Introduction of Neuroanatomy

SPINAL CORD

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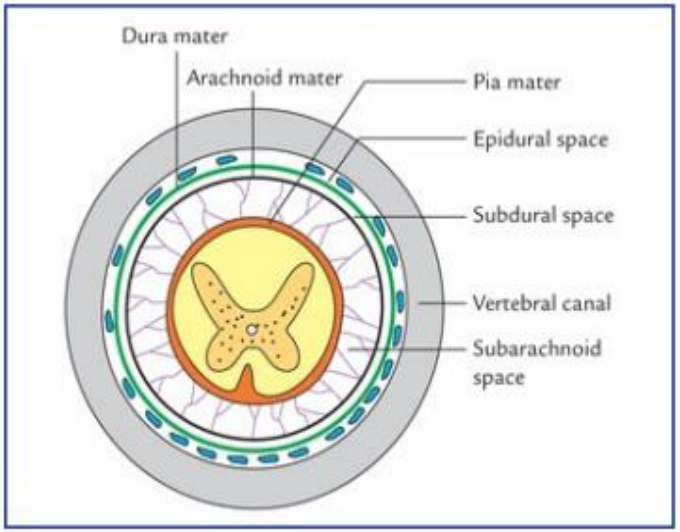
- In the **brain** (except the brainstem), the **grey matter** is present at the **periphery** and the **white matter** in the **centre**.
- Contrary to it, in the **spinal cord** the **grey matter** is present in the **centre** and **white matter** at the **periphery**.
- The adult brain constitutes about one-fiftieth of body weight and weighs about 1400 g in males and 1200 g in females.

- The spinal cord is part of the central nervous system (CNS).
- It is situated inside the vertebral canal of the vertebral column.
- During development, there's a disproportion between spinal cord growth and vertebral column growth.
- The spinal cord finishes growing at the **age of 4**, while the **vertebral column finishes growing at age 14-18**. This is the reason why, in adults, the spinal cord occupies only the upper two thirds of the vertebral canal.

- Spinal cord measures about **45 cm (18”) in adult male and 42 cm in adult female**, and weighs about 30 g.
- It extends as a downward continuation of medulla oblongata from the upper border of the posterior arch of first cervical vertebra (C1) to the lower border of the first lumbar vertebra (LI).

Spinal meninges

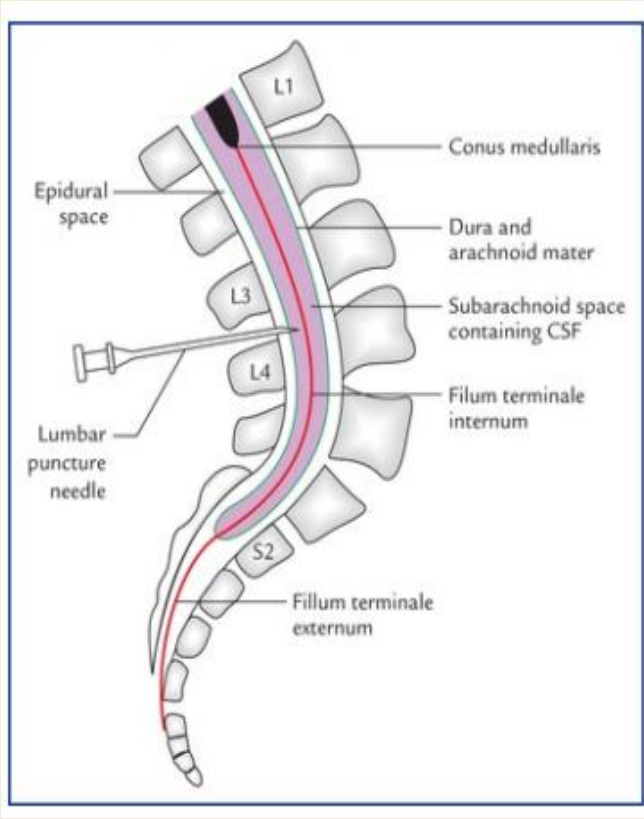
- Surrounded by three protective membranes called spinal meninges.
- Provides a protective barrier against physical impacts and contains the cerebrospinal fluid (CSF) within the subarachnoid space
- Acts as a cushioning layer and helps to contain the CSF.
- Provides a blood supply to the spinal cord and produces CSF.



Schematic transection of vertebral canal showing spinal cord and its surrounding meninges.

Spinal Dura	Cranial Dura
Single layered and consists of meningeal layer only	Double layered and consists of an inner meningeal layer and outer endosteal layer
Does not form folds	Forms folds, viz. falxcerebri, falxcerebelli, tentoriumcerebelli and diaphragma sellae
Epiduralspace present	Epiduralspace absent

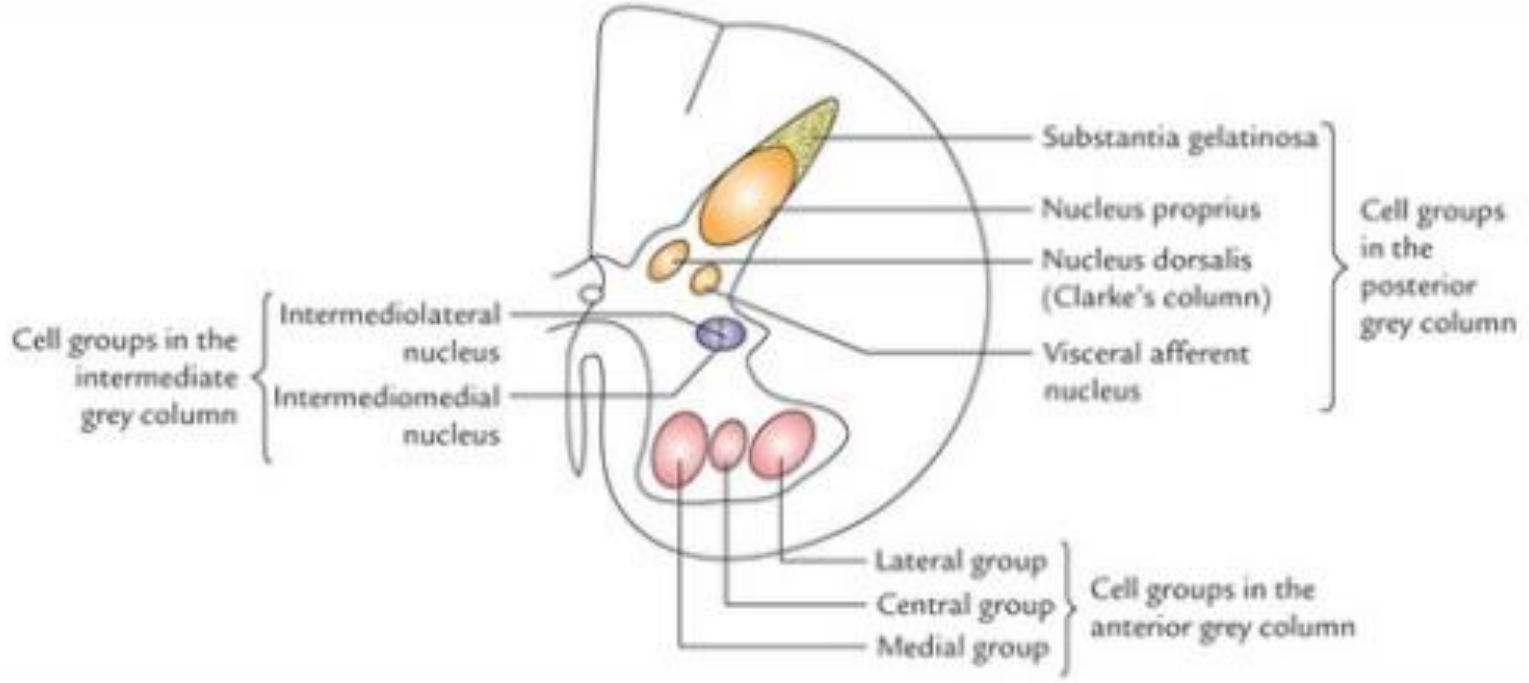
- Lumbar puncture is done to withdraw cerebrospinal fluid for various diagnostic and therapeutic purposes
- A horizontal line joining the highest points of the iliac crests passes through the spine of the fourth lumbar vertebra.
- Therefore, the interspinous spaces immediately above and below this landmark can be used with safety.
- The interspinous space between L3 and L4 is the most preferred site.



