# The Spinal Cord

Lab 3

January 19, 2026 - Dr. Stiver (mikaela.stiver@ubc.ca)

## *Objectives:*

1. Describe the gross anatomy of the spinal cord and its relationship to the vertebral canal and the organization of blood supply to the spinal cord.
2. Identify the locations of the corticospinal tract, the posterior column-medial lemniscus system and the anterolateral system in a cross section of the spinal cord.
3. Identify the location of somatic sensory, visceral sensory, somatic motor and visceral motor neurons in the gray matter of the spinal cord.
4. Sketch the longitudinal course of the corticospinal tract, the posterior column-medial lemniscus system and the anterolateral system throughout the spinal cord and brainstem and demonstrate an understanding of somatotopic arrangement, site of crossing fibres, and modalities carried within these tracts.
5. Identify the meningeal layers around the spinal cord and relate these to the spaces they border with and define. Explain the functional importance of these spaces for clinical practice.
6. Describe how the neuroanatomy of micturition relates to the underlying pathways and their locations in the brainstem and spinal cord. Correlate clinical presentations of bladder dysfunction to lesions of these pathways.
7. Describe the typical symptoms seen in spinal cord injuries as they relate to motor, sensory and autonomic function to the tracts discussed in this lab.

## Resources

Below are the e-tutorials, videos, and web resources for this lab – click the green buttons to access them.

Spinal Cord (Module) | Spinothalamic Tract (Module) | Corticospinal Tract (Module)

PCML Pathway (Module) | Micturition (Module)

Spinal Cord (Video) | Spinal Nerves (Video) | Web Syllabus & Links

*This icon located throughout the lab manual indicates **checklist items**!*

*Check out our neuroanatomy game **Cerebro**!*

APK Download (Android)
App Store (iOS)

***Note:*** Slides and a brief post-lab video wrap-up will be posted on Entrada within 24 hours following the lab.

Please use these cases to apply your knowledge to the clinical scenario. Try to reason through the cases rather than memorizing an answer. Every patient presents differently and your ability to manipulate and apply your knowledge will lead towards diagnosis.

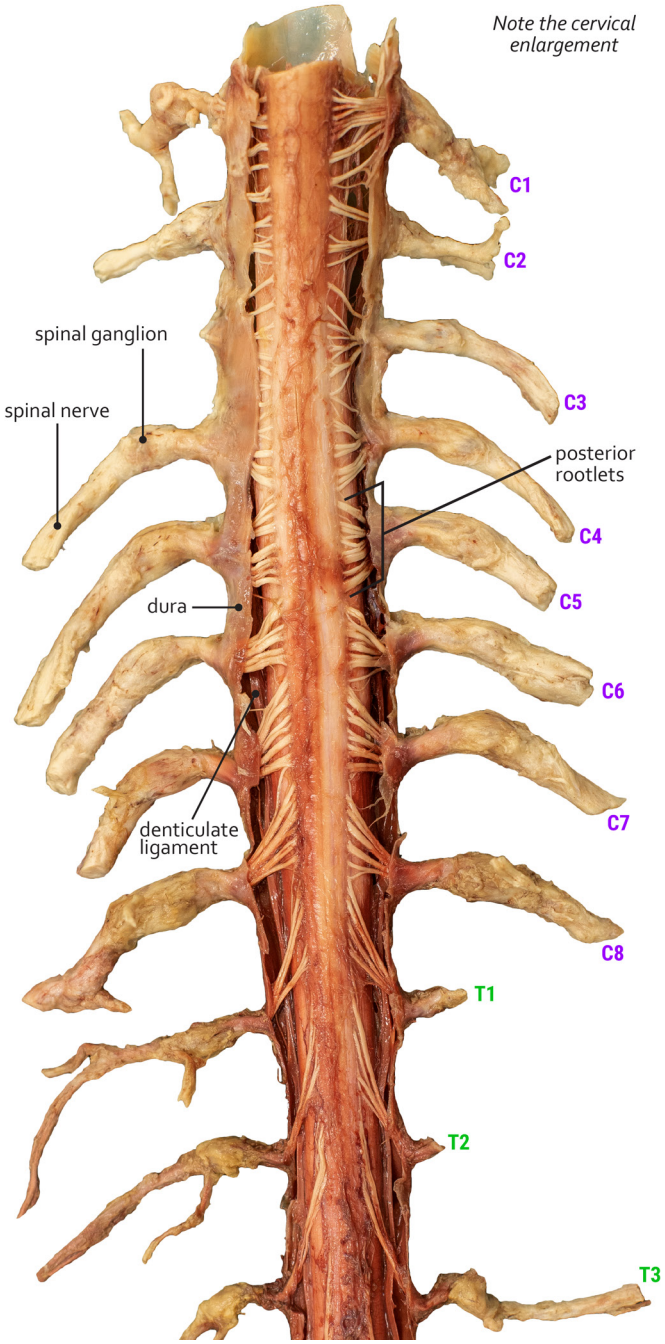
***Remember: neurology is applied neuroanatomy!***

** NOTE: Interactive PDFs are best viewed on desktop/laptop computers - functionality is not reliable on mobile devices **

## Gross Anatomy

***Identify the following structures on a spinal cord specimen:***

- enlargements
- conus medullaris
- spinal nerves with anterior & posterior roots
- spinal ganglion
- filum terminale
- denticulate ligament

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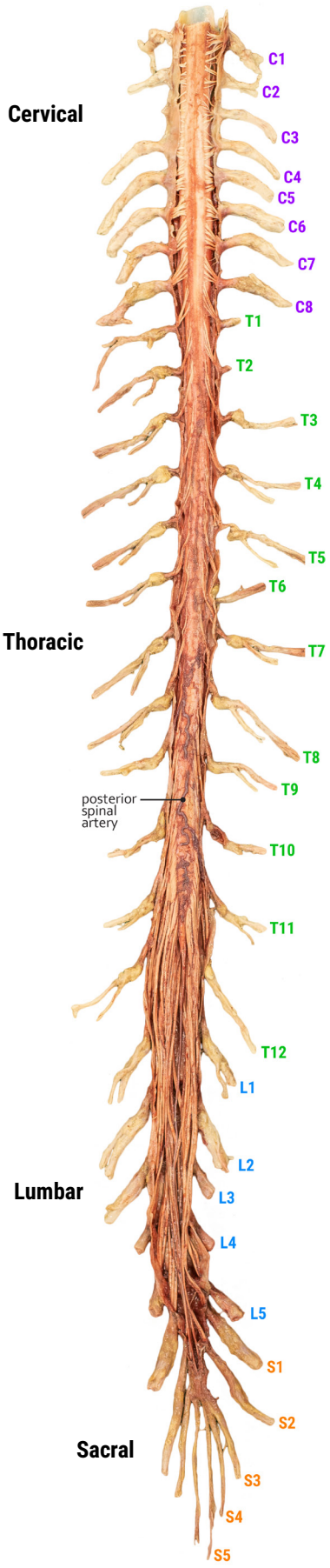
*Dissection of Cervical Spinal Cord*



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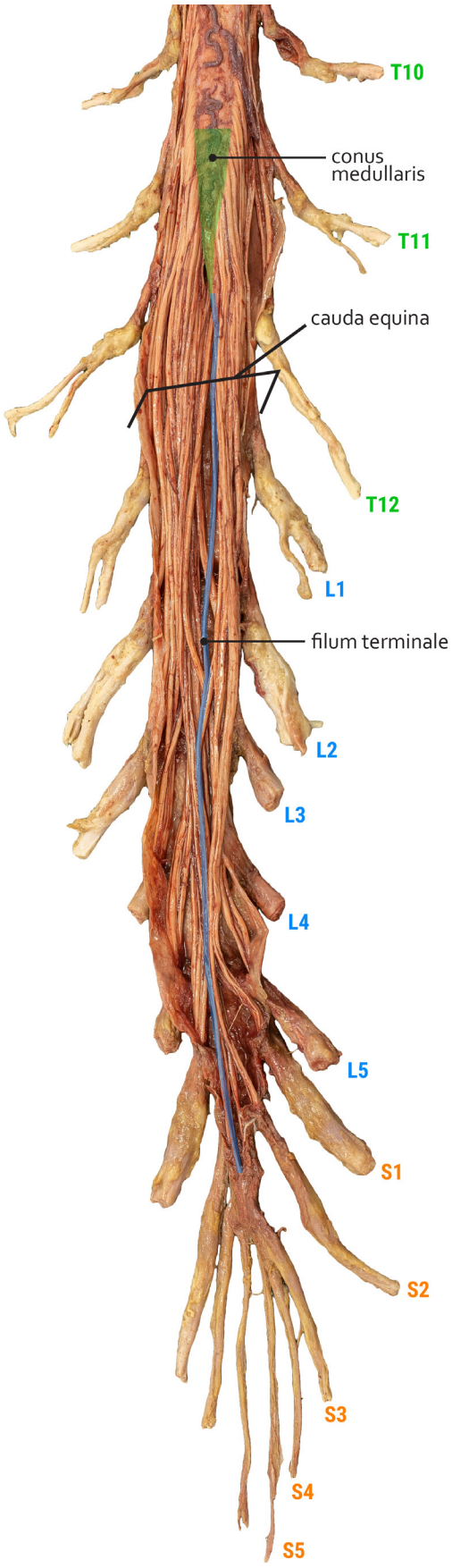


