***Clinical applications:

- If there is destruction of lateral spinothalamic tract (LSTT), sensory loss will be on the opposite side below the level of lesion due to crossing at the level of spinal cord. Therefore loss of LSTT modalities: pain and thermal sensation.

- If there is destruction of fasciculus gracilia and cuneatus (in PCML), sensory loss will be on the same side below the level of the lesion. Therefore loss of muscle joint sense, proprioception(position sense), vibration, and tactile discrimination.

- Brown-Séquard Syndrome: Symptoms related to injury seen in Hemisection like stap wounds, which results in damage to the ALS and posterior columns. It’s a very rare case. Example, A lesion on the right at C4 to C5 will result in:
  1. Loss of PCML modalities(proprioception, vibratory sense, and discriminative touch) on the same side below the level of the lesion.
  2. Loss of ALS modalities(pain and temperature) on the opposite side below the level of lesion.
  3. Motor loss(muscle weakness or paralysis (hemiparesis, hemiplegia)) on the same side below the level of lesion.
Note: Remember that in the descending motor tract, fibers cross the midline at the level of the brain, so in the example above, the motor fibers that were damaged on the right side are from the left cortex, and these fibers on Rt. Side, after crossing the midline, are the one that innervate muscles and glands. So motor loss is on the Rt. side.

***Quick recap of E-lecture:

-Blood supply of brain: **Internal carotid artery** which enters the brain by carotid opening and canal, and the **vertebral artery** which is a branch of the 1st part of subclavian, which enter the transverse foramina of cervical vertebra.

-Vertebral artery when it pass through the entire cervical vertebra, Rt. and Lt. vertebral artery enter the cranial cavity through foramin magnum. Rt. and Lt vertebral artery meet to give rise to **basilar artery**.

-Internal carotid artery and basilar artery **form circle of willis** which supply the entire brain.

-Now in the case of the spinal cord, Rt. and Lt. vertebral artery gives roots for **anterior spinal artery** (direct branch of vertebral artery) which pass through anterior midian fissure to supply the spinal cord.

-Posterior inferior cerebellar artery (PICA) (branch of vertebral artery) supplies the cerebellum. Rt. and Lt. PICA, gives a branch which is posterior spinal artery (Rt. and Lt.).

-So collectively, we have 1 anterior spinal artery and 2 posterior spinal artery which supply the spinal cord. These arteries as they descend in the spinal cord gives off branches called **vasa corona** (Anterior and posterior), which are the one that enter the spinal cord and supply it.

-Posterior spinal artery and vasa corona supply posterior column system and peripheral part of ALS. **Keep in mind that there is an anastomosis between anterior and posterior spinal artery.**

-Anterior spinal artery extend to grey mater and adjacent part of white mater.

**Central cord syndrome:**

- Occur in case of occlusion or impairment in the blood supply of anterior spinal artery, which often occur in the case of neck hyperextension.
- This results in **bilateral** weakness in extremities, more in upper than lower extremities.
• **Why Bilateral weakness?** Because remember that we have one anterior spinal artery that supply both right and left side.

• **Why upper extremities are effected more than lower?** Because the origin of Anterior spinal artery are from the vertebral A., so its blood supply is coming from above so its effected more, furthermore the lower extremities receive blood supply from other sources.

• Also its characterized by bilateral pain and thermal sensation loss, bladder dysfunction.(related to lateral horn).

-If posterior spinal artery is compromised which mainly supply posterior column, it leads to ipsilateral loss of PCML modalities at and below the segment level. Its ipsilateral since we have 2 posterior spinal arteries, so both of them must be damaged to have bilateral loss.

***END OF REVISION (Get back to E-learning lecture for better understanding)***

***Now our next main subject is **Brain stem:*****

-Reminder: Hindbrain consist of Medulla, Pons and Cerebellum.


-Brain stem is Stalk like in shape, and connects spinal cord to higher centers of forebrain.