Regions	Spinal segments	Vertebral level	General rule
Upper cervical	C2	C2	Same level
Lower cervical	C6	C5	One vertebra above
Upper thoracic	T5	T3	Two vertebrae above
Lower thoracic	T10	T7	Three vertebrae above
Lumbar	L1–L5	T10–T11	Three to five vertebrae above
Sacral and coccygeal	S1–S5 and C × 1	T12–L1	Six to ten vertebrae above

Approximate vertebral levels of the spinal cord segments

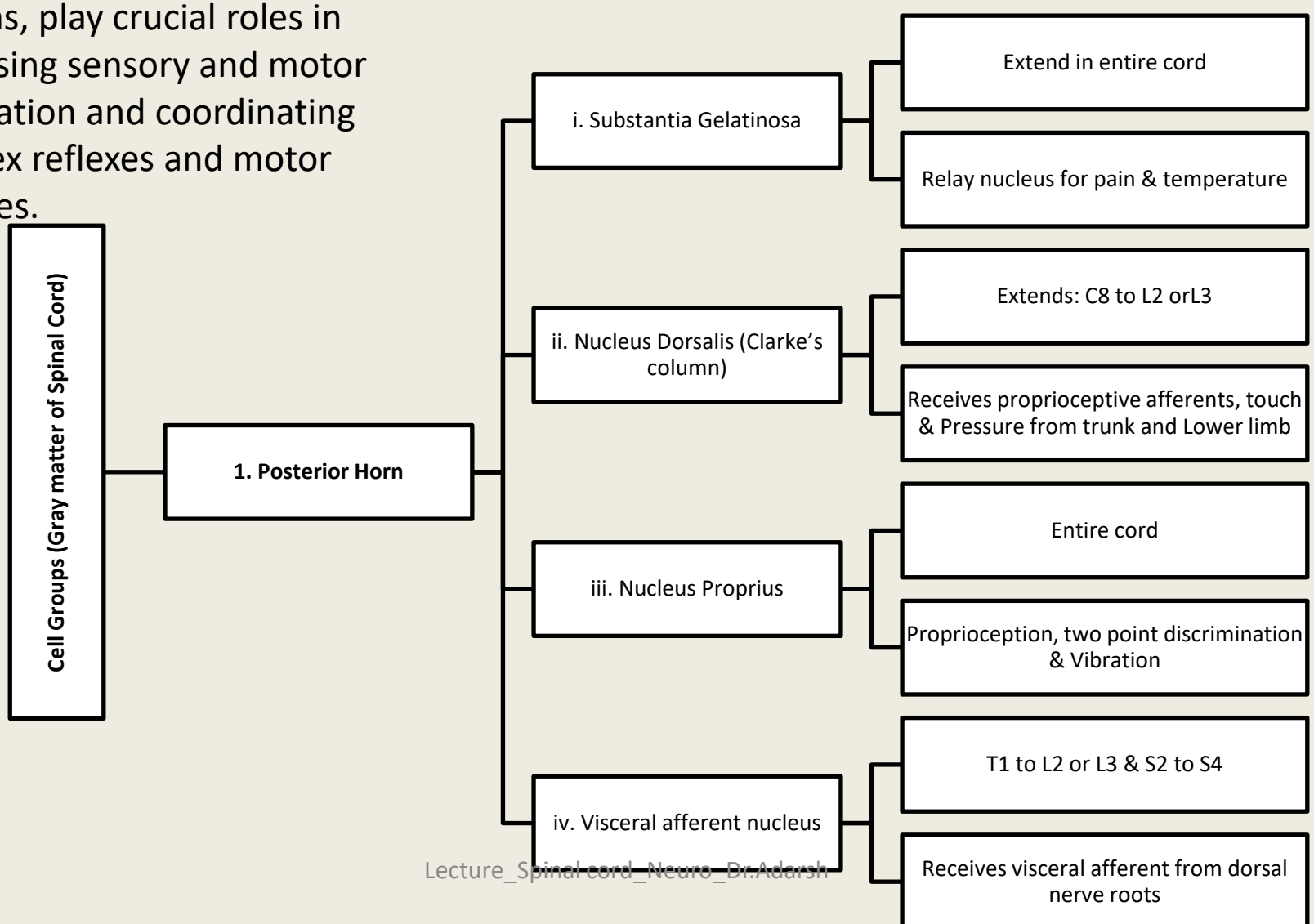
Grey matter

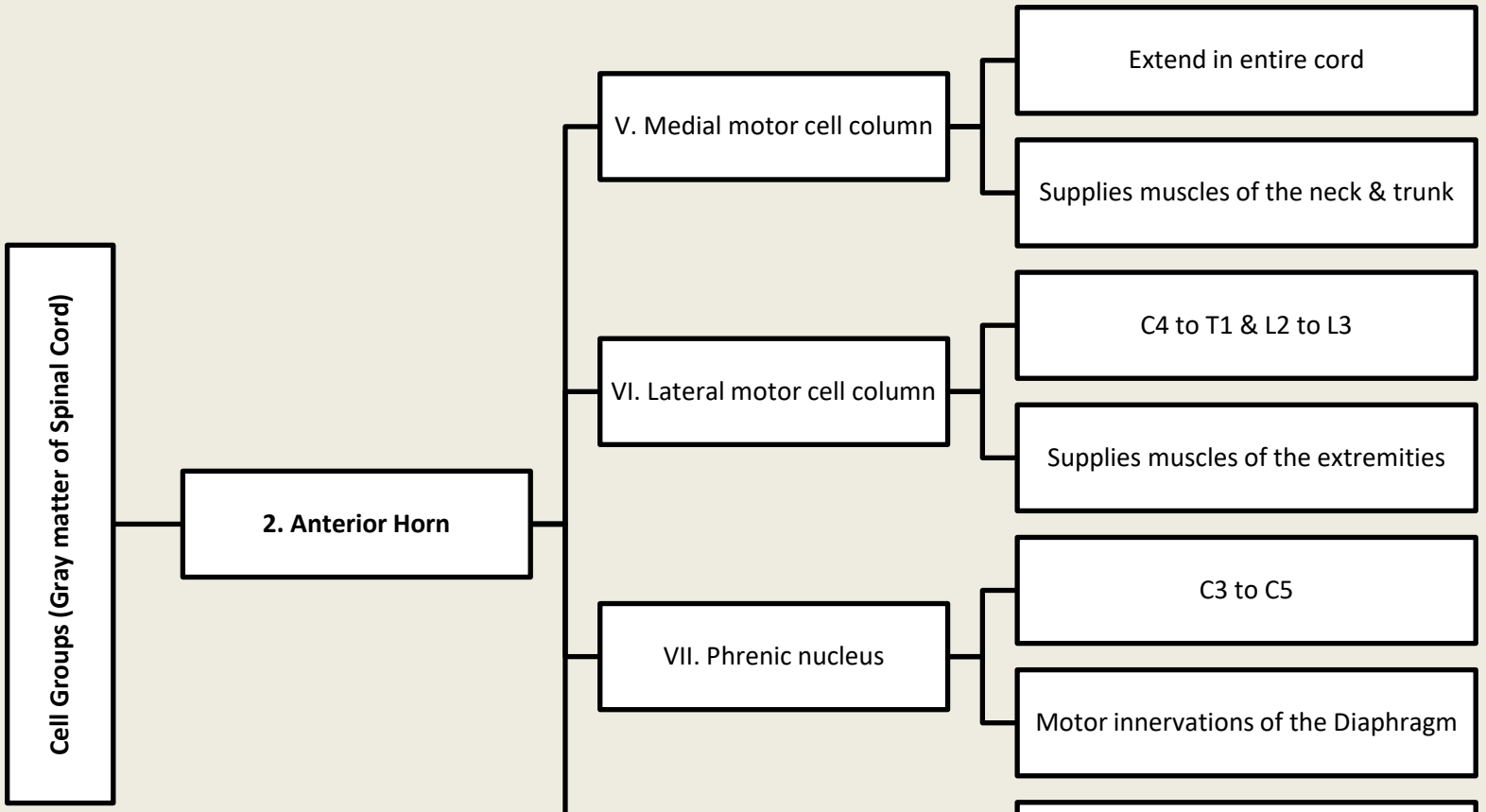


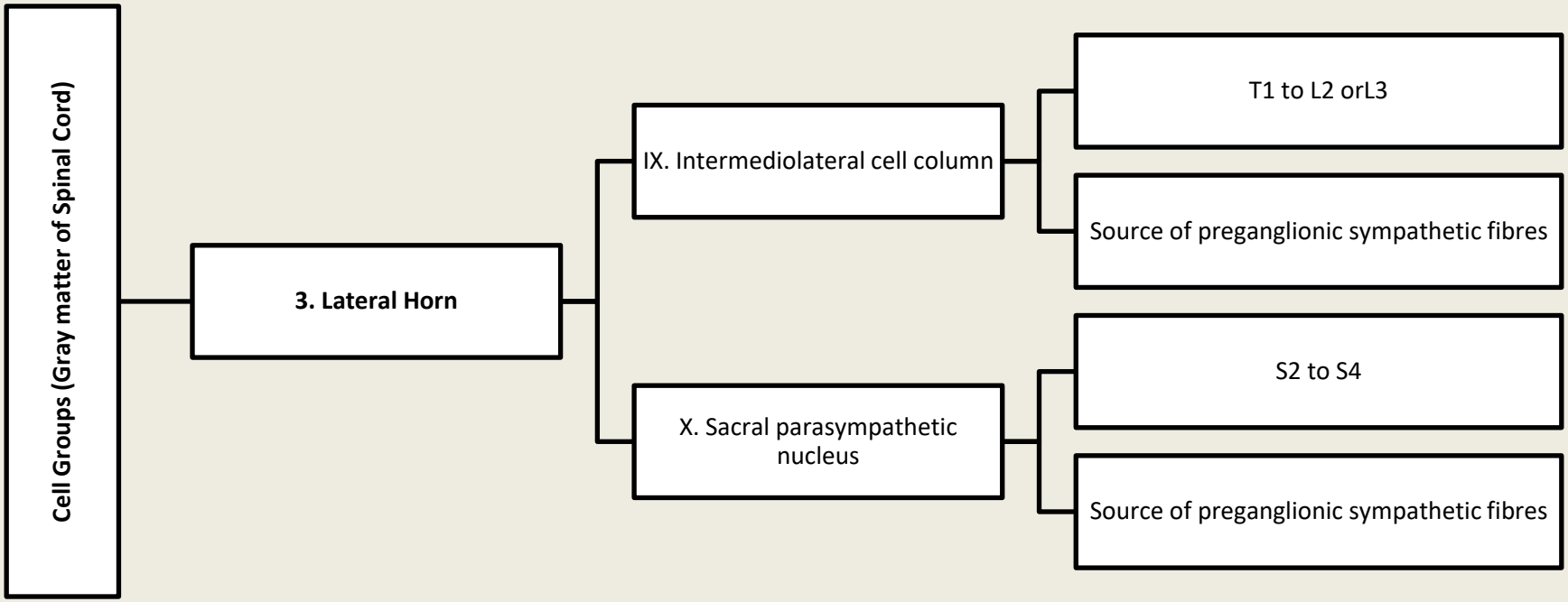
Nerve cell groups in grey columns of the spinal cord.

Cell groups

