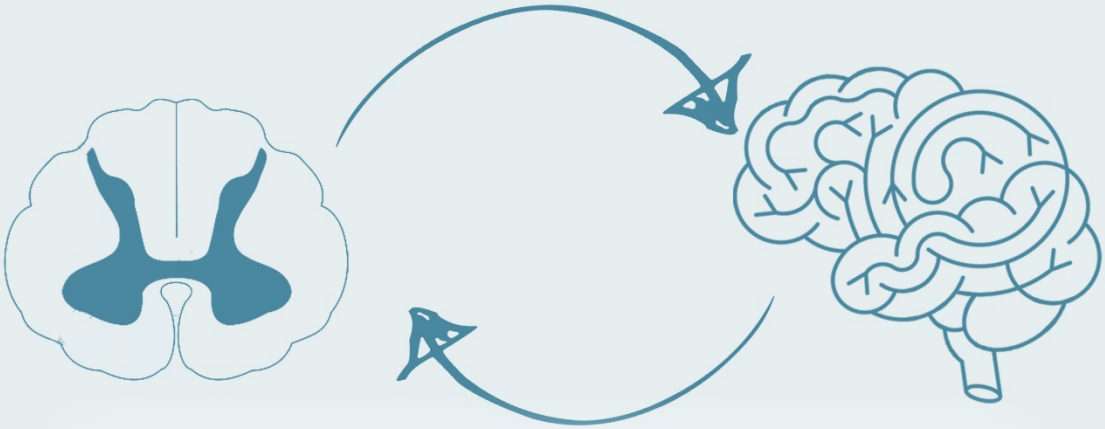


CNS

physiology

0 slides 0 sheets

number **4**

Done by **Sondos Al-Najjar**

Correction **Enas Ajarma**

Doctor **Loai Alzgoul**

Few points you must have known by now:

- We've started talking about sensation and we discussed the different types of receptors which are transformers that convert one type of energy (thermal, chemical, mechanical…) to neuronal signal that will be transmitted to the brain.

- The **labeled lined-theory** states that: the receptor is connected to the brain via a line and by experience the brain will recognize the nature of this sensation as thermal (if its connected to thermal receptor) or pain (if it's connected to nociceptor)…etc. And any stimulation at any point along this line (until its destination) will lead to the same experience; that means if the receptor is stimulated or any neuron along its pathway, the result will be the same.

- There are different receptors arranged at different locations "not for memorizing".

- Classification of somatic sensation " any sensation from the body":
  1- Mechanical (touch for example)
  2-Thermal
  3-Nocieceptor
  Touch is an example of mechanical receptor, and depending on the neuronal pool touch can be calssified into crude touch or discrimintive touch "nowadays it's called two points discrimination".

QUESTION/What is the receptor?

The recepter is ususally a soma cell body alone (extension and enlargement of the distal part of the dendrites) and sometimes it has a specific type of ion channels (**switching ion channels** not voltage gated)for switching or conversion between one type of energy to another one. If it's responsible for mechanical changes for example, there must be a mechanical gated ion channels. And if it's responsible for chemical changes, it will contain chemical/ligand gated ion channels. Also if it's a visiual receptor, there must be an internal mechanisim to detect light and

change it into opening or closing ion channels. ***The ion channels here are not voltage gated, they are of a switching type as mentioned in the previous paragraph.*

An important thing to mention here is that there is no action potential on the receptor, only graded potential (receptor potental) which has a positive relation with the stimulus (more stimulus means more graded potential which leads to the increasing in frequesuncy of action potential). This is one way of coding the severity of stimulus which is the **receptor potential coding**.

There is another way of coding, which is the increase in the number of active neurons as a result of increasing the stimulus. **This is the neuronal rhetorical theory of coding**. If one neuron is activated by an X stimulus, a stronger stimulus will activate two neurons.

