Sensory communication to spinal cord

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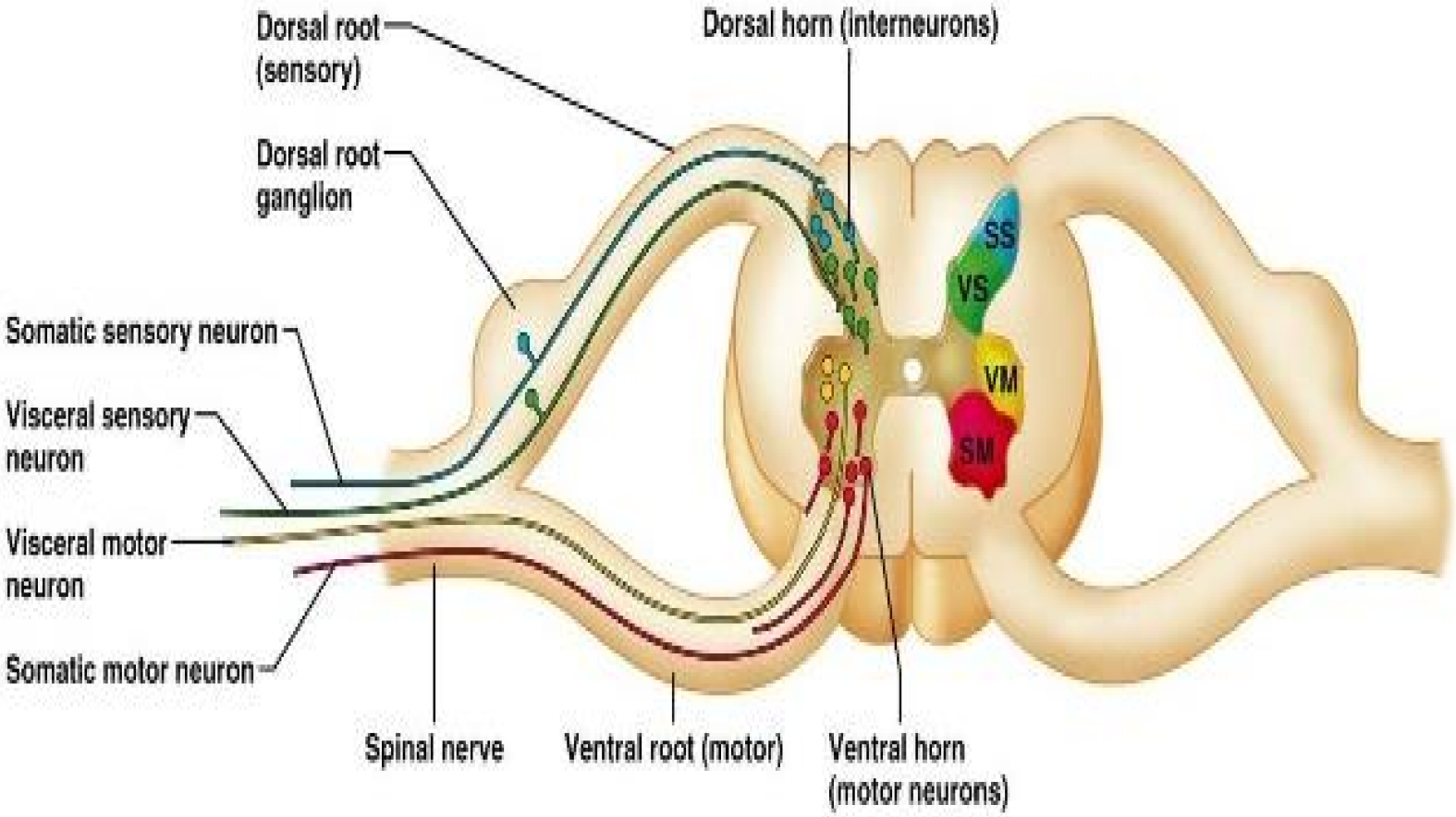
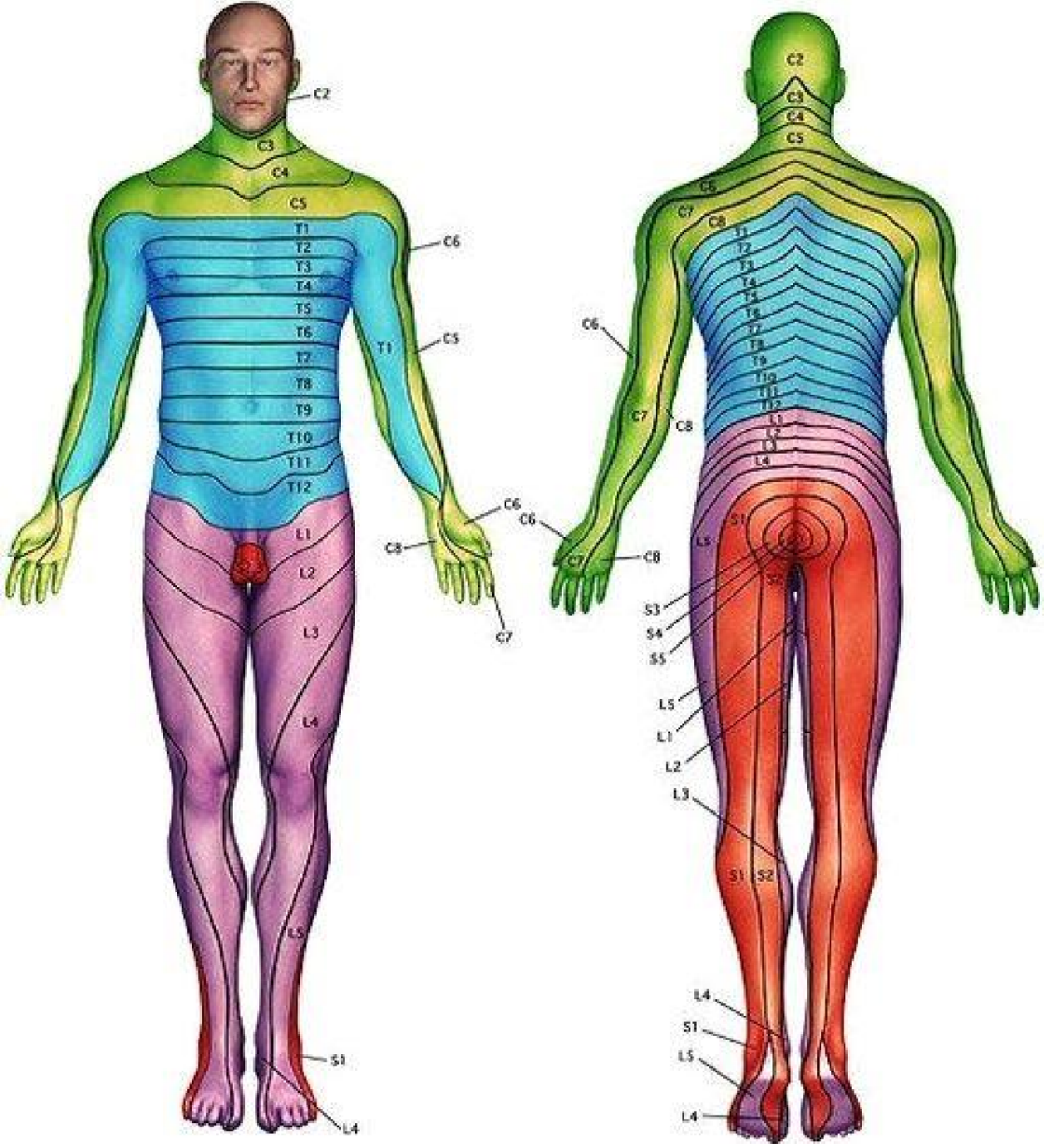
Organization of spinal nerve

