

"Spinal Cord (Part 2/4)"

White Matter of Spinal Cord

- Divisions:

- i) Anterior white column (funiculus)
- ii) Lateral white column (funiculus)
- iii) Posterior white column (funiculus)
- iv) Anterior white commissure

- Components:

- Nerve fibers
- Neuroglia
- Blood vessels

- Surrounds gray matter and appears white due to a high proportion of myelinated nerve fibers.

Ascending Tracts of Spinal Cord

- Tracts:

- Anterior spinothalamic tract
- Lateral spinothalamic tract
- Posterior white column, medial lemniscus (Fasciculus Gracilis & Fasciculus Cuneatus)
- Posterior spinocerebellar tract
- Anterior spinocerebellar tract
 - Cuneocerebellar tract
 - Spinotectal tract
 - Spinoreticular tract
 - Spino-olivary tract
- Visceral sensory tract

Ascending Sensory Pathway

- Organized into three neuronal chains:

- i) First-order neuron
- ii) Second-order neuron
- iii) Third-order neuron

-> First-Order Neuron

- Cell body in posterior root ganglion
- Peripheral process connects with sensory receptor
- Central process enters spinal cord via posterior root
- Synapses with second-order neuron in spinal gray matter

-> Second-Order Neuron

- Cell body in posterior gray column of spinal cord
- Axon crosses midline (decussates)
- Ascends and synapses with third-order neuron in VPL nucleus of thalamus

-> Third-Order Neuron

- Cell body in VPL nucleus of thalamus
- Gives rise to projection fibers to cerebral cortex, postcentral gyrus (sensory area)

Lateral Spinothalamic Tract (LST) – Pain & Temperature Sensations

- Mnemonic: "Pa-Te-La" (Patella = sesamoid bone in knee)
- Axons of second-order neurons:
 - Cross obliquely in anterior gray commissure within one spinal segment
 - Ascend in contralateral white column as LST
 - Accompanies anterior spinothalamic & spinotectal tracts in the medulla Forms spinal lemniscus

Lemniscus (Ascending Sensory Tracts)

- Spinal lemniscus: Anterior spinothalamic + Lateral spinothalamic + Spinotectal tracts
- Medial lemniscus: Crossed posterior column fibers
- Lateral lemniscus: Third neuron of auditory pathway

Pathway of Lateral Spinothalamic Tract

- Third-order neurons in VPL nucleus of thalamus
- Axons pass through posterior limb of internal capsule & corona radiata
- Project to somesthetic area in postcentral cerebral cortex

» Pain & Temperature Transmission

> Overview

- Input: Free nerve endings & thermal receptors
 - Fibers: Delta A & C fibers
 - Central process:
 - Enters spinal cord via posterior nerve root
 - Reaches dorsal gray column tip

> Second-Order Neuron

- Location: Dorsal horn
 - Pathway:
 - Crosses to contralateral ventral column
 - Ascends & terminates in VPL nucleus of thalamus

> Third-Order Neuron

- Location: VPL nucleus of thalamus

- Pathway:

- Projects to cerebral cortex (areas 3, 1, 2)

Motor Homunculus (Precentral Gyrus Representation)

- Contralateral half of body is inverted:
 - Hand & mouth - Inferior
 - Leg - Superior
- Foot & anogenital region - Medial hemisphere surface

Internal Capsule & Corona Radiata

- White matter of cerebral cortex contains myelinated nerve fibers supported by neuroglia

- Three Fiber Groups of Cerebral White Matter:

- Commissural fibers
- Association fibers
- Projection fibers

» Anterior Spinothalamic Tract – Light Touch & Pressure Sensations

> Overview

- Inputs: Free nerve endings, Merkel's tactile disks

• Pathway

-> First-Order Neuron

- Dorsal root ganglion (all levels)

-> Second-Order Neuron

- Location: Dorsal horn

• Pathway:

- Crosses midline (decussates obliquely in anterior gray & white commissures within several spinal segments)
- Ascends in contralateral ventral column
- Terminates in VPL nucleus of thalamus

-> Third-Order Neuron

- Location: VPL nucleus of thalamus
- Projects to cerebral cortex (areas 3, 1, 2)

Anterior Spinothalamic Tract in Medulla

- Accompanies lateral spinothalamic & spinotectal tracts Forms spinal lemniscus

Projection to Cerebral Cortex

- Axons of third-order neurons:
 - Pass through posterior limb of internal capsule & corona radiata
 - Reach somesthetic area in postcentral gyrus

Body Representation

- Contralateral half of body is inverted:
 - Hand & mouth – Inferior
 - Leg – Superior

