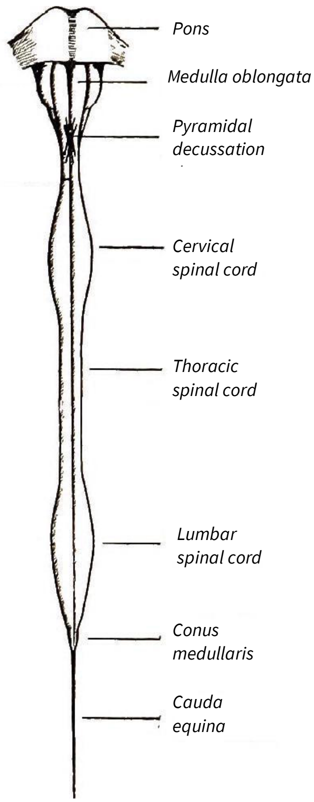
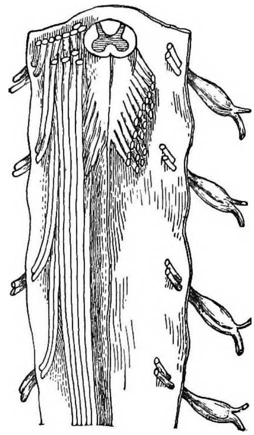
# 8 THE SPINAL CORD

If the brain is the capital city and the brainstem is the bridge, then the **spinal cord** is the highway on which nerves travel to and from their destination. Just as cars exit from the highway to take side streets, nerves traveling in the central nervous system branch off of the spinal cord and exit the vertebral column when they get close enough to their destination, at which point they continue their journey as **peripheral nerves**. In this chapter, we will learn about the spinal cord in more detail, with the next chapter devoted to the peripheral nervous system in all of its glory.

The spinal cord is traditionally divided into three regions, with the **cervical** spinal cord in the neck, the **thoracic** spinal cord in the chest, and the **lumbar** spinal cord in the abdomen. As you can see in the diagram on the right, there are enlargements in both the cervical and lumbar regions that correspond to the increased number of nerves shooting off here to go to the arms and legs, respectively. After the lumbar enlargement, the spinal cord begins to thin into a tapered region known as the **conus medullaris**. The spinal cord officially ends around the first or second lumbar vertebrae. However, even after the spinal cord ends, many of the nerves that have branched off from it continue to run downwards in a cluster of nerves known as the **cauda equina** (Latin for “horse’s tail,” which makes sense given its appearance).

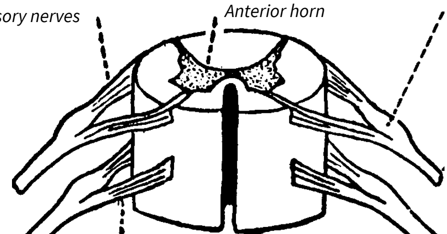




When talking about the spinal nerves that exit from the spinal cord, it's important to note that the place where a nerve branches off of the spinal cord is *not* the same place where it exits from the vertebral column! Instead, these nerves generally travel in the vertebral column for a while before exiting (as seen in the image to the right). For example, the T1 spinal nerve exits the vertebral column below the first thoracic vertebra, but it likely split off from the spinal cord somewhere in the cervical region. This is something that is easy to get confused about, but it's important to grasp as it explains why there are spinal nerves from the sacral and coccygeal regions (in the pelvis) even though the spinal cord ends up in the lower back (as these nerves exit the *spinal cord* before its termination at L1/L2 but do not exit the *vertebral column* until the sacral region).

Spinal nerves are **mixed nerves** containing both sensory and motor neurons. While the two kinds of neurons intermingle for most of the length of the nerve, close to the spinal cord the two types separate, with efferent motor neurons exiting on the *anterior* side of the spinal cord and afferent sensory nerves entering on the *posterior* side (somewhat like the on-ramps and off-ramps of a highway like we talked about back in Chapter 2).

Another difference between sensory and motor nerves involves the position of their cell bodies. The cell bodies of *sensory* nerves lie *outside* the spinal cord in clusters known as **dorsal root ganglia**, while the cell bodies of *motor* nerves lie *inside* the spinal cord in a region known as the **anterior horn**. You can use the word "**SO-MA**" (another name for neuronal cell bodies) to keep this pattern straight. The soma of **S**ensory nerves are **O**utside the spinal cord in the dorsal root ganglia, while for **M**otor nerves they are inside in the **A**nterior horn!




***Spinal nerves*** *connecting to the* ***spinal cord****.*

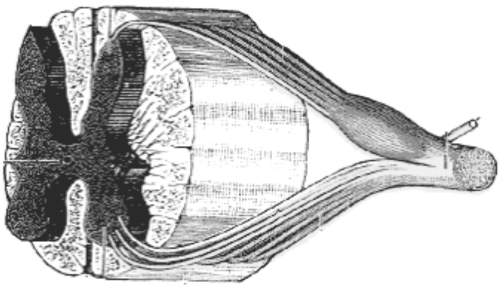
**Sensory nerves** enter in the **posterior spinal cord**,
while **motor nerve** exit from the **anterior spinal cord**.

