Spinal Cord & Brainstem

Somatosensory Spinal Cord & Brainstem

Spinal Cord General Principles

1. The **gray matter** of the spinal cord has two main components:
   a. The **dorsal horn**, which is made up of neurons involved in somatosensation.
   b. The **ventral horn** (sometimes called the **anterior horn**), which is made up of **motor neurons** that innervate our skeletal muscles.
      i. It turns out that the cells within the ventral horn have a characteristic arrangement.
         1. They innervate muscles in a pattern such that:
            a. Lateral cells innervate distal musculature.
            b. Medial cells innervate proximal musculature.
            c. Dorsal cells innervate flexors.
            d. Ventral cells innervate extensors.
               i. **You can remember this by picturing an arm overlaid on the ventral horn** (see image at below right).

2. One can generally distinguish what level of the spinal cord is being viewed by remembering the following principles:
   a. The arms and legs require a lot of sensory and motor innervation.
      i. Thus, the **cervical & lumbosacral spinal cord levels (which supply the arms and legs, respectively) will have very prominent dorsal and ventral horns** (see at image below left).
   b. White matter from the different spinal cord levels layers atop one another like rings on a tree.
      i. For example, consider the sacral cord sending white matter up to cortex.
         1. White matter from the lumbar cord will layer on top of that sacral white matter, forming, in essence, a ring on a tree.
         2. Thoracic & cervical levels layer in the same way, adding more rings to the tree.
      ii. From this example, it should be clear that **the amount of white matter increases as you move higher up in the spinal cord** (see image below left).
         1. So if you see a section with a lot of white matter, it is likely cervical spinal cord.
         2. **Keep in mind that the image below is stained for myelin (so white matter appears dark)!**
Let’s look more closely at the thoracic spinal cord.
1. **Lissauer’s Tract**  
   a. The entrance of small diameter pain/temperature fibers into the spinal cord.

2. **Intermediolateral nucleus (IML)**  
   a. Appears as a little bulge between the dorsal and ventral horns.  
   b. Gives rise to preganglionic neurons of the sympathetic nervous system.  
   c. Extends from T1-L2 (remember Anatomy?!?)  
      i. For all intensive purposes, **seeing it is a giveaway that you’re in thoracic spinal cord**.

3. **Dorsal Column**  
   a. Comprised of axons carrying fine touch information up to the medulla, where they will synapse on the dorsal column nuclei (i.e. the gracile nucleus and cuneate nucleus).  
      i. Sometimes the dorsal column is divided into a medial gracile fasciculus (going to the gracile nucleus) and a lateral cuneate fasciculus (going to the cuneate nucleus).

4. **Ventral Funiculus**  
   a. Generic name for a slew of fiber tracts running in the ventral part of the spinal cord. Included:  
      i. **Vestibulospinal tract**  
         1. Involved in balance.

5. **Lateral Funiculus**  
   a. Generic name give to a slew of fiber tracts running in the lateral part of the spinal cord. Includes:  
      i. **Spinothalamic tract**  
         1. Carries pain/temperature information to VPL of the thalamus.  
      ii. **Corticospinal tract**  
         1. As you’ll learn, this carries axons from motor cortex which go to innervate motor neurons in the ventral horn.  
            a. This circuitry allows us to move our muscles.  
      iii. **Dorsal Spinocerebellar tract**
1. This tract carries proprioceptive information up to the cerebellum.
   1. Specifically, a sensory neuron having its soma in the **dorsal root ganglion** (DRG) receives proprioceptive information from muscle spindle organs on the process it sends out to **muscles** (not skin).
      a. To transmit this information, the neuron sends another process into the spinal cord to synapse on **Clarke’s nucleus** (sometimes called **nucleus dorsalis**).
         i. The cells in Clarke’s nucleus send processes to the cerebellum via the **dorsal spinocerebellar tract**.
         1. Note that Clarke’s nucleus is only found in T1-L2.
            a. For all intensive purposes, **seeing it is a giveaway that you’re in thoracic or upper lumbar spinal cord**.