Cell groups in the spinal cord, also known as nuclei or clusters of neurons, play crucial roles in processing sensory and motor information and coordinating complex reflexes and motor activities.

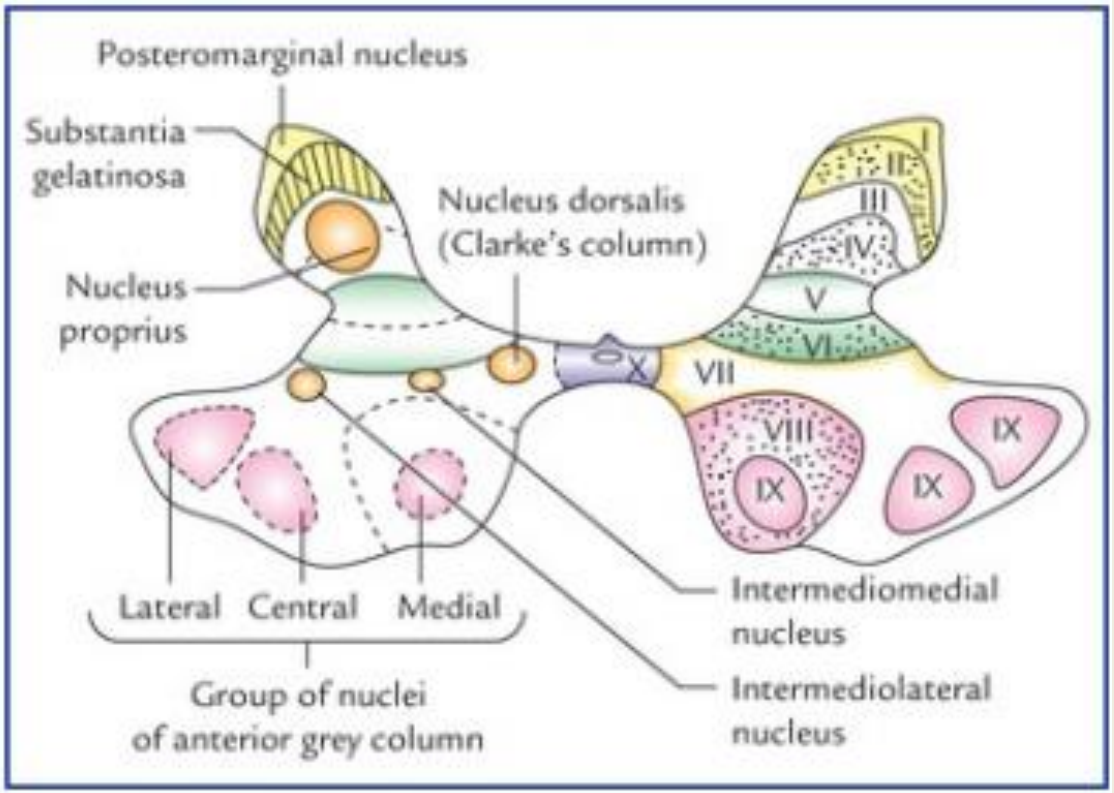



Cell Groups (Gray matter of Spinal Cord)
2. Anterior Horn
V. Medial motor cell column
Extend in entire cord
Supplies muscles of the neck & trunk
VI. Lateral motor cell column
C4 to T1 & L2 to L3
Supplies muscles of the extremities
VII. Phrenic nucleus
C3 to C5
Motor innervations of the Diaphragm
VII. Spinal accessory nucleus
C1 to C5
Origin of spinal root of accessory nerve