***SO-MA****:*
***S****ensory cell bodies on the* ***O****utside (in dorsal root ganglia),*
***M****otor cell bodies on the inside in the* ***A****nterior horn.*

## SPINAL CORD ANATOMY

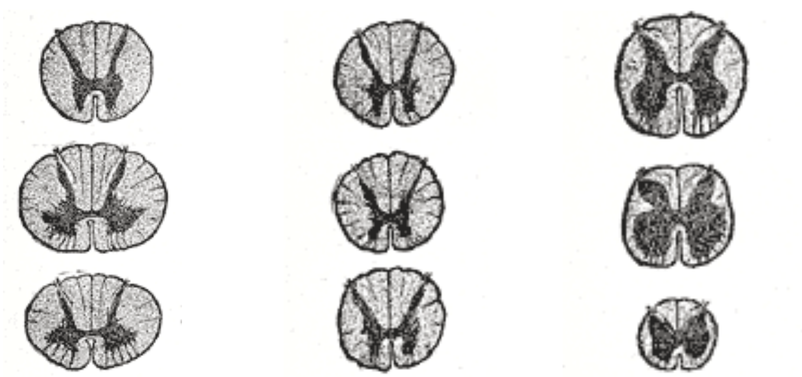
The spinal cord is not a disorganized tangle of nerves thrown together in a haphazard fashion. Instead, the spinal cord features a surprising degree of organization owing to the fact that, as in the other parts of the nervous system we have discussed so far, **nerves that do similar things tend to travel together**. This allows us to understand and name the various parts of the spinal cord that we see.

When you cut horizontally across the spinal cord to make a cross-section, the first difference you'll notice is the separation between grey and white matter. Unlike the cerebrum (where the grey matter is on the outside and the white matter is on the inside), the spinal cord features the opposite arrangement, with the white matter on the *outside* and the grey matter on the *inside* in a butterfly-like shape as seen below:



*The **spinal cord**, with **grey matter** on the inside and **white matter** on the outside.*

While the composition of the grey and white matter changes depending on which region of the spinal cord you are in, overall this butterfly-like appearance remains remarkably consistent down the entire length of the cord:



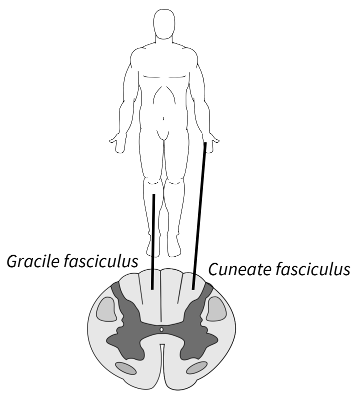
***Cervical** region* ***Thoracic** region* ***Lumbar** and **sacral** regions*

Within the grey and white matter are further subdivisions based on function. To understand these, we'll need to look at the various pathways traveling through the spinal cord in more detail, starting with the two sensory pathways and then moving onto the motor tract.

## THE DORSAL COLUMN—MEDIAL LEMNISCUS PATHWAY

Recall from Chapter 2 that there are two kinds of sensory neurons: **protopathic neurons** (which carry crude touch, pain, and temperature) and **epicritic neurons** (which carry fine touch, vibration, and proprioception). We'll focus first on epicritic neurons which travel in the **dorsal column—medial lemniscus pathway**.

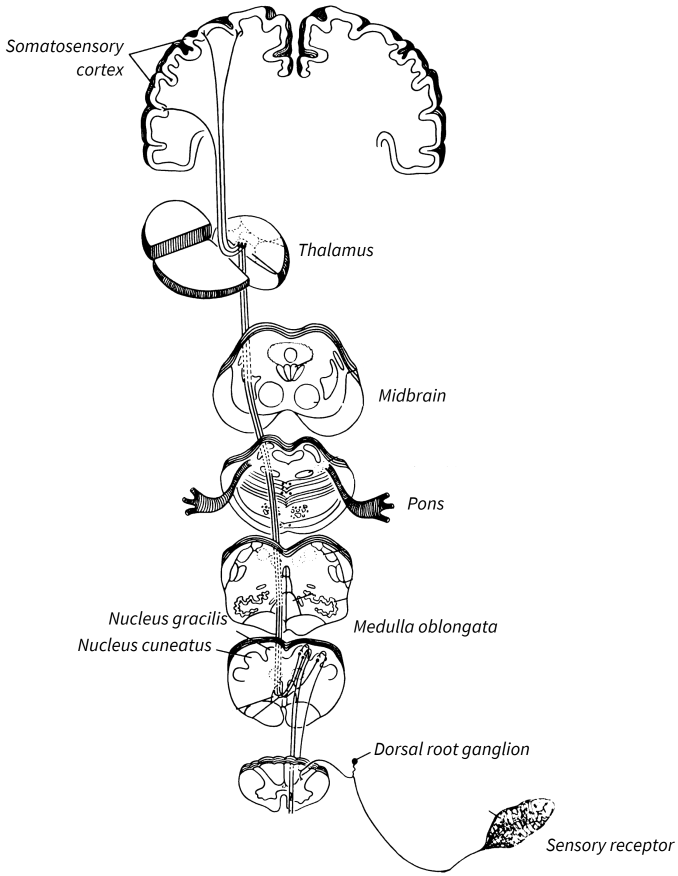
Epicritic neurons travel in the spinal cord within the **dorsal column** (located between the two upper wings of the butterfly). The dorsal column is further split into two parts known as the **gracile fasciculus** and the **cuneate fasciculus**. There are two important things to note here! First, information from the *lower* body is carried in the **gracile fasciculus**, while information from the *upper* body is carried in the **cuneate fasciculus**. Use the phrase, "**Walk grac**efully and **eat** with your **hands**" to associate legs with the **grac**ile fasciculus and hands with the cune**ate** fasciculus. Second, the gracile fasciculus is *medial* to the cuneate fasciculus, so injuries to the middle of the cord will result in sensory loss in the legs, while injuries to the side will instead cause sensory loss in the arms. (This is different from the other two pathways we will talk about in this chapter where the pattern is reversed!) To associate this pattern with this particular pathway, think of it as the dorsal column—**medial leg**-niscus pathway.