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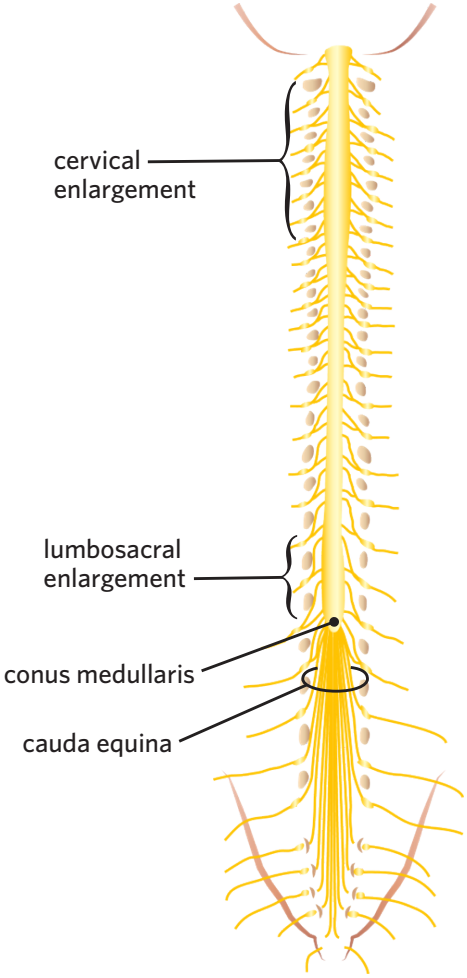
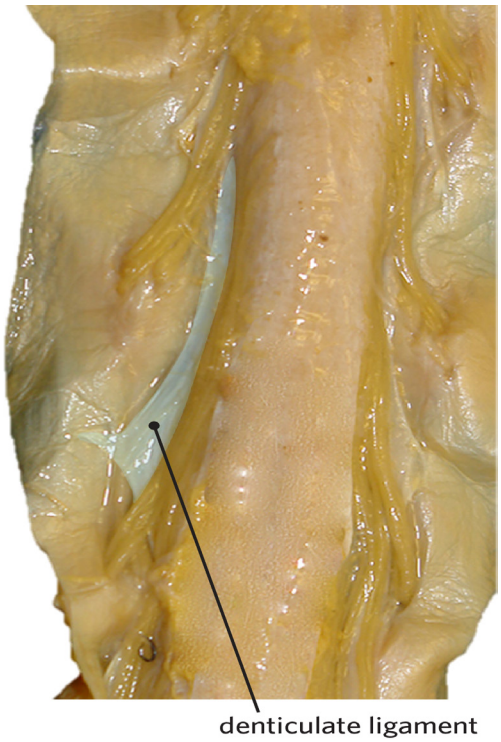
*Dissection of Terminal Portion of Spinal Cord*



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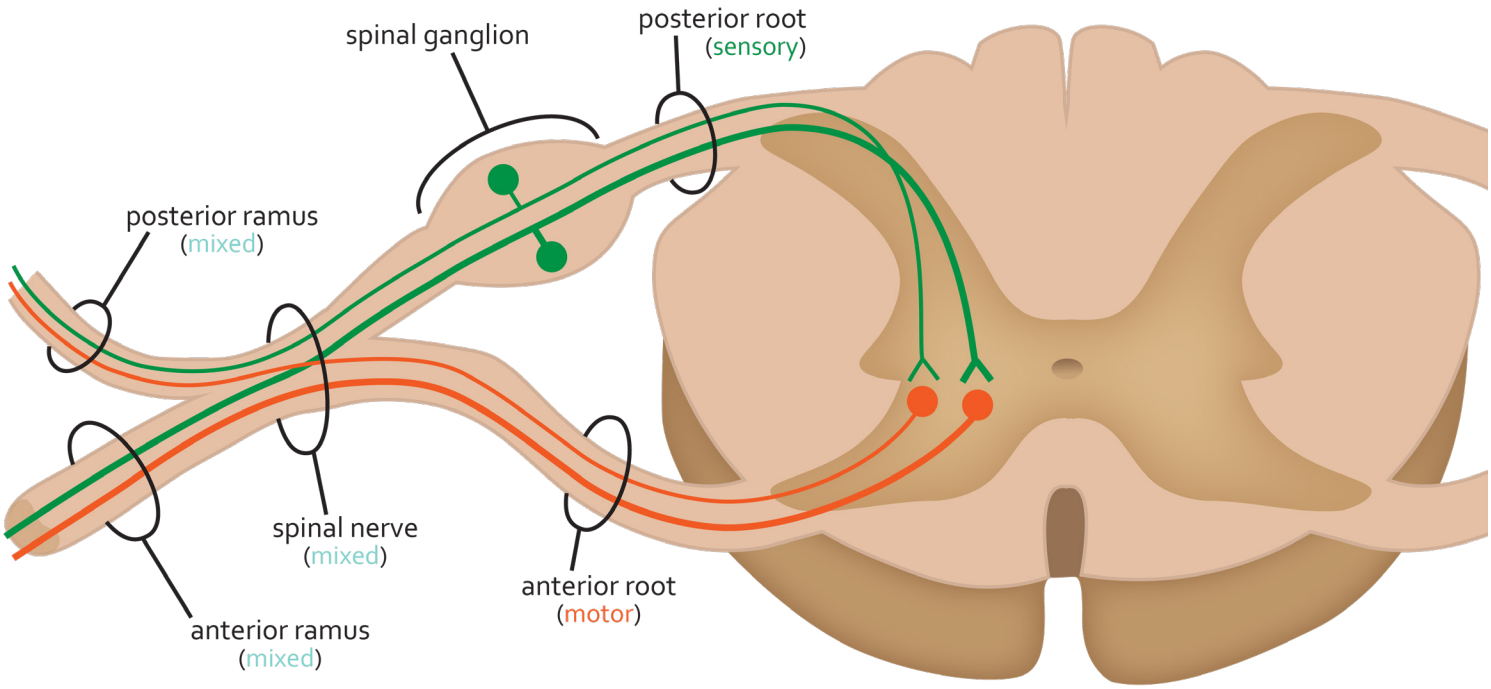


*Schematic of Spinal Nerve Components*

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## Blood Supply

The **spinal cord** and **brainstem** are supplied by the **vertebrobasilar system**.

The **cortex** is supplied by both the **vertebrobasilar system** and **internal carotid system**.

All along the **spinal cord** you can find **one anterior spinal artery** and **two posterior spinal arteries**.

*They receive their blood supply from two major sources:*

1. vertebrobasilar system
2. segmental medullary arteries

***Identify the following arteries:***

- ○ basilar
- ○ vertebral
- ○ anterior spinal

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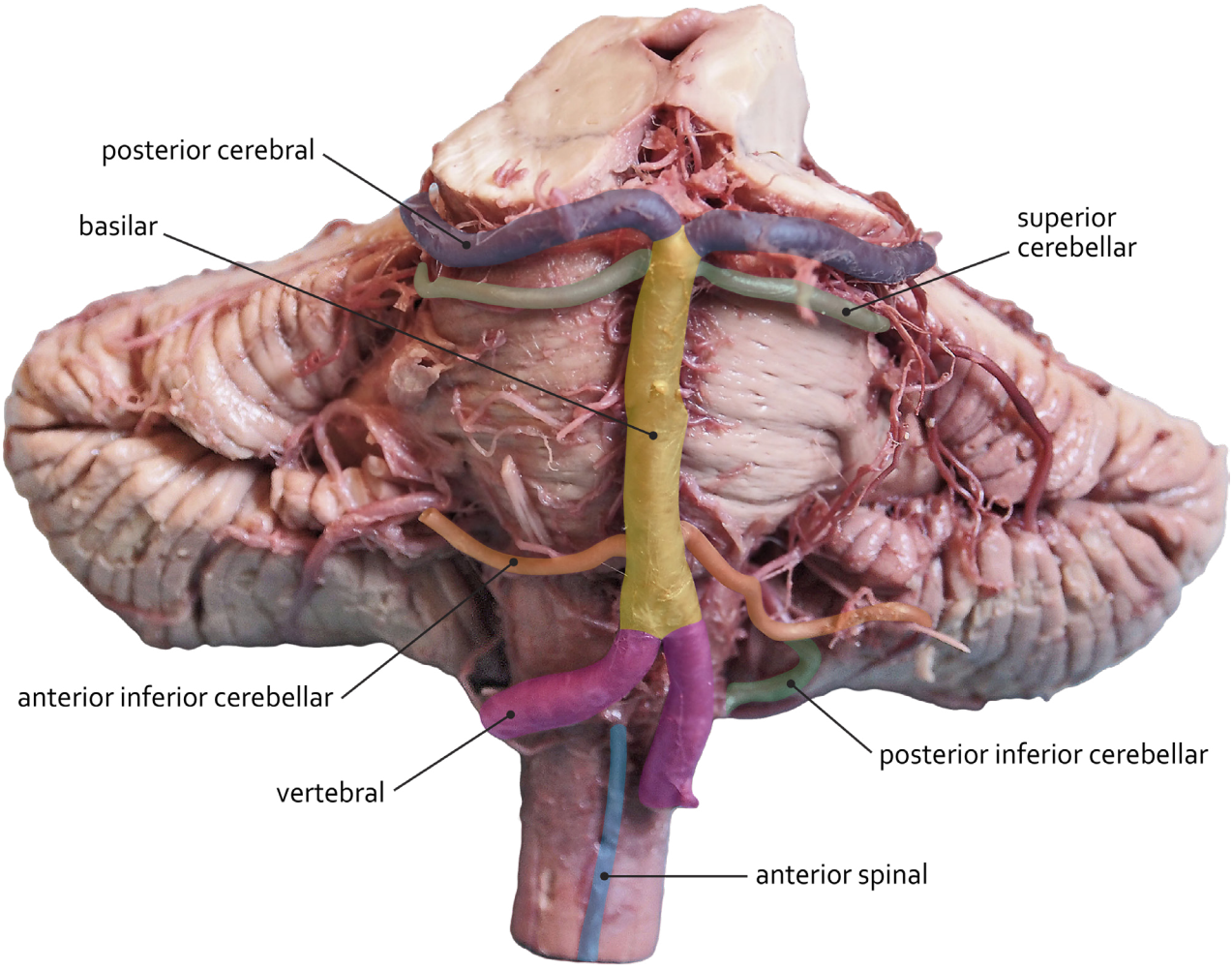
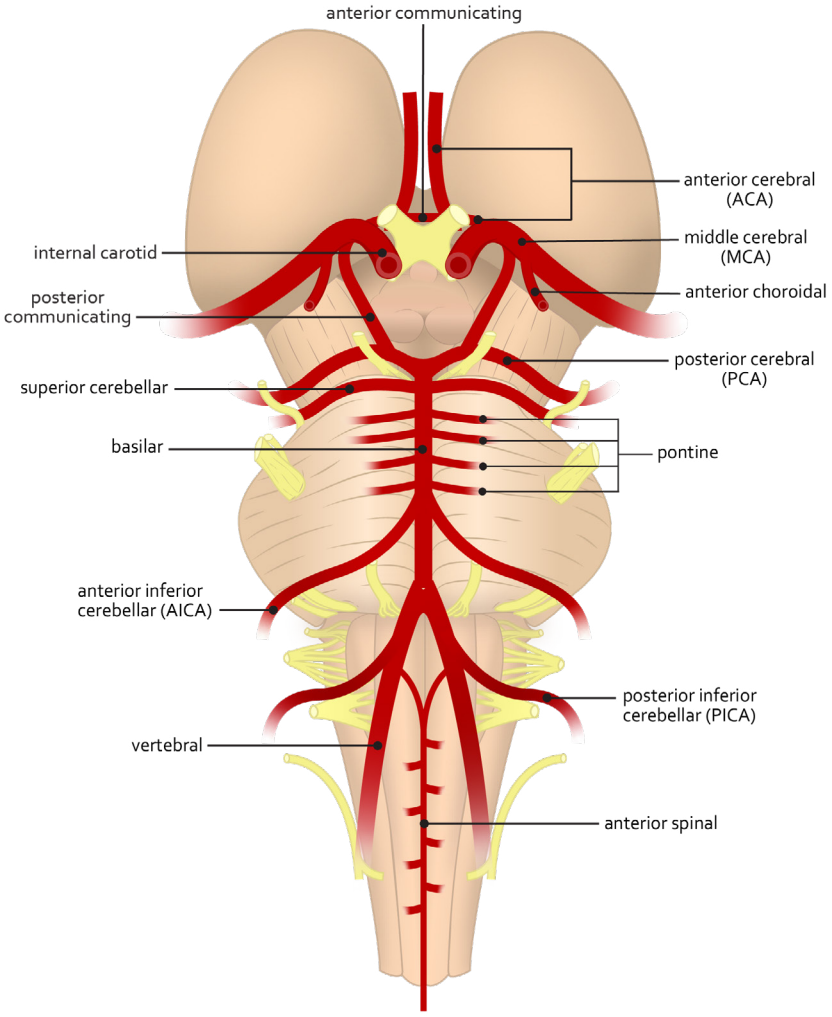



