Physiology Team

LECTURES 21-22

Pathways of proprioception &

Physiology of the proprioceptors in Balance

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OBJECTIVES

At the end of this lecture, student should be able to describe:

1-Identify the major sensory pathways.

2-Describe the components, processes and functions of the sensory pathways.

3-appreciate the dorsal column system in conscious proprioception (anatomy & functions).

4- describe the pathway of spinocerebellar tract in unconscious proprioception from muscles,tendons,and joints.

5-differentiate between sensory and motor ataxia.

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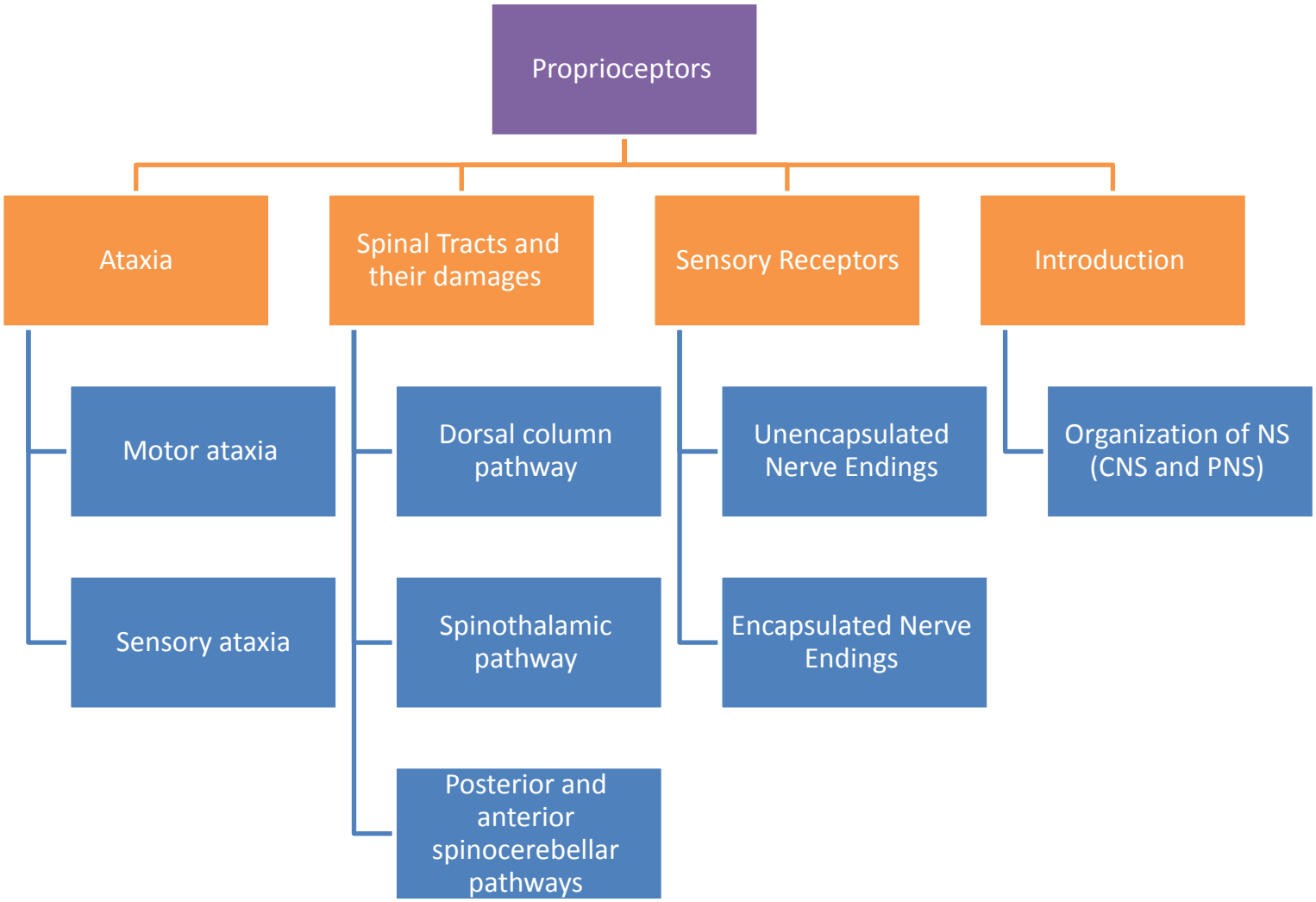
MIND MAP



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INTRODUCTION

- **Proprioception**

- From Latin *proprius*, meaning "one's own", "individual" and perception,
- Is the sense of the relative position of neighboring parts of the body and strength of effort being employed in movement.
- **Exteroception**, by which one perceives the outside world,
Interoception, by which one perceives pain, hunger, etc., and the movement of internal organs.

The initiation of proprioception is the activation of a proprioceptor (sensory neuron)in the periphery.

Types of proprioception:-

1- conscious proprioception reach the level of cerebral cortex sensory area via dorsal column tract.
2- Unconscious proprioception reach the level of cerebellum via spinocerebellar tracts

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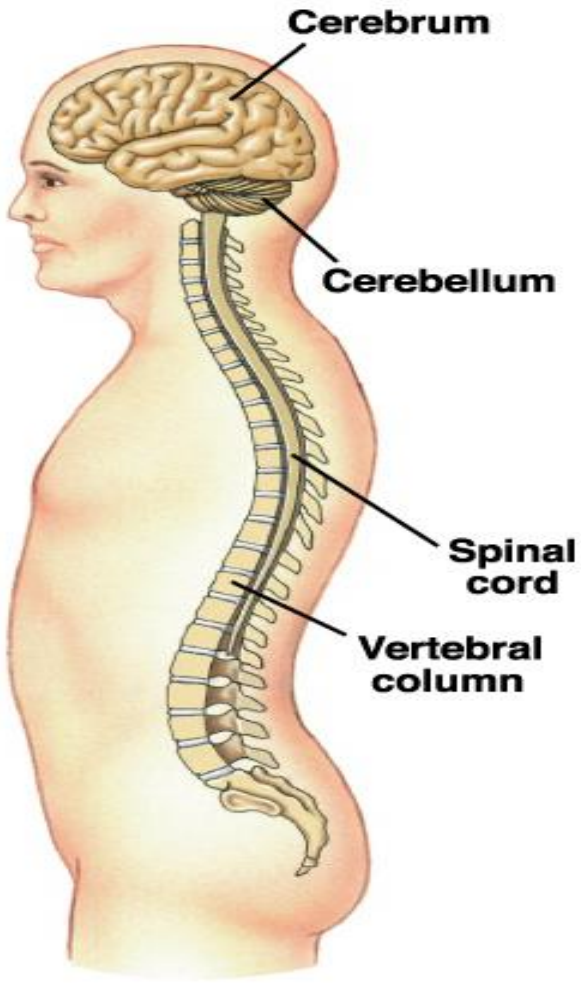
• Organization of Nervous System:



Central Nervous System

The brain + the spinal cord

The center of integration and control

Peripheral Nervous System

The nervous system outside of the brain and spinal cord

Consists of:

31 Spinal nerves Carry info to and from the spinal cord

12 Cranial nerves Carry info to and from the brain

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Spinal Cord

- A Cross-section view of spinal cord- wider laterllay than anteroposteriorly. In the middle on the dorsal side is a shallow groove called the posterior median sulcus and on the ventral side is the anterior median fissure (deeper).
- center consist of gray matter shaped like a butterfly and there is an opening at the center
- Spinal cord is protected by three layers of meninges. The only difference from the brain is that the dural matter does not attach to bone. The dural matter is surrounded externally by a layer of cushioning fat called epidural space.