-Remember that brain stem is a passage for ascending and descending tracts. Also, Cranial nerves have sensory and motor nuclii found in brain stem. Also brain stem has vital centers in reticular formation in the core.

-Pons is a bridge found between cerebrum and cerebellum, not between medulla oblongate and midbrain. (Refer to figure)

-In the following figure you can see the 2pyramids found in medulla oblongata in corticospinal tract. And at lower part of medulla crossing occur in 85-90% of fibers called lateral corticospinal fibers. And the rest called anterior corticospinal fibers. SO cut in these pyramids causes motor loss on the same or opposite side, depending on site of cut, if above(opposite) or below (same) decussation.

- Olive is found on either side of pyramid, which is found due to olivery nuclear complex. Olive have a motor function.
***brain stem will be divided into 8 sections (4 in medulla, 2 in pons, 2 in midbrain)

***First let's start with Medulla oblongata:

Medulla oblongata is divided into 4 sections (from down up):

1. Level of decussation of pyramids (most inferior) (motor decussation) (closed medulla)
2. Level of decussation of leminisci (sensory decussation) (closed medulla)
3. Level of olives (opened medulla)
4. Level Just Inferior to the Pons (There is a little difference between 3 and 4 so they can be considered as one section)

In each one of these sections there is a cavity that you should identify. (Central canal/4th ventricle)

4th ventricle is the cavity of the hindbrain. It's bounded anteriorly by pons and medulla oblongata, and posteriorly by cerebellum. Its tent-like cavity with floor (diamond shaped) related to pons and upper part of medulla and roof.

Medulla oblongata is divided into 2 halves: Lower half is called closed medulla because it has a small cavity called central canal, and upper half is called opened medulla because it has a large cavity called 4th ventricle. 

First: Level of pyramidal decussation (Motor)

-Lowest level of medulla.
-It's a closed medulla because central canal is the cavity of the section as in the figure.

-Anterior to center canal, there is primary pyramidal decussation which are fiber in the pyramid in descending tract, called Lateral corticospinal fibers. Section was named according to it.

-The posterior column system is unchanged, there is fasciculus gracilis (medially) and fasciculus cuneatus (laterally) and the beginning of their nucleus in the posterior aspect of this section. Fasciculus toward outside and nucleus is found inside the section as in the figure. So white matter in general is found to outside like spinal cord.

-Laterally, there is spinal nucleus of trigeminal, which receive sensory from head and neck area by trigeminal nerve. (Biggest cranial nerve which originate from mid pontine area)

Note: Trigeminal nerve have 4 nuclei, 1 motor (motor nucleus of trigeminal) and 3 sensory.

-3 sensory nuclei according to modality (NOT that it have 3 divisions, mandibular, maxillary and ophthalmic) which are: 1. Spinal nucleus of trigeminal 2. Principle nucleus 3. Mesencephalic nucleus.
• 1 motor: muscles of mastication (tensor tympani, tensor veli palatine, mylohyoid, ant. Belly of digastric).
• Its called a spinal nucleus because it extend from spinal cord up to brain stem at mid pontine area where it ends, at which its replaced by principle sensory nucleus at that level. So this spinal nucleus is an extension of the upper cervical segment substantia gelatinosa (lamina II).
• Modalities of sensory nucleus:
  1. Spinal nucleus: pain and temperature (like spinothalamic tract)
  2. Mesensephalic: proprioception
  3. main/principle sensory: crude touch.
• Note: Spinal nucleus of trigeminal receive pain and temperature sensation from other cranial nerves like facial, glossopharyngeal and vagus, But most of sensation come from trigeminal fibers, so its named according to it.
• Note: The outside surrounding of spinal nucleus is white mater which is the spinal tract of trigeminal nerve (refer to figure above for better understanding).

- The lateral and anterior white columns system is unchanged (same as spinal cord). They get closer to each other a little bit.

