Physiology of the sensory system

***Two points discrimination depends mainly on two factors:

1)number of receptors per area (receptor density)

*** (**Number** of Receptors **/area** which covered by the receptors→ density of sensory receptor
The **Receptive field of a receptor or neuron:** area in which stimulation leads to response of a particular neuron.
IF the number of the receptors increase or the area decreases, the density will increase, increasing the ability 2 points discrimination.

Number of receptors in an area determines the ability for 2 points discrimination

→**the smaller the receptive fields, the more accurate a representation**
*if we have a neuron supplying the whole hand , it will be activated wherever we touch the hand , but if we have a neuron restricted to the tip of the finger , it will only be activated in that area. This allows for greater discrimination in sensory inputs. (the accuracy is inversely proportional with the Receptive area for that nerve).

↑ receptor density >>>>>↓ receptive field >>>>>↑ sensitivity and 2 points discrimination

Hand and fingertip and feet>>>> the highest receptor density and lowest receptive field in comparison with arms and legs, and the least receptor density is for the back and abdomen>>>>>so 2 points discrimination better at hands and fingers , less better in the arm, and worse in the abdomen.)

2) design of pathway (pathway arrangement) – (more important)

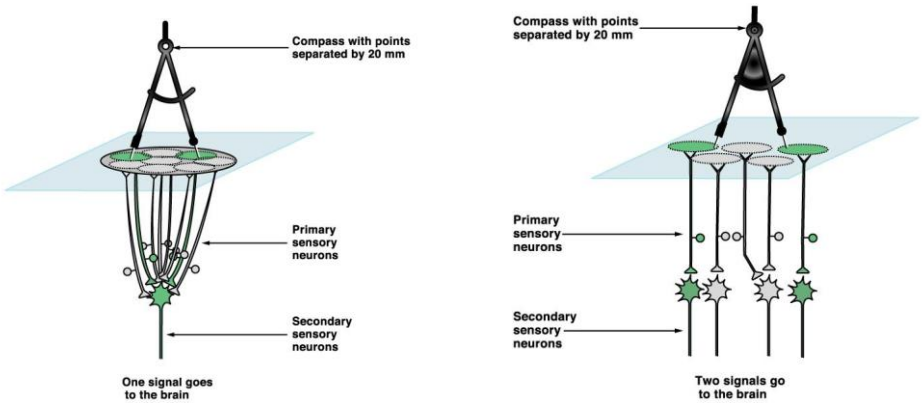
1**)conversion** :many neurons make synapse on one neuron that usually goes brain.

2) diversion : one neuron synapse with many neurons.

3) lateral inhibition : This is the process by which neurons inhibit signals from nearby neurons via an intermediate neuron in the CNS
Ex: when 2 neurons are activated, but one of them is activated more, it will inhibit the other one.

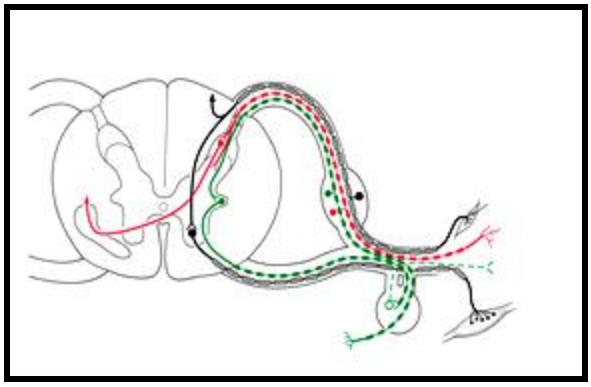
This enhances the difference between strong signals (at the point of the stimulus) and weaker signals (generated nearby the stimulus), thus the body can pinpoint more exactly where the stimulus is coming from.)>>>>> so the acuity of two-point discrimination is .improved by lateral inhibition.

reliable conduction on one way band >>>> we can't sense 2 point discrimination



If there is convergence , the signal reach the brain as one signal and there is no discrimination between the two signals
but if there where no convergence, we can differentiate between the two signals.

The sensory system detects and brings sensation from the periphery to the CNS & spinal cord .



In the spinal cord:

A)Sensory nerve can cause effect at the spinal cord level to induce reflexes directly .