*Vertebrobasilar System on Brainstem*

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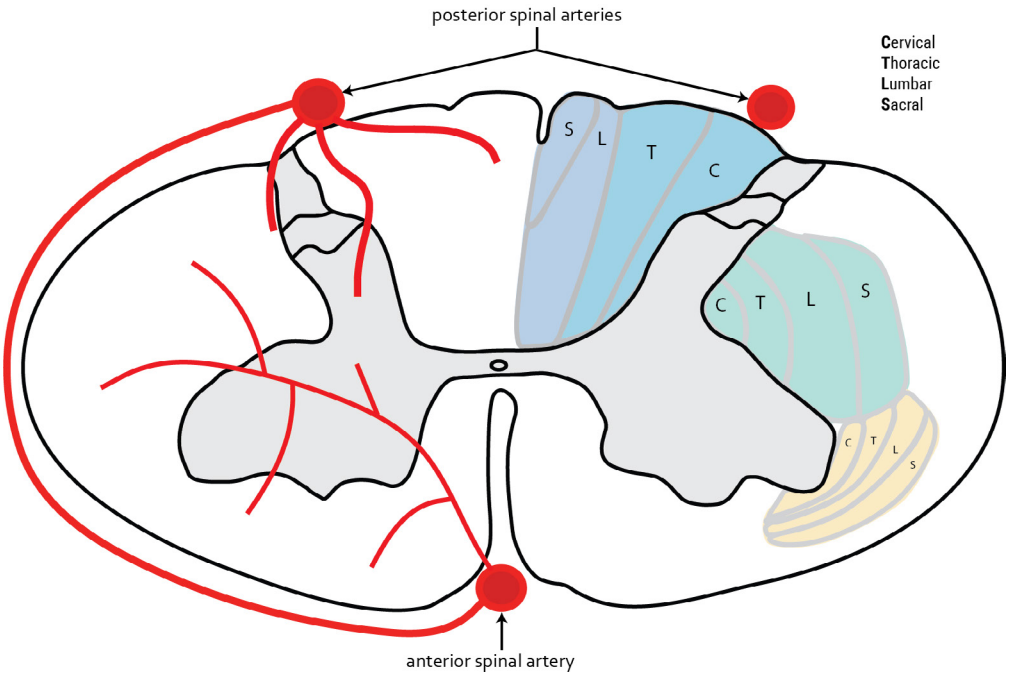
*Cerebral Arterial Circle (Circle of Willis) on Anterior Brainstem*




Show Perfusion Areas

*Spinal Arteries in Spinal Cord Cross-Section*

## *Gray Matter & White Matter*

Micrographs (Web)

*(interactive atlas for all micrographs)*

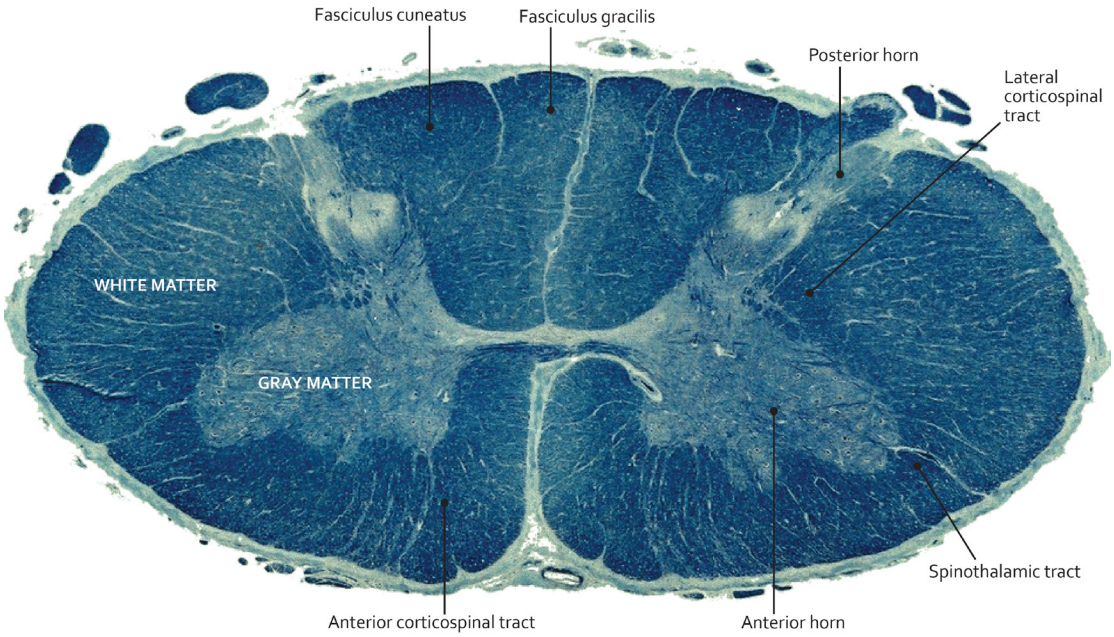
***On micrograph #1 identify the following structures:***

**Gray Matter:**

- ◯ anterior horn
- ◯ posterior horn

**White Matter:**

- ◯ spinothalamic tract
- ◯ posterior column (fasciculus gracilis & fasciculus cuneatus)
- ◯ lateral and anterior corticospinal tracts




*Below the T6 spinal level, the posterior column is only comprised of the fasciculus gracilis... can you explain why?*

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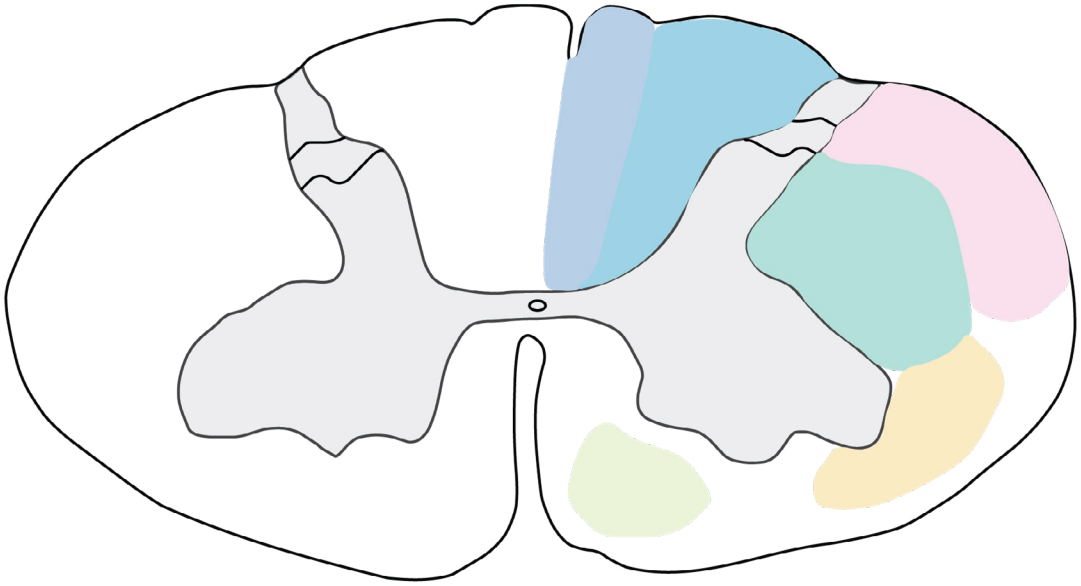
*Spinal Cord in Cross-Section*



**Fasciculus gracilis**
sensory (fine touch, proprioception, vibration) from ipsilateral lower limb

**Fasciculus cuneatus**
sensory (fine touch, proprioception, vibration) from ipsilateral upper limb

**Spinocerebellar tract**
proprioception from limbs to cerebellum

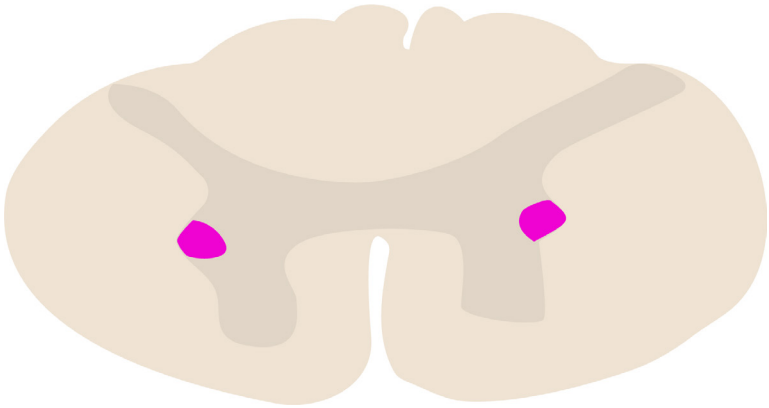
**Lateral corticospinal tract**
motor to ipsilateral ventral horn mostly limb musculature