- Afferent nerve fibers enter spinal cord through dorsal root and efferent fibers leave spinal cord through ventral root
- Dorsal root is sensory and ventral root is motor
- **Bell- Magendie Law**


Dorsal root (sensory)
Dorsal horn (interneurons)
Dorsal root ganglion
Somatic sensory neuron
Visceral sensory neuron
Visceral motor neuron
Somatic motor neuron
SS
VS
VM
SM
Spinal nerve
Ventral root (motor)
Ventral horn (motor neurons)

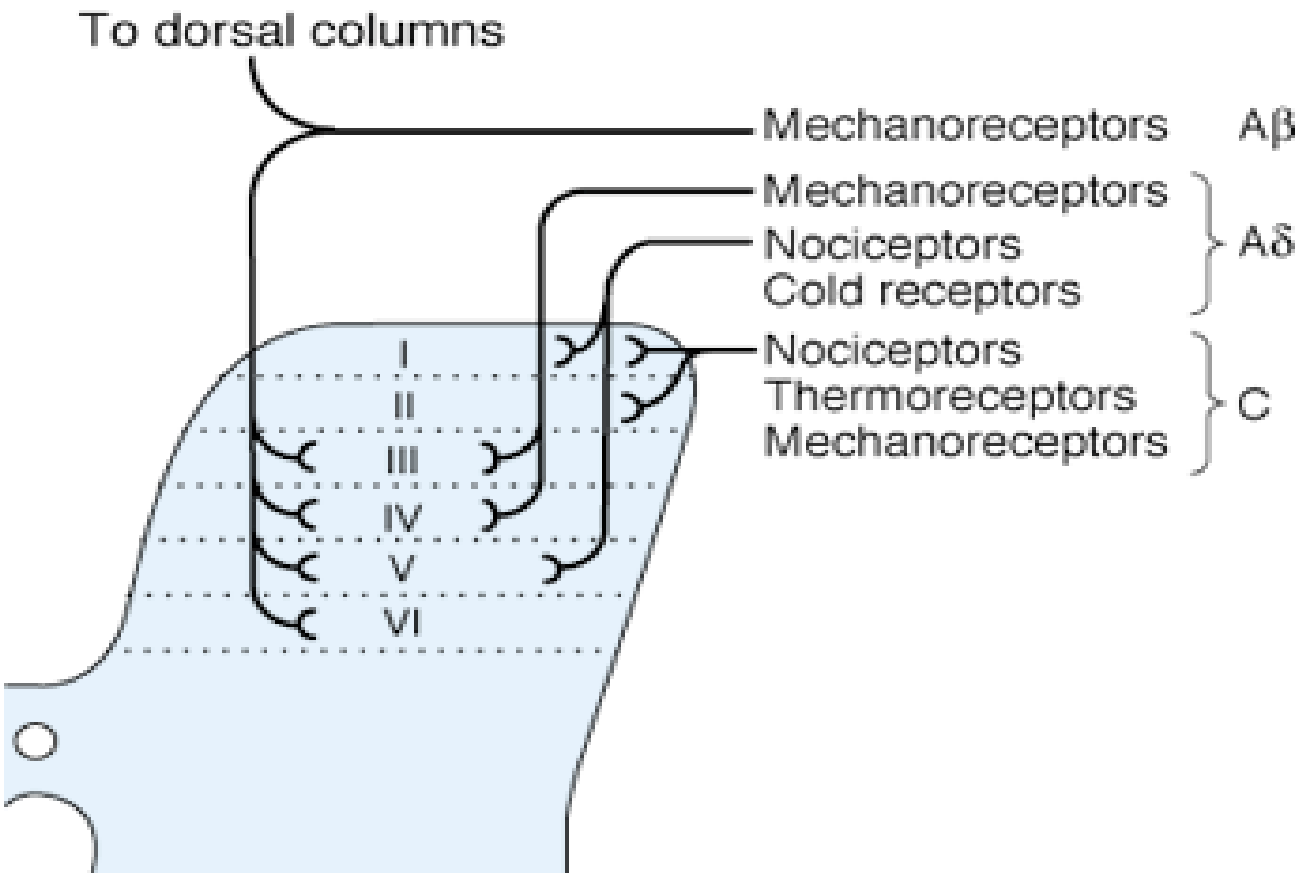
- Each spinal cord segment through its sensory nerve gets input from a specific region of skin- Dermatome
- The entire dermatomes give rise to the Somatosensory map



MAP KEY

L1,2,3,4	Anterior and inner surface of lower limbs
L4,5, S1	Foot
L4	Medial side of great toe
S1,2,L5	Posterior and outer surface of lower limbs
S1	Lateral margin of foot and little toe
S2,3,4	Perineum
T10	Level of umbilicus
T12	Inguinal or groin regions
C5	Clavicles
C5, 6, 7	Lateral parts of upper limbs
C8, T1	Medial sides of the upper limbs
C6	Thumb
C6, 7, 8	Hand
C8	Ring and little fingers
T4	Level of nipples