B)end at spinal nerve without reflexes or/ and make synapses

C)go up to brain !!!
<u>OR MORE THAN ONE OF THE ABOVE</u>

NOTES :
*Note that not all reflexes are only {sensory → motor directly }, some reflexes require initiating bigger circuits in the spinal cord on many levels.
*Remember that there are many types of receptors (we took some of them in the previous lecture).

<u>A somatosensory pathway</u> typically have three long neuron:
*** 1st,2nd and 3rd order neurons

The **first neuron (pseudomonopolar neuron**) is the cell body of the <u>dorsal root ganglion</u> of the spinal nerves.

The **second neuron** has its cell body either in the spinal cord or in the brainstem. This neuron is ascending >>>>axons will decussate to the opposite side either in the spinal cord .or in the brainstem(medulla).

third neuron(form in the thalamus always) ends in the postcentral gyrus(anatomical .name,according to its place) of the parietal lobe.

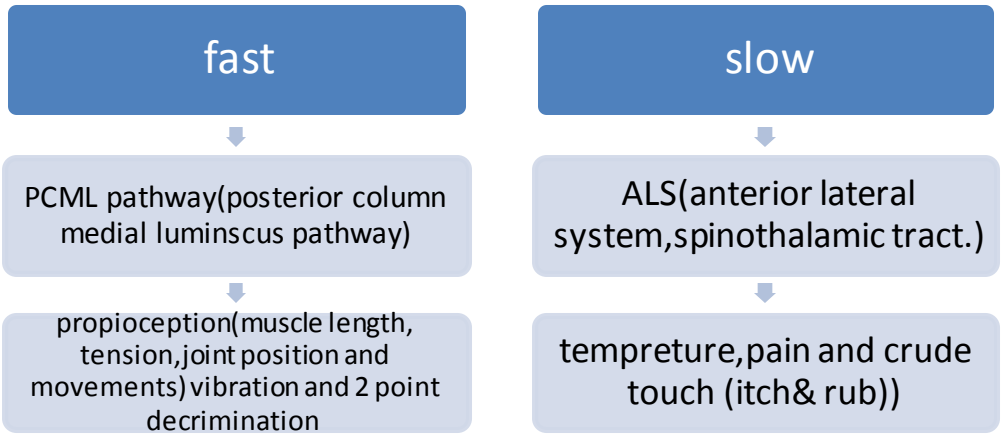
Postcentral gyrus also called somatosensory cortex (physiological name) and called area(3,1,2) in numbering system .

((1st order neuron locate where the cell body of neuron locate!!!))

**The 2nd neuron may start reflexes or end at spinal cord or go to brain but eventually all 2nd neurons must go to cortex.

#all sensations reach neurons but some inputs are very important so neurons carry them quickly and some can wait so carried slowly.

Sensations modalities→ somatosensory pathways



** pressure receptors are similar to touch receptors. (pressure related to PCML pathway – Fast pathway)
EXAMPLE: if you hit your little toe while walking, you will jump before feeling pain
EXPLAIN WHY THIS HAPPENS?
because the pain is carried by slow pathway.
we will learn about pain later, pain has two pathways.

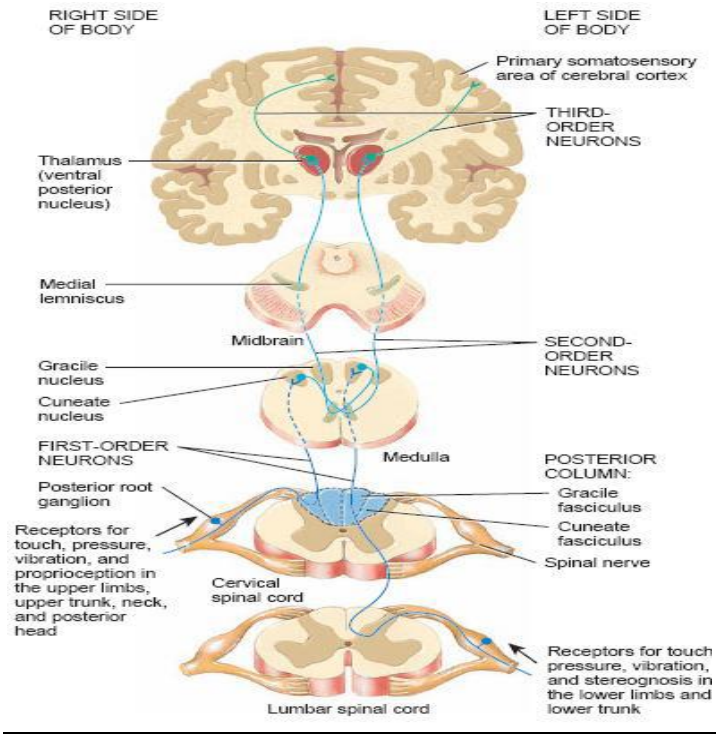
PCML pathway:

Sensation begins from periphery ,then there is 1st order neuron(pseudounipolar neuron in dorsal root ganglia)enter spinal cord and ascend through it until reach medulla ,in medulla 1st order neuron synapse to form 2nd neuron

Sensory decussation (crossing other side) occurs on medulla

2nd continue to thalamus(gait way for sensation) to become 3rd order neuron which go to cortex (3,1,2). (Postcentral gyrus / somatosensory cortex)

*all level of spinal cord contribute in PCML but upper and lower extremities (in cervical and lumber regions)are the majority ,so post. Column of spinal cord large and rounded on lumbar region and large and ovale on cervical region .



*sensory nerves of lower limbs enter spinal cord before upper limbs nerves ,so they locate medially .

(**Graciles** >>>lower limb >>>>medially) & (**cuneat**<<upper limbs <<laterally)

(mass on grey matter of s.cord if it enlarges laterally it will damage sensory of U.L but if it is expanding mass , or mass from outside(ex: from middle ear) ,it will affect the nerves of the L.L.
IN LOWER PART OF THE BRAIN STEM SOMATOTOPIC ORGANISATION IS:
Lower limb Anterior , and upper limb posterior
After that shifting happens and then it will twist (and then it the upper pons they will be straight and horizontal and in the midbrain it will make shifting , so the LL will be Post and the UL Anterior – that's what the dr. said in Section #2 {16:30 to 16:50}) it will reach the cortex , where the body is represented upside down.

MRI
we depend on the shape, at the beginning the spinal cord will be round and at the end it will be oval
remember :Lumber vertebrae has triangular vertebral foramen , thoracic has circular and cervical has triangular foramen
You will take them in details in the anatomy, study them well.
you should recognize them in the clinical orientation.

*PCML Function:

A) 2 points discrimination

B) Vibration

c) Proprioception :

1) STEREOGNOSIS: ability to judge 3D without seeing (form shape and characteristics without seeing the object), vibration has minimal effect on it . → depend on A & B & C mentioned above.

2)GRAPHESTHESIA: Ability to judge what people are touching you for (ie : the direction of movement) Ex: recognize writing on the skin purely by the sensation of touch
you draw a circle and he tells you that it is a circle even without seeing it. → depend on (A & B & C) but mainly on 2 points discremenation

3)Help in movement and Wight recognition → depend mainly on propioception

*PCML lesion associated symptoms(lose two points discrimination)

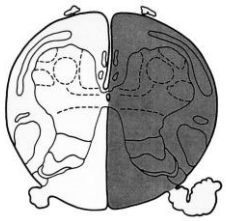
→ASTEREOGNOSIS / STEREOGNOSIA

→AGRAPHESTHESIA

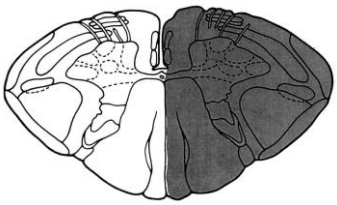
→ABAROGNOSIS: in ability to judge the weight

→SENSORY ATAXIA: no coordination between movement (remember that all coordination of muscles depend on proprioception)

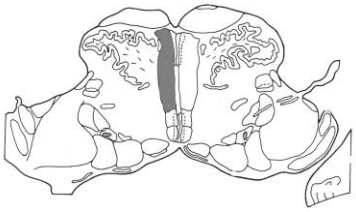
* Clinical Cases in slides 35&36: (deal with these pic as MRI ,in relation to the direction):



Left pic on slide 35: injury on Left lower part of spinal cord (on lumber region)<< which cz loss of PCML on l.t lower limb.
causes loss of two point discrimination ,proprioseption, and vibration. .