Cell Groups (Gray matter of Spinal Cord)
3. Lateral Horn
IX. Intermediolateral cell column
T1 to L2 orL3
Source of preganglionic sympathetic fibres
X. Sacral parasympathetic nucleus
S2 to S4
Source of preganglionic sympathetic fibres

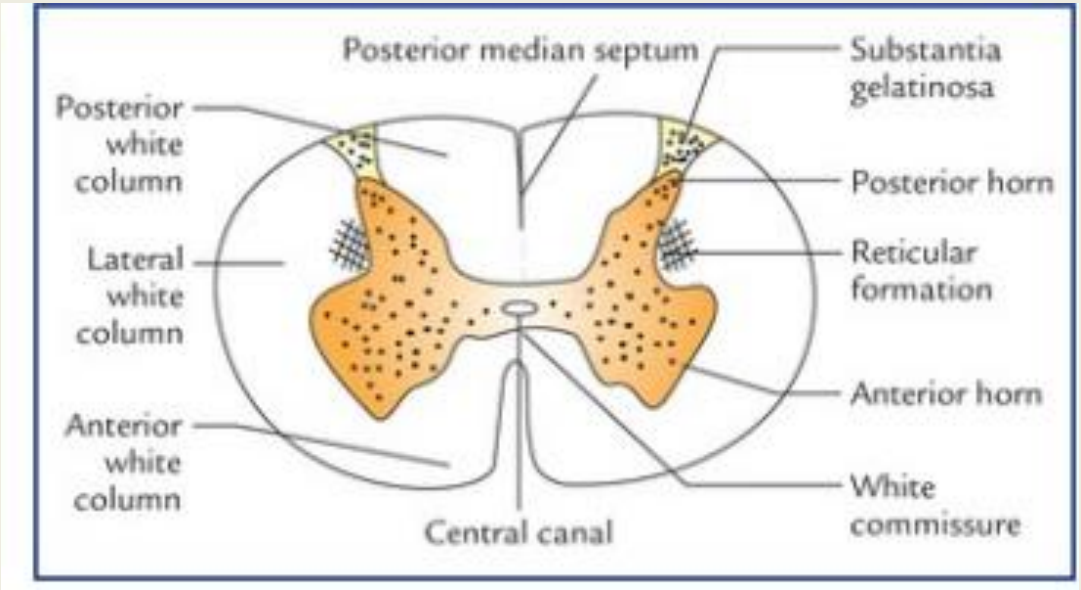
Rexed laminae and nuclear groups

Introduced by the Swedish neuroscientist Bror Rexed in the 1950s, provides a detailed map of the spinal cord's internal organization, helping to understand the processing of sensory and motor signals.



Laminae	Corresponding grey column nuclei
I	Posteromarginal nucleus
II	Substantia gelatinosa
III and IV	Nucleus proprius
V and VI	Base of dorsal column
VII	Nucleus dorsalis (Clarke's column) and intermediolateral and intermediomedial nuclei of lateral horn
VIII and IX	Medial and lateral groups of nuclei of anterior grey column
X	Surrounds the central canal and composed of the grey commissure and substantia gelatinosa centralis