All in all, a stronger stimulus in periphry will lead to a stronger stimulus centrally that will be interpreted by the brain in two coding systems:

1- Receptor potential coding
2- Neuronal rhetorical theory of coding

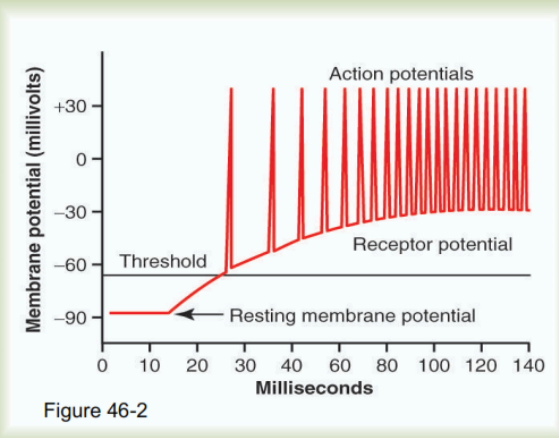


Figure 46-2

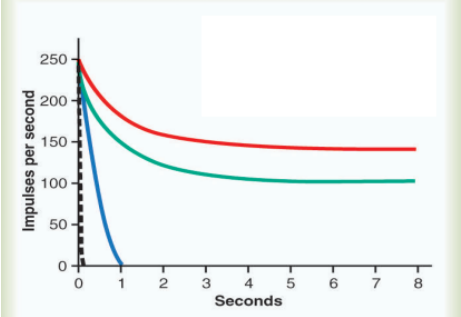
This sheet will cover these concepts:

1- sensory adaptation
2-The physiology of main sensory pathways (PCML and ALS)
3-Dermatomes

Sensory adaptation

It's a change over time in responsiveness of the sensory system to a constant stimulus. In other words, the brain gets used to this stimulus and will not respond again (or at a lower degree). There are three processes that help in sensory adaptation:

1- Receptor adaptation
2- Central adaptation
3- Central regulation



ONE: Receptor adaptation

If there is a continous stimulus applied to a receptor, the receptor potential will decay with time. For ex: A stimulus X is applied on a receptor and lead to a graded potential 100 and a frequency of action potential 100 action potential/second. You will see that after awhile the receptor itself will undergo adaptation so the same stimulus will produce less graded potential with less frequency of action potential. "*This is one form of desensetoization"*

And based on the receptor adaptation, receptors can be classified into quickly and slow adapted receptors.

1- **Quickly adapted** : within second they might adapt to zero
2- **Slow adapted**: the stimulus will continously be there and produce graded potential *"it might decrease with time, but it will always be there"*

TOW: Central adaptation

Even if the receptor adaptation is not working or not giving the desired effect, the neurons within the signaling pathway will adapt by decreasing the frequency of action potential .

***Remember the signaling pathway starting from the receptor, then 1st order neuron to the 2nd and finally the 3rd order neuron.*

***One or more than one neuron within this pathway could do this adaptation*

THREE: Central regulation/ central desenstization *"the most importent one*"

If the receptor is not adapting and the action potential is still reaching the brain, the brain itself will try to spare this signal to make a space for another processing. The coretx or subcortex will send certain signals to that area inhibiting it .

For example: descending mechanisims in the central regulation of pain will inhibit certain lamina and its synapses at the spinal cord, so a pain from a relating area to the part will be inhibited, and at the end the central nervous system will not sense the pain.

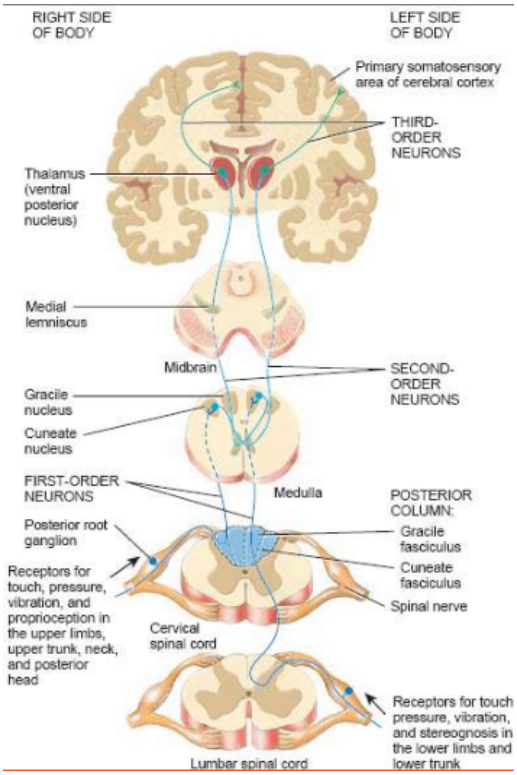
The physiology of sensory pathways

Sensation modalities can be classified into two categories:

1- **Fast**
   -It travels through the posterior column system (PCML)
   -Fibers are big and mylinated
   -Includes two-points discrimination, vibration and proprioception.
2- **Slow**
   -It travels through the anterolateral system (ALS)
   -Fibers are small and less mylinated
   -Includes crude touch, temp. and pain.