R.t pic (slide35): injury on upper part of spinal cord (cervical region)and on l.t side <<< which cz loss of PCML modalities on all parts of l.t side (L.l & U.L)



Pic (on slide 36): injury on R.t PCML on Brain stem<<< cz loss of PCML on L.T side

(remember :decussation of PCML nerves occur on medulla(brainstem))

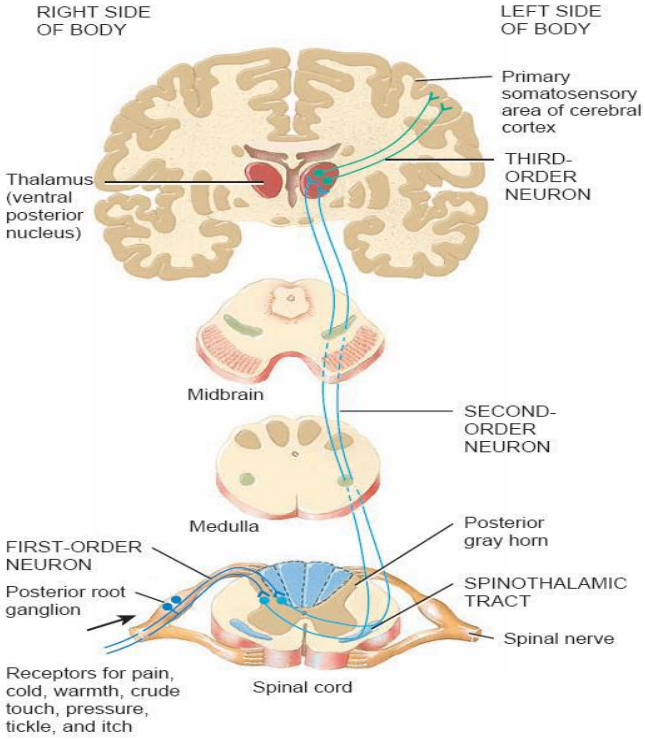
ALS(spinothalamic pathway) :

its pathway similar to PCML but differ on site of decussation.

From the periphery >>> to 1st order neuron (dorsal root ganglia)>>>synape on spinal cord to form 2ND order neuron in the gray matter of the spinal cord >>>> decussating happens in the spinal cord >>>ascend in the anterior lateral part of the spinal cord until it reaches the thalamus (3rd order neuron)>>> somatosensory cortex .

***crossing in the spinal cord is not directly at the same level of 1st order neuron, it occurs after one or two segments

Ex:if neuron enter at the level of c5 ,the crossing occurs at the level of C3



Dermatoms :

*All sensation enter spinal cord through spinal nerves
So information from the body will enter through one of the spinal nerves .this mean that we can do mapping of the sensory areas in the body based on the spinal nerve number and locations.