Grey Matter

- Dorsal half – sensory roots and ganglia
- Ventral half – motor roots
- Dorsal and ventral roots fuse laterally to form spinal nerves
- Four zones are evident within the gray matter – somatic sensory (SS), visceral sensory (VS), visceral motor (VM), and somatic motor (SM)

White Matter

- Fibers run in three directions – ascending, descending, and transversely
- Divided into three funiculi (columns) – posterior, lateral, and anterior
- Each funiculus contains several fiber tracks
- Fiber tract names reveal their origin and destination
- Fiber tracts are composed of axons with similar functions

An Overview of Sensory Pathways and the Somatic Nervous System

Efferent Pathway	Afferent Pathway
• Motor commands coming from the brain and spinal cord, through peripheral nerves to effecter organs .	• Sensory information coming from the sensory receptors through peripheral nerves to the spinal cord and to the brain
	• Sensory systems allow us to detect, analyze and respond to our environment
	• **"ascending pathways"** Carry information from sensory receptors to the brain
	Sensations from body reach the opposite side of the brain

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Sensory receptors classified according to:
Location _ Type of stimulus detected _ Structure

Sensory Receptors

UNENCAPSULATED NERVE ENDINGS

Types:
- Free nerve endings of sensory neurons
- Modified free nerve endings (Merkel discs)
- Hair follicle receptors

ENCAPSULATED NERVE ENDINGS

Consist of one or more end fibers of sensory neurons
Enclosed in connective tissue
Include four main types:
- Meissner's corpuscles
- Pacinian corpuscles
- Ruffini's corpuscles
- **Proprioceptors (**Monitor stretch in locomotory organs**)**

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This slide is just for your INFO.

Boy's slide

ENCAPSULATED	FUNCTION
Meissner's corpuscle	Sensitive to lightest touch
Ruffini's end-organ	Send impulses about touch or pressure applied to skin or joints
Pacinian corpuscle	Detect vibration
NON-CAPSULATED	
Hair end organ	Detect movement of objects that displaces the hair over the skin
Markel's disc	Send impulses about touch against the skin
Free nerve endings	Elicit tickle and itch senses

- Even though Touch, pressure, vibration are often classified as separate and distinct sensations but they are detected by the same general classification of somatic senses which is mechanoreceptors .(NB. Also proprioception are considered mechanoreceptor)
- Six types of mechanoreceptors are classified as tactile receptors

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Adaptation time of the receptors

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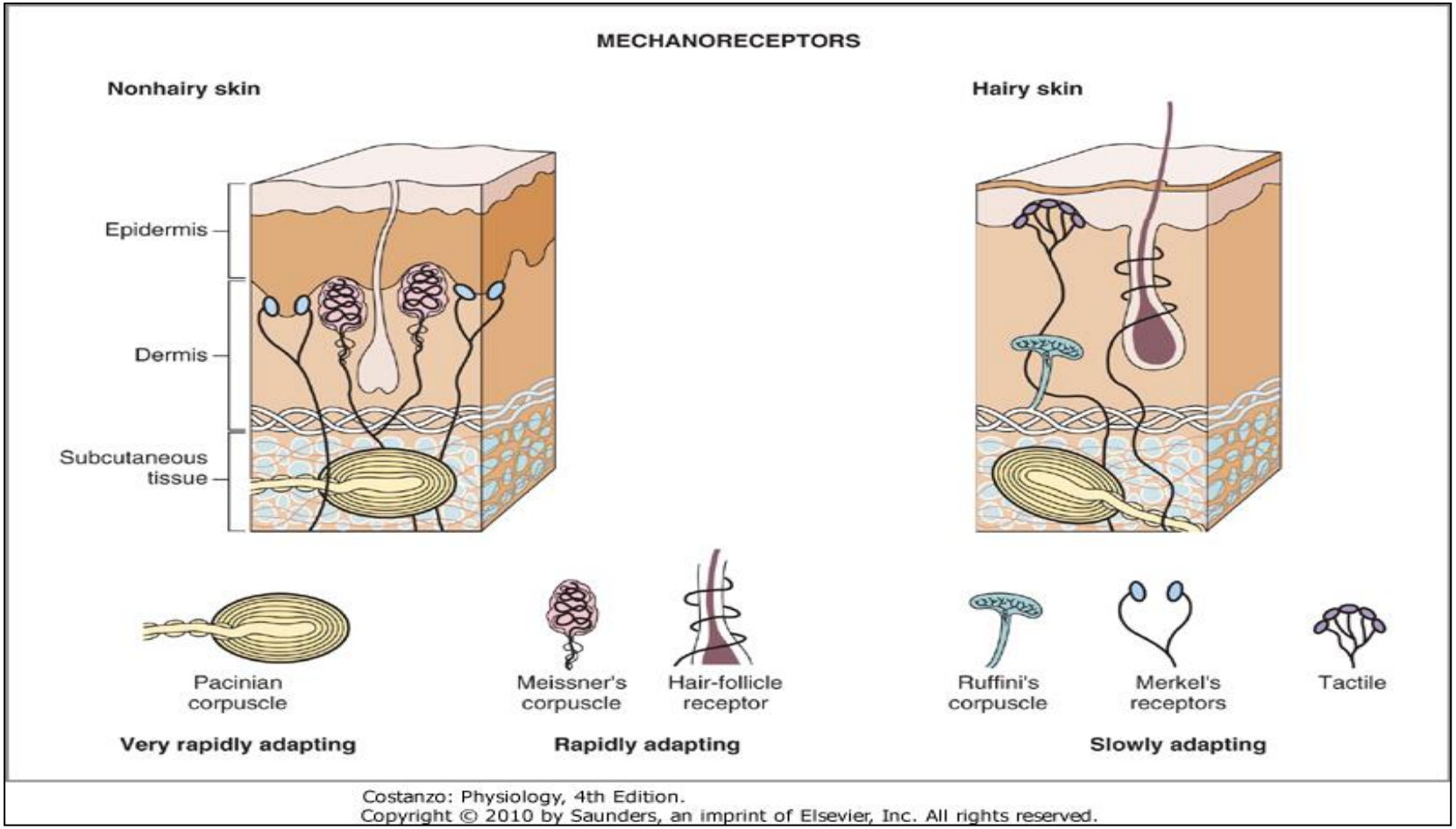