**Epicritic neurons** from the **legs** travel **medially** in the **gracile fasciculus**, while those from the **arms** travel **laterally** in the **cuneate fasciculus**.

***Walk grac**efully and **eat** with your **hands**.*
*In the dorsal column—**medial leg**-niscus pathway, the **legs** are **medial**!*

These neurons travel in the dorsal column of the spinal cord until they hit the medulla where they join with a cluster of cell bodies known as the **nucleus gracilis** and **nucleus cuneatus**. After synapsing here, these neurons **cross over** from left-to-right and right-to-left in the **sensory decussation** (just like we talked about in the last chapter). From there, these neurons continue their journey through the brainstem on a bundle of axons known as the **medial lemniscus** before hitting the **thalamus** (which you'll recall is the brain's "switchboard" for *th*en*th*ory information) and in particular the ventral posterolateral nucleus (since the VPL is where a Very Painful Leg is sensed). From the thalamus, the signal is passed on to its final target: the **somatosensory cortex** in the parietal lobe. You can remember the order of these steps using the phrase "**D**iscover **N**ew **D**irections for **M**oving **V**ibration & **P**roprioception."




*The **dorsal column—medial lemniscus pathway**.*

The **dorsal column—medial lemniscus pathway** carries **epicritic neurons**.

***D**iscover **N**ew **D**irections for **M**oving **V**ibration & **P**roprioception:*
***D**orsal columns (gracile fasciculus and cuneate fasciculus)*
***N**ucleus gracilis and nucleus cuneatus*
***D**ecussation*
***M**edial lemniscus*
***V**entral posterolateral nucleus of the thalamus*
***P**arietal lobe*

## THE SPINOTHALAMIC TRACT

The dorsal column—medial lemniscus pathway is just one of the two possible routes that sensory information can take through the central nervous system. The other route, known as the **spinothalamic tract**, carries information about **crude touch**, **pain**, and **temperature** and has its own way of doing things!

Peripheral nerves carrying protopathic neurons first enter the spinal cord on the posterior side. They initially enter an area known as the **posterolateral tract** or **Lissauer's tract**. Lissauer's tract features an interesting quirk: nerves here often move up or down a spinal level or two (seemingly for no good reason other than to confuse students!). Because of this, protopathic sensory loss related to a spinal cord injury is often "off" a level or two from what you would expect (either too high or too low).

After passing through Lissauer's tract, these neurons then enter into one of two areas that are both contained in the upper wings of the butterfly: the **substantia gelatinosa** (which is named for the "goopy" gelatin-like texture of this tissue caused by the lack of myelin in these nerves) and the **nucleus proprius**.

Unlike the nerves traveling in the dorsal column (which wait until the medulla to cross over), the nerves in the spinothalamic tract cross over soon after entering the spinal cord in a bundle called the **anterior white commissure**. You can remember this by thinking that **F**ine touch, **V**ibration, and **P**roprioception are **F**eeling **V**ery **P**atient (they can wait until the medulla to cross over), while **N**on-discriminative touch, **T**emperature, and **P**ain are **N**ot **T**hat **P**atient and want to cross over *immediately*.

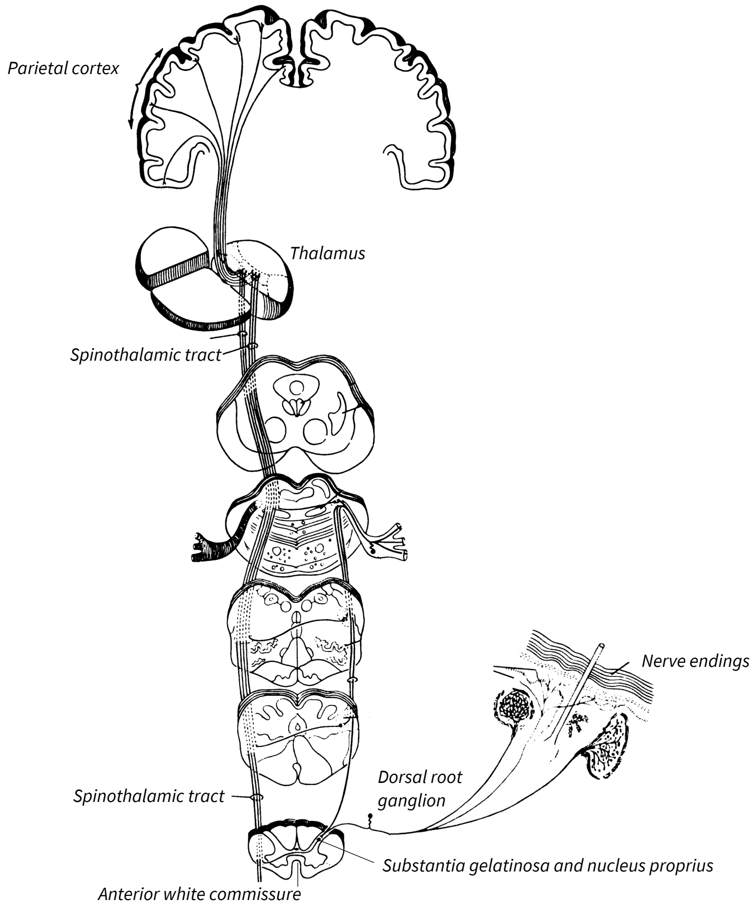
**Protopathic neurons cross over immediately** in the **anterior white commissure** of the spinal cord, while **epicritic neurons wait** to cross over in the **medulla oblongata**.