The main sensory pathways are (1) PCML and (2) ALS

1- Posterior column medial leminiscal pathway (PCML):



- **A general look:**

It transmits two-points discriminatioin, vibration and proprioception from periphral to the CNS. The 1st order neuron has its body in the dorsal root ganglia and its axon will reach the lower part of medulla to synapse with the 2nd order neuron at Gracillus and Cuneate nuclei. The 2nd order neuron will cross in the medulla and ascend up as "medial leminiscus" to reach the VPL (ventroposterior lateral) nucleus in the thalumus and then terminates in the somatosensory cortex.

- **Somatotopic organization:**

The **lower part of spinal cord** contains only the sacral fibers (from lower extremeties) that's why these fibers will occupy the medial part, sparing the lateral side for the trunk and upper extremeties fibers. (**Medial:sacral and Lateral cervical**).

In the **medulla**, Gracillus nucleus is more medially and Cuneate neucleus is the lateral one. Fibers reaching the medulla will form the medial leminiscus, in which the upper limb fibers "cervical" will be posteriorly and the lower limb "sacral" anteriorly.

In **pons** another shifting will occur and the cervical fibers will be more medial while the sacral ones will be more lateral. And they will continue in this way till they reach the thalamus and synapse with the 3rd order neuron.

Finally, the 3rd order neuron will lead to another shifting in this lamination in order to have the lower part of the body "sacral fibers" more medially and upper part "cervical" more laterally in the **1ry somatosensory cortex**.

****Sacral fibers will start medially in spinal cord, posteriorly in medulla, laterally in pons and finally at the medial part of the 1ry somatosensory cortext.*

****Cervical fibers will start laterally in spinal cord, anteriorly in medulla, medially in pons and finally at the lateral part of the 1ry somatosensory cortext.*

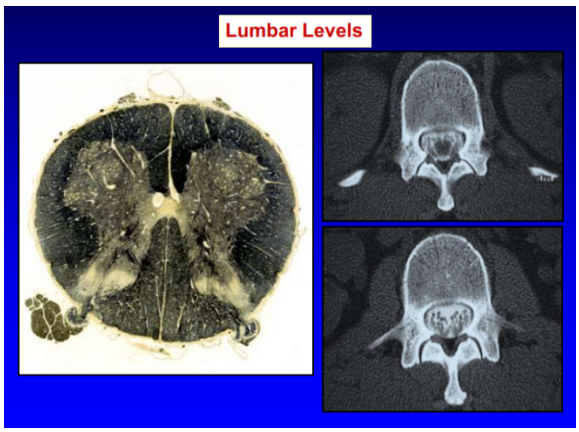
****The blood supply will be mentioned in anatomy.*

Please note that in medulla the sacral fibers are anterior and the cervical fibers are posterior.

- **PCML at different levels using MRI**

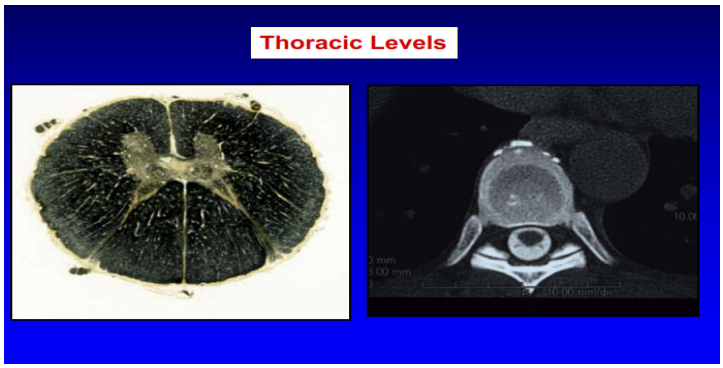
Check put these pictures that represent cross sections at different levels in the spinal cord "stain sections showing the posterior column":