Spinal cord laminae



- Different laminae in the dorsal and ventral horn of spinal cord (Laminae I to X)
- Dorsal horn- sensory laminae (Laminae I to VI)
- Ventral horn- motor laminae (Laminae VII to IX)
- Laminae X is intercommissural laminae

Ascending pathways (Essay)

- Carry sensations from peripheral structures to different areas of brain
- Set of neurons arranged in series
- First order, second order, third order neurons

First order neuron

- Primary afferent neuron
- Start from receptor and travel in the peripheral nerve to reach spinal cord via dorsal root
- Cell bodies in dorsal root ganglion (DRG)
- Terminate in second order neuron

Second order neuron

- Start from first order neuron
- Located in spinal cord or brainstem
- Transmit impulse from first order neuron to the thalamus
- Second order neuron cross the midline

Third order neuron

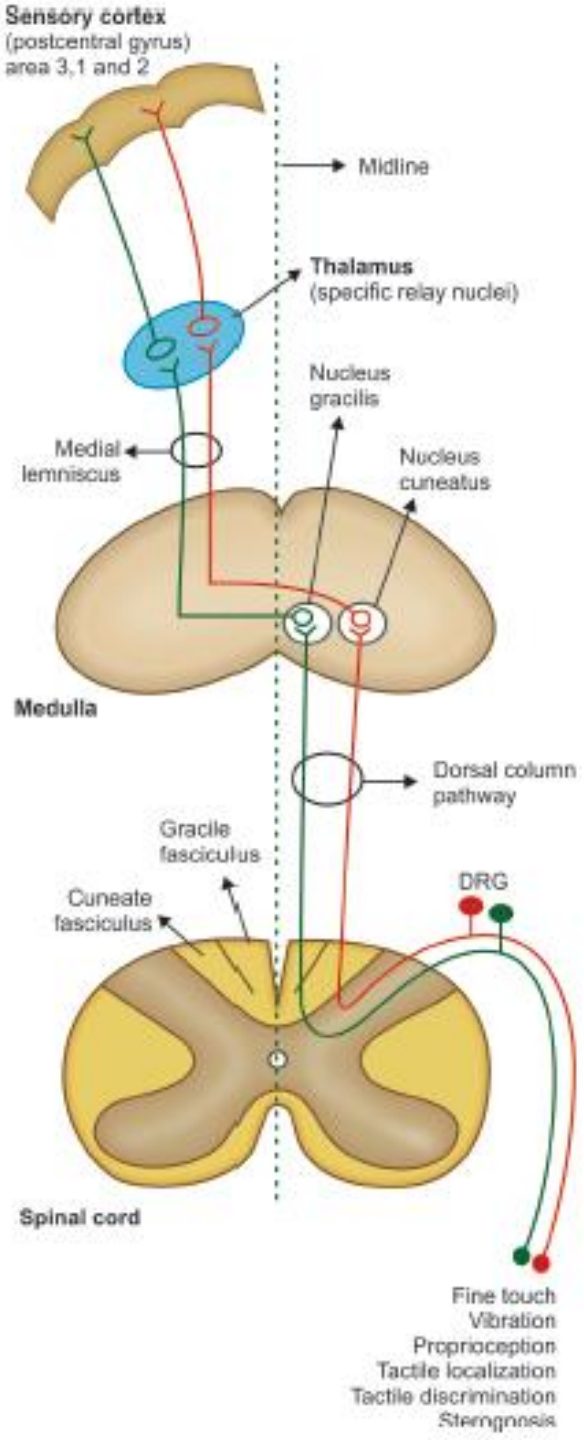
- Originate from the specific nuclei in the thalamus
- Terminate in sensory cortex
- Thalamus – main sensory relay center

Classification

- Dorsal column pathways/ Lemniscal system
- Anterolateral systems
  - Anterior spinothalamic tract
  - Lateral spinothalamic tract
- Other ascending pathways
  - Spinocerebellar tract
  - Spinotectal tract
  - Spinoolivary tract
  - Spinoreticulothalamic tract
  - Spinocervicothalamic tract