**The strip of skin that is innervated by the peripheral cutaneous branches of a given

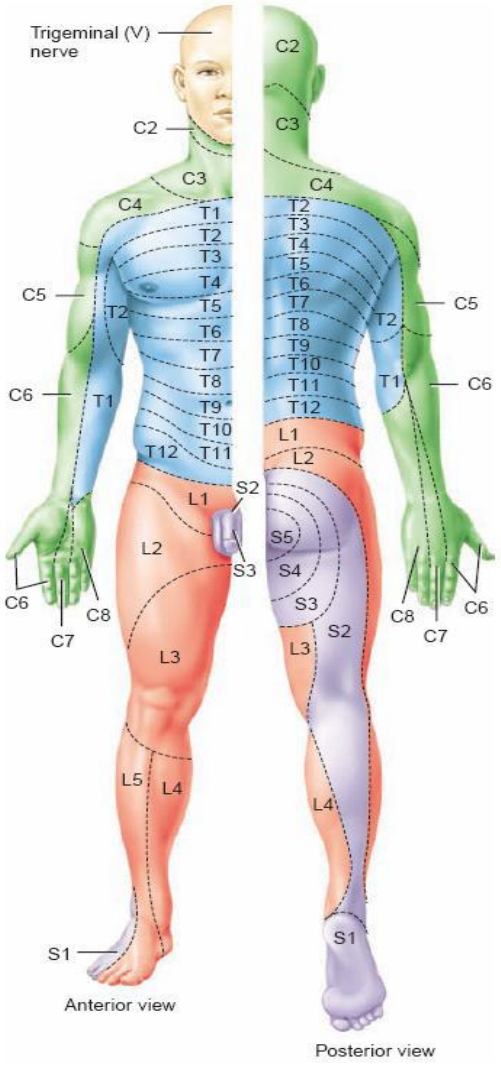
spinal nerve is called a **dermatome**

*each part of body represented by spinal nerves

**** we must memorized dermatoms for hand ,shoulder , nipples ,leg, knee,umbilical genitalia, Big toe, lateral side of the feet, and abdomen.(plz refer to pictures in the slides)

C6 related to thumb / Umbilicus>>>>>>T10

Hand >>>>**C6,7,8** >>>> but there is individual variation (middle finger >>>>C7&6 !!(mostly from 7)



referred pain

Referred pain: is pain perceived at a location other than the site of the painful stimulus

** all **visceral pains are referred pain**

All the sensory input enter through one of the spinal nerves.

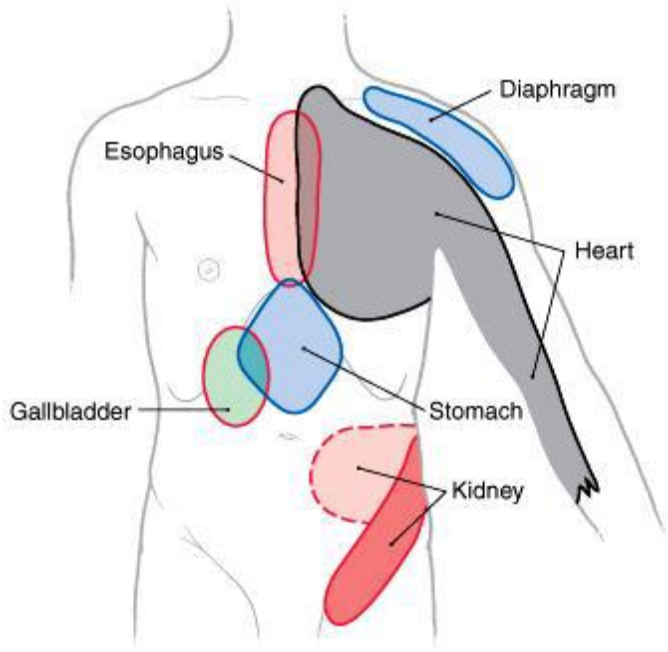
>>>>> as dr. said there is no pathway for sensation from visceral organs (ex: stomach) to brain through spinal cord !!!!
it will be presented as referred pain in an area innervated by a certain spinal nerve

When we are still infants our brain didn't recognize pain in thumb as it is in the thumb , it only knows that there is pain sensation from C6 , but after many stimuli, the brain understands that this pain C6 is for the thumb. If we brought a needle and sting C6 , we will

feel it as pain in the thumb :P :P
so according to this example:
if visceral organ supply by sensory nerve enter spinal cord through C6 >>> pain on this activate C6!!! >>> pt may feel pain on thumb even there is no problem on it .

visceral referred pain :

Plz refer to the pictures in the slides.



Ex:

Gall bladder inflammation >>>> tip of shoulder and the scapula on the back (refer to the picture in the slide 59)
stomach >>>> the abdomen

Heart >>>> left arm and left side of the chest

Liver>>>> shoulder ,, and also the scapula on the back

Kidney>>>> back >>> may mistake with intramuscular spasm but actually it is ascending infection on kidney .

The doctor answered a question asked by one of the students:
Gateway pathway : firstly pain will induce activation only in the big fibers , and then it will activate more and more fibers and there will be lateral inhibition for the other pathways and the pain will get localized.
remember that not all of the nerves are activated at the same time.

Sorry for any mistakes

Good Luck all