*__F__ine touch, __V__ibration, and __P__roprioception are __F__eeling __V__ery __P__atient,*
*while __N__on-discriminative touch, __T__emperature, and __P__ain are __N__ot __T__hat __P__atient.*

Because the dorsal column—medial lemniscus pathway and the spinothalamic tract cross over at different places, a patient with damage to their spinal cord can have **crossed findings** with numbness of crude touch, pain, and temperature on the right half of their body and numbness of fine touch, vibration, and proprioception on the left (or vice versa). This occurs if the injury is located *after* the spinothalamic tract has crossed over but *before* the dorsal column–medial lemniscus pathway has crossed.

After crossing over in the anterior white commissure, the spinothalamic tract travels upwards in the white matter surrounding the anterior horn of the spinal cord, with information from *lower* in the body being carried on the most *lateral* aspect while information from the *upper* body is carried more *medially*. (Note that this is the *opposite* pattern of what we saw with the dorsal column—medial leg-niscus pathway!) They then travel to the brainstem where they *don't* cross over in the medulla (as they have done this already in the spinal cord since they're **N**ot **T**hat **P**atient!). They then synapse in the ventral posterolateral nucleus of the **thalamus** before completing their journey in the somatosensory cortex of the **parietal lobe**.

Like with the dorsal column—medial lemniscus pathway and its "**D**iscover **N**ew **D**irections for **M**oving **V**ibration & **P**roprioception" mnemonic, we can use another phrase here to remember the steps of the spinothalamic tract: "**L**ist **S**ome **P**roper **A**venues for **S**ending **T**emperature & **P**ain."




*The **spinothalamic tract**.*

The **spinothalamic tract** carries **protopathic neurons** from the body to the brain.

***L**ist **S**ome **P**roper **A**venues for **S**ending **T**emperature & **P**ain:*
***L**issauer's (posterolateral) tract*
***S**ubstantia gelatinosa and nucleus **P**roprius*
***A**nterior white commissure*
***S**pinothalamic tract*
***T**halamus*
***P**arietal lobe*

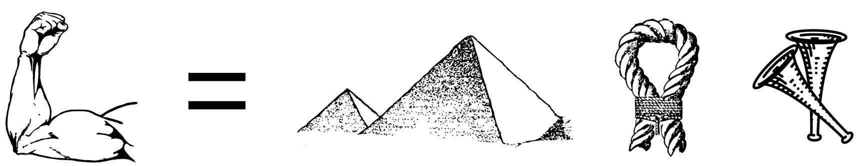
## THE CORTICOSPINAL TRACT

Now that we have covered both sensory pathways, we will shift our attention to the motor neurons that make up the other half of nerves flowing through the spinal cord. The vast majority of motor neurons travel through the spinal cord in the **corticospinal tract**. The corticospinal tract is itself divided into two parts: the *lateral* corticospinal tract and the *anterior* corticospinal tract. The lateral corticospinal tract is the larger of the two, accounting for around 90% of all motor neurons in the spinal cord. In general, motor neurons going towards the upper extremities travel more *medially* while those going to the lower extremities are found more *laterally*. (This is the *same* pattern as the spinothalamic tract but the *opposite* pattern of the dorsal column—medial lemniscus pathway!)

When it comes time to exit the highway and take the side streets to their final destination, nerves in the lateral corticospinal tract synapse onto motor neurons in the **anterior horn** of the spinal cord (the bottom half of the butterfly's wings). This marks the position of a clinically important divide between **upper motor neurons** and **lower motor neurons**. The neurons that carry the motor signal at any point from the motor cortex in the cerebrum up until the anterior horn cell are considered *upper* motor neurons, while those that carry the signal down from the anterior horn cell to the muscle itself are considered *lower* motor neurons (as seen in the diagram on the opposite page). On a clinical level, damage to upper motor neurons produces different signs and symptoms compared to damage to lower motor neurons (a concept that we will revisit in more detail in Chapter 18).