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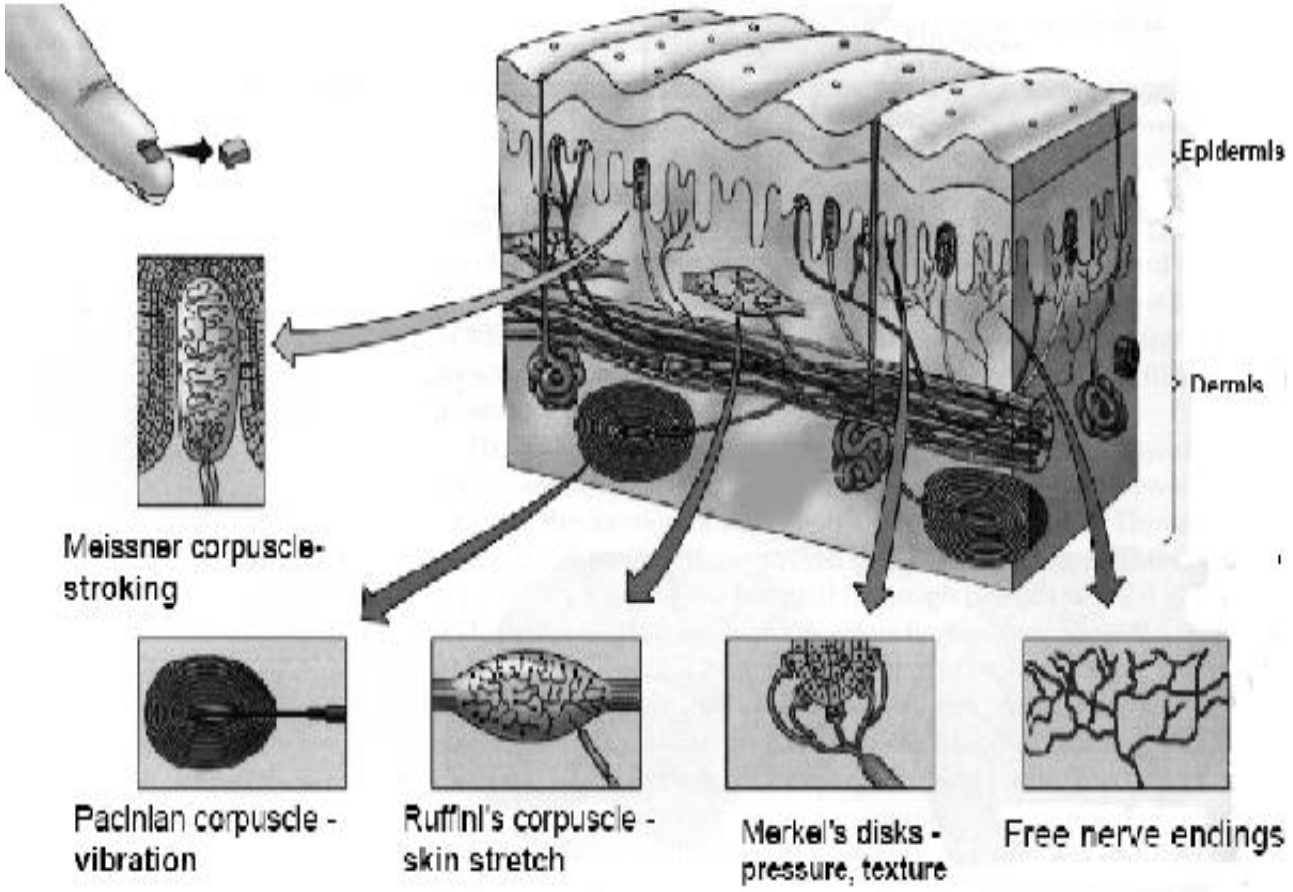
Additional Picture



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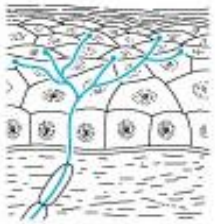
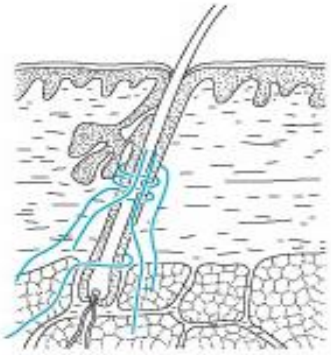
Unecapsulated Nerve Endings

Table 14.1 General Sensory Receptors Classified by Structure and Function (1 of 3)

Anatomical Class (structure)	Illustration	Functional Class According to Location (L) and Stimulus Type (S)	Body Location
UNENCAPSULATED			
Free nerve endings of sensory neurons		L: Exteroceptors, interoceptors, and proprioceptors S: Nociceptors (pain), thermoreceptors (heat and cold), possibly mechanoreceptors (pressure)	Most body tissues; densest in connective tissues (ligaments, tendons, dermis, joint capsules, periostea) and epithelia (epidermis, cornea, mucosae, and glands)
Modified free nerve endings: Merkel discs		L: Exteroceptors S: Mechanoreceptors (light pressure)	Basal layer of epidermis
Hair follicle receptors		L: Exteroceptors S: Mechanoreceptors (hair deflection)	In and surrounding hair follicles

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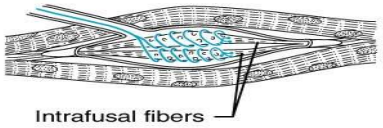
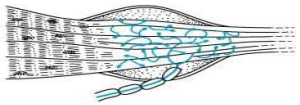
Types of proprioceptors

Types of proprioceptors	Muscle spindles	Golgi tendon organ	Joint kinesthetic receptors
Location	Imbedded in the perimysium between muscle fascicles	located near the muscle-tendon junction	Sensory nerve endings within the joint capsules
Function	measure the changing length of a muscle	Monitor tension within tendons	**(all 3 types are mechanoreceptors)**

TABLE 14.1 General Sensory Receptors Classified by Structure and Function *(continued)*

Structural Class	Illustration	Functional Class According to Location (L) and Stimulus Type (S)	Body Location
PROPRIOCEPTORS			
Muscle spindles		L: Proprioceptors S: Mechanoreceptors (muscle stretch)	Skeletal muscles, particularly those of the extremities
Golgi tendon organs		L: Proprioceptors S: Mechanoreceptors (tendon stretch)	Tendons
Joint kinesthetic receptors (Pacinian and Ruffini endings, free nerve endings, and receptors resembling Golgi tendon organs)		L: Proprioceptors S: Mechanoreceptors and nociceptors	Joint capsules of synovial joints

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Spinal Tracts

- **Spinal tracts**- These are known as sensory and motor pathways consisting of multineuron pathways connecting the CNS to the PNS. At some point most pathways crossover (decussate),
- A. Ascending (sensory) Pathways- Four main ascending tracts that conduct afferent signals to send it to the cerebral cortex and the other two to the cerebellum.

