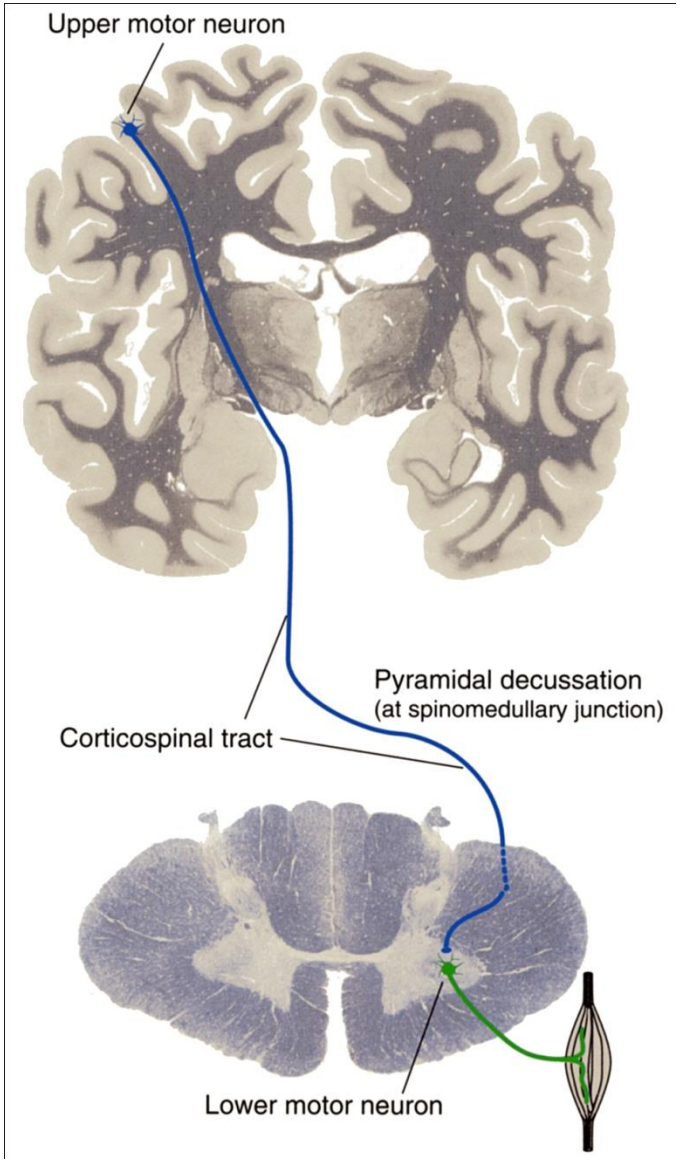
- (Lower) motor neuron in a cranial nerve nucleus in the brainstem or the ventral horn of the spinal cord

  (axons exit CNS via a cranial nerves or ventral roots)

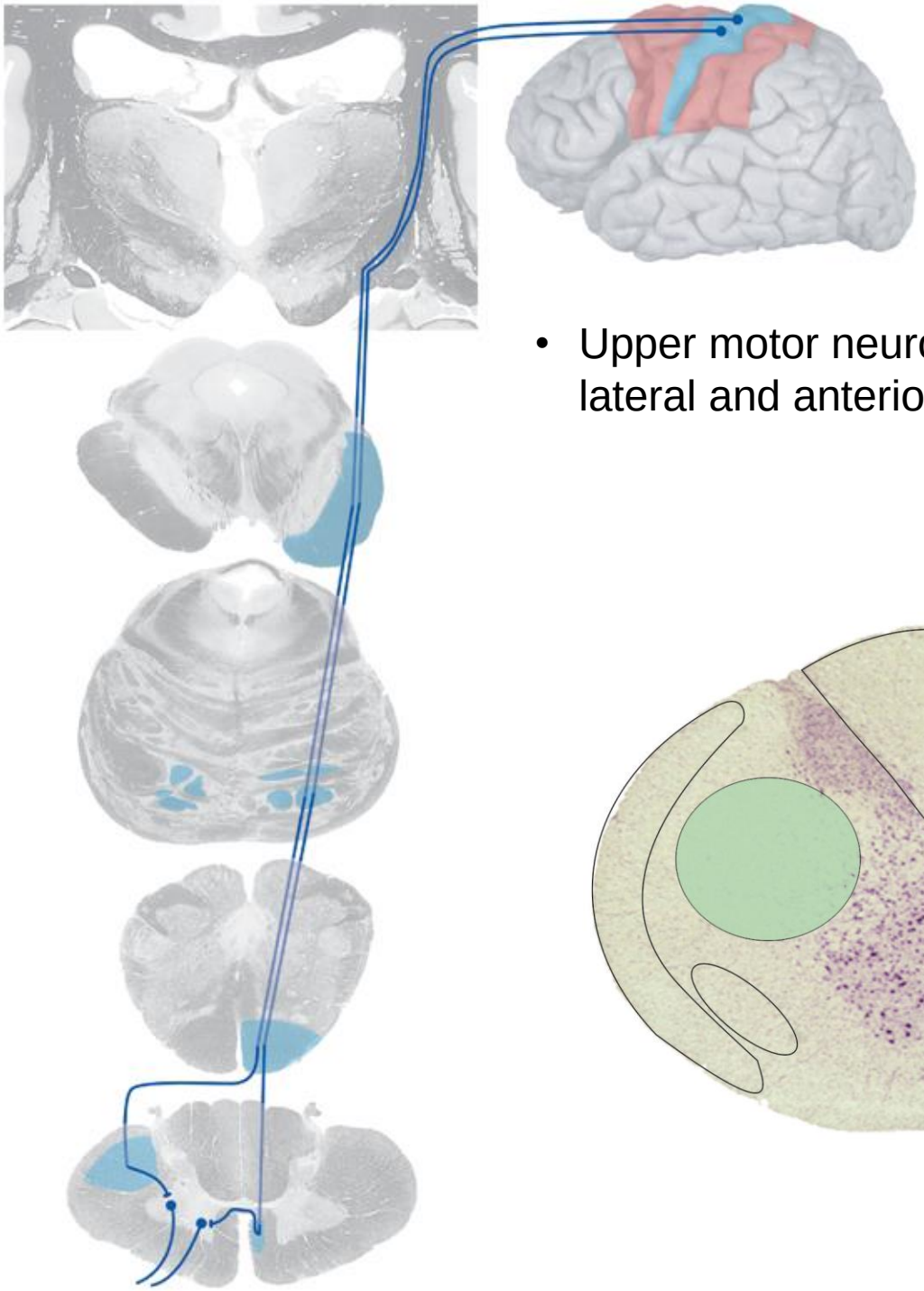
  -synapses with-

- Muscle fiber

  (each muscle fiber has a single neuromuscular synapse; a single motor neuron can innervate multiple muscle fibers)



## Motor System



- Upper motor neurons descend from cortex in the lateral and anterior corticospinal tracts.