CNS
Spinal cord

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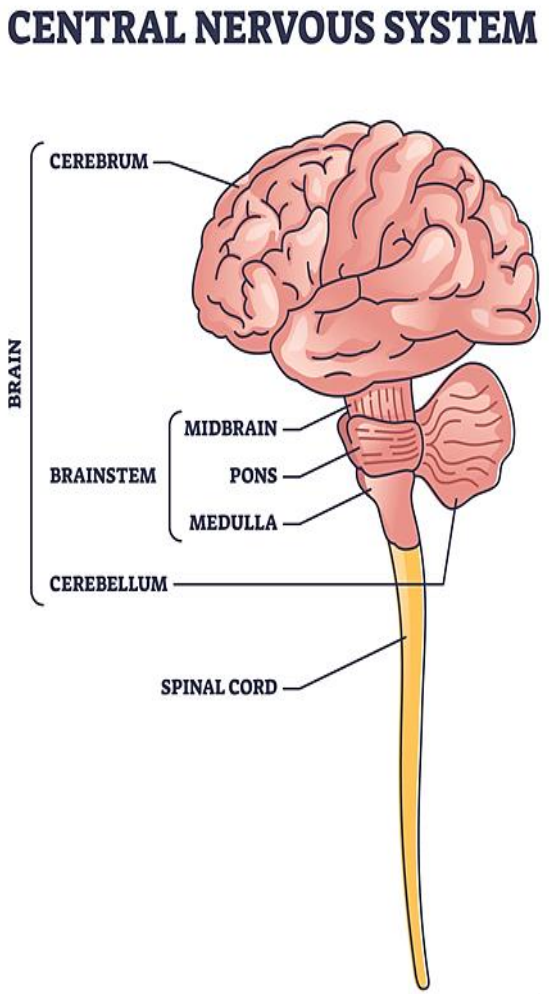
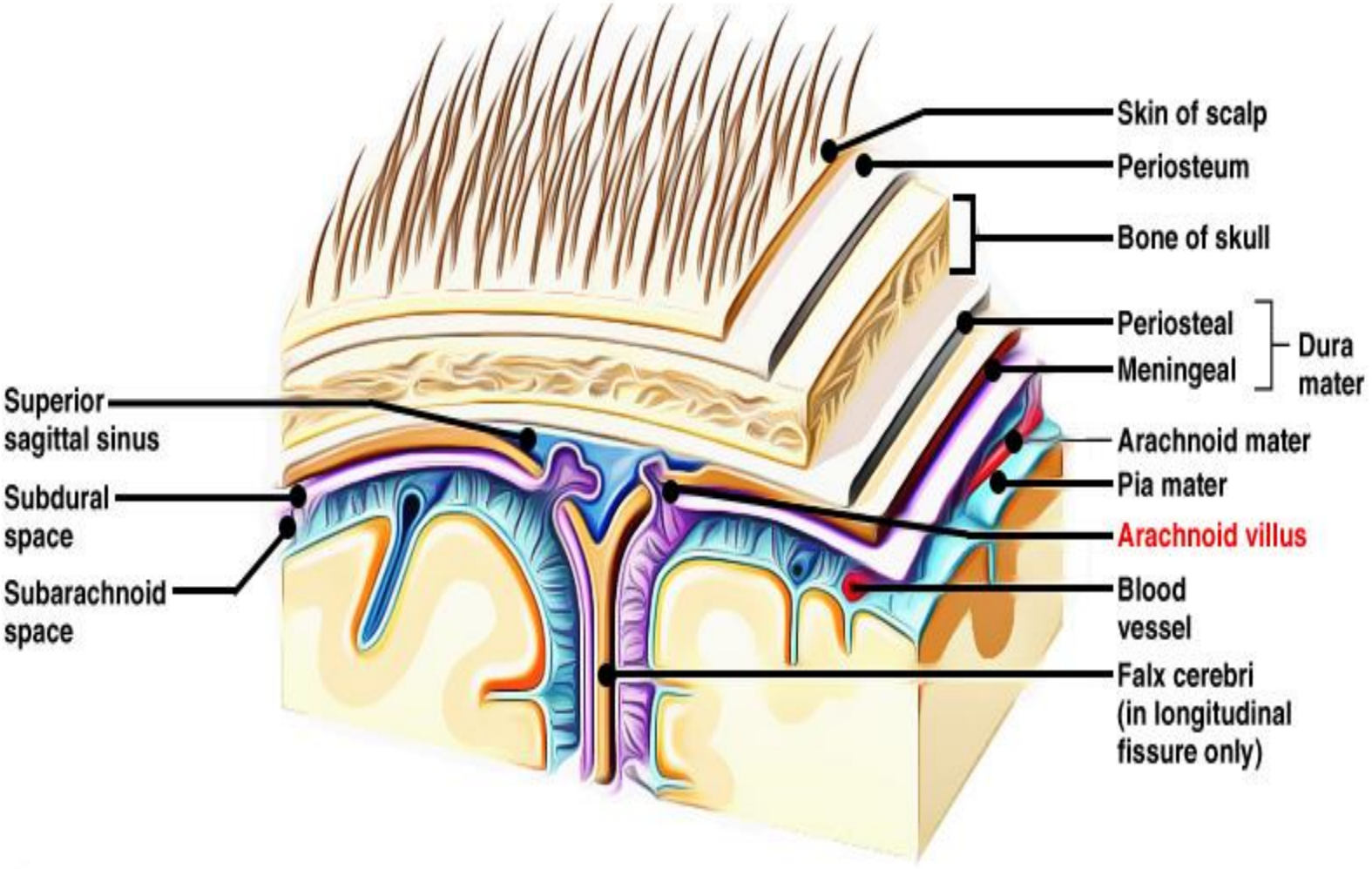
CENTRAL NERVOUS SYSTEM