Dorsal column pathway
(Short essay/ Draw diagram)

- Also called tract of Goll and Burdach
- Carry the sensations
  - Fine touch
  - Vibration
  - Proprioception (input from muscle, tendon and joint machanoreceptors that inform about movements of joints and body parts)
  - Tactile localization
  - Tactile discrimination (minimal distance that permits two touch stimulus to be perceived as two separate points when applied simulateously)
  - Stereognosis (ability to identify known object by handling them with closed eyes)


Sensory cortex
(postcentral gyrus)
area 3,1 and 2
Midline
Thalamus
(specific relay nuclei)
Nucleus
gracilis
Medial
lemniscus
Nucleus
cuneatus
Medulla
Dorsal column
pathway
Gracile
fasciculus
DRG
Cuneate
fasciculus
Spinal cord
Fine touch
Vibration
Proprioception
Tactile localization
Tactile discrimination
Stereognosis

First order neuron

- Starts from receptor
- Cell body is in DRG
- Enter through dorsal root of spinal cord
- Then leaves the grey matter and enter into the dorsal white matter
- Then first order neuron ascend up from the lower limb and lower part of trunk as Fasciculus Gracilis and from the upper limb and upper part of trunk as Fasciculus Cuneatus
- Fasciculus Gracilis is placed medially and Fasciculus Cuneatus is placed laterally
- Terminate in Nucleus Gracilis and Nucleus Cuneatus in the medulla

Second order neuron

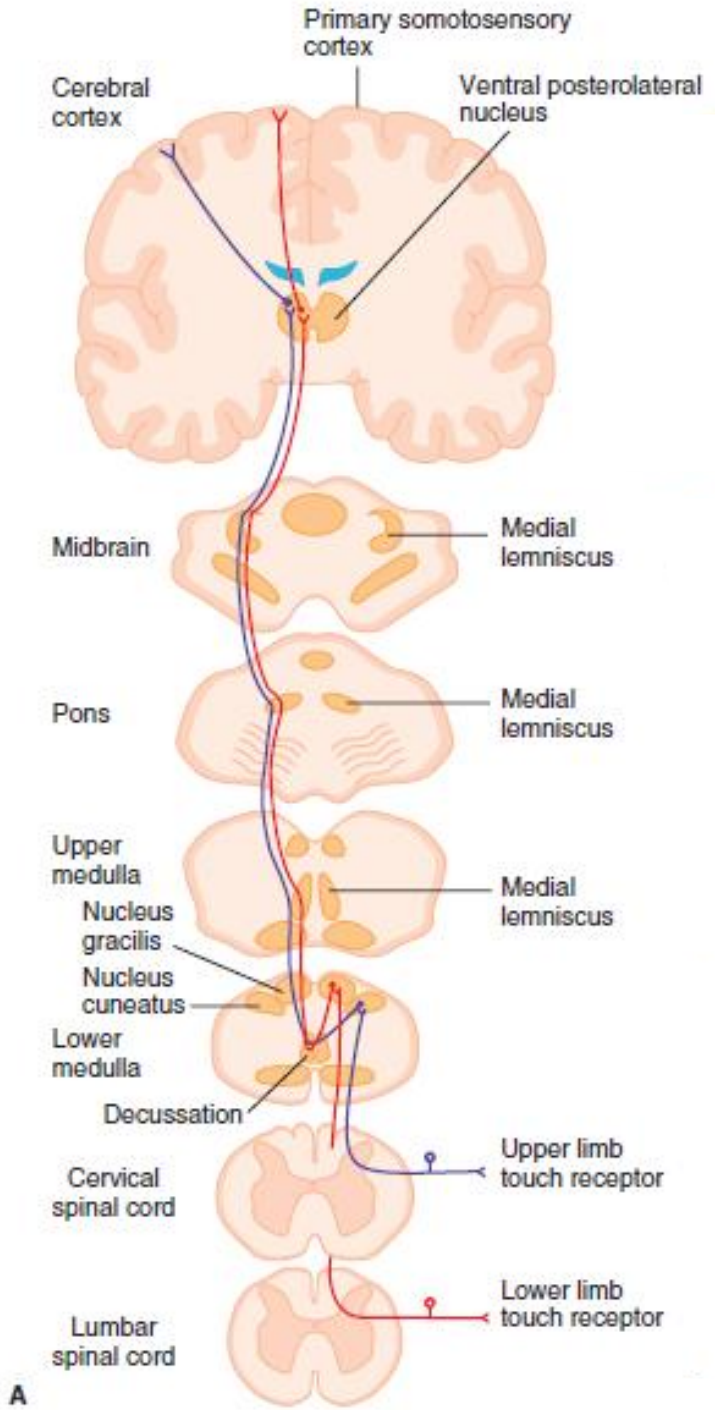
- Cell bodies in the nucleus gracilis and cuneatus in medulla (dorsal column nuclei)
- Fibers from these nuclei cross the midline to the opposite side of medulla and ascend up in the medial lemniscus to reach VPL nucleus of thalamus (contralateral thalamus)