**Spinothalamic tract**
pain, temperature and non-discriminative/coarse touch from contralateral side of the body

**Anterior corticospinal tract**
motor to ipsi- and contralateral ventral horn, mostly axial musculature

## *Location of* sympathetic *neurons*

- in the lateral horn of the spinal cord at the T1-L2 spinal levels



*Sympathetic Neurons in Thoracic Cord*

## *Location of* parasympathetic *neurons*

- in the brainstem (associated with CN III, VII, IX, X) and in the lateral horns of the spinal cord at the S2-S4 spinal levels

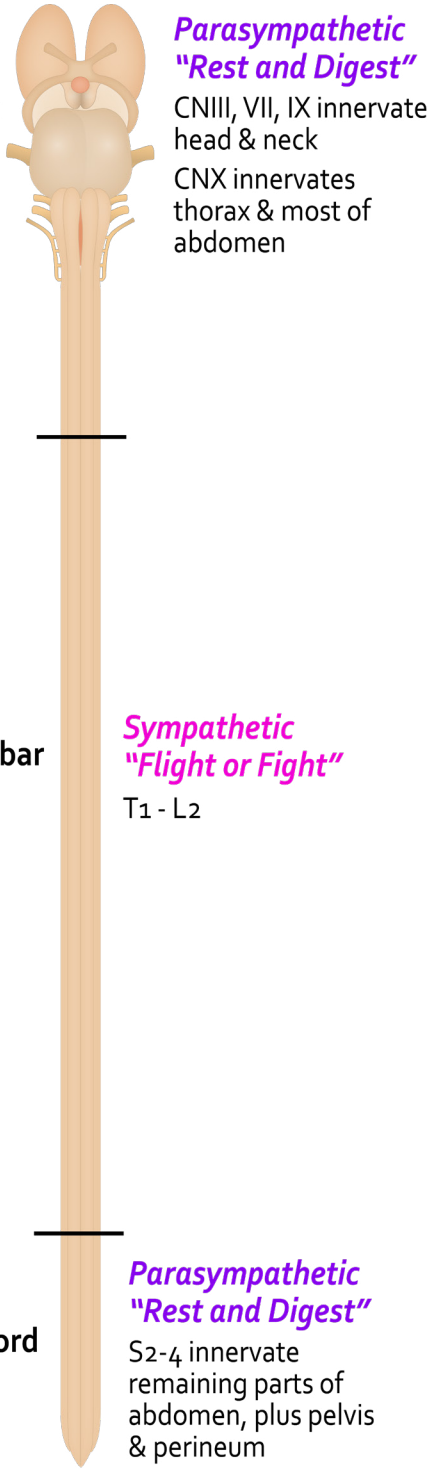
*Parasympathetic Neurons in Sacral Cord*

Note:
There is a study and some evidence that the sacral outflow may need to be re-defined as sympathetic. This is a matter of great controversy at the moment. Stay tuned to this research!

***Spiral from MEDD 411:***

Sympathetic NS (Video)

Parasympathetic NS (Video)



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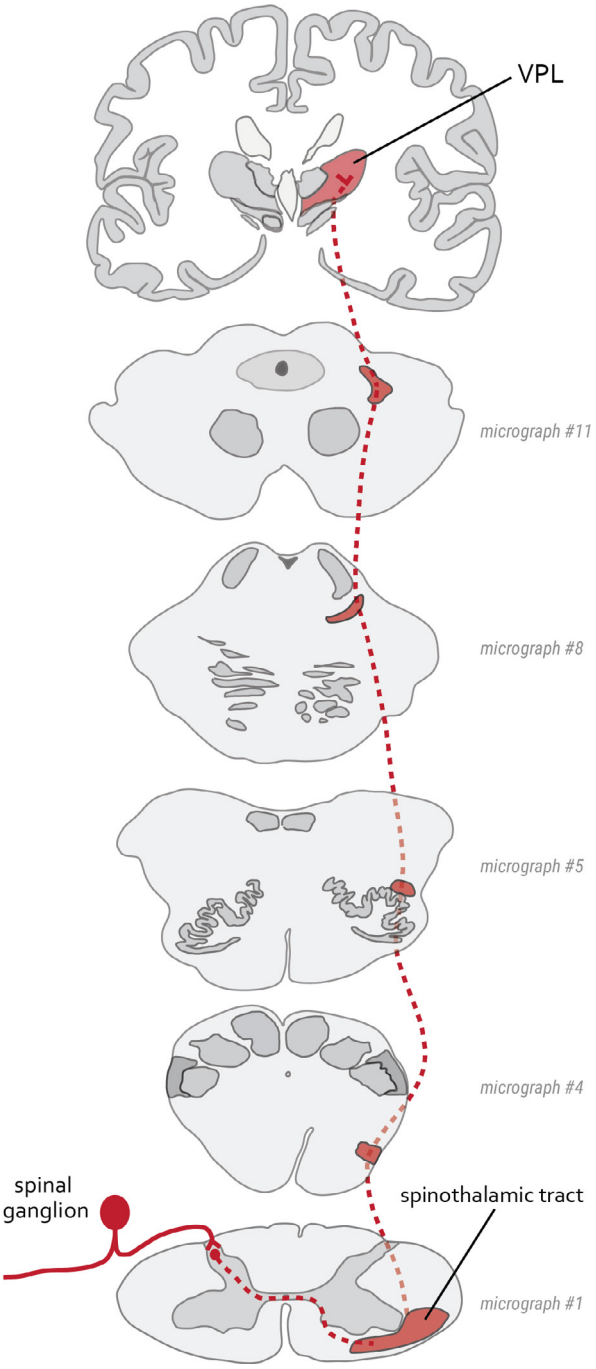
## *Spinothalamic Tract*

Spinothalamic Tract (Module)

- Pain and temperature
- Non-discriminative (coarse) touch




5 The spinothalamic tract terminates in the ventral posterior lateral (VPL) of the thalamus. From the thalamus fibers project through the internal capsule and corona radiata to terminate in the primary somatosensory cortex (postcentral gyrus).

4 The spinothalamic tract (spinal lemniscus) lies lateral (in the pons) and posterior (in the midbrain) to the medial lemniscus.

3 In the rostral medulla, the spinothalamic tract (spinal lemniscus) lies just posterior and lateral to the inferior olivary nucleus.

2 Spinothalamic tract (also called the 'spinal lemniscus' in in the brainstem) in the caudal medulla.

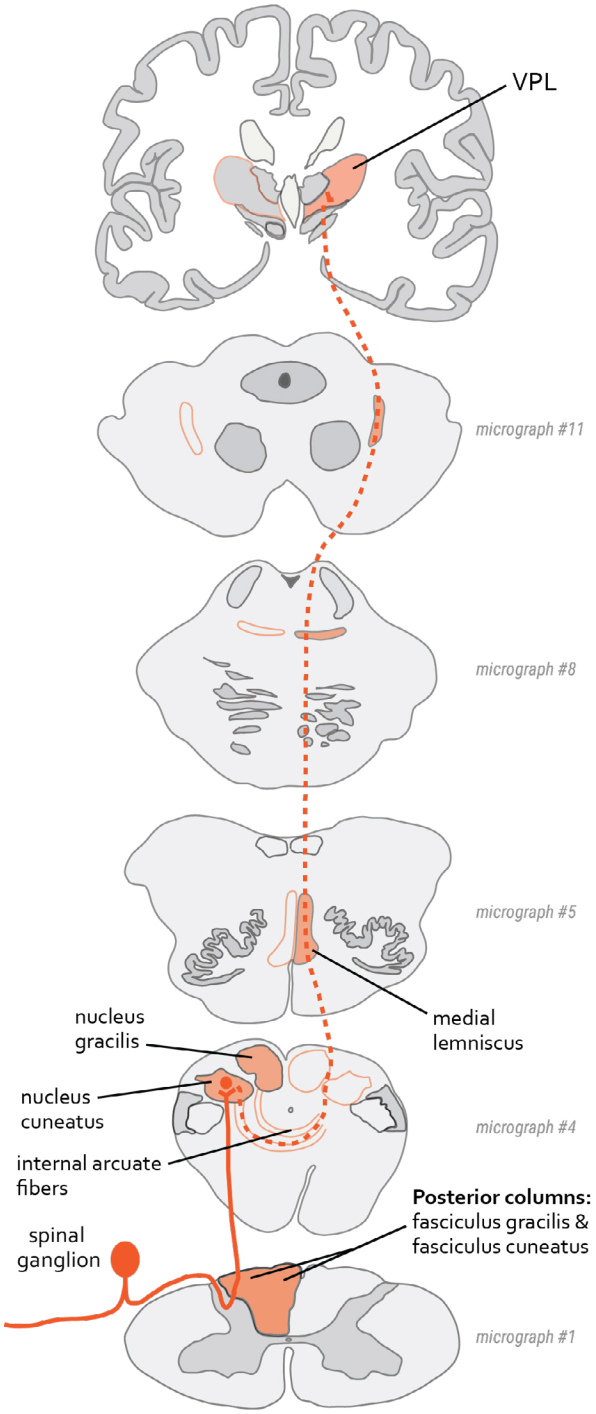
1 Axons enter the spinal cord via the spinal ganglion, travel up or down 1-2 segments in the posterolateral tract (eponym = Lissauer's tract) and then synapse in the posterior horn.

Axons of secondary neurons cross the midline in the anterior white commissure and ascend as the spinothalamic tract in the spinal cord.

## Posterior Column Medial Lemniscus Pathway

- Discriminative (fine) touch, vibration and conscious proprioception

PCML Pathway (Module)




6. The medial lemniscus terminates in the ventral posterior lateral (VPL) of the thalamus. From the thalamus fibers project through the internal capsule and corona radiata to terminate in the primary somatosensory cortex (postcentral gyrus).