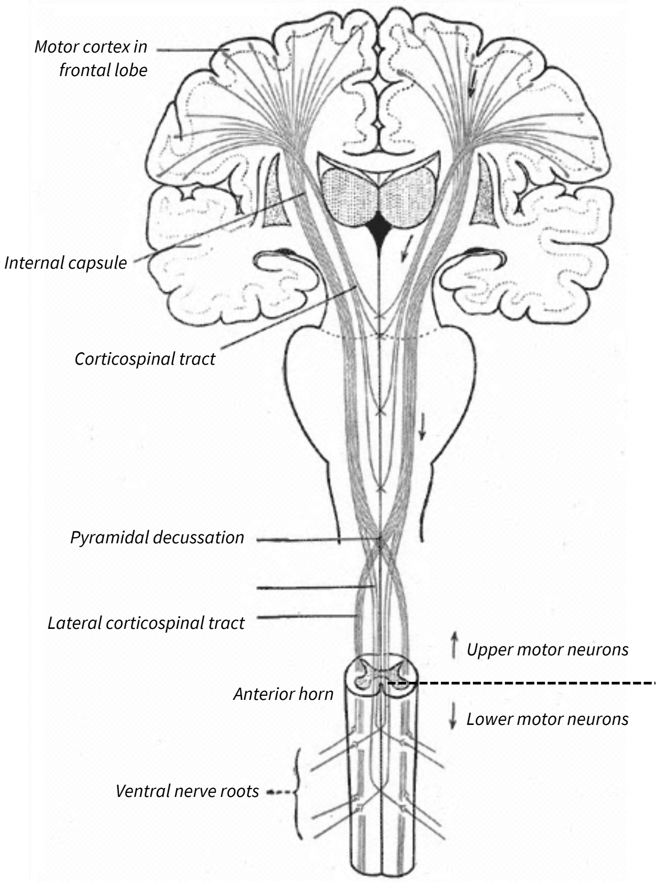
After picking up the signal from the upper motor neurons in the anterior horn, lower motor neurons then exit the spinal cord as the anterior nerve root (remember "SO-MA"!) before joining afferent nerves from the dorsal root to form a spinal nerve.

And with that, the motor pathway is done! (If you've made it this far, use your corticospinal tract to give yourself a high-five.) A visual summary of the corticospinal tract is found on the next page. You can use the phrase, "**F**lexing **I**nvolves **P**yramids, **C**ords, and **H**orns" to remember each step on this path!



The **corticospinal tract** carries **motor signals** from the brain to the body.

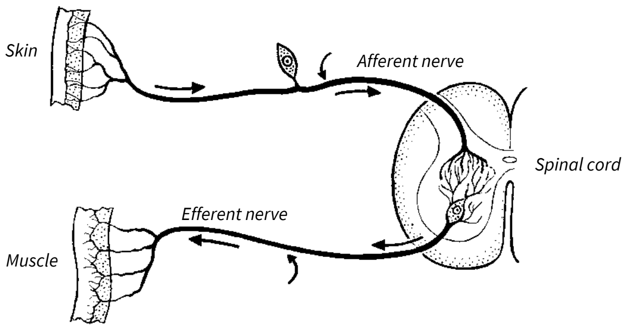
*__F__lexing __I__nvolves __P__yramids, __C__ords, and __H__orns:*
*__F__rontal lobe*
*__I__nternal capsule*
*__P__yramidal decussation*
*__C__orticospinal tract*
*Anterior __H__orn*




*The **corticospinal tract**.*

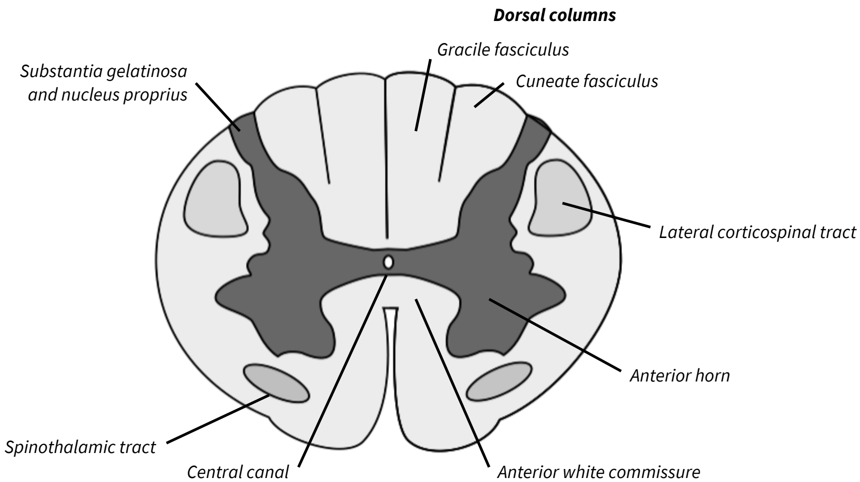
## SPINAL REFLEXES

Thus far, we have primarily talked about neurons traveling between the brain and the rest of the body by way of the spinal cord, including both motor and sensory neurons. However, the spinal cord also contains connections between neurons that *don't* involve the brain at all and are instead contained entirely within the spinal cord itself! These connections are responsible for several **spinal reflexes** that occur without conscious effort. Someone who receives a sensory stimulus (say, by accidentally stepping into a fire) will activate sensory neurons in the skin. Signals from these neurons will first travel along their axons to their main cell bodies in the dorsal root ganglion before entering the spinal cord. While some neurons will continue up to the brain via the spinothalamic tract, others will instead synapse with **interneurons** (or neurons that connect neurons to each other) that then synapse directly onto motor neurons in the anterior horn. These neurons will send motor signals to leg flexors that will then act to quickly withdraw the foot from the fire. Because this reflex arc only involves a few neurons and takes place entirely at the level of the spinal cord, it can occur with lightning-fast speed. In fact, the person may find that they have already moved their foot by the time their brain registers any conscious sensation of pain!




A number of **stretch reflexes** activate certain muscles in response to that muscle being stretched. This phenomenon should be familiar to anyone who has been to a doctor, as testing reflexes by tapping on them is very common! As we will cover in Chapter 13, testing these reflexes can be helpful for localizing where damage to the spinal cord has occurred, as each specific reflex maps to a particular level of the spinal cord. The absence of a particular reflex suggests damage to some aspect of the reflex arc (either the sensory nerves, the motor nerves, or the spinal cord connecting them) at or around this level.