- The central nervous system (CNS) includes the brain and spinal cord.
- The brain consists of the cerebrum, cerebellum, and brain stem
- The CNS is covered by three connective tissue layers, the meninges, but contains very little collagen or fibrous tissue throughout its substance, making it relatively soft and easily damaged by injuries.



Meninges


Skin of scalp
Periosteum
Bone of skull
Periosteal
Meningeal
Dura mater
Superior sagittal sinus
Subdural space
Subarachnoid space
Arachnoid mater
Pia mater
Arachnoid villus
Blood vessel
Falx cerebri (in longitudinal fissure only)

Meninges

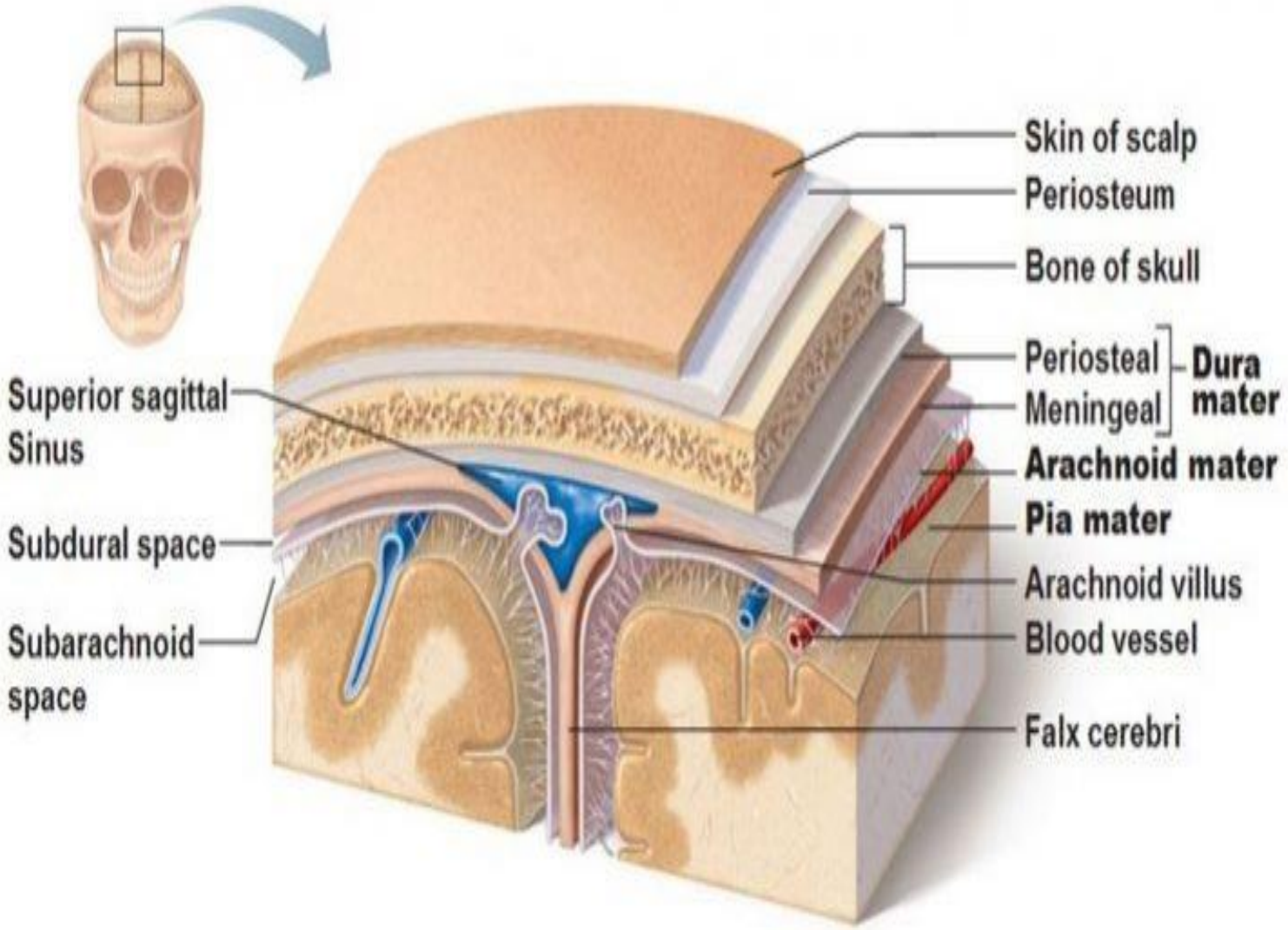