Dorsal column nuclei

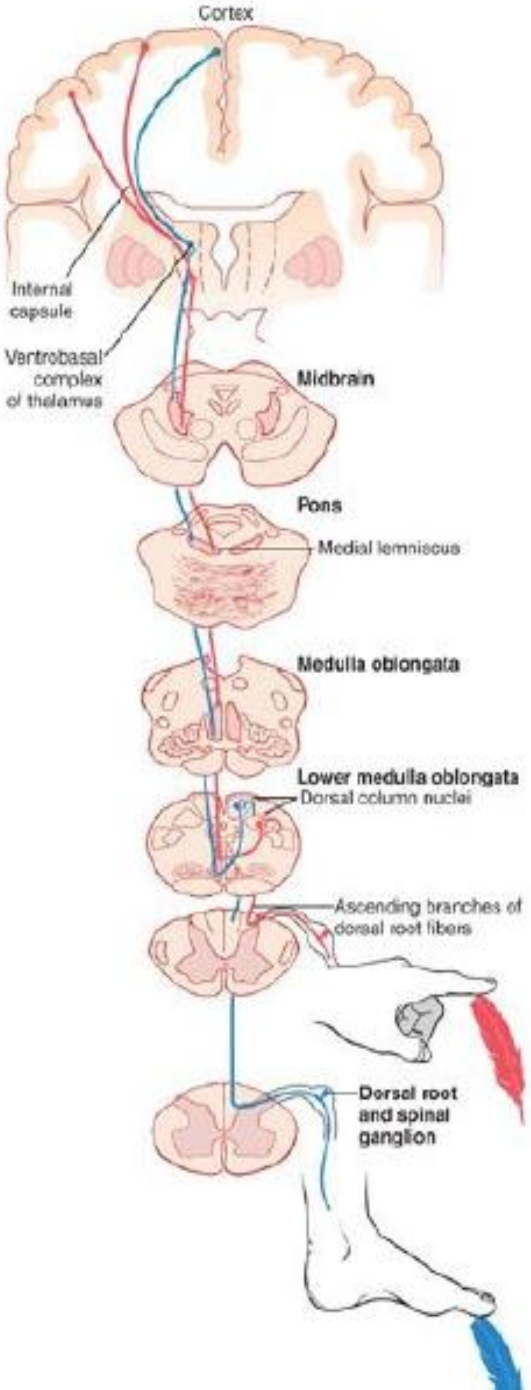
- Face is arranged laterally, trunk and lower limb medially
- There are two types of zones in the dorsal column nuclei
- Cluster zone
  - Main part of dorsal column nuclei
  - Receives the input from dorsal column pathways and project to opposite side of thalamus and then to sensory cortex
- Non -Cluster zone
  - Situated more rostrally
  - Get input from cortex as well as dorsal column and project to nonthalamic areas like Cerebellum, Red nucleus, Tectal and pretectal area
  - Helps to bring a sensory motor co-ordination

Third order neuron

- Originates from VPL nucleus in thalamus
- Project to somatosensory area of the cerebral cortex (Post central gyrus or Area 3,1 and 2)