» Dorsal Column Medial Lemniscus Pathway (DCML)

Functions

- Mediates:
 - Tactile discrimination, vibration, and proprioception
 - Fine touch & two-point discrimination
 - Joint & muscle sensation
- Receives input from:
 - Pacinian & Meissner corpuscles
 - Joint receptors
 - Muscle spindles
 - Golgi tendon organs (GTOs)

Pathway

-> First-order neuron

- Located in dorsal root ganglion (all levels)

• Sends two separate pathways:

i) Upper limb (T6 and above) Fasciculus
cuneatus Synapse in nucleus cuneatus
(medulla oblongata)

ii) Lower limb (Below T6) Fasciculus gracilis
Synapse in nucleus gracilis (medulla
oblongata)

-> Second-order neuron

- Located in the gracile & cuneate nuclei of the
medulla

- Axons form internal arcuate fibers,
decussate, and form the medial lemniscus

- Ascend through the brainstem to the VPL
nucleus of the thalamus

- Third-order neuron
- Located in the VPL nucleus of the thalamus
- Sends projection fibers via the posterior limb of the internal capsule & corona radiata to the postcentral gyrus (sensory cortex)

Dorsal Column Medial Lemniscus Pathway Features

- Second-order fibers from the nucleus cuneatus terminate in the accessory cuneate nucleus
- Axons enter the cerebellum via inferior cerebellar peduncle as the cuneocerebellar tract
- Function: Carries muscle joint sense information to the cerebellum

Proprioception Pathways

- Conscious Proprioception Carried by DCML pathway
- Unconscious Proprioception Carried by Spinocerebellar pathway

Nucleus Gracilis and Nucleus Cuneatus

- Located in the gray matter of the medulla oblongata

Dorsal Column Medial Lemniscus (DCML) Pathway

Functions

- Mediates tactile discrimination, vibration, form recognition, and joint & muscle sensation.
- Mediates conscious proprioception.
- Allows appreciation of touch with fine gradations of intensity, exact localization, and two-point discrimination.

- Enables conscious recognition of vibratory sense and body position.

- Receives input from:

- i) Pacini and corpuscles
- ii) Meissner corpuscles
- iii) Joint receptors
- iv) Muscle spindles
- v) Golgi tendon organs (GTOs).

First-Order Neurons

- Carry sensory information (touch, proprioception, vibration) from peripheral nerves to the medulla oblongata.

- Pathways:

> Upper limb signals (T6 and above)

Fasciculus cuneatus (lateral dorsal column)

Synapse in nucleus cuneatus (medulla oblongata).

> Lower limb signals (below T6) Fasciculus gracilis (medial dorsal column) Synapse in nucleus gracilis (medulla oblongata).

Fasciculus Gracilis

- Present throughout the spinal cord.
- Contains long ascending fibers from sacral, lumbar, and lower six thoracic spinal nerves.

Fasciculus Cuneatus

- Present laterally in the upper thoracic & cervical segments of the spinal cord.
- Contains long ascending fibers from upper six thoracic and all cervical spinal nerves.

Second-Order Neurons

- Located in the gracile and cuneate nuclei of the caudal medulla.
- Give rise to internal arcuate fibers which decussate (sensory decussation) and form a compact fiber bundle – the medial lemniscus.
- The medial lemniscus ascends contralaterally through the brainstem and terminates in the ventral posterolateral (VPL) nucleus of the thalamus.

Decussation & Medial Lemniscus Pathway

- Axons of second-order neurons (internal arcuate fibers) sweep anteromedially around central gray matter.
- Cross the median plane decussate with corresponding fibers from the opposite side.
- Ascend as a compact medial lemniscus bundle through:
 - Medulla oblongata
 - Pons
 - Midbrain

Third-Order Neurons

- Located in the VPL nucleus of the thalamus.
- Project via the posterior limb of the internal capsule and corona radiata to the postcentral gyrus (somatosensory cortex).

Accessory Cuneate Nucleus & External Arcuate Fibers

- Few second-order fibers from nucleus cuneatus terminate in the accessory cuneate nucleus.
- These axons enter the cerebellum through the inferior cerebellar peduncle as the cuneocerebellar tract.
- The fibers are known as external arcuate fibers.
- This tract carries muscle joint sense information to the cerebellum.

Proprioception

- Conscious Proprioception Carried by DCML pathway.
- Unconscious Proprioception Carried by Spinocerebellar pathway.

Nucleus Gracilis & Nucleus Cuneatus Location

- Both are gray matter structures