- The skull and the vertebral column protect the CNS, but between the bone and nervous tissue are membranes of connective tissue called the meninges. Three meningeal layers are distinguished: the dura, arachnoid, and pia maters.

- **Dura Mater:**

-The thick external dura mater (tough mother) consists of dense, fibroelastic connective tissue that is continuous with the periosteum of the skull.

-The internal surface of all dura mater, as well as its external surface in the spinal cord, is covered by simple squamous epithelium

The Dura Mater



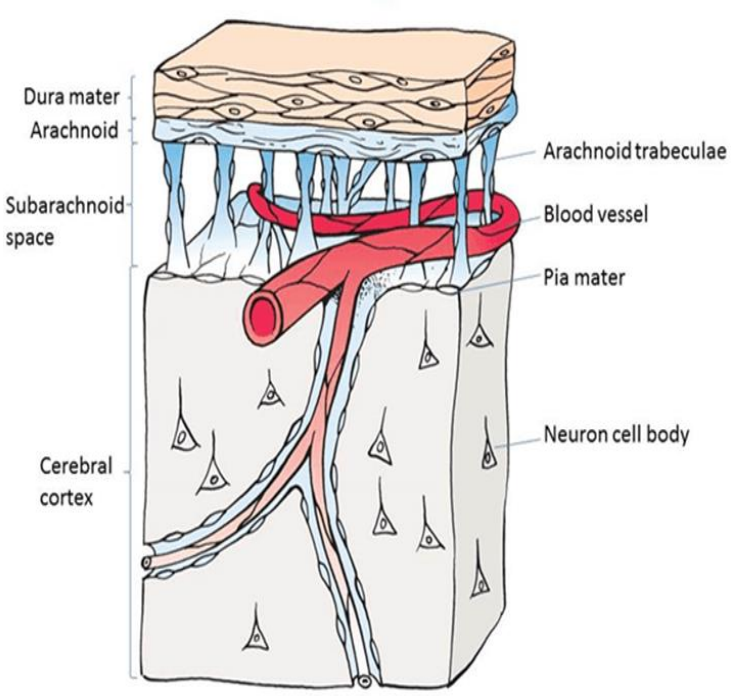
Arachnoid mater:

- The arachnoid (spiderweblike) has two components:

(1) a sheet of connective tissue in contact with the dura mater and

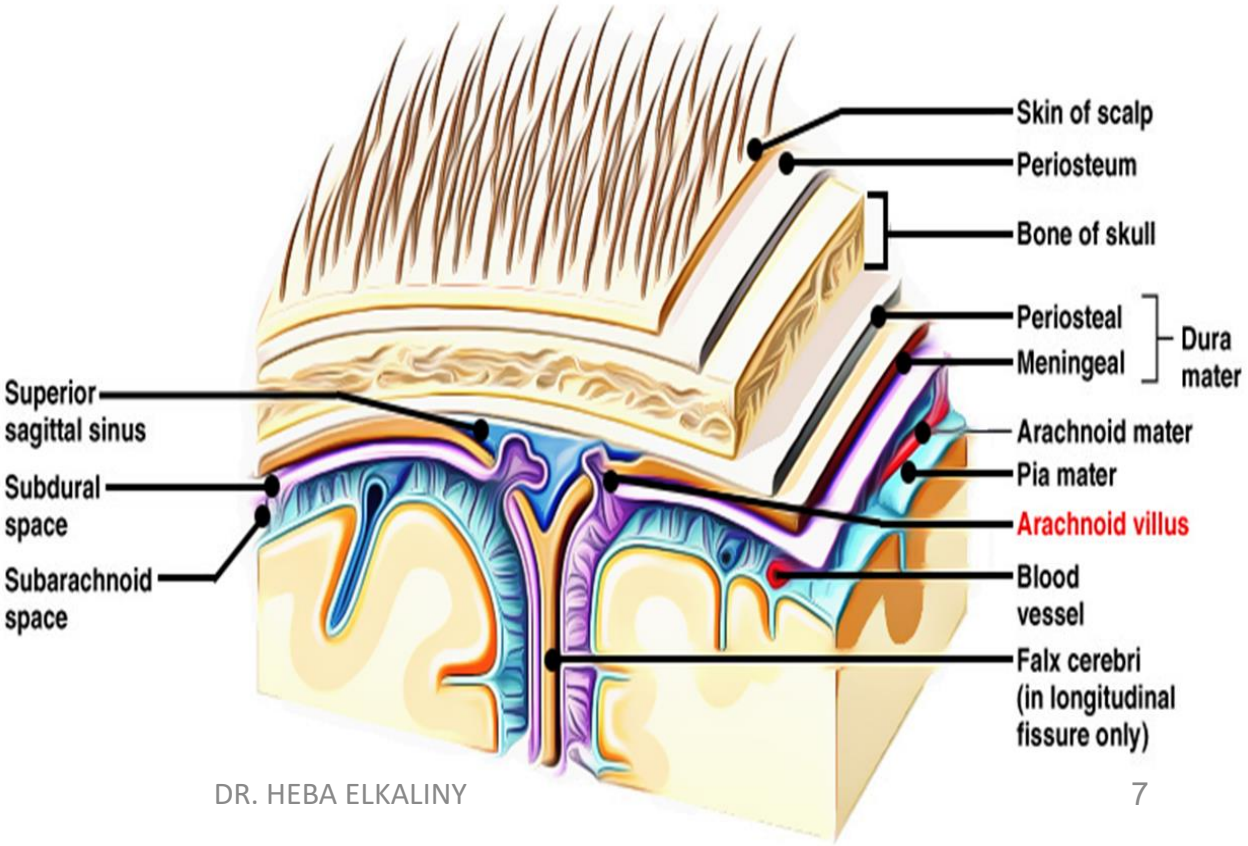
(2) a system of loosely arranged trabeculae composed of collagen and fibroblasts, continuous with the underlying pia mater layer.

- Surrounding the trabeculae is a large, sponge-like cavity, the subarachnoid space, filled with CSF communicates with the ventricles of the brain where the CSF is produced.