Before we move on, let's recap what we've learned about the anatomy of the spinal cord using this diagram. Feel free to refer back to this image as often as needed!

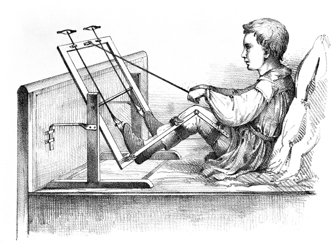


## SPINAL CORD PATHOLOGY

The best way to reinforce everything we've learned about the anatomy of the spinal cord so far is to look at what happens when something goes wrong. Injuries to the spinal cord can come from various sources, from mechanical injuries like a car crash to infectious diseases like polio. When looking at the effects of spinal cord injuries, the column-like nature of the spinal cord introduces a new complication. It's no longer enough to simply say *what part* of the spinal cord we are talking about. Instead, we also need to specify at *what level* of the spinal cord the damage has occurred. While the *nature* of the deficits (such as whether there are motor deficits, sensory deficits, or both) can help us to figure out the structures involved, the *location* of the deficits in the body (such as whether they are in the arms or legs) will help us figure out the level. For example, someone who sustains an injury at the level of their chest will likely lose all sensory and motor ability in their legs (but will retain these abilities in their arms). This is because the spinal nerves for the upper extremities have already exited the spinal cord in the neck, while those traveling to the legs have yet to depart.

The simplest kind of spinal cord injury to understand is a **complete spinal injury** in which all function below the level of the lesion is lost. In cases of **incomplete spinal injury**, however, only a part of the spinal cord has been damaged, so some functions will be lost while others will be retained. As we talk about the different forms of incomplete spinal injury, refer back to the cross-section of the spinal cord on the previous page to link the findings to everything that we've learned so far!

### ANTERIOR CORD SYNDROME

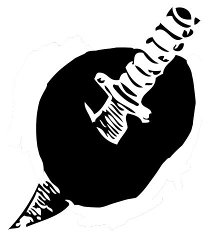


An injury to the anterior half of the spinal cord causes a **motor paralysis** as well as **numbness of crude touch, temperature, and pain** sensation below the level of the lesion. The paralysis is due to the fact that motor neurons are found in the *anterior* horn of the spinal cord, while the numbness is due to the placement of protopathic neurons within both the (anteriorly located) spinothalamic tract as well as their crossing in the anterior white commissure. Notably, fine touch, vibration, and proprioception remain intact, as epicritic neurons travel in the (posteriorly located) *dorsal* columns!

### POSTERIOR CORD SYNDROME

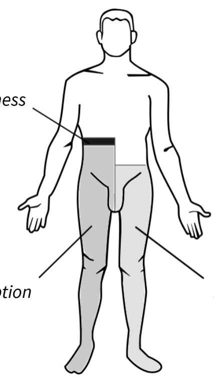
Logically, posterior cord syndrome involves the *opposite* findings as anterior cord syndrome! Because the dorsal columns are located in the posterior spinal cord, an injury here results in deficits of **fine touch, vibration, and proprioception** below the level of the injury. Importantly, crude touch, temperature, and pain sensation as well as motor function all remain intact! Due to the loss of proprioception, people with posterior cord syndrome often develop a "stomping" gait as a way to compensate for their inability to sense posture and position. Posterior cord syndrome is most often caused by metabolic or inflammatory insults. As one example, infection with syphilis can lead to demyelination of the dorsal columns, resulting in a permanent posterior cord syndrome known as **tabes dorsalis**.

**BROWN-SÉQUARD SYNDROME**



**Brown-Séquard syndrome** (also known as **spinal hemiplegia**) occurs when one half of the spinal cord (either the right or the left) is injured more than the other half. In these cases, motor function and fine touch, vibration, and proprioception are compromised on the *same* side as the injury, while crude touch, temperature, and pain are affected on the *opposite* side from the lesion. (Remember that, of all the motor and sensory nerves in the spinal cord, only those carrying **N**on-discriminative touch, **T**emperature, and **P**ain are **N**ot **T**hat **P**atient and want to cross over immediately, which is why these are the specific deficits that are found *contra*lateral to the lesion.)

While Brown-Séquard syndrome can occur due to any process that injures the spinal cord, the most common cause is direct penetrating trauma as in a gunshot or stab wound. You can remember this by thinking that **B**rown-**S**équard is what happens when someone tries to **B**ack**S**tab you but only does it **halfway**.




*Crossed findings as seen in* ***Brown-Séquard syndrome****.*

**Brown-Séquard syndrome** is a **unilateral spinal cord injury** resulting in **ipsilateral motor weakness** and loss of **epicritic sensation** as well as loss of **contralateral protopathic sensation**.

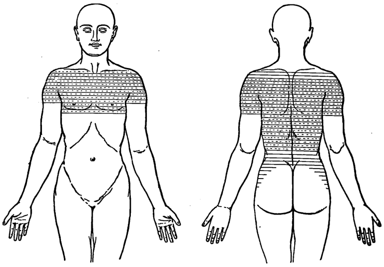
***B****rown-****S****équard is when someone tries to* ***B****ack****S****tab you but only does it* ***halfway****.*

**CENTRAL CORD SYNDROME**

An injury to the center of the spinal cord causes greater weakness of the **arms** compared to the legs (remember that the motor neurons traveling to the arms are *medial* to those traveling to the legs!). Loss of crude touch, pain, and temperature sensation below the level of the injury is often seen as well due to the proximity of the spinothalamic tract to the center of spinal cord, although some degree of **sacral sparing** is often seen (as these fibers are going lower in the body and are therefore located *laterally* away from the center). Common causes of a central cord syndrome include tumors (such as an ependymoma or astrocytoma) which can arise from *within* the spinal cord.