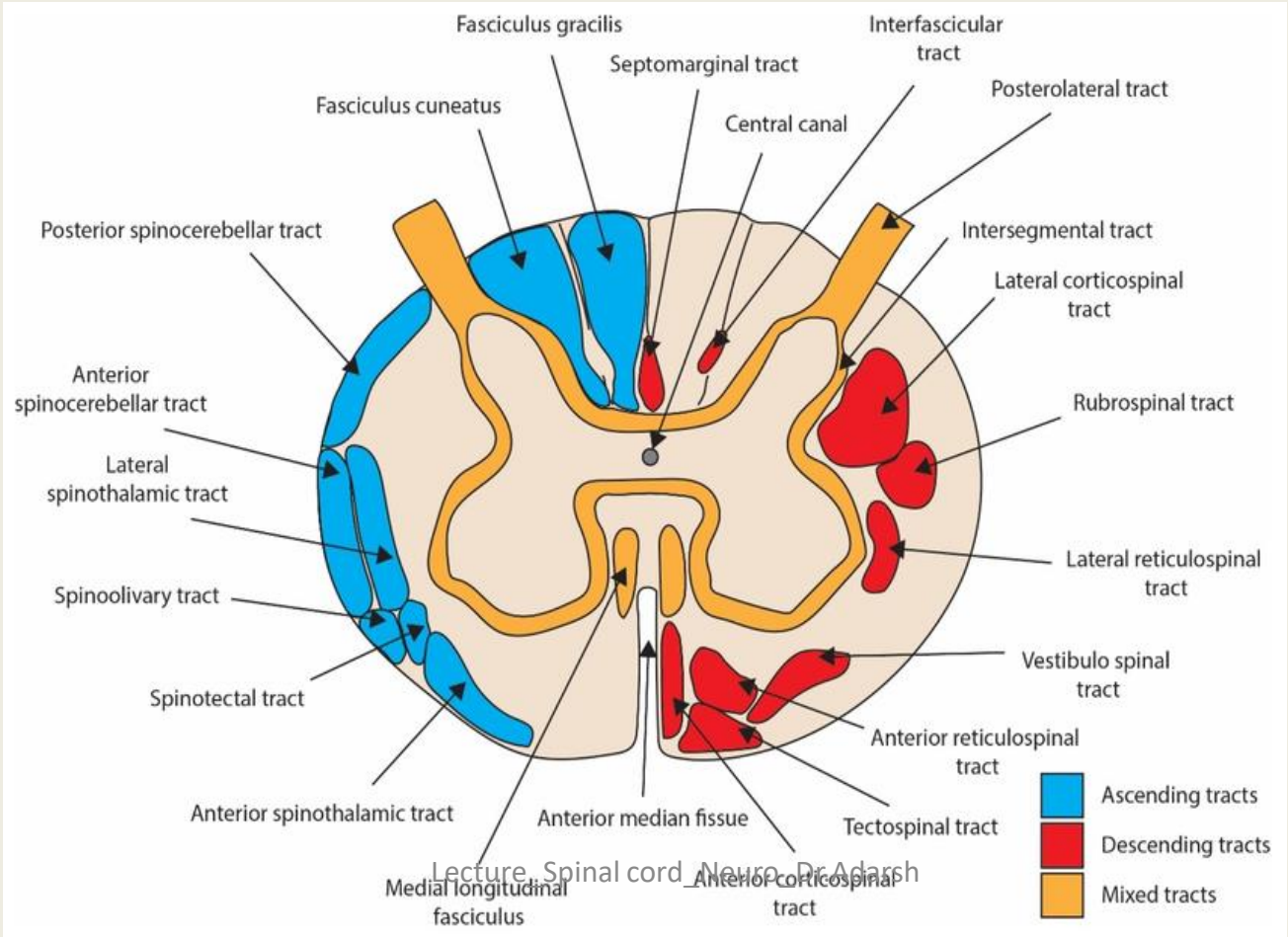
White matter

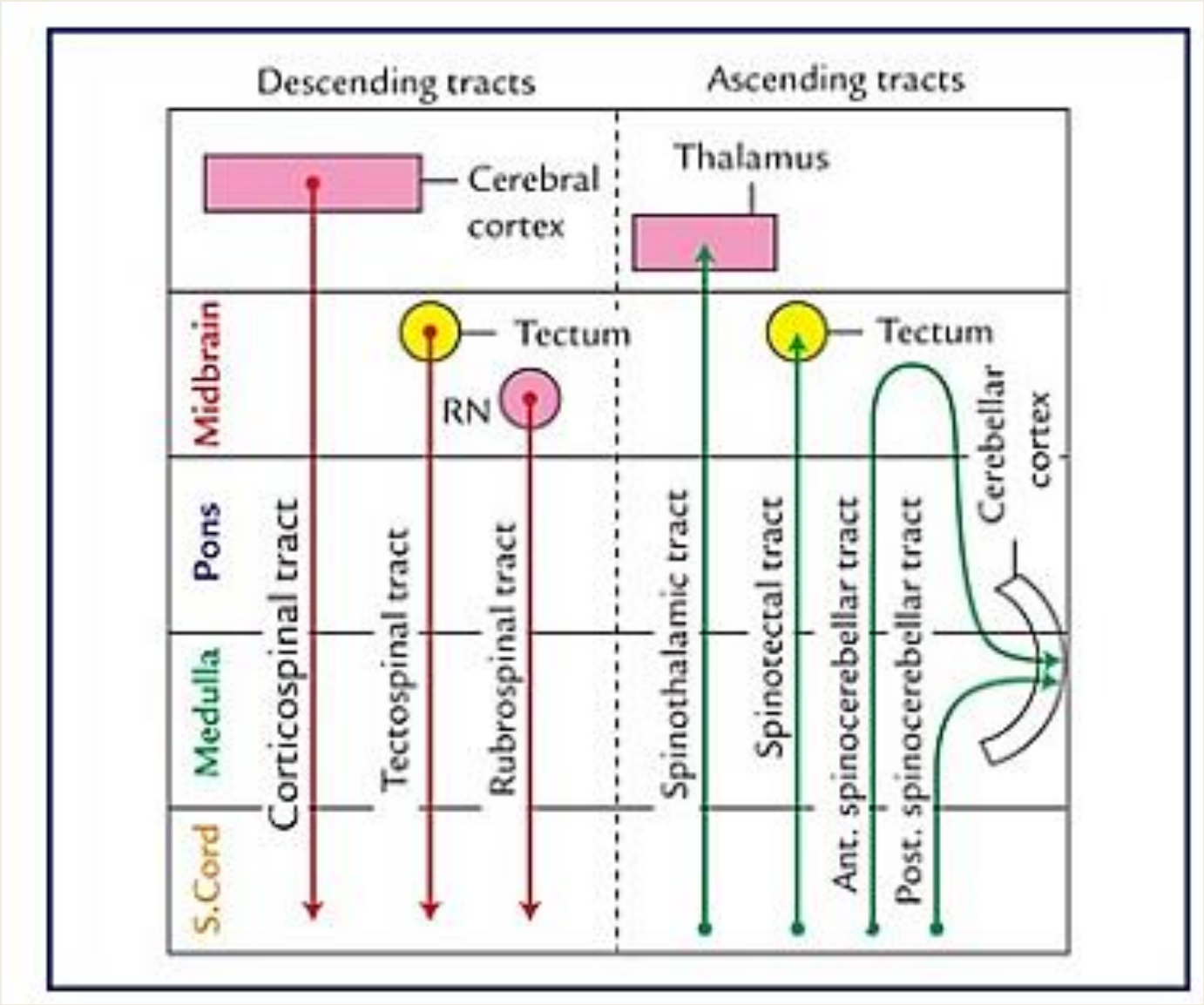


- 'H-shaped mass of grey matter, and mainly consists of nerve fibres, the large proportion of them being myelinated, give it a white appearance'
- Each half of the spinal cord, the white matter is divided into three parts called **white columns or funiculi**
- **Posterior white column,** between the posterior median septum, and the posterior horn (sensory)
- **Lateral white column,** between the anterior and posterior horns (mixed)
- **Anterior white column,** between the anterior median fissure and the anterior horn (motor)

Tracts of the Spinal Cord

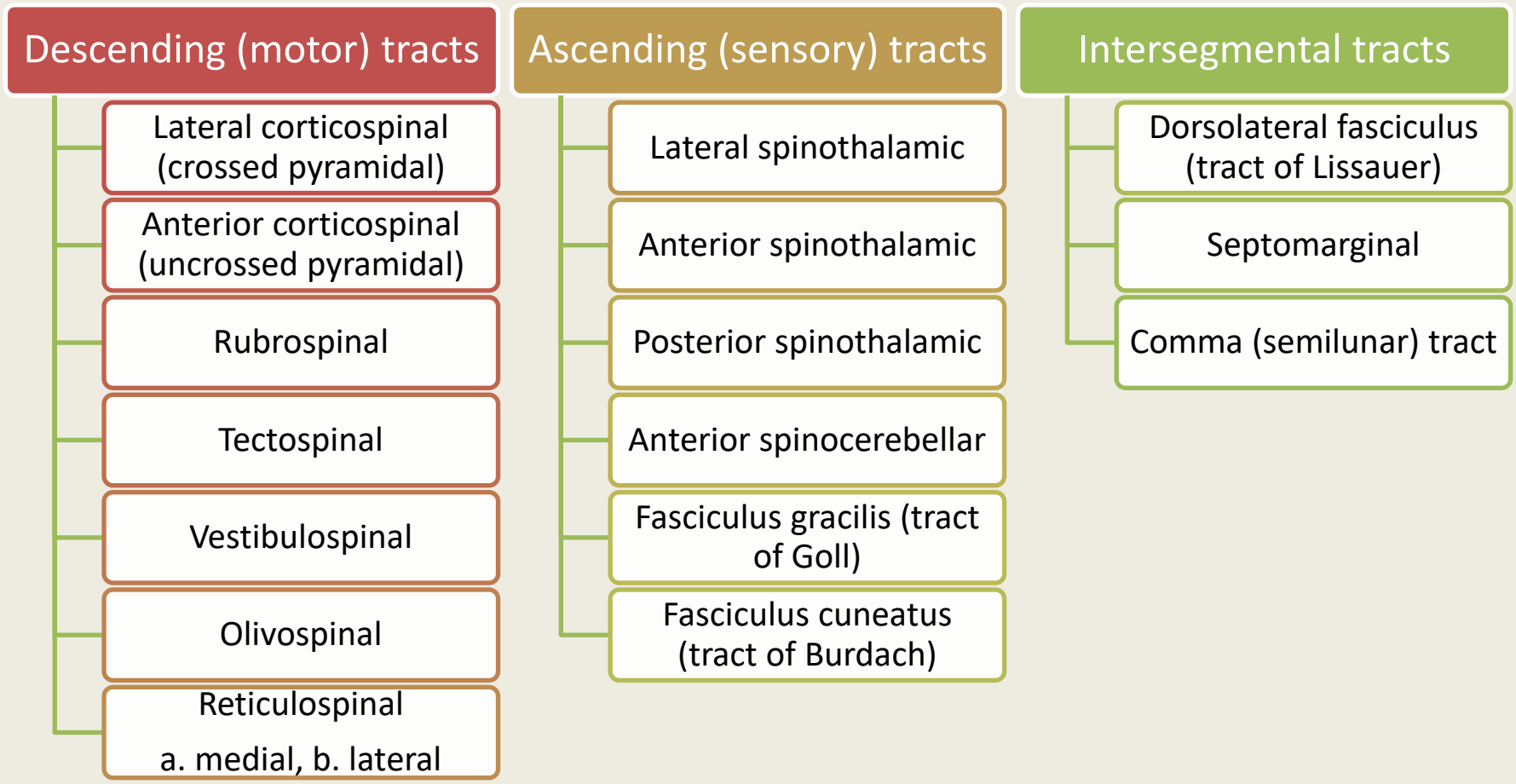
- "Collections of nerve fibres within the central nervous system"
- Ascending tracts are located at the periphery and the Descending tracts in the centre