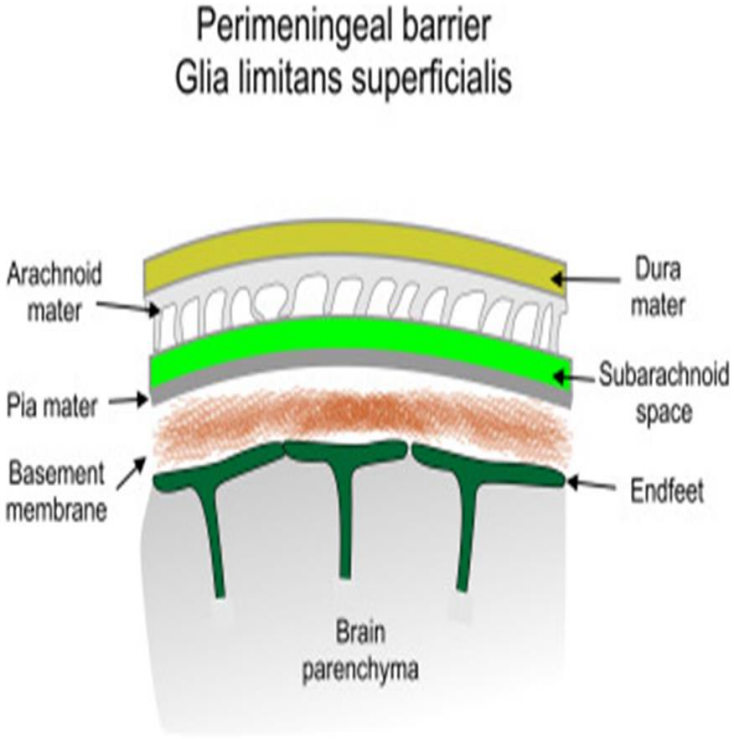
Adopted from: M.H.Ross and W. Pawlina. Histology: a text and atlas, *Lippincott Williams & Wilkins*, 2011

- In some areas, the arachnoid penetrates the dura mater and protrudes into blood-filled venous sinuses located within that layer. These CSF-filled protrusions, which are covered by vascular endothelial cells lining the sinuses, are called arachnoid villi, which function as a site for absorption of CSF into the blood of the venous sinuses.



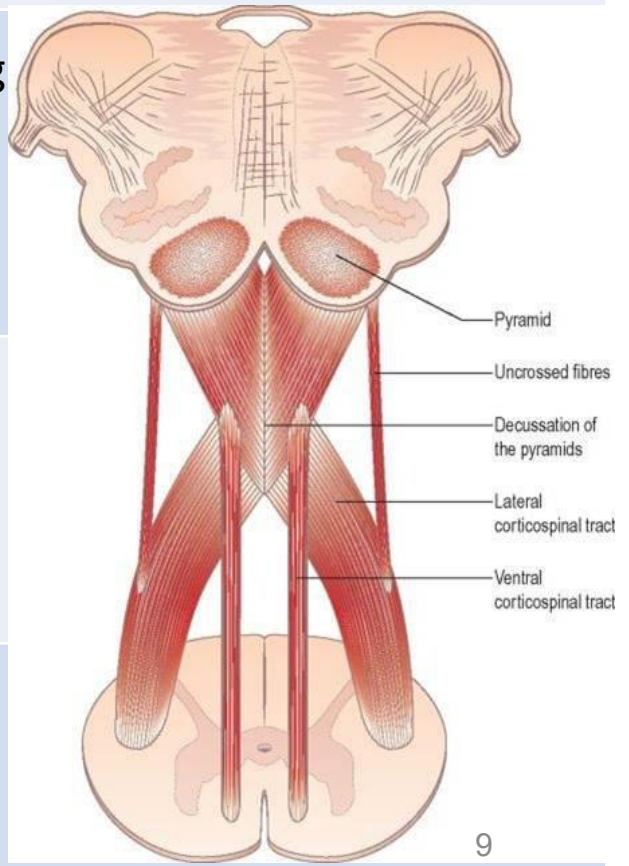
Pia Mater:

- The innermost pia mater (tender mother) consists of flattened, mesenchymally derived cells closely applied to the entire surface of the CNS tissue.
- The pia does not directly contact nerve cells or fibers, being separated from the neural elements by the very thin superficial layer of astrocytic processes, which adheres firmly to the pia mater.
- Together, the pia mater and the layer of astrocytic end feet with its basement membrane form a physical barrier separating CNS tissue from CSF in the subarachnoid space



Some terms related to the C.N.S

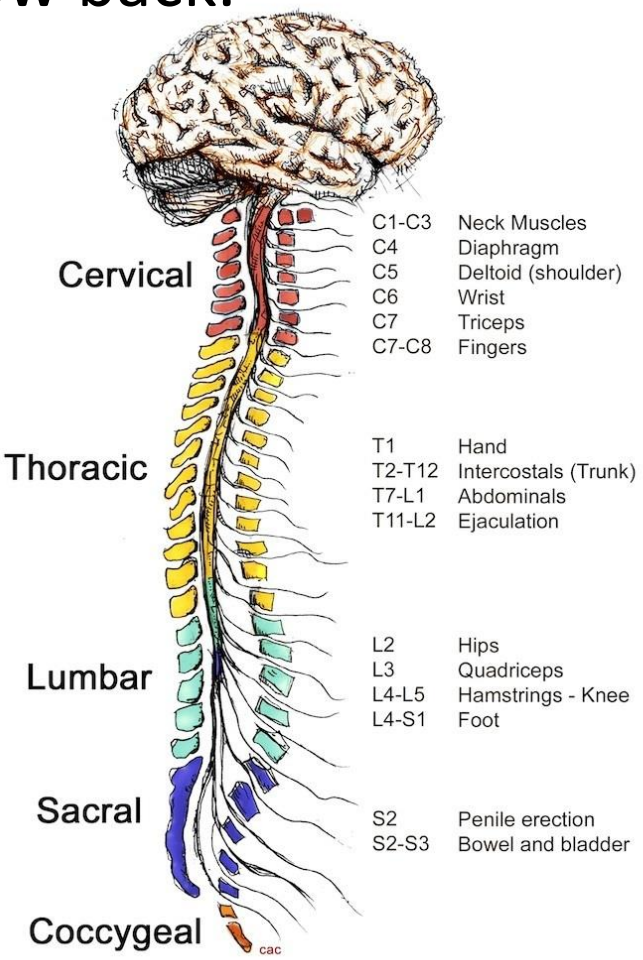
Terms	Definition
A nucleus	A group of nerve cells lying very close to each other inside CNS and having the same function.
A ganglia	A group of nerve cells lying very close to each other outside nervous system.
A commissure	A band of grey or white matter connecting a part of C.N.S on one side with the same on the other side as **Corpus callosum**
A pathway	It is group of neurons that transmit certain excitation from the body to CNS (sensory) or from CNS to the body (motor pathway).
A decussation	The site of intersection of fibers of right and left identical tracts which cross the midline from both sides.



A tract	group of nerve fibers (axons) which arise from the same origin and terminate at the same site and they have the same function. It is a part of a pathway.
A fasciculus (bundle):	Group of nerve fibers, some ascending (sensory) and others descending (motor). Arise from different origins, end at different terminations and carry different function.
Grey matter	Bodies of nerve cells, dendrites, unmyelinated axons and neuroglia.
White matter	Many myelinated axons (form tracts which convey information into & out of CNS), few unmyelinated axons & neuroglia

THE SPINAL CORD

- The main sensory and motor link between brain and body. Spinal cord is a cylindrical structure that runs through the centre of spine, from brainstem to low back.