- 1. **Dorsal column pathway-** carries signal of fine touch, pressure, vibration , stereognsis and proprioception, ascends up dorsal white column in fasciculus gracilis or cutaneatus to medulla oblongata to the thalamus to primary somatosensory cortex (post central gyrus).

- 2. **Spinothalamic pathway**- carries signals of pain, temperature, deep pressure, and course touch. From posterior gray horn decussate into lateral and anterior funiculi up to the thalamus to primary somatosensory cortex (postcentral gyrus).

- 3,4- **Posterior and anterior spinocerebellar pathways-** carry subsconcious proprioception. Dorsal gray horn- to lateral column- to medulla oblongata- to pons – to cerebellum.

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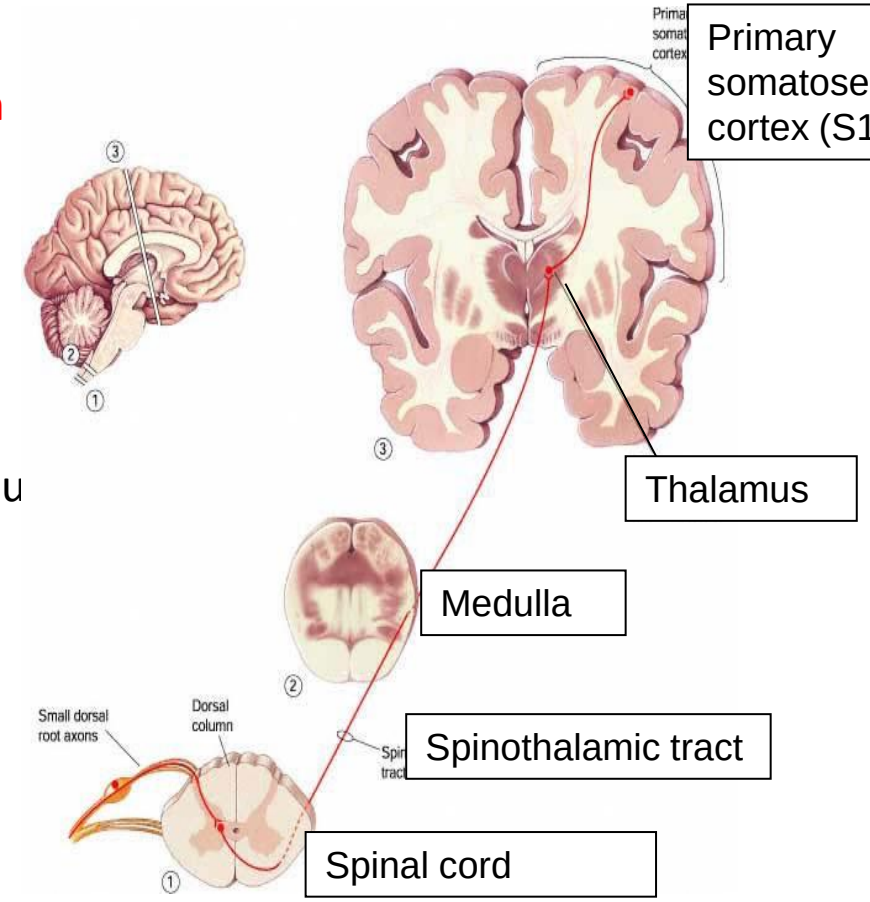
Spinothalamic pathway

- Carries pain, temperature, touch and pressure signals
- 1st neuron enters spinal cord through dorsal root
- 2nd neuron crosses over in spinal cord; ascends to thalamus
- 3rd neuron projects from thalamu to somatosensory cortex



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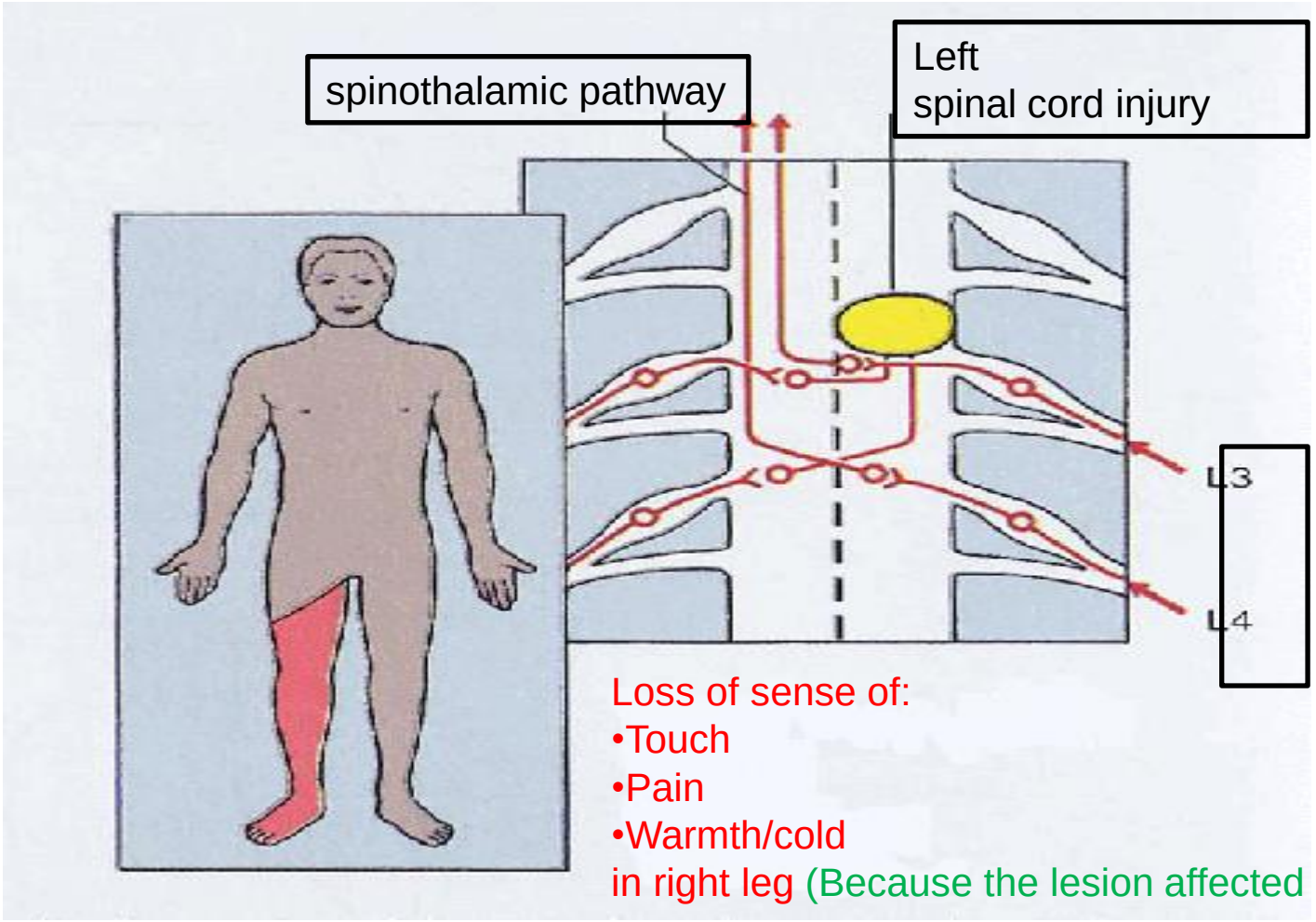
Spinothalamic damage