*“See him go fly!”*

Another potential cause of central cord syndrome that is frequently tested is **syringomyelia**, a condition in which a fluid-filled cavity (known as a syrinx) forms within the spinal cord. The classic presentation of syringomyelia involves **bilateral weakness** as well as **crude touch, pain, and temperature numbness** in the chest, back, and upper arms (often referred to as a “**cape-like distribution**”). This is due to the cyst forming from the cerebrospinal fluid-filled central canal and impinging upon the anterior white commissure and spinothalamic tract. (This also explains why fine touch, vibration, and proprioception are spared, as these travel in the dorsal columns.) Protopathic sensation in the lower extremities is not affected, as these neurons travel more laterally in the spinothalamic tract than those coming from the upper extremities. You can remember to associate syringomyelia and a cape-like distribution by renaming it to **“see-him-go-fly”-lia**. This should put the image of a **flying superhero** with a **cape** into your mind when you hear the word!



***Syringomyelia** causes weakness and numbness in a “**cape-like distribution**.”*

**Syringomyelia** typically presents as a **bilateral weakness** and **crude touch, pain, and temperature numbness** in a **cape-like distribution**.

***“See-him-go-fly”-lia**:*
*Visualize a **flying superhero** wearing a **cape**!*

## SUBACUTE COMBINED DEGENERATION OF THE SPINAL CORD

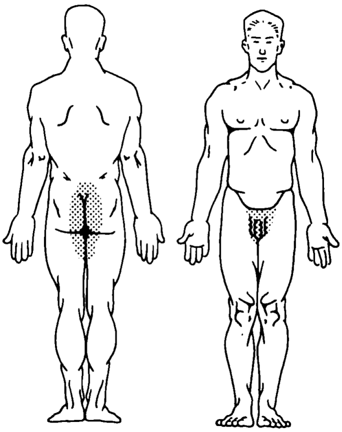
**Subacute combined degeneration** is a condition in which the myelinated tracts of the spinal cord (the dorsal columns and the corticospinal tract) slowly lose their myelin, leading to **poor balance and falling** (due to demyelination of the dorsal columns) and **muscle weakness** in the arms and legs (due to demyelination of the corticospinal tract). Because the nerves in the spinothalamic tract are already unmyelinated by default, crude touch, pain, and temperature sensation remains intact. The most common cause of subacute combined degeneration is a **deficiency of vitamin $B_{12}$** which you can remember by thinking that a lack of B**12** leads to damage in not ***1*** but ***2*** areas of the spinal cord!

**Subacute combined degeneration of the spinal cord** results in **demyelination** of both the **dorsal columns** and **corticospinal tract**, with sparing of the spinothalamic tract. **Vitamin $B_{12}$ deficiency** is a common cause.

*Lack of vitamin B**12** leads to not **1** but **2** forms of spinal cord injury!*

**CAUDA EQUINA SYNDROME**

While intuitively it would make sense that the nerves coming out of the cauda equina (the "horse's tail" at the lowest end of the spinal cord) would go to the lowest part of the body (the feet), in reality these nerves instead travel to the pubic and anal areas. (We'll go over the reasons for this in the next chapter!) For this reason, **cauda equina syndrome** leads to deficits in both motor and sensory function in the **pelvic region**, including loss of bowel and bladder control, muscle paralysis and hyporeflexia in the lower body, and numbness around the perineum (sometimes called **"saddle anesthesia**" because the numbness is in the same area that would be in contact with a horse's saddle). It's not hard to use a little bit of mental imagery to connect an injury in the **horse**'s tail with a **saddle** distribution.

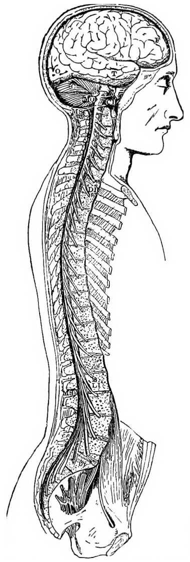


*"**Saddle anesthesia**" as seen in cases of **cauda equina syndrome**.*

An injury to the **cauda equina** leads to **bowel and bladder incontinence**, **muscle paralysis** in the lower body, and **saddle anesthesia**.

*Connect the **horse**'s tail (cauda equina) with numbness in a **saddle** distribution.*

## PUTTING IT ALL TOGETHER



And with that, it's time to exit the central nervous system and head for the peripheral nervous system! Before we go, let's review each of the three pathways we have covered in this chapter: the **dorsal column—medial lemniscus pathway** (large myelinated epicritic neurons carrying fine touch, vibration, and proprioception), the **spinothalamic tract** (small unmyelinated protopathic neurons carrying crude touch, temperature, and pain), and finally the **corticospinal tract** (large myelinated motor neurons carrying motor signals from the brain).