5. As the medial lemniscus continues to ascend through the rostral pons and midbrain, it moves laterally and becomes oriented in the sagittal plane.

4. In the caudal pons, the medial lemniscus becomes oriented in the frontal / coronal plane.

3. In the rostral medulla, the fibers travel as the medial lemniscus adjacent to the midline.

2. They terminate in nucleus gracilis or nucleus cuneatus. From these nuclei, axons of secondary neurons cross the midline as internal arcuate fibers, and form the medial lemniscus.

1. Axons enter the spinal cord from the spinal ganglion and pass directly to the ipsilateral dorsal column.

   Caudal fibers (below T6) enter fasciculus gracilis (medial) and rostral fibers (at & above T6) enter fasciculus cuneatus to ascend.

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## *Lateral and Anterior Corticospinal Tract*

Corticospinal Tract (Module)

- Voluntary motor control (below the head)

1. Upper motor neurons (UMNs) of the corticospinal tract originate in the motor cortex.

   Descending fibers contribute to the corona radiata, and converge as the posterior limb of the internal capsule.

2. Corticospinal fibers (UMNs) descend through the middle of the cerebral peduncles in the anterior part of the midbrain.

3. In the pons, the fibers are broken up into many bundles by horizontal tracts connected to the cerebellum.

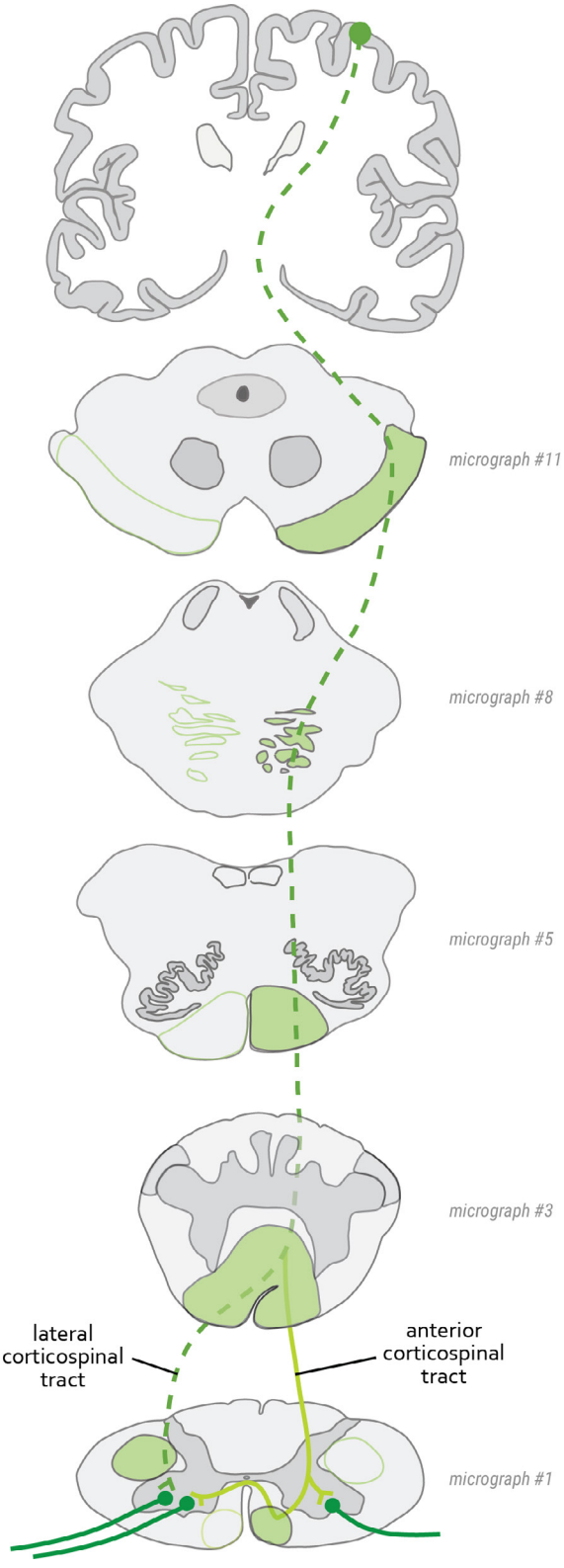
4. The corticospinal fibers (UMNs) descend as the pyramids in the anterior part of the medulla.

5. At the junction of the medulla and spinal cord, most (85–90%) fibers cross the midline in the decussation of the pyramids. These crossed fibers go on to form the lateral corticospinal tract in the spinal cord.

   Uncrossed fibers (10–15%) descend through the spinal cord as the anterior corticospinal tract.

6. UMNs in the lateral corticospinal tract synapse with ipsilteral lower motor neurons (LMNs) in the anterior horn of the spinal cord.

   Some UMNs in the anterior corticospinal tract cross the midline in the anterior white commissure at the level where they terminate, while others stay ipsilateral before synapsing with LMNs in the anterior horns.



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## *Identify on micrographs:*

Micrographs (Web)

*(interactive atlas for all micrographs)*

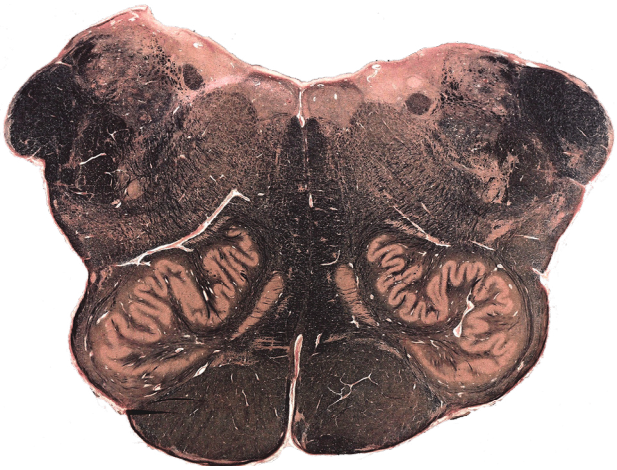
#11 (rostral midbrain)

- ◯ medial lemniscus
- ◯ medial longitudinal fasciculus
- ◯ spinothalamic tract (spinal lemniscus)

#8 (rostral pons & cerebellum)

- ◯ medial lemniscus
- ◯ medial longitudinal fasciculus
- ◯ corticospinal fibers
- ◯ spinothalamic tract (spinal lemniscus)

#5 (rostral medulla)



- ◯ medial lemniscus
- ◯ medial longitudinal fasciculus
- ◯ spinothalamic tract (spinal lemniscus)
- ◯ spinocerebellar tract
- ◯ pyramid

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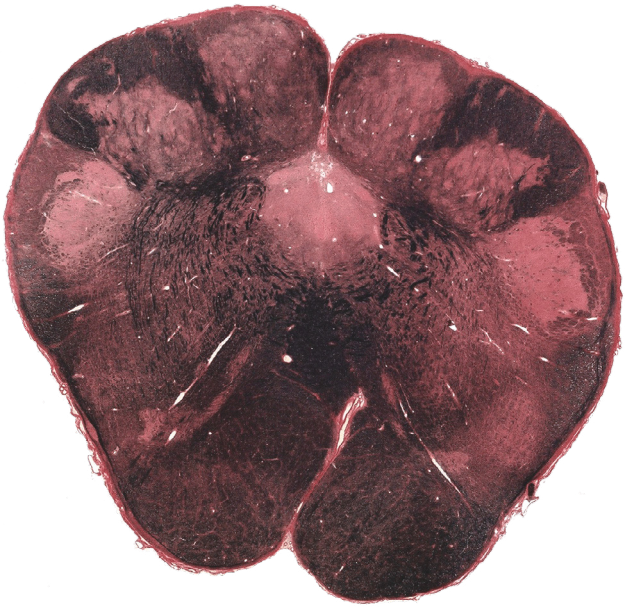
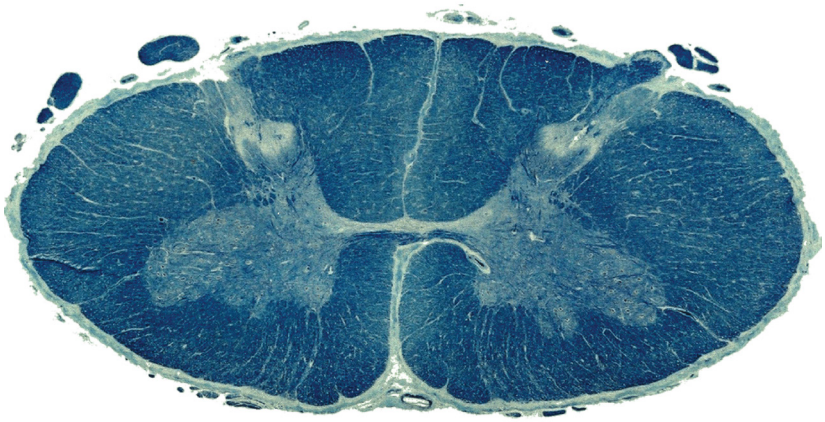
#4 (medulla)



- ◯ fasciculus gracilis, fasciculus cuneatus (posterior column)
- ◯ nucleus gracilis, nucleus cuneatus
- ◯ internal arcuate fibers
- ◯ spinothalamic tract (spinal lemniscus)
- ◯ spinocerebellar tract
- ◯ pyramid

#1 (spinal cord)



- ◯ anterior & lateral corticospinal tracts
- ◯ fasciculus gracilis, fasciculus cuneatus (posterior column)
- ◯ anterior & posterior horns
- ◯ spinothalamic tract (spinal lemniscus)
- ◯ spinocerebellar tract
- ◯ anterior white commissure

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*Illustration: Milo Applejohn*

## Case #1

**Mr. Grant (he/him) presents with the following neurological symptoms:**

1. Spastic paralysis of the left leg, positive Babinski sign (toes upgoing) on the left; both upper limbs have full strength and show no spasticity.
2. Loss of discriminative touch, vibration and joint position sense from approximately the level of the nipples down on the left side only.
3. Loss of pain and temperature sensation from the mid-abdomen downward on the right side.