1- Lumbar level



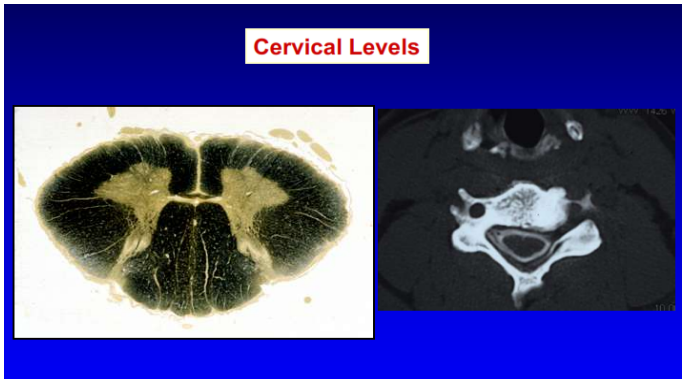
Note that the lower part of the vertebral canal doesn't contain spinal cord and what's seen in the MRI above is the **cauda equina**.

2- Thoracic level



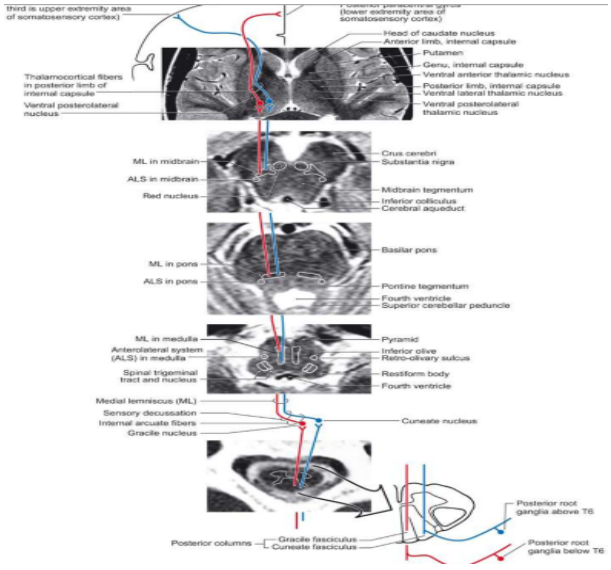
The spinal cord in the thoracic part is almost round (little bit triangular)

3- Cervical level



In the cervical part, the spinal cord looks like butterfly with wings (triangle)

4- An MRI for the total PCML pathway



- **The importance of this pathway:**

As we said, PCML transmits two-points discriminatioin, vibration and proprioception and this important in:

1- **Stereognosis:** you will guess what it's in your hand if it's a coin or a key and sense it without even seeing it.
2- **Graphesthesia**: you can write something or feel what's being written on your hand
3- **Movement and weight recognition**: You can logically apply forces depends on the weight or by experiencing pressure.

If at any point, the PCML is damages, you can't do the mentioned functions and a lesion causes Asterognosis, Agraphesthesia and sensory ataxia.

*You can say Asterognosis or Sterognosia as they are the same

*Ataxia: dysregulation between motor and sensation and it's usually more involved with cerebellum. (You can describe it as applying a lot of force in walking.)

*Senosry ataxia: applying inappropriate amount of movement

*There are PCML modulaities that terminate in cerebellum and this tract is called "spinocerebellum tract". Any problem in this tract also will lead to sensory ataxia.

*So we can say problems in PCML or spinocerebellar tracts will lead to sensory ataxia, but it's more associated with PCML.

- **Clinical applications:**

**In questions like these, your answer should include 3 things: (the dysfunctional modality, at which part of the body, at any half/side?)*

1- Case 1

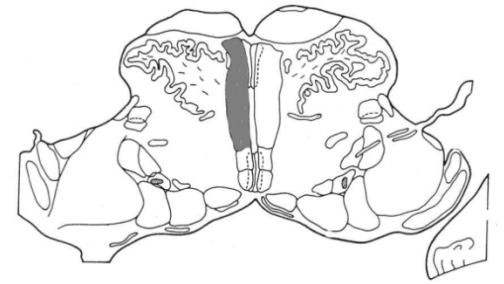
A cross section in a cervical segment with a lesion on the right side, what are the symptoms?