For the dorsal column—medial lemniscus pathway, the phrase "**D**iscover **N**ew **D**irections for **M**oving **V**ibration & **P**roprioception" will help you remember that these nerves first travel in the **D**orsal columns (with information from the legs in the gracile fasciculus and information from the arms in the cuneate fasciculus). Next, they synapse in the **N**ucleus gracilis and nucleus cuneatus within the medulla before **D**ecussating (crossing over). They then travel in the **M**edial lemniscus before synapsing in the **V**entral posterolateral nucleus of the thalamus before finally reaching their destination in the **P**arietal cortex.

For the spinothalamic tract, the phrase "**L**ist **S**ome **P**roper **A**venues for **S**ending **T**emperature and **P**ain" can remind you that protopathic neurons first enter via **L**issauer's tract, often going up or down a level or two before synapsing in the **S**ubstantia gelatinosa or nucleus **P**roprius. These neurons then cross over in the **A**nterior white commissure before traveling in the **S**pinothalamic tract in the lateral spinal cord. They then synapse again in the ventral posterolateral nucleus of the **T**halamus before traveling on to the **P**arietal cortex.

Finally, for the corticospinal tract, the phrase "**F**lexing **I**nvolves **P**yramids, **C**ords, and **H**orns" will allow you to recall that motor neurons originating in the **F**rontal cortex first pass through the posterior lib of the **I**nternal capsule and then into the brainstem before crossing over in the **P**yramidal decussation within the medulla. They then continue on in the spinal cord as the **C**orticospinal tract before synapsing on an interneuron entirely within the spinal cord which itself synapses onto the third and final neuron in the Anterior **H**orn. This lower motor neuron then exits the spinal cord on its anterior aspect and completes its journey to the muscle as a spinal nerve.

Make sure you know each of these pathways down cold before moving on!

## REVIEW QUESTIONS

1. A 78 y/o M makes an appointment to see a doctor. He reports no significant medical history. On exam, the doctor notices that his ability to sense the position of his toes with his eyes closed is impaired. He does not detect a vibrating tuning fork when it is applied to his feet. Which of the following pathways is most likely damaged?
    - A. Gracile fasciculus
    - B. Cuneate fasciculus
    - C. Spinothalamic tract
    - D. Posterolateral (Lissauer's) tract
    - E. Lateral corticospinal tract
    - F. Anterior corticospinal tract

2. A 52 y/o F comes to the hospital after sustaining second-degree burns on her right hand. While cooking dinner, she did not notice that her hand was touching a pot of boiling water. On exam, she is noted to have absent pain and temperature sensation in both arms as well as the back and shoulders, with motor weakness in a similar distribution. Pain and temperature sensation is normal throughout the lower extremities. Vibration and proprioception are intact throughout as well. Magnetic resonance imaging reveals the following image:

Which region of the spinal cord has most likely been affected?

A. Anterior
B. Posterior
C. Center
D. Periphery
E. Left
F. Right

3. A 27 y/o F is brought to the hospital for a neurological evaluation. She is noted to have significant motor weakness in both her right arm and right leg, with an inability to make a fist with her right hand or raise her right foot off of the ground. Sensory exam is notable for loss of fine touch and vibration on the right side, with loss of pain and temperature on the left. Which of the following is the most likely event that precipitated this presentation?

    A. Sudden onset following a focal bacterial infection
    B. Slow onset due to a nutritional deficit
    C. Rapid onset following significant blood loss during childbirth
    D. Onset at birth due to a genetic mutation
    E. Immediate onset following complete transection of the spinal cord during a motor vehicle accident

1. **The best answer is A.** The gracile fasciculus is the part of the dorsal columns that carries sensory information about fine touch, vibration, and proprioception from the lower extremities to the brain. While the cuneate fasciculus also carries this information, it connects to the upper extremities, not the lower (answer B). The spinothalamic tract and posterolateral tract both carry crude touch, pain, and temperature sensation (answers C and D), while the lateral and anterior corticospinal tract carry motor signals to voluntary skeletal muscles (answers E and F).

2. **The best answer is C.** This patient's loss of motor strength and protopathic sensation occurs in a cape-like distribution which combined with the intact epicritic sensation should make you think of syringomyelia. Syringomyelia is often caused by a cyst forming in the central canal of the spinal cord, which is why the dorsal columns on the periphery are generally spared (answer D). While anterior spinal cord syndrome involves the same combination of deficits as syringomyelia (motor weakness with intact epicritic sensation), the cape-like distribution helps to differentiate this, as an anterior cord syndrome would instead show these deficits below the level of the lesion in the lower extremities but not the upper (answer A). The intact epicritic sensation effectively rules out posterior cord syndrome (answer B). A spinal injury on either the right or left side would present as Brown-Séquard syndrome (answers E and F).

3. **The best answer is A.** This vignette describes a case of Brown-Séquard syndrome in which one-half of the spinal cord (either the right or left side) is injured. This results in a characteristic combination of ipsilateral motor weakness, ipsilateral loss of epicritic sensation, and contralateral loss of protopathic sensation. While Brown-Séquard syndrome is most classically associated with stab injuries to the back, it can occur as a result of any lesion that affects one side of the spinal cord over the other (in the case of this vignette, a focal bacterial abscess that is located in only one side of the spinal cord). Systemic causes of spinal cord damage such as nutritional deficits (answer B), shock (answer C), and genetic diseases (answer D) would be expected to affect both sides of the spinal cord equally. Complete transection of the spinal cord would result in bilateral loss of all movement and sensation in areas below the lesion (answer E).