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**Caudal (Closed) Medulla**

![Image of a cross-section of the medulla with labeled structures]

1. Structures to focus on:
   a. **Gracile Nucleus**
      i. Receives fine touch information from lower body via the **dorsal column** (specifically, the gracile fasciculus of the dorsal column).
      ii. Its fibers cross into the medial lemniscus (not pictured here) and ascend to VPL.
   b. **Cuneate Nucleus**
      i. Receives fine touch information from upper body via the **dorsal column** (specifically, the cuneate fasciculus of the dorsal column).
      ii. Its fibers cross into the medial lemniscus (not pictured here) and ascend to VPL.
   c. **Trigeminal Spinal Nucleus**
      i. Receives pain/temperature information from the face.
      ii. Its fibers cross and ascend to VPM.
   d. **Accessory Nucleus**
      i. Gives rise to the spinal part of the **accessory nerve** (CN XI).
ii. Innervates trapezius and sternocleidomastoid muscles.

2. Structures you will eventually need to know:
   a. **Corticospinal Tract**
      i. As you’ll learn, this carries axons from motor cortex which go to innervate motor neurons in the ventral horn.
         1. This circuitry allows us to move our muscles.
      ii. It is sometimes called **pyramidal tract** since it looks like paired pyramid-shaped bulges.

Rostral (Open) Medulla

1. Structures to focus on:
   a. **Trigeminal Spinal Nucleus**
      i. This is the exact same structure seen in the previous slide; we are just seeing how it looks more rostrally.
   b. **Medial Lemniscus**
      i. This is the fiber tract projecting from the **dorsal column nuclei** (i.e. the **gracile** and **cuneate** nuclei), to the VPL.
         1. Note that it is a paired structure that is oriented vertically at this level.
   c. **Hypoglossal Nucleus**
      i. Gives rise to the **hypoglossal nerve** (CN XII).
      ii. Innervates muscles of the tongue.
   d. **Dorsal Nucleus of X**
i. This structure **gives rise to the parasympathetic neurons** of the body (at least the ones going to bodily structures above the transverse colon).

1. Spinal levels S2-S4 give rise to the remaining parasympathetics (remember Anatomy?!).

e. **Nucleus of the Solitary Tract**
   i. Receives taste information (from CN VII), as well as autonomic information from CN IX & X (which innervate chemo/baroreceptors in the carotid and aortic bodies, respectively).

2. Structures you will eventually need to know:
   a. **Corticospinal Tract**
   b. **Inferior Olivary Nucleus**
      i. Has a wavy appearance that is impossible to miss.
      ii. Sends information to the cerebellum.
      iii. Involved in motor adaptation.

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**Rostral (Open) Medulla...slightly more rostral than previous slide**

![Diagram of brainstem structures](image)

1. Structures to focus on:
   a. **Medial Lemniscus**

2. Structures you will eventually need to know:
   a. **Corticospinal Tract**
   b. **Inferior Olivary Nucleus**
   c. **Inferior Cerebellar Peduncle**
      i. This is actually the way by which the inferior olivary nucleus communicates with the cerebellum (see blue arrow in the diagram at above right).
      1. The diagram above shows a sagittal view of the brain stem, and the level of this section is indicated with a black line.
a. Note how we are catching the inferior cerebellar peduncle right before it meets up with the cerebellum.
   ii. It also carries the dorsal spinocerebellar tract.

d. Vestibular Nuclei
   i. These receive information from the vestibular apparatus in the inner ear.
   ii. Involved in balance.

e. Cochlear Nuclei
   i. These receive information from **cochlea** (the main sensory organ involved in hearing).
   ii. Involved in hearing.

Caudal Pons

a. **Medial Lemniscus**
   i. Note how the **medial lemniscus is starting to orient horizontally** in this section.

b. **Facial Nucleus**
   i. Gives rise to the **facial nerve** (CN VII).
   ii. Innervates muscles of the face.