Loss of sense of:
- Touch
- Pain
- Warmth/cold

in right leg (Because the lesion affected L3&L4)

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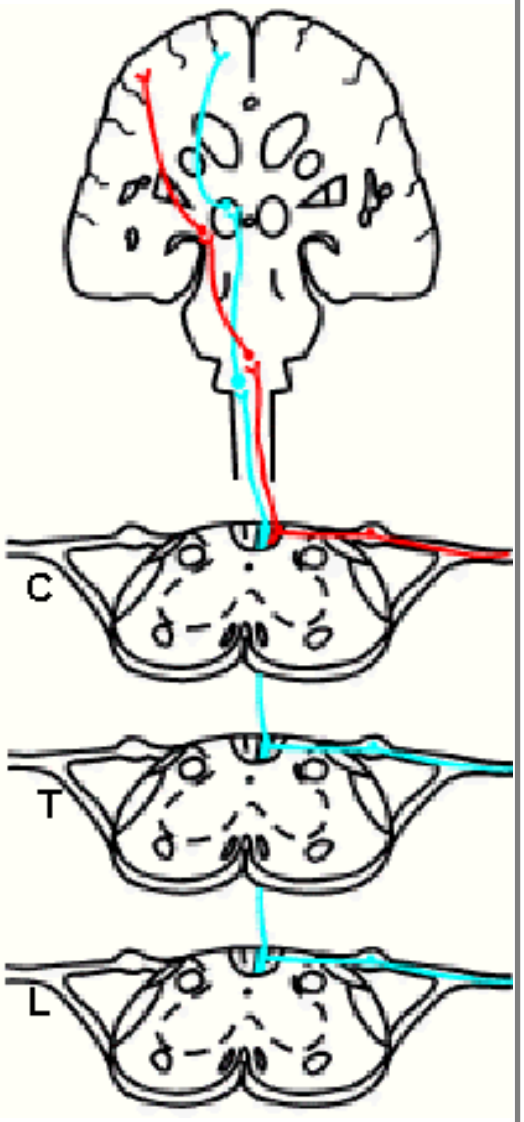
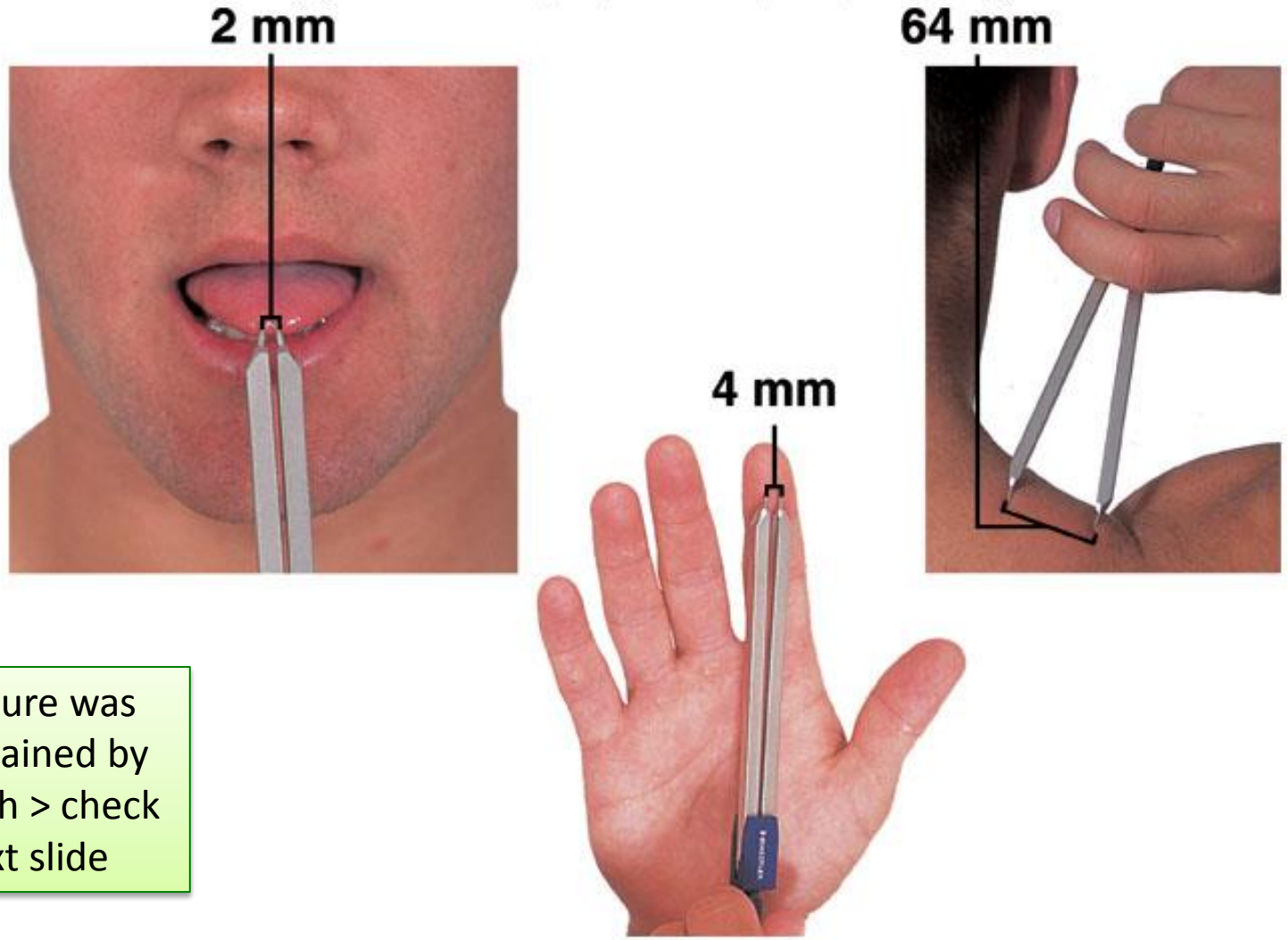
Types of proprioception:-