Loss of two-points discrimination, vibration and proproioception at upper and lower extremeties "because it's a loss below the cervical" on the right side of the body/ ipsilateral "because PCML fibers crosses the medline in the medulla".

**This patient will face other symptoms will be mentioned later but now since we've only talked about PCML, only symptoms related to it are mentioned.*

**There is no need to say sensory ataxia because his all sensory and motor parts are lost.*

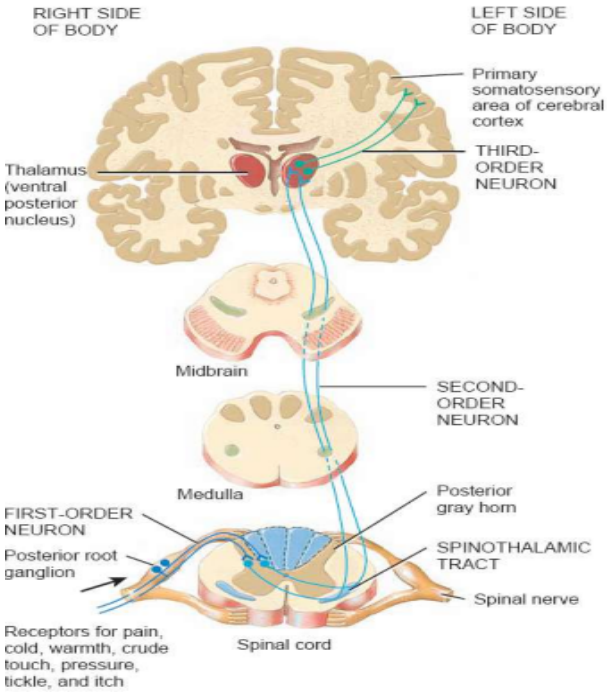
2- Case 2



This section from the **medulla** which has a lesion in the medial leminiscus on the left side. So what are the symptoms?

Loss of two-points discrimination, vibration and proproioception at upper and lower extremeties on the right side of the body/ contralateral "because PCML fibers have already been crossed".

2- Anterolateral system (ALS):



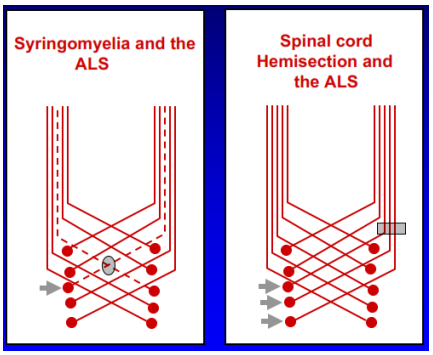
- **A general look:**

It transmits crude touch, pain and temperature from periphral to the CNS. The 1st order neuron has its body in the dorsal root ganglia that will synapse with the 2nd order neuron at the dorsal horn of spinal cord. The 2nd order neuron will cross the midline and ascend up forming the ALS pathway untill it reaches the VPL nucleus in the thalumus and then terminates in the somatosensory cortex. The ascending mechanisim will happen simultaneously with crossing; as a result of that the crossing will not be at right angles.

To illustrate this:

A fiber enters at the level of C4 from the right side, after being completely crossed the midline to reach the left side it will be at the level of C2. And at the level of C3 this fiber will be at the white commissure.

So a lesion at the right side within ALS at the level of C2 only will cause a loss of pain, temp and crude touch at the level of C4 and below on the left side.