Draw diagram

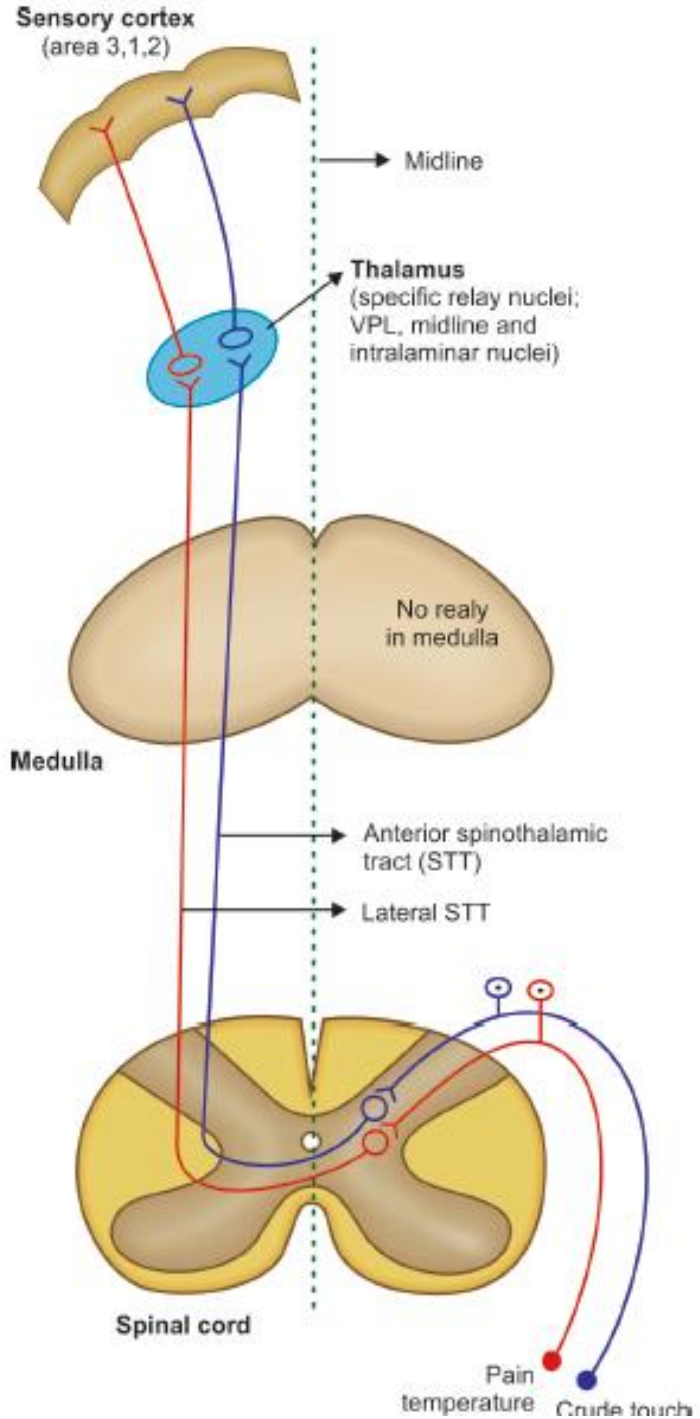


- Mark first, second and third order neurons
- Fasciculus gracilis and cuneatus
- Nucleus gracilis and cuneatus

Anterior spinothalamic tract

Short essay

- Carry sensation of crude touch and pressure



First order neuron

- Originating from mechanoreceptors
- Fiber enters spinal cord through dorsal root and cell bodies are present in the DRG
- Terminate on second order neuron present on the same side of the dorsal horn of the spinal cord