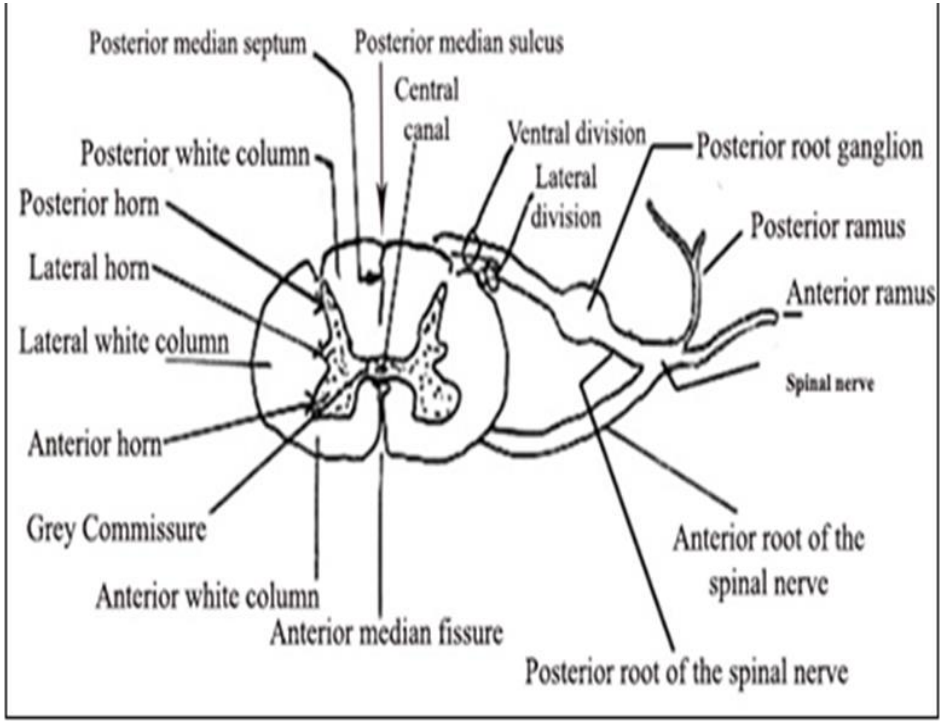
- Each spinal nerve is connected to the spinal cord by two roots:

i) Anterior or motor root (efferent) ventral

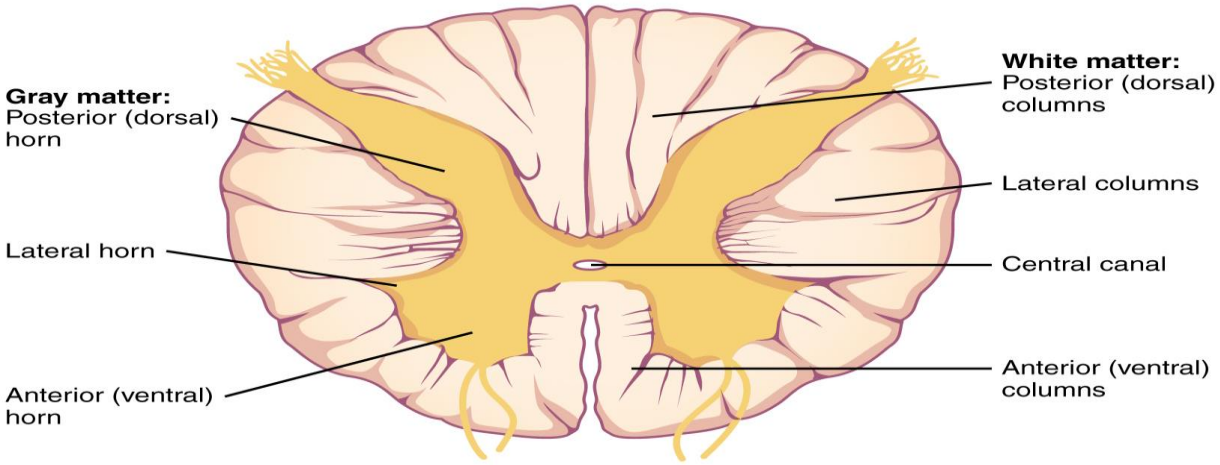
ii) Posterior or sensory root (afferent) dorsal (except 1st cervical).

- Each posterior root has a posterior or dorsal root ganglion (DRG),

-At each intervertebral foramen, anterior and posterior roots unite to form spinal nerve **(31)** which divides at once to anterior &posterior rami (mixed, contain sensory & motor fibers).



Internal structure of the spinal cord