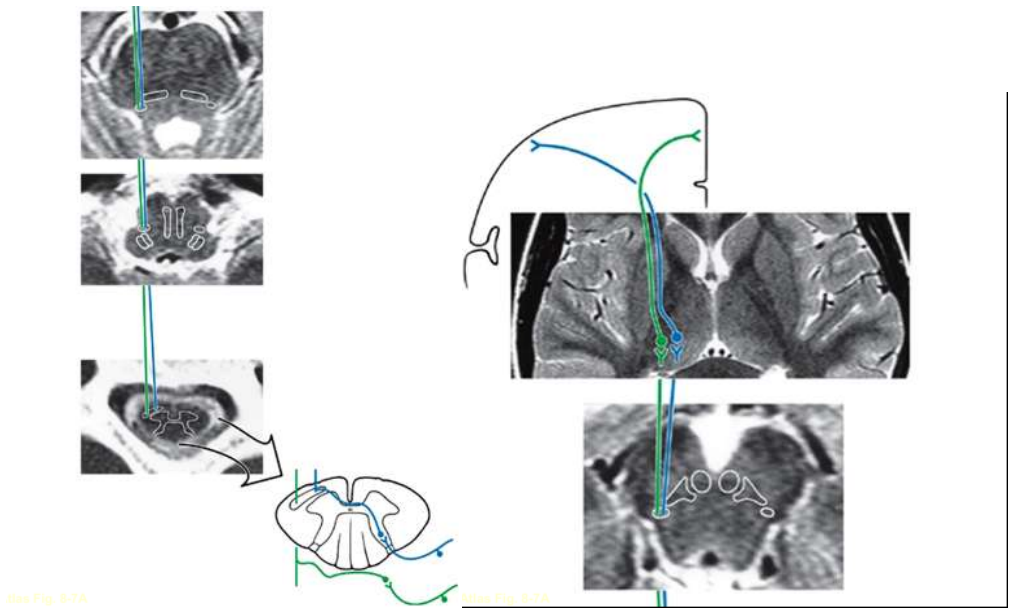
In the **spinal cord**, the ALS will be in the antero lateral part and the sacral fibers (from lower extremeties) will occupy the lateral part, sparing the medial side for the trunk and upper extremeties fibers.

In the **cortex**, the organiztion of ALS is the same as PCML. The lower part of the body "sacral fibers" more medially and upper part "cervical" more laterally.

**Note that the pressure is not mentioned in the above two pathways, because the difference between touch and pressure is not specified. But if we were to put it in one of the pathways, it will be considered as discrominitve touch so with PCML.*

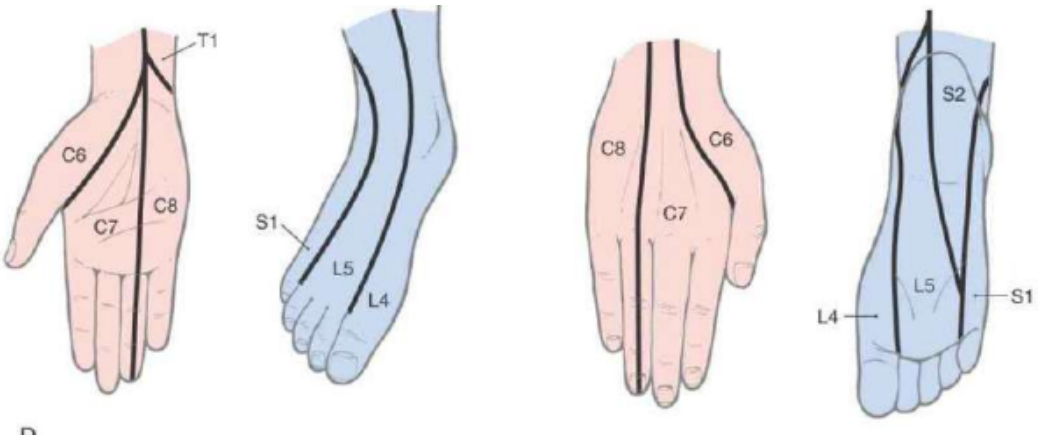
- **Localization of the ALS in MRI:**

In spinal cord, this tract will be at the antero lateral part while in medulla it's near the notch. Note that it's far away from PCML here, but at pons where so many fiber tracts present, they will come to a close proximity. And you can see it in the midbrain laterally. In the thalamus ALS has the same nucleus as PCML and at the end it will reach the cortex.



Dermatomes

We took it deeply in anatomy, but you have to understand that each segment of the spinal cord recieves sensation from specific parts of the body and you have to memorize the most important ones; hands, legs and the scattered ones below as they are very important in the clinical practice.



- Shoulder (C5-C6)
- Hand (C6-C8)
  Thumb (C6)
  Index (C7)
  Small finger (C8)
- Nipple (T4)
- Umbilicus (T10)
- Inguinal Region (T12-L1)
- Along the pelvic rim (L1)
- knee (L3-L4)
- The big toe (L4-L5)
- Genitalia and anus (S4-S5)

"DO THINGS FOR YOU, NOT FOR THE APPROVAL OR SATISFACTION OF OTHERS"

GOODLUCK