*List the complaints and a possible neuroanatomical location for the complaints.*

*Where do you think the lesion could be?*

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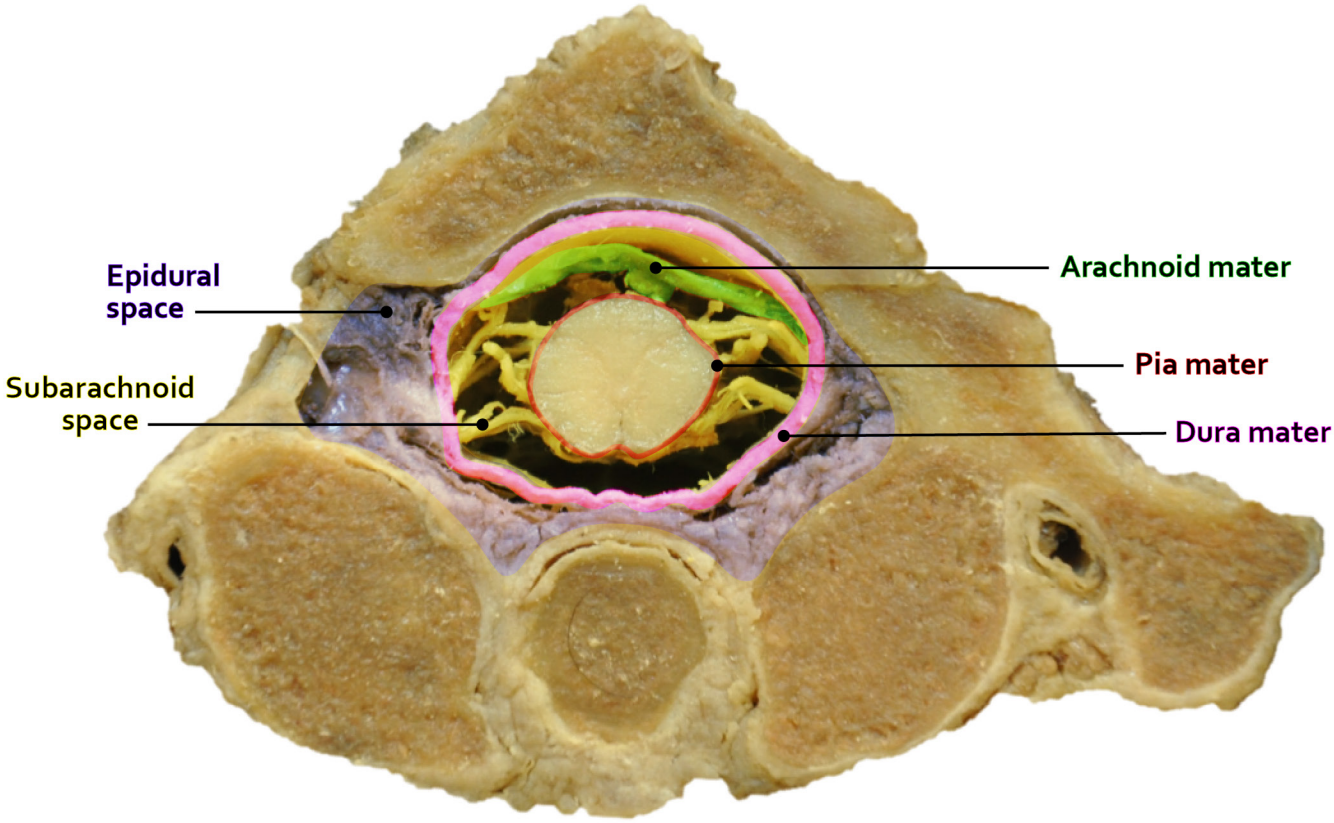
## Meninges

***Identify the following structures on a spinal cord specimen:***

- Spinal meninges
  - Dura mater
  - Arachnoid mater
  - Pia mater
- Epidural space
- Subarachnoid space




*Cervical Spinal Cord and Spinal Column (cross-section)*

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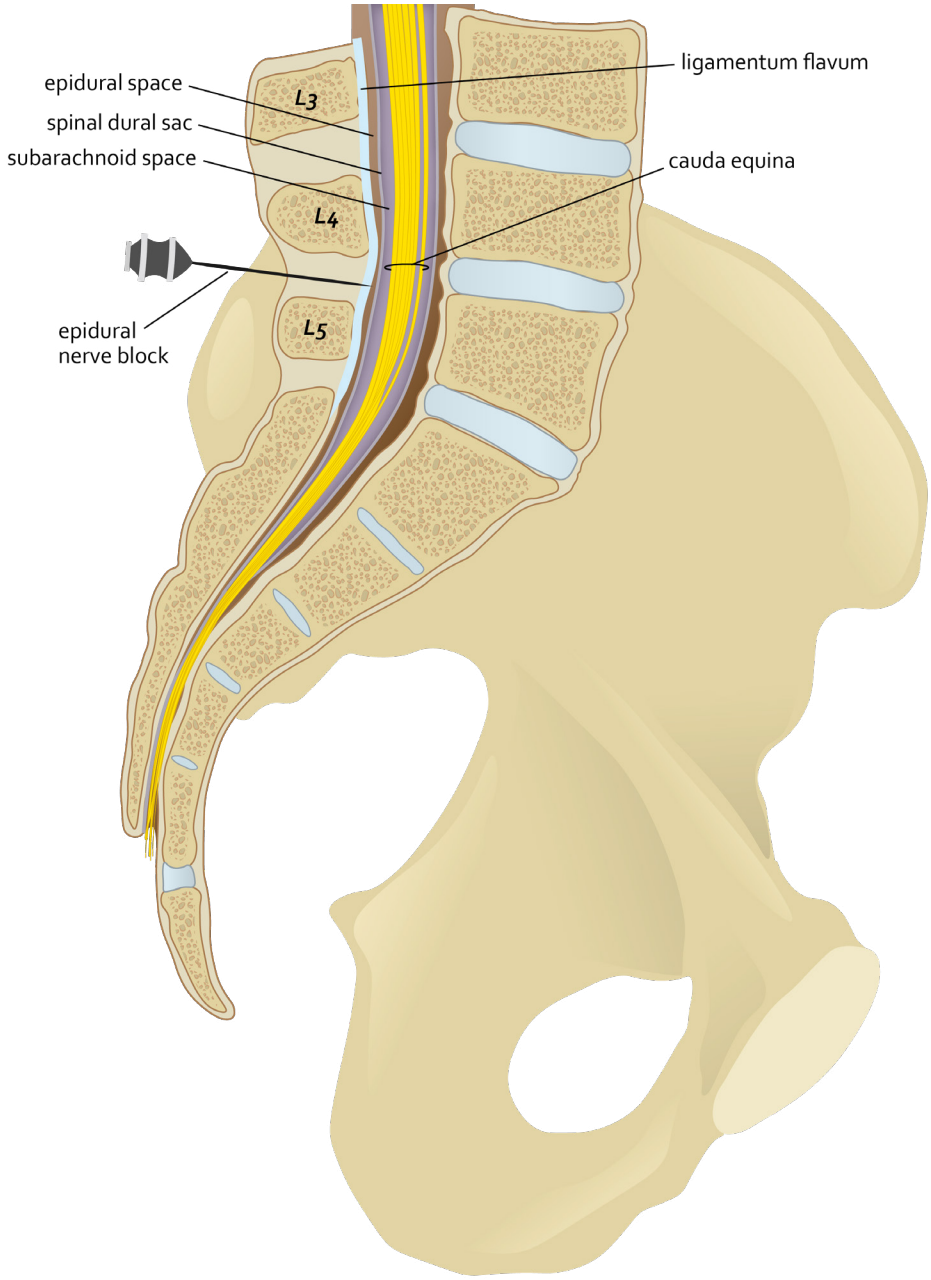
## The anatomical layers around the spinal cord are important for clinical practice.

The **epidural space** is used to administer anaesthetic for temporary pain relief.

The **subarachnoid space** is filled with CSF. You can insert a needle into this space to obtain a sample of CSF.

*Check out this video for a clinical guide to performing a spinal tap:* CSF Sampling (Video)

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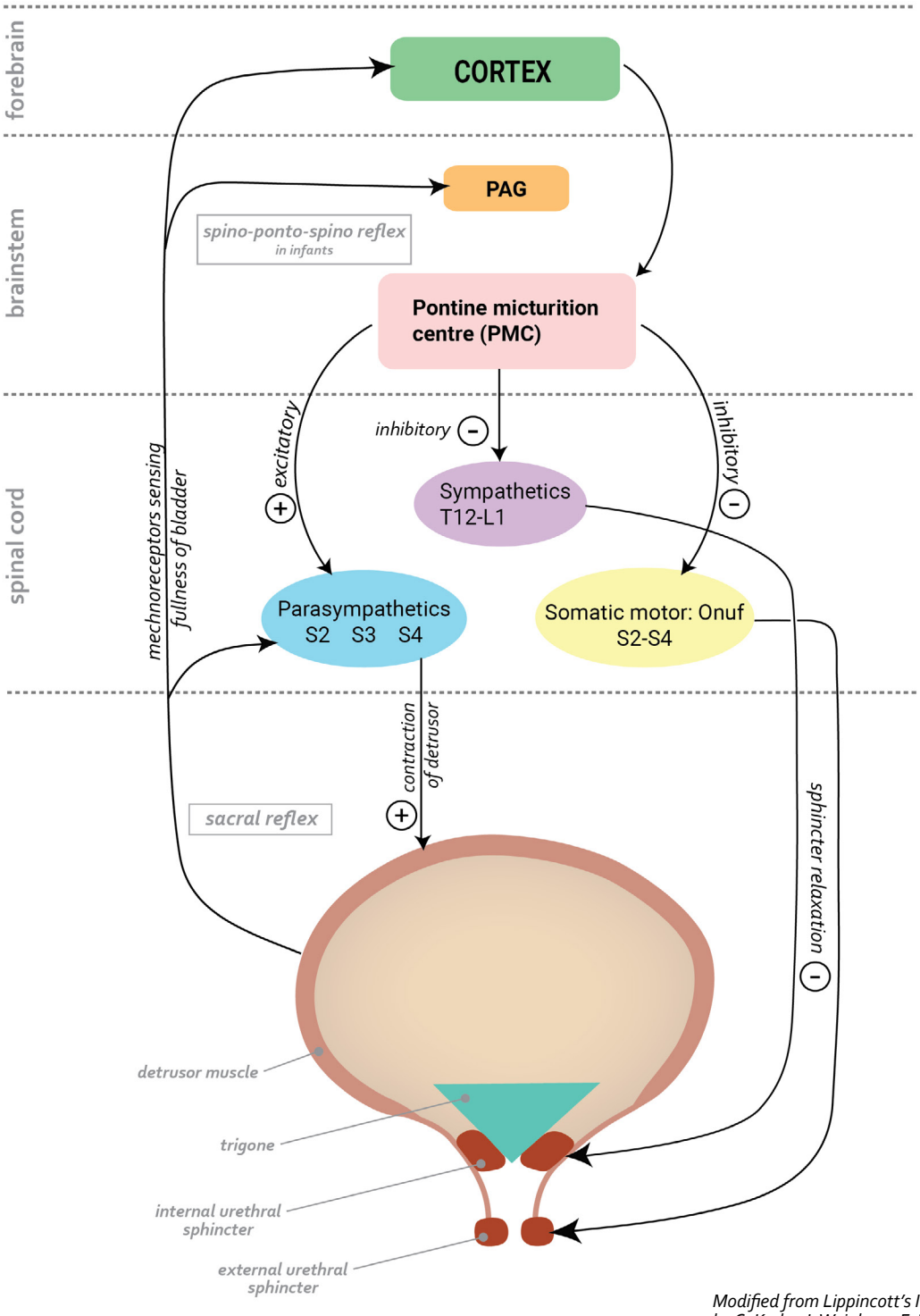
## Micturition