Basis of nomenclature of the tracts

Classification of the tracts of the spinal cord

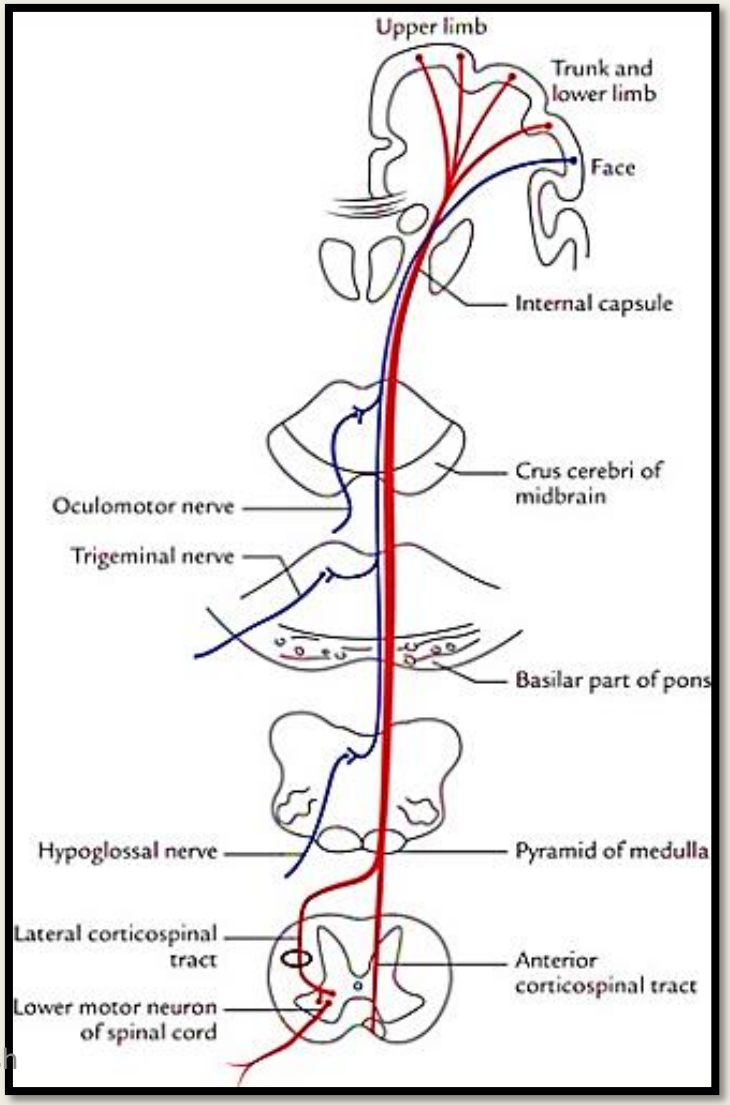


Descending Tracts

Tract	Location	Origin*	Termination	Functions
Lateral corticospinal (crossed pyramidal) tract	Lateral white column of spinal cord	Primary motor cortex (area 4), premotor cortex (area 6) of the opposite cerebral hemisphere (upper motor neurons)	Anterior horn cells of the spinal cord (lower motor neurons)	Controls conscious skilled movements especially of hands (contraction of individual or small group of muscles particularly those which move hands, fingers, feet and toes)
Anterior corticospinal (uncrossed pyramidal) tract	Anterior white column	Primary motor cortex (area 4), premotor cortex (area 6) of the opposite cerebral hemisphere upper motor neurons)	Anterior horn cells of the spinal cord (lower motor neurons)	Same as that of lateral corticospinal tracts
Rubrospinal tract	Lateral white column	Red nucleus of the opposite side located in midbrain	Anterior horn cells of the spinal cord	Unconscious coordination of movements (controls muscle tone and synergy)
Vestibulospinal tract	Anterior white column	Vestibular nucleus	Anterior horn cells of the spinal cord	Unconscious maintenance of posture and balance
Tectospinal tract	Anterior white column	Superior colliculus of the opposite side	Cranial nerve nuclei in medulla and anterior horn cells of the upper spinal segments	Controls movements of head, neck and arms in response to visual stimuli
Lateral reticulospinal tract	Lateral white column	Reticular formation in midbrain, pons and medulla	Anterior horn cells of the spinal cord	Mainly responsible for facilitatory influence on the motor neurons to the skeletal muscles
Medial reticulospinal tract	Anterior white column	Reticular formation in medulla	Anterior horn cells of the spinal cord	Mainly responsible for inhibitory influence on the motor neurons to the skeletal muscles

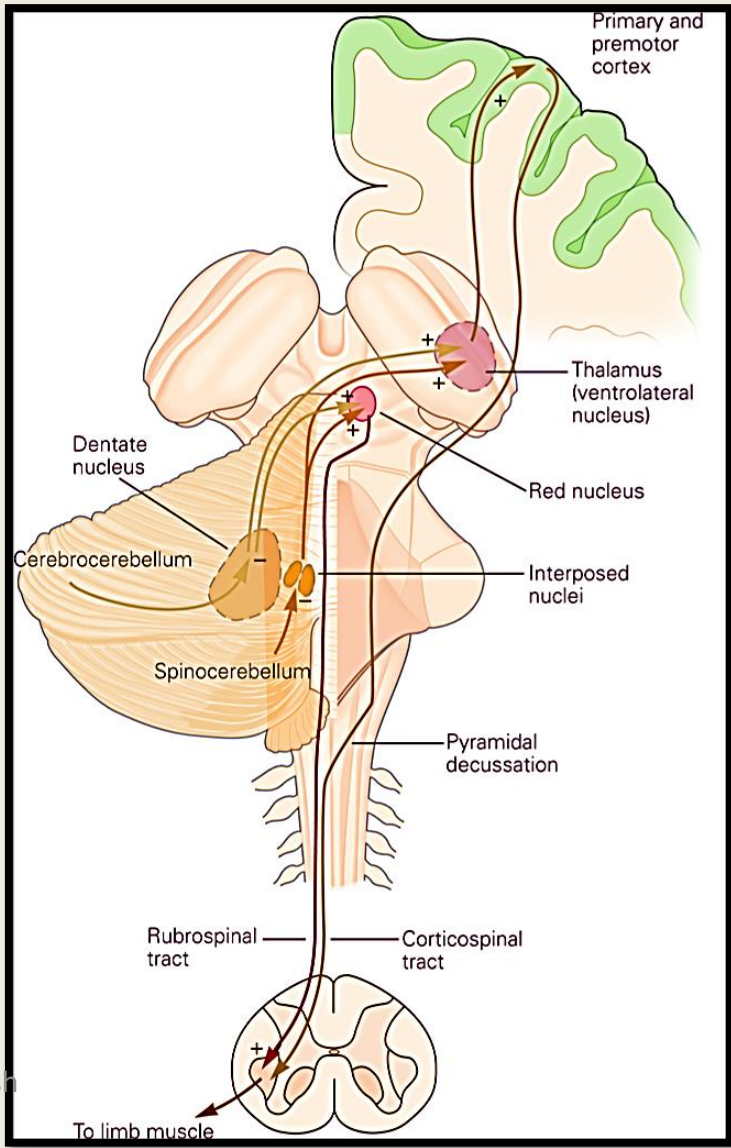
Corticospinal tract (pyramidal tract)