1- conscious proprioception reach the level of cerebral cortex sensory area dorsal column via medial lemniscus.
2- Unconscious proprioception reach the level of cerebellum via spinocerebellar tracts



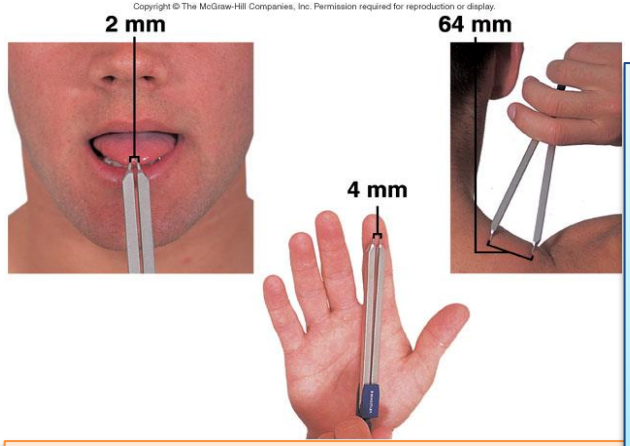
2.2 Dorsal column pathway

- **Carries fine touch & pressuae, , Stereo gnosis, vibration and conscious proprioception signals**
- 1st neuron enters spinal cord through dorsal root; ascends to medulla (brain stem)
- 2nd neuron crosses over in medulla; ascends to thalamus
- 3rd neuron projects to somatosensory cortex



This picture was fully explained by Dr.Fawziah > check the next slide

http://www.youtube.com/watch?v=CEiVbK31wj0



Two-Point Discrimination

Highest threshold for two point discrimination present where in our body?

- **Lips** (highest, remember reading Qura'an),
- **Index**, (remember al-tashahod; as the index has large portion in the somatosensory area)

Something the Dr. mentioned : (lips have highest receptors that's why kissing is the most expressive way to convey your emotions)

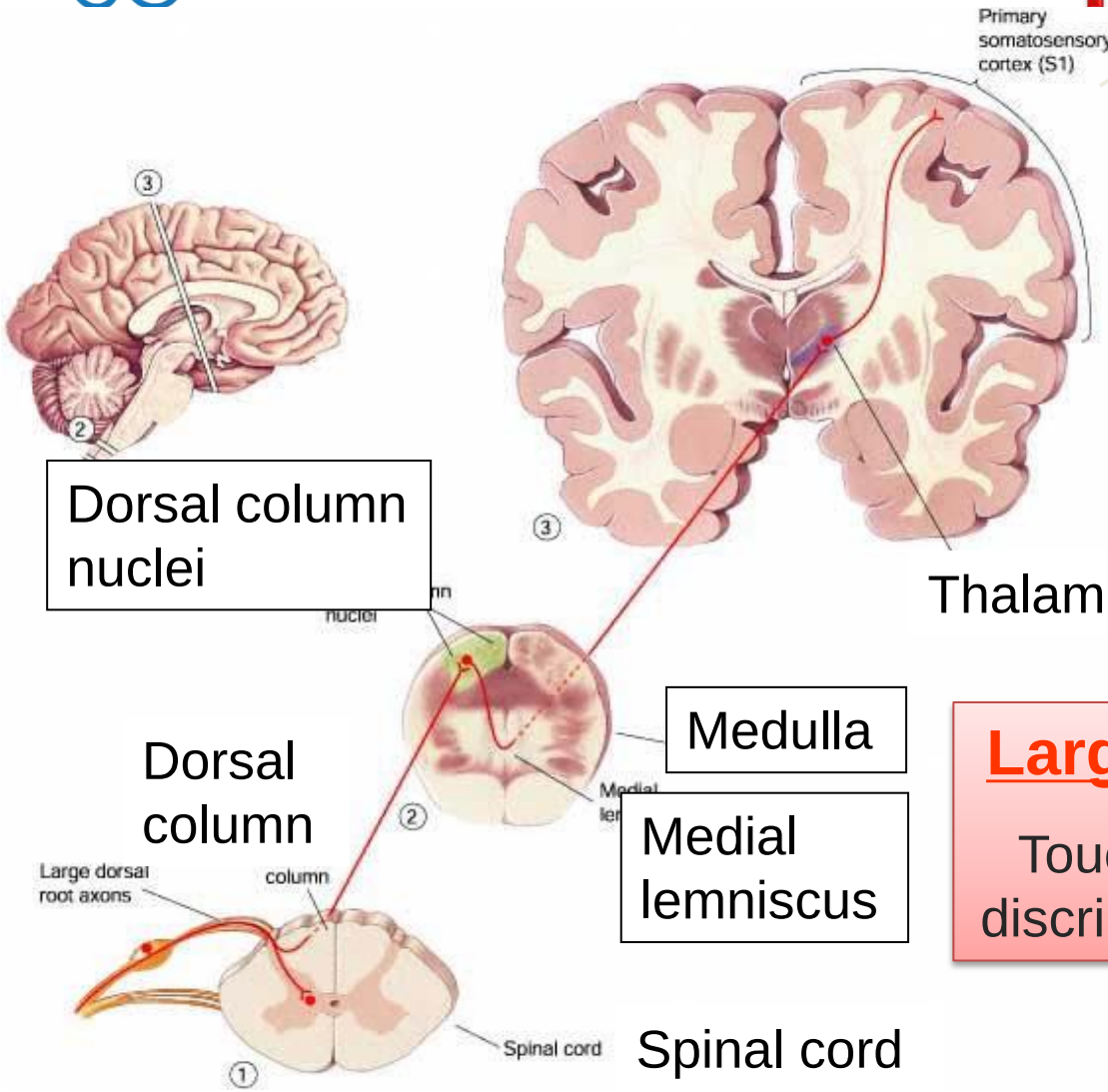
Sensation depends on what?

- No. of receptors.
- Representation area in brain. (Every part of the body has a portion in the somatosensory area, some have large portions others have small portions.)