**Second: Level of decussation of lemnisci (sensory decussation)**

- It’s a closed medulla, since it have central canal.
- Posterior to central canal: Nuclues gracilis (medially) and nucleus cuneatus (laterally). At this level synapse between 1st and 2nd order neuron occur. Then 2nd order neuron fibers are responsible for sensory decussation crossing midline and are called internal arcuate fibers. This decussation is anterior to central canal and posterior to pyramids.
- Remember in brainstem, there is nucli for cranial nerve. In this section, there is Hypoglossal nucleus (For hypoglossal nerve #12, lowest nucleus), which has only one pure motor nucleus (NO sensory). It gives motor innervation to muscles of the tongue. Remember that this nucleus have cell body of lower motor neuron. Hypoglossal nucleus is approximately close to central canal.
- Anterior to sensory decussation: is the pyramid, its fibers are from the same side cortex, because at this point decussation still hasn’t occurred (Remember we are ascending in sections)
- Some nucleus like spinal nucleus of trigeminal, as we said are longitudinal extensions, so they are found in multiple sections/levels of brainstem until pontine area.
- Anterolateral system is unchanged very much at this level as well. But it starts to form spinal lemniscus with spinotectal tract.
In this section you still can’t see medial lemniscus because it’s about to form following internal arcute fibers.

- Spinal nucleus of the trigeminal nerve is lateral to the internal arcute fibers. (from slides)

**Level of sensory decussation**

1. ant. Median fissure
2. post. Median sulcus
6. nucleus gracile
7. nucleus cuneatus
8. int. arcute fibers
9. decussation of medial lemniscus
10. pyramids

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**Third: Level of olives (open medulla)**

- It's open medulla, because its cavity is 4th ventricle. Posterior aspect (Red arrows) of the section includes the floor of the 4th ventricle.

- Anteriorly, there are Lt. and Rt. pyramids

- Check in the figure midline structures which include: (Refer to figure)
  1. Medial lemniscus (Remember its above level of sensory decussation),
  2. tectospinal tract, Behind medial lemniscus (Remember its for visual reflexes).
  3. medial longitudinal fasciculus is Behind tectospinal tract.

- Note: **Medial longitudinal fasciculus** (Remember fasciculus mean circular arrangement of fibers) is a white mater, that makes a connection between vestibular(#8) nucleus and motor nucleus of oculomotor(#3), trochlear(#4) and abducent(#6) nucleus, they are responsible for movement of the eyeball and maintenance of balance. Remember that we have bi-ocular vision, so contraction of lateral rectus muscle in one eyeball, by default cause medial rectus muscle contraction to occur on the other eyeball, so your eyeballs can’t look in opposite directions normally.

- In the corner of the section, there is **inferior cerebellar peduncle**, which is a white mater connecting medulla oblongata with cerebellum.
Central grey matter is found in this section just underneath the floor of the 4th ventricle, which include (From medial to lateral): (refer to figure)

1. Hypoglossal nucleus: Motor nucleus of Hypoglossal nerve, which is found in previous section. Just keep in mind that in this section its close to 4th ventricle. (Blue arrow)
2. Dorsal vagal nucleus: for vagus cranial nerve which carry many modalities including motor, general, visceral and special sensory, and parasympathetic of abdomen and thorax viscera. Vagus N. is the only cranial never that leave head and neck area. Parasympathetic nucleus of vagus is another name for dorsal vagal nucleus. (purple arrow)
3. Nucleus of tractus solitarius: it's a sensory nucleus of 2 types, include special sensory for taste and visceral sensory. It takes fibers from vagus mainly but also cranial nerves 7,9 and 10. (orange arrow)

**Note:** Innervation of the tongue for taste sensation include:

1. Anterior 2/3 by Facial nerve (chorda tympani)
2. Posterior 1/3 by Glosopharyngeal nerve

**Note:** Taste buds on epiglottis are innervated by vagus nerve for taste.

**Note:** Remember that nucleus of tractus solitarius receive taste sensation from all these cranial nerves.