2. Structures you will eventually need to know:
   a. **Corticospinal Tract**
      i. Note that it weaves between the pontine nuclei, but **HAS ABSOLUTELY NOTHING TO DO WITH THEM!**
   b. **Pontine Nuclei**
      i. These send information to the contralateral **cerebellum** via the **middle cerebellar peduncle**.
         1. This is illustrated in the diagram at above right where the green arrow represents information from the pons, and it is travelling into the cerebellum through the middle cerebellar peduncle.

   a. The level of section is indicated by the black line.
1. Structures to focus on:
   a. **Medial Lemniscus**
   b. **Trigeminal Motor Nucleus**
      i. Innervates muscles of mastication.
      ii. Follows the general developmental principle in which motor structures are located medially to sensory ones.
   c. **Trigeminal Principal Nucleus**
      i. Receives fine touch information from the face.
      ii. Projects **BILATERALLY** to VPM.
         1. Thus, sensory information is duplicated, and a lesion on one side would not cause complete loss of sensation since sensory information is still present in fibers on other side.
      iii. Follows the general developmental principle in which sensory structures are located laterally to motor ones.

2. Structures you will eventually need to know:
   a. **Pontine Nuclei**
   b. **Middle Cerebellar Peduncle**
1. Structures to focus on:
   a. **Medial Lemniscus**
      i. Note how at this level it gets pushed against the lateral part of the brainstem, right near substantia nigra.
   b. **Substantia Nigra**
      i. Contains dopaminergic cells.
      ii. Loss of these cells leads to **Parkinson’s Disease**.
   c. **Cerebral Peduncle**
      i. This is actually the **rostral continuation of the corticospinal tract**.
      1. To give the big picture, axons from motor cortex cells project down and out of the brain, forming the cerebral peduncle and corticospinal tract along the way to their final destination (which is motor neurons in the ventral horn of the spinal cord).
   d. **Periaqueductal Gray** (PAG)
      i. Surrounds the **cerebral aqueduct** (thus its name).
      ii. Involved in modulating sensitivity to pain.

2. Structures you will eventually need to know:
   a. **Superior Cerebellar Peduncle**
      i. This large fiber tract is the main output of the cerebellum. It travels up the brain stem to higher brain levels.
      1. The diagram at above right shows cerebellar outputs (red arrow) leaving via the superior cerebellar peduncle.
2. The black line indicates the level of section.
3. We are slightly above the body of the cerebellum, so cannot see it on the section.

b. **Trochlear Nucleus**
   i. Gives rise to the **trochlear nerve** (CN IV).
   ii. Innervates one extraocular muscle: the **superior oblique**.

c. **Inferior Colliculus**
   An auditory relay station.

### Rostral Midbrain

![Diagram of brainstem structures](image)

1. Structures to focus on:
   a. **Medial Lemniscus**
   b. **Substantia Nigra**
   c. **Cerebral Peduncle**
   d. **Periaqueductal Gray** (PAG)

2. Structures you will eventually need to know:
   a. **Occulomotor Nucleus**
      i. Gives rise to the **occulomotor nerve** (CN III).
      ii. Innervates four extraocular muscles: **superior rectus**, **inferior rectus**, **medial rectus**, and **inferior oblique**.
      iii. Note that it sits in the same position as the trochlear nucleus, just more rostral in the brainstem.

   b. **Superior Colliculus**
      i. Involved in visual sensory-motor coordination.
      ii. Note that it sits in the same position as the inferior colliculus, just more rostral in the brainstem.

   c. **Red Nucleus**
      i. The superior cerebellar peduncle runs around the red nucleus (and some of the fibers end in the nucleus). This gives the “capsule” around the nucleus.
         1. This makes sense anatomically: it is located in the same position as the superior cerebellar peduncle, just more rostral in the brainstem.