- The pyramidal tract is so named because corticospinal tract traverses the medullary pyramids
- The lesions of pyramidal tract above the level of decussation (i.e. upper motor neuron (UMN) lesions) result in the loss of voluntary movements in the opposite half of the body below the level of the lesion
- The muscles are not actually paralyzed but the control of upper motor neurons and the lower motor neurons (LMN) supplying muscles is lost
- As a result LMNs become hyperactive and the tone of muscles is increased leading to spastic paralysis.



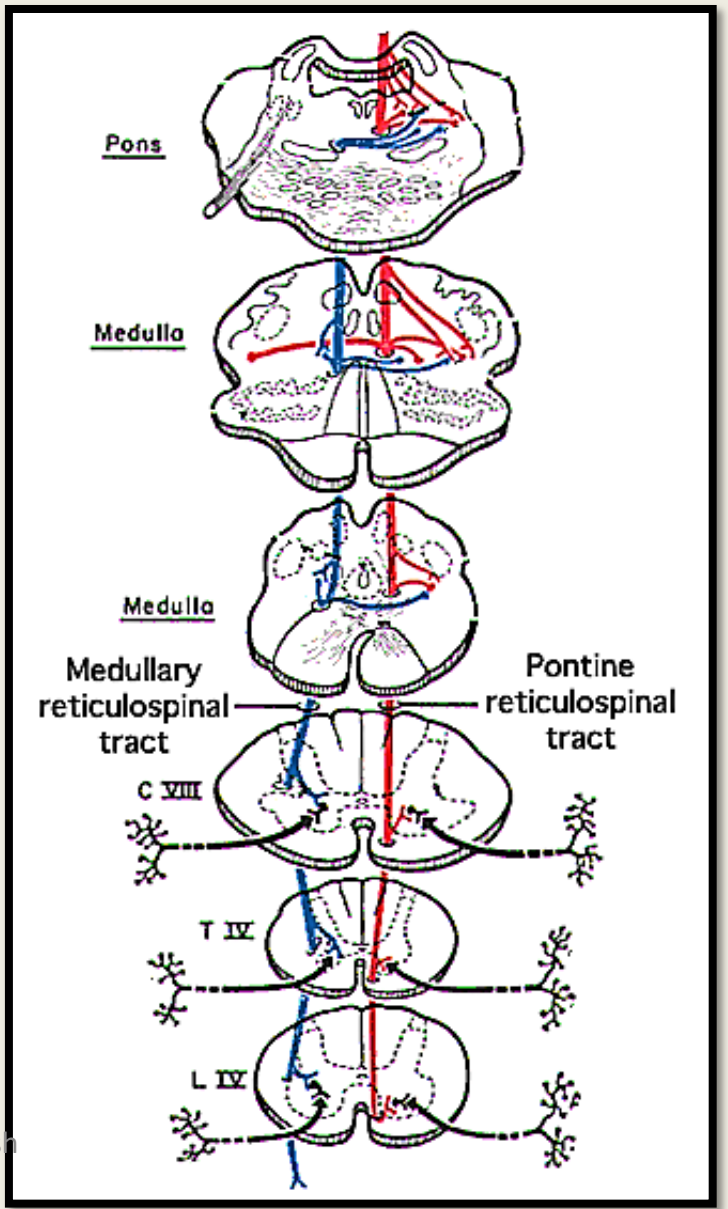
Rubrospinal tract

- Fibres arise from the cells of red nucleus (nucleus ruber) located in the midbrain and immediately caudal to red nucleus they decussate with those of the opposite side and descend as a compact bundle in the lateral white column of the spinal cord
- Facilitates the activity of the flexor muscles and inhibits the activity of the extensor or anti-gravity muscles



Reticulospinal tracts

- **Lateral reticulospinal tract:** lies in the lateral white column.
- Its fibres arise from cells of the reticular formation in the brainstem (midbrain, pons and medulla) and relay in the anterior horn cells.
- This tract exerts facilitatory influence on the motor neurons, which supply the skeletal muscles.
- **Medial reticulospinal tract:** lies in the anterior white column.
- Its fibres arise from the cells of the reticular formation in the medulla and relay in the anterior horn cells of the spinal cord.
- This tract exerts inhibitory influence on the motor neurons supplying the skeletal muscles



Ascending Tracts

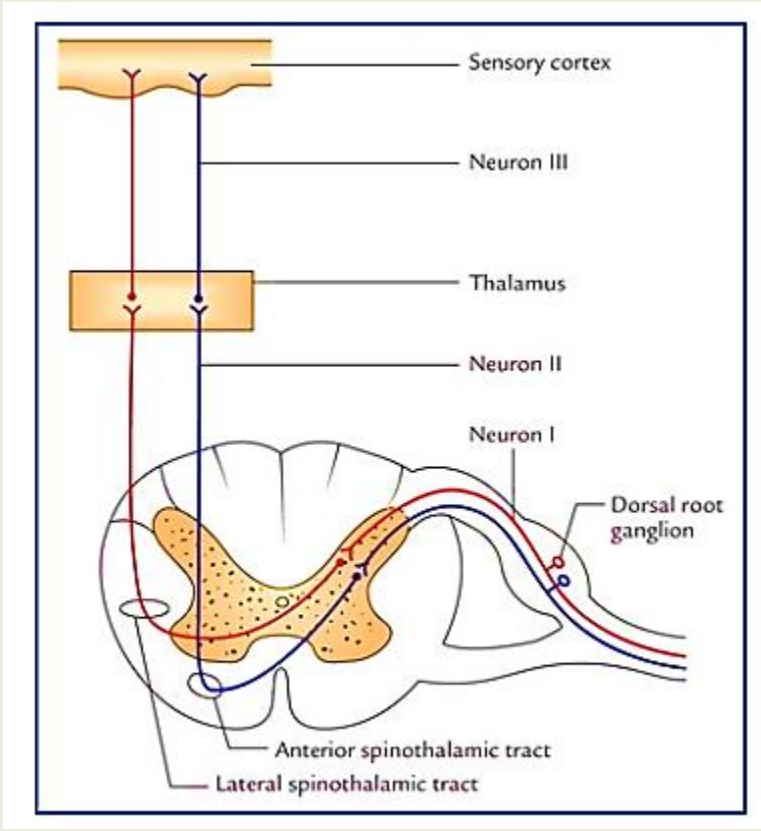
Tract	Location	Origin*	Termination	Functions
Lateral spinothalamic tract	Lateral white column	Posterior horn cells of spinal cord of opposite side	Ventral posterolateral (VPL) nucleus of thalamus	Carry pain and temperature from opposite side of the body
Anterior spinothalamic tract	Anterior white column	Posterior horn cells of spinal cord of opposite side	Ventral posterolateral (VPL) nucleus of thalamus	Carry light touch, pressure, tickle, and itch sensation from opposite side of the body
Spinotectal tract	Lateral white column	Posterior horn cells of spinal cord of opposite side	Superior colliculus of tectum of midbrain	Visuomotor reflexes, . head and eye movements towards the source of stimulation
Spinocerebellar (anterior and posterior) tracts	Lateral white column (superficially)	Posterior horn cells of spinal cord of same side	Cerebellum	Unconscious kinaesthesia (proprioception)
Fasciculus gracilis and fasciculus cuneatus (tracts of Gall and Burdach)	Posterior white column of spinal cord	Dorsal root ganglia of spinal nerves of the same side	Nucleus gracilis and nucleus cuneatus in medulla of the same side	Joint sense, vibration sense, two-point discrimination, stereognosis, conscious kinaesthesia