Now, when you examine, the lowest distance between two point discrimination will be felt in the :

- Lips or tip of the tongue mostly (2mm distance, only)
- And also the index (4 mm).
- Other areas for example in the 3rd picture you will not feel the two point until (64 mm distance). In other words, when you decrease the distance (lower than 64) you feel the two-point as only one point!
  - The lowest distance felt = the more receptor in the area = representation area is large .

Dorsal column pathway



Primary somatosensory cortex (S1) in parietal lobe

Large sensory nerves:

Touch, vibration, two-point discrimination, proprioception

Spinal cord

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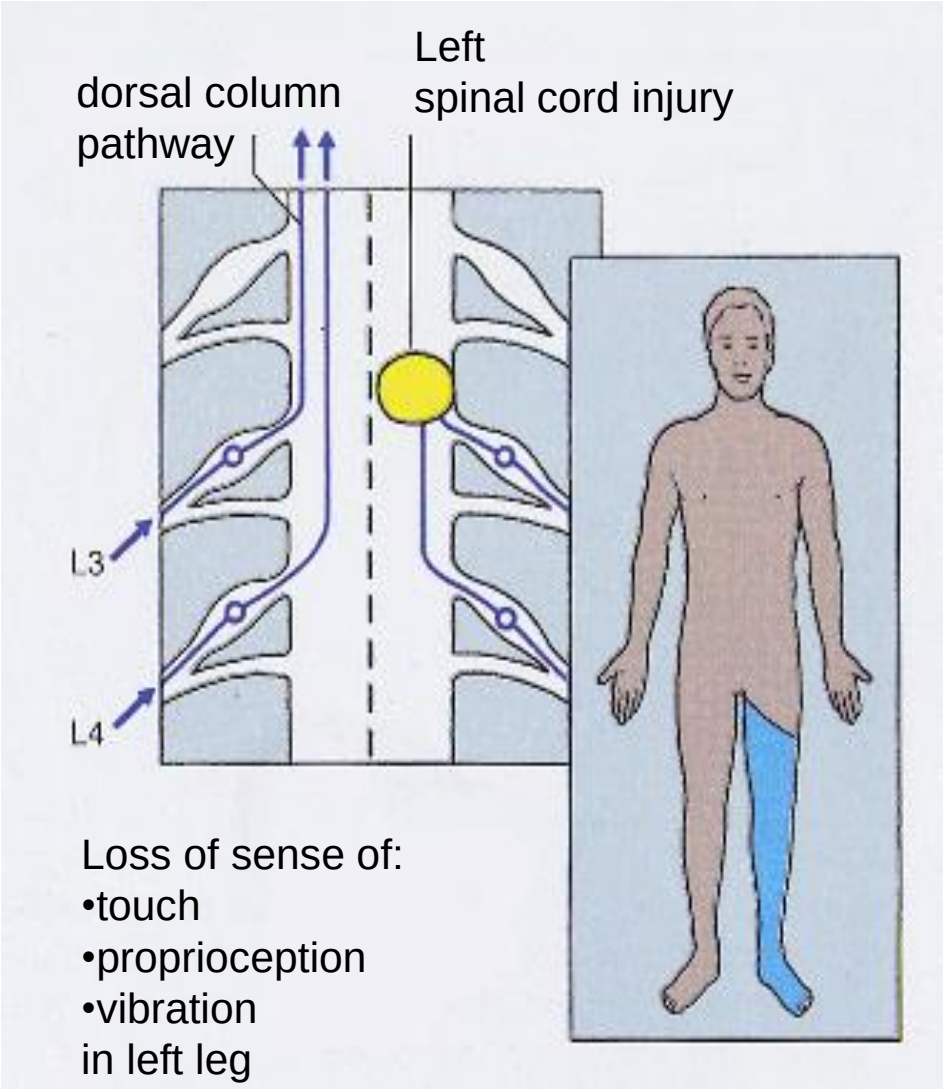
Dorsal column damage



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Dorsal column damage

- Sensory ataxia
- Patient staggers; cannot perceive position or movement of legs
- Visual clues help movement

Dorsal column damage

Everything in this slide was mentioned by Dr. Fawziah

- The patient when he closes his eye cannot identify his position in place , (receptors are intact) but the dorsal column is damaged **; Unlike** the patients who have problems in the cerebellum (the dorsal column in those will be intact).
- **Examination** most be with aid of vision and without the aid of vision.
- **To differentiate** tell the patient to close his eye ; when you see him walking but his walk is more of a drunk walk >>> problem in the cerebellum and the dorsal column is intact
- But when the patient walks but he tries to locate his steps and he doesn't have the drunk walk >>> problem in the dorsal column
- **Note that patients with damaged dorsal column when they open their eyes : they still tries to locate their steps and position but vision may actually help them doing that.**

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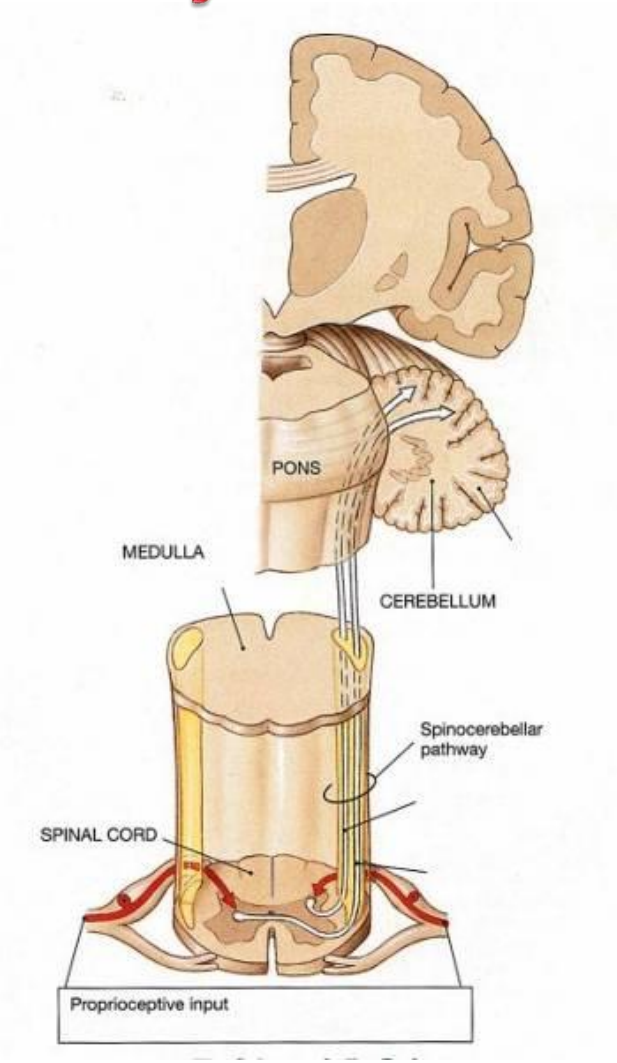
3.3 Spinocerebellar pathway

- Carries unconscious proprioception signals
- Receptors in muscles & joints
- 1st neuron: enters spinal cord through dorsal root
- 2nd neuron: ascends to cerebellum
- No 3rd neuron to cortex, hence unconscious



Spinocerebellar tract damage

- Cerebellar ataxia or motor ataxia
- Clumsy movements
- Incoordination of the limbs **(intention tremor) =** when he moves, there is tremor. Unlike static tremor.
- Wide-based, reeling gait (ataxia)
- Alcoholic intoxication produces similar effects!

Additional info ;

- **Intention tremor :** A tremor that occurs when a voluntary movement is made
- While**, static tremor:** irregular involuntary muscle contractions that occur when a patient makes an effort to hold the trunk or limbs in certain positions

Motor & Sensory Ataxia

Ataxia and Gait Disturbances

- Pathophysiology
  - Result from any condition that affects the central and peripheral nervous systems
  - **Ataxia**: Types
    - Motor ataxia
    - Sensory ataxia

Motor Ataxia

Caused by cerebellar disorders

- Intact sensory receptors and afferent pathways
- Integration of proprioception is faulty
- Midline cerebellar lesions cause truncal ataxia
- Lateral cerebellar lesions cause limb ataxia
- Thalamic infarcts may cause contralateral ataxia with sensory loss

Sensory Ataxia

- Failure of proprioceptive information to the CNS
- May be due to disorders of spinal cord or peripheral nerves
- Can be compensated for by visual inputs

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4. Somatosensory cortex : located in the postcentral gyrus of the human cerebral cortex.

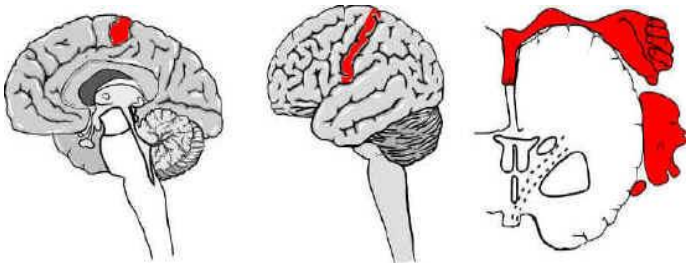
Spatial orientation of signals :

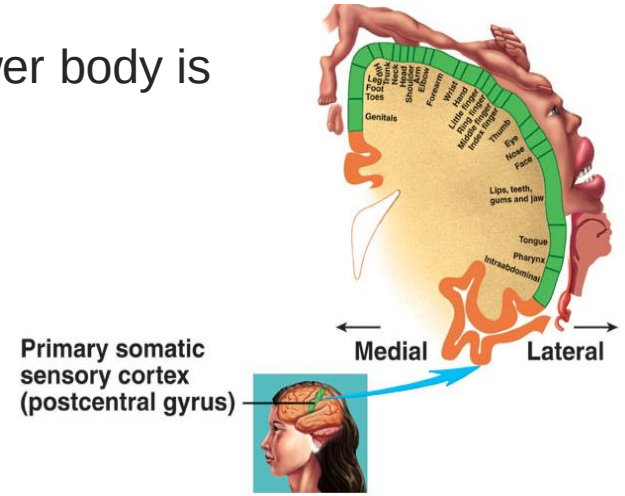
1) Each side of the cortex receives sensory information exclusively from the opposite side of the body (the exception: the same side of the face).

2)The lips, face and thumb are represented by large areas in the somatic cortex,

whereas the trunk and lower part of the body, relatively small area.

3)The head in the most lateral portion, and the lower body is presented medially





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SUMMARY

- **Types of proprioception:-**
  1- conscious proprioception via dorsal column tract; reach the level of cerebral cortex sensory area.
  2- Unconscious proprioception via spinocerebellar tracts; reach the level of cerebellum.
- The initiation of proprioception is the activation of a proprioreceptor in the periphery.The proprioceptive sense is believed to be composed of information from **sensory neurons located in the inner ear (motion and orientation)** and **in the stretch receptors located in the muscles** and the joint-supporting ligaments (stance).
- **Three Types of Proprioceptors :**

(Muscle spindles , Golgi tendon organs and Joint kinesthetic receptors)

- **Dorsal column damage ;** Sensory ataxia ; Patient staggers; cannot perceive position or movement of legs
- **Spinocerebellar tract damage ;** Cerebellar ataxia ; Clumsy movements + Incoordination of the limbs (intention tremor)+(ataxia) +Alcoholic intoxication produces similar effects.

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From khulood Al-Raddadi

SUMMARY

Pathway	Functions	1st neuron	2nd neuron	3rd neuron	Injury leads to
Spinothalamic	Carries **pain, temperature, touch** and **pressure** signals	Enters spinal cord through dorsal root	**Crosses over in spinal cord**; ascends to thalamus	Projects from thalamus to somatosensory cortex	❑ **Loss of sense of:** -Touch -Pain -Warmth/cold in the opposite side
Dorsal column	Carries **fine touch & pressure, , Stereo gnosis, vibration** and **conscious proprioception** signals	Enters spinal cord through dorsal root; **ascends to medulla** (brain stem)	**Crosses over in medulla**; ascends to thalamus	Projects from thalamus to somatosensory cortex	❑ **Loss of sense of:** - Touch - Proprioception - Vibration in the same side ❑ **Sensory ataxia**
Spinocerebellar	Carries **unconscious proprioception** signals	Enters spinal cord through dorsal root	Ascends to cerebellum	No 3rd neuron to cortex unconscious	**Cerebellar ataxia**

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QUESTIONS

Q1 = D
Q2 = B
Q3 = C
Q4 = B

1- Which of the following is the function of proprioceptor?

A- measure the changing length of a muscle
B- Monitor tension within tendons
C- Monitor stretch in locomotory organs
D- All of the above

2- What will happened if there spinothalamic damage?

A- Death
B- Loss the sensation of pain and temperature
C- paralysis of lower limb muscles
D- Loss the sensation of discrimination touch

3- Which of the followings is true about dorsal column damage?

A-The patient has drunk walk
B- Visual clues doesn't help the patient while walking
C- Patient staggers and cannot perceive position or movement of legs
D- Death

4- Which of the following is true about Spinocerebellar tract damage:

A- Patient has static tremor
B- Patient has intention tremor
C- Blindness
D- Non of the above

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THE END

If there are any Problems or Suggestions,
Feel free to contact:

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THANK YOU