The control of micturition is a complex interplay between the visceral and somatic nervous systems, and it involves various levels of the spinal cord, the brainstem, and the cortex. Patients with spinal cord injuries will have this system impacted.




Micturition (Module)

E-tutorial with a step-by-step interactive guide to micturition

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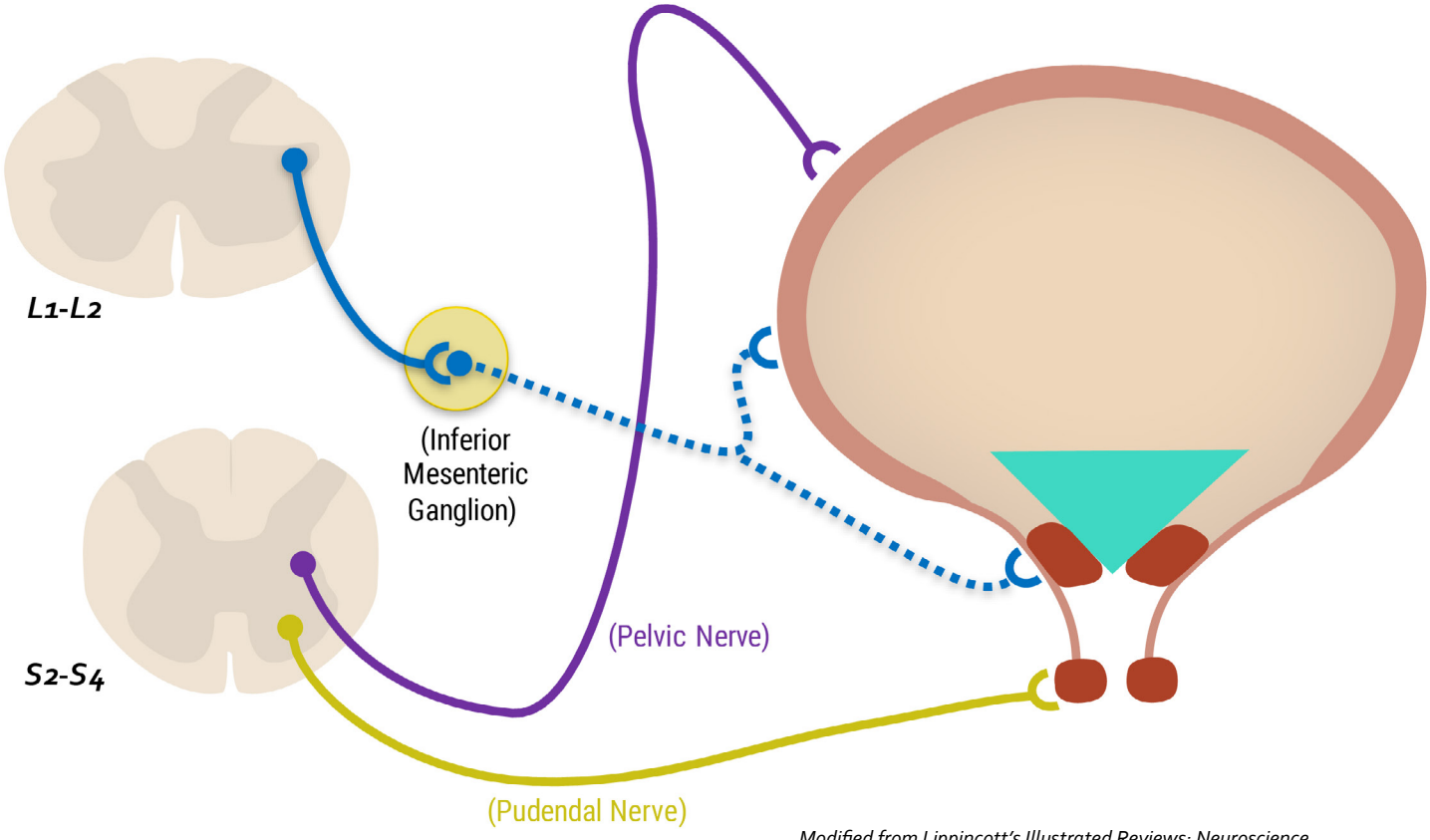
## Innervation of the Bladder

1. **Pain and temperature (somatic afferent)**
   - from mucosa of fundus; fibers travel with sympathetics, reach spinal cord at T11–L2 spinal levels; from there via spinothalamic tract to brainstem and cerebrum
   - from neck of bladder; travel with sympathetics, reach spinal cord at S2–S4 spinal levels; from there via spinothalamic tract to brainstem and cerebrum
2. **Fullness of bladder (visceral afferent)**
   - mechanoreceptors in the bladder wall; signal to sacral parasympathetics (S2–S4 spinal levels), brainstem, and cerebrum
3. **Voiding (parasympathetic visceromotor)**
   - detrusor muscle of bladder innervated by parasympathetics from S2–S4 spinal levels
4. **Innervation of the internal urethral sphincter (sympathetic visceromotor), males only**
   - sympathetic visceromotor neurons (T11–L2 spinal levels)
5. **Innervation of the external urethral sphincter (somatic motor, pudendal nerve)**
   - Onuf nucleus at S2–S4 spinal levels; axons form pudendal nerve
6. **Micturition centres**
   - Cortical: superior frontal gyrus
   - Pons: pontine micturition centre and pontine storage centre



## Approach to Innervation of the Bladder

### What do you want to do?

#### *Voiding Urine*

- Is the bladder full? **sensory fibers (signaling to spinal cord and brain)**
- Is it appropriate? **cortical decision**
- Let's coordinate voiding! **Pontine micturition centre (PMC)**: in the pons
- To void, the detrusor needs to contract and the sphincter needs to relax
- **Detrusor muscle** of bladder is innervated by **parasympathetic fibers** from S2–S4 spinal levels in the spinal cord (*2-neuron peripheral pathway; analogous to somatic LMN for skeletal muscle*)
  - they get their input from the **PMC**
- **External sphincter** is innervated by **somatic fibres** from S2–S4 spinal levels (*2-neuron peripheral pathway; analogous to somatic LMN for skeletal muscle*)
  - they get their input from the **PMC**
- PMC **stimulates the parasympathetics** (detrusor) and **inhibits the somatics** (sphincter)
- In males, there is also an **internal urethral sphincter** that receives **sympathetic innervation** (T11–L2 spinal levels)
  - it is also inhibited by the **PMC**

#### *Retaining Urine*

- When you want to retain urine in the bladder, the **pontine storage center (PSC) coordinates the reverse**
  - **contraction of sphincter(s)** and **relaxation of detrusor**

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## Case #2

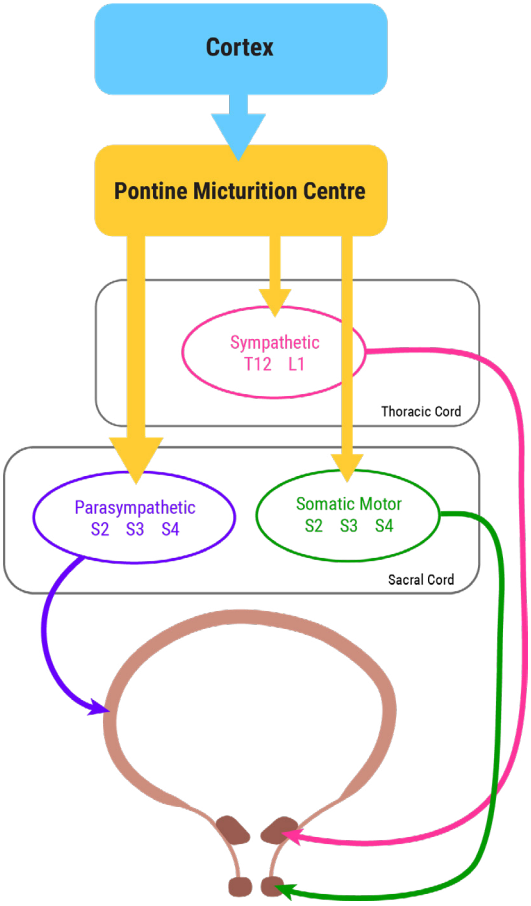
**Travis (they/them; 24 years old) comes in severely injured in a mountain biking accident. Although conscious, they report excruciating back pain, as well as loss of motor and sensory function in their lower limbs. They are placed in spinal precautions and air-lifted to a trauma centre.**