Second order neuron

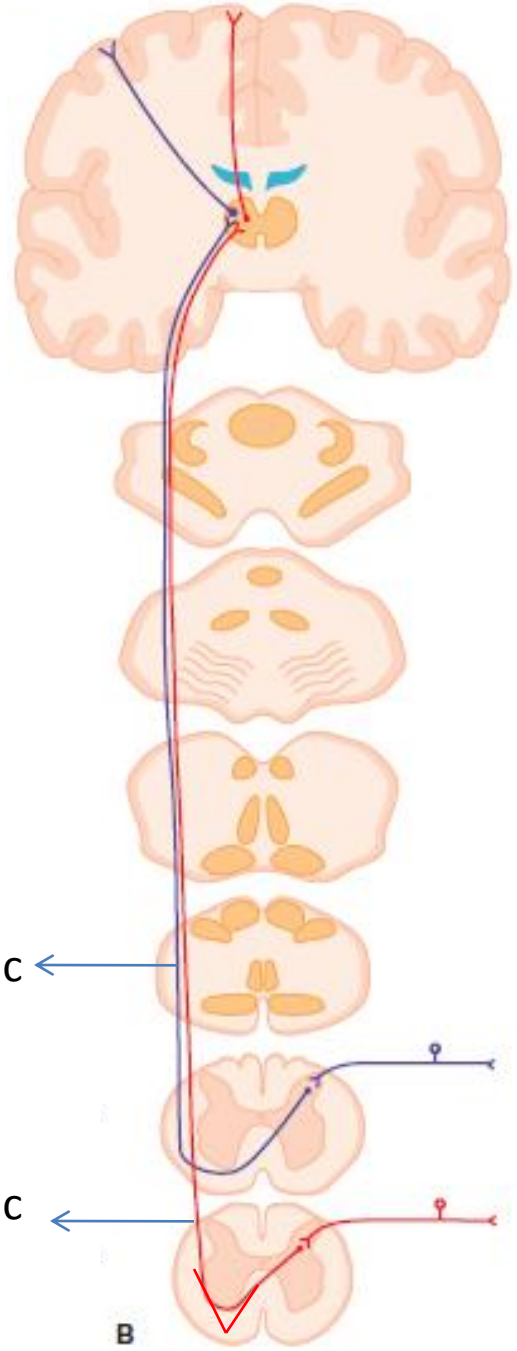
- Cell bodies present in the dorsal horn of the spinal cord (Laminae I, II and V)
- Axon cross the midline in the same spinal segment and ascend up in the opposite side to reach thalamus
- Because these fibers are placed anteriorly the tract is called anterior or ventral spinothalamic tract

Third order neuron

- Neurons originate from the VPL, midline and intralaminar nuclei of the thalamus and project to specific areas in sensory cortex

Draw diagram

- Mark first, second, third order neurons
- DRG
- Midbrain, pons, upper and lower medulla, sensory cortex
- Thalamus with nuclei



Applied aspects

- Astereognosis/ tacile agnosia
  - Inability to identify the object by touch
- Visual agnosia
  - Inability to identify an object by sight
- Auditory agnosia
- Positional agnosia
  - Inability to identify position of limbs

Abnormalities of tactile sensations

- Anesthesia
  - Complete loss of all forms of sensations
  - Seen in peripheral nerve lesions
  - Leprosy
- Hypesthesia
  - Partial loss of sensation
  - Seen in lesions at thalamus, internal capsule and cortex

Dissociated anesthesia

- Sensation of pain and temperature is lost with preservation of touch
- Causes
- Syringomyelia, intramedullary tumors, brainstem lesions etc
- Spinal cord grey matter surrounding the central canal is damaged
- Dorsal column is spared but spinothalamic tract is damaged

- Hemianesthesia
  - Loss of sensation of one side of body
- Hyperesthesia
  - Exaggerated response to sensory stimulation
  - Seen in thalamic lesion
- Allosthesia
  - Stimulus given on the side of hemisensory loss is experienced on the corresponding area of opposite side
  - Cause- lesion of right side putamen

- Paresthesia/ dysesthesia
  - Sensations are abnormal and distressing
  - Cause- nerve compression
- Agraphesthesia
  - Loss of sense of cutaneous localization and figure writing
  - Lesion of sensory cortex

Romberg sign

- Inability to maintain a balanced standing position with feet together and eyes closed
- Due to lack of position sense
- Seen in Posterior/dorsal column lesion
- Called as sensory ataxia
- Gait- Stamping gait

Essay

- A 40 years old man came to the OPD with a gait characterized by raising his feet unnecessarily high and bringing it down in a stamping manner (stamping gait). He also stood with his feet wide apart and tended to fall to the right with the eyes closed. Answer the following questions based on your knowledge in physiology :

- Where is the lesion in this patient.
- Describe the neural tract involved in this patient with the help of a diagram.
- What are the sensations carried by this tract
- What is dissociated anesthesia (1+5+2+2=10)