- The important ascending tracts fall into the following three types:

1. Those concerned with pain and temperature sensations and crude touch, e.g. **lateral and anterior spi-nothalamic tracts.**
2. Those concerned with fine touch and conscious proprioceptive sensations, e.g. **fasciculus gracilis and fasciculus cuneatus.**
3. Those concerned with unconscious proprioception and muscular coordination, e.g. **anterior and posterior spinocerebellar tracts.**

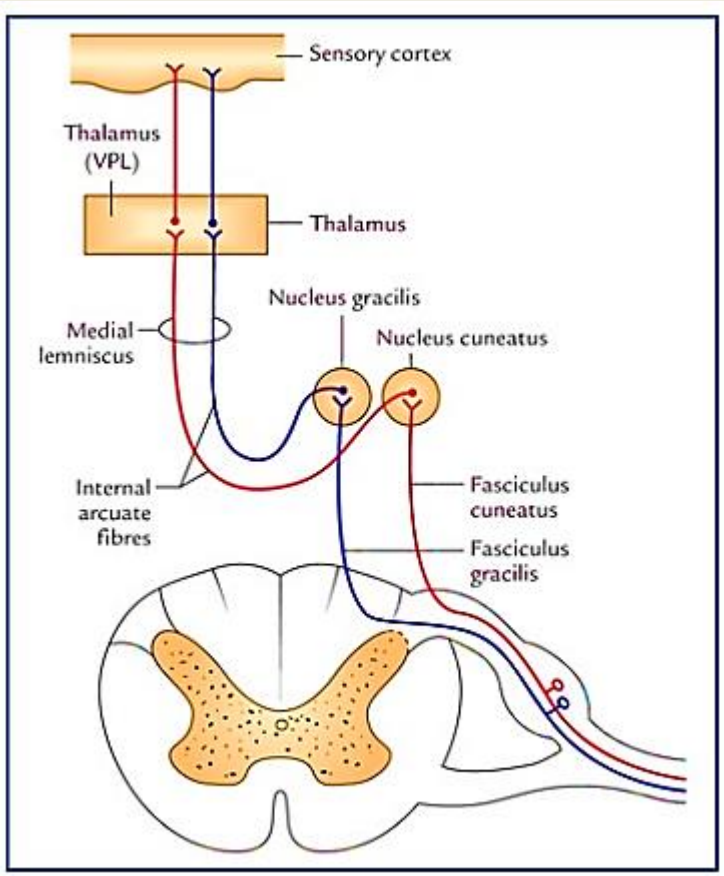
Spinothalamic tract

- **Origin:** Neurons in the dorsal horn of the spinal cord.
- **Termination:** Thalamus (ventral posterior lateral nucleus), then tertiary neurons project to the somatosensory cortex.
- **Function:** Carries pain, temperature, and crude touch information.
- **Clinical Correlation:** Damage to the spinothalamic tract can result in loss of pain and temperature sensation contralaterally below the level of the lesion, seen in conditions such as syringomyelia where a cyst forms within the spinal cord.
- The **lateral spinothalamic tract** carries pain and temperature sensations whereas **anterior spinothalamic tract** carries sensations of crude touch and pressure.



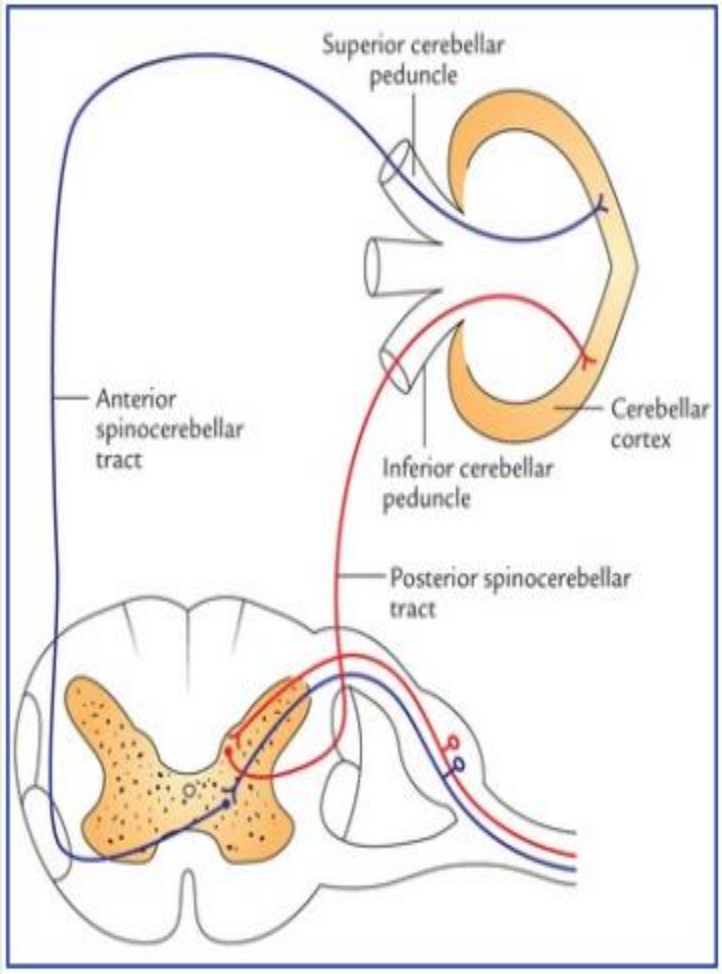
Fasciculus gracilis (tract of Goll) & fasciculus cuneatus (tract of Burdach)

- **Origin- Fasciculus gracilis:** T6 and below, carrying sensory information from the lower body.
- **Fasciculus cuneatus:** Above T6, carrying sensory information from the upper body.
- **Termination:** Medulla oblongata at the nucleus gracilis and nucleus cuneatus. From here, secondary neurons decussate (cross over) and continue to the thalamus.
- **Function:** Carries fine touch, vibration, and proprioception
- **Clinical Correlation:** Lesions in the dorsal column can lead to loss of fine touch and proprioception below the level of the lesion, resulting in conditions like tabes dorsalis, which is associated with neurosyphilis.



Spinocerebellar tracts

- **Origin: Dorsal spinocerebellar tract:** Clarks nucleus (T1-L2).
- **Ventral spinocerebellar tract:** Spinal border cells in the lumbar and sacral segments.
- **Termination:** Cerebellum via the inferior and superior cerebellar peduncles.
- **Function:** Carries proprioceptive information to the cerebellum for coordination of movement.
- **Clinical Correlation:** Lesions can lead to ataxia, a lack of voluntary coordination of muscle movements, as seen in conditions like Friedreich's ataxia.



To be continued....