*Illustration: Milo Applejohn*

*What level of the spinal cord would be injured?*

*Think specifically about bladder function - which tracts are affected?*

*What are the consequences for bladder function?*



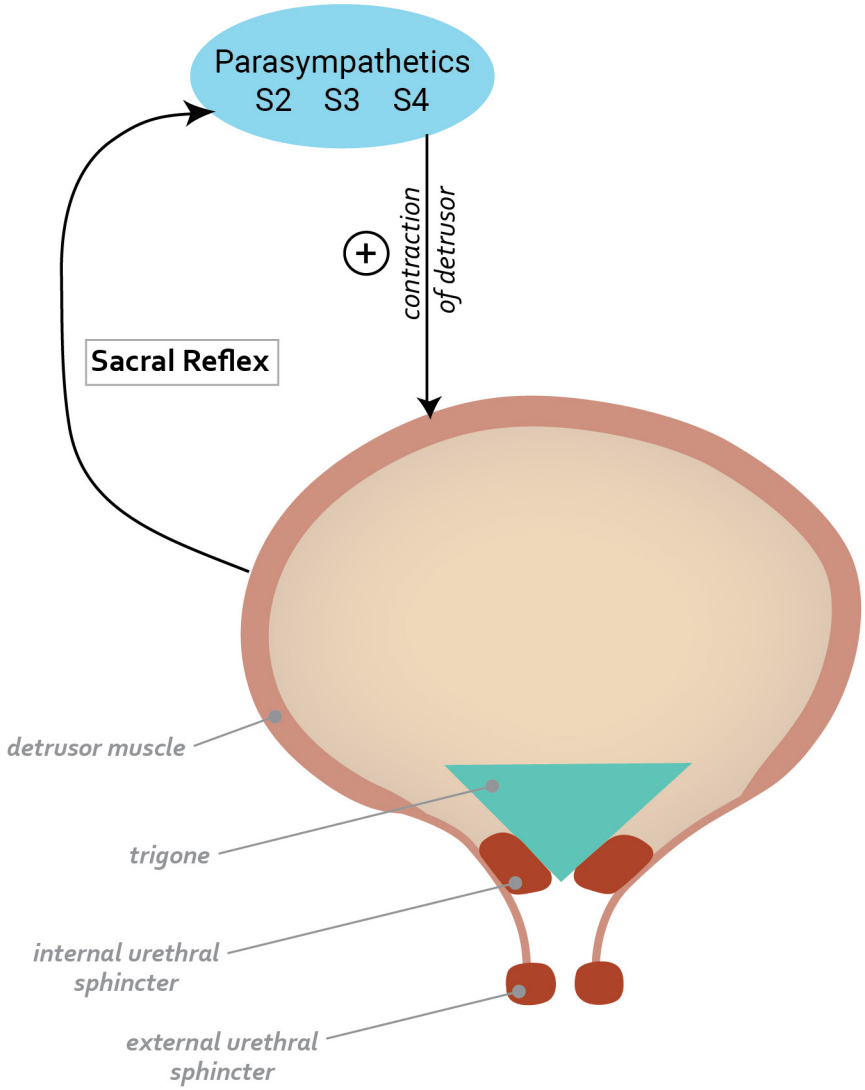

Use this diagram to conceptualize the affected tracts and the consequences for function.

## Sacral Reflex Pathway

1. Stretch receptors in bladder wall are activated
2. Stretch receptor output is transmitted via afferent fibers of the pelvic nerve to the sacral spinal cord
3. Preganglionic parasympathetic neurons (S2–S4 spinal levels) are activated and the detrusor muscle contracts

**In infants:** there is no control over the external sphincter

**In adults:** the external sphincter is under somatic control via the pudendal nerve




*Modified from Lippincott's Illustrated Reviews: Neuroscience by C. Krebs, J. Weinberg, E.J. Akesson, and E. Dilli. For educational use only.*

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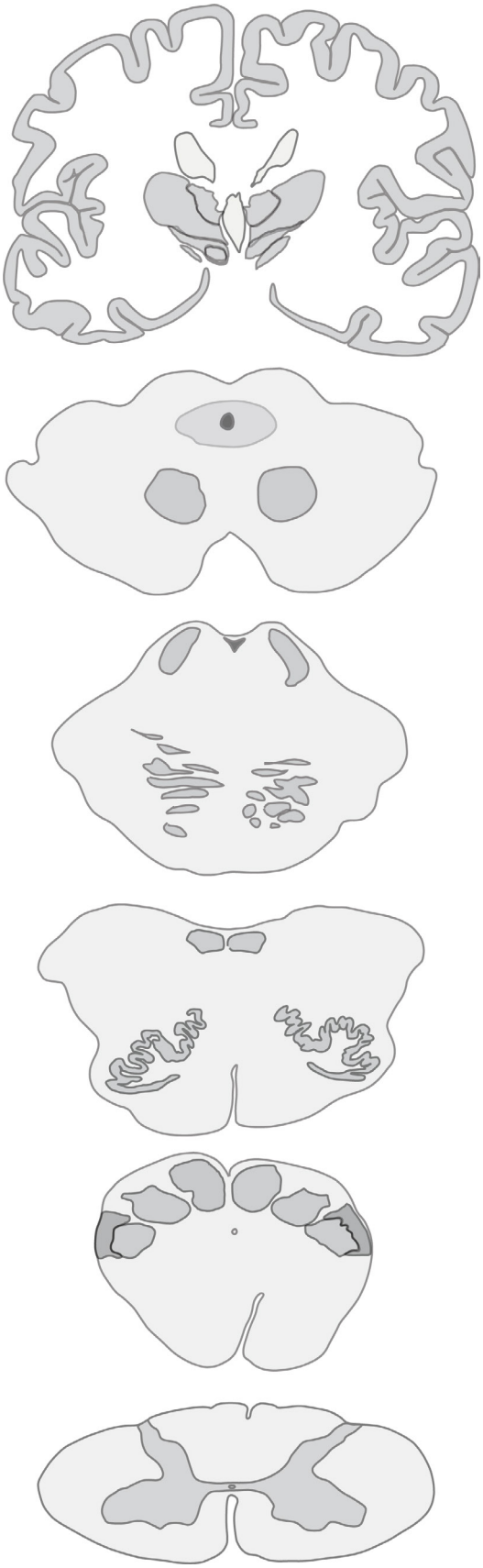
***You can use the following templates to practice drawing the different pathways:***



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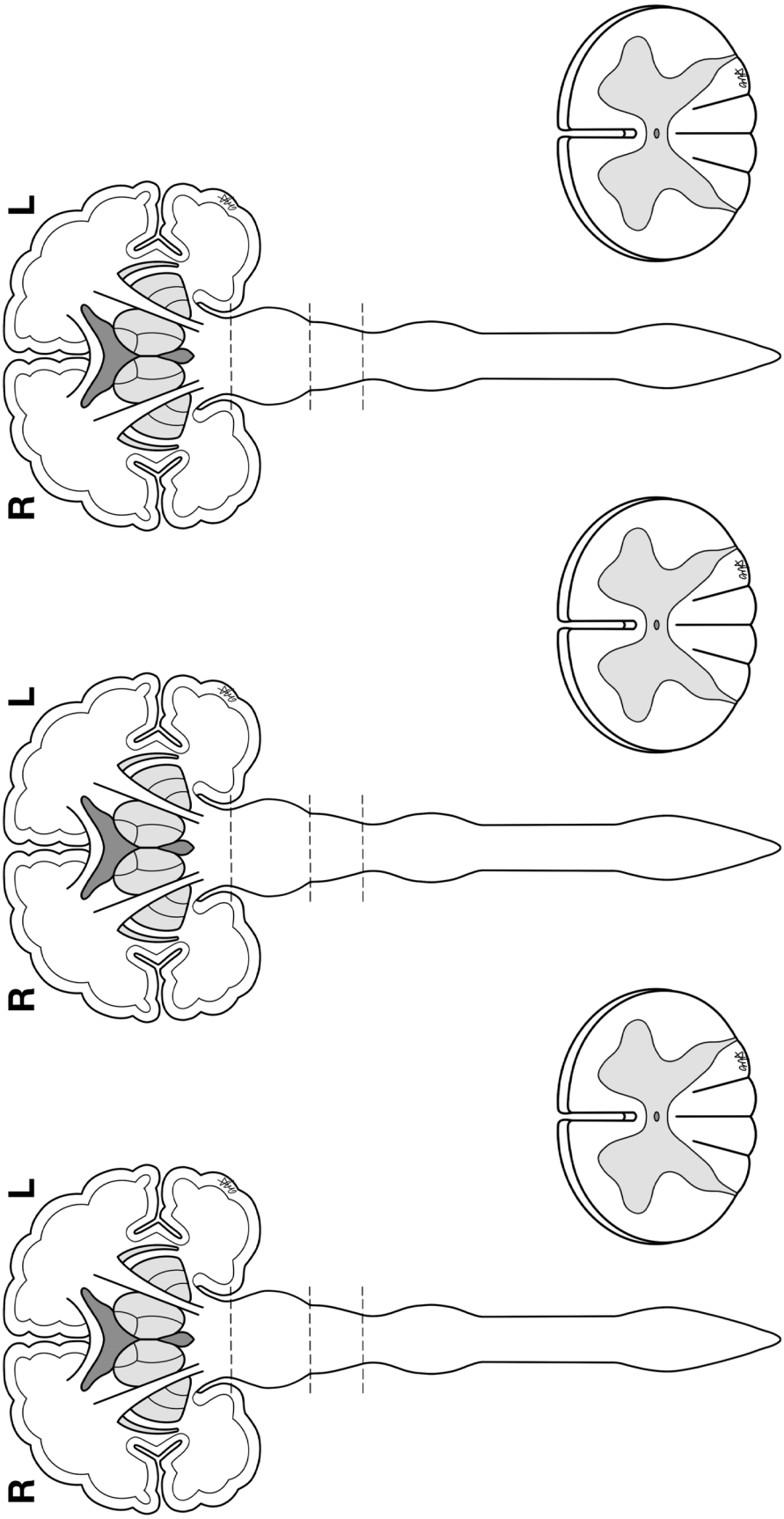

## RESOURCES

### *Websites:*

**Neuroanatomy | Entrada**

### *Recommended Textbooks:*

**Lippincott Illustrated Reviews: Neuroscience**
By: Claudia Krebs, Joanne Weinberg, Elizabeth J. Akesson, Esma Dilli
Lippincott Williams & Wilkins
ISBN 978-1-4963-6789-1

**Neuroanatomy Through Clinical Cases**
By: Hal Blumenfeld
Sinauer
ISBN 978-0-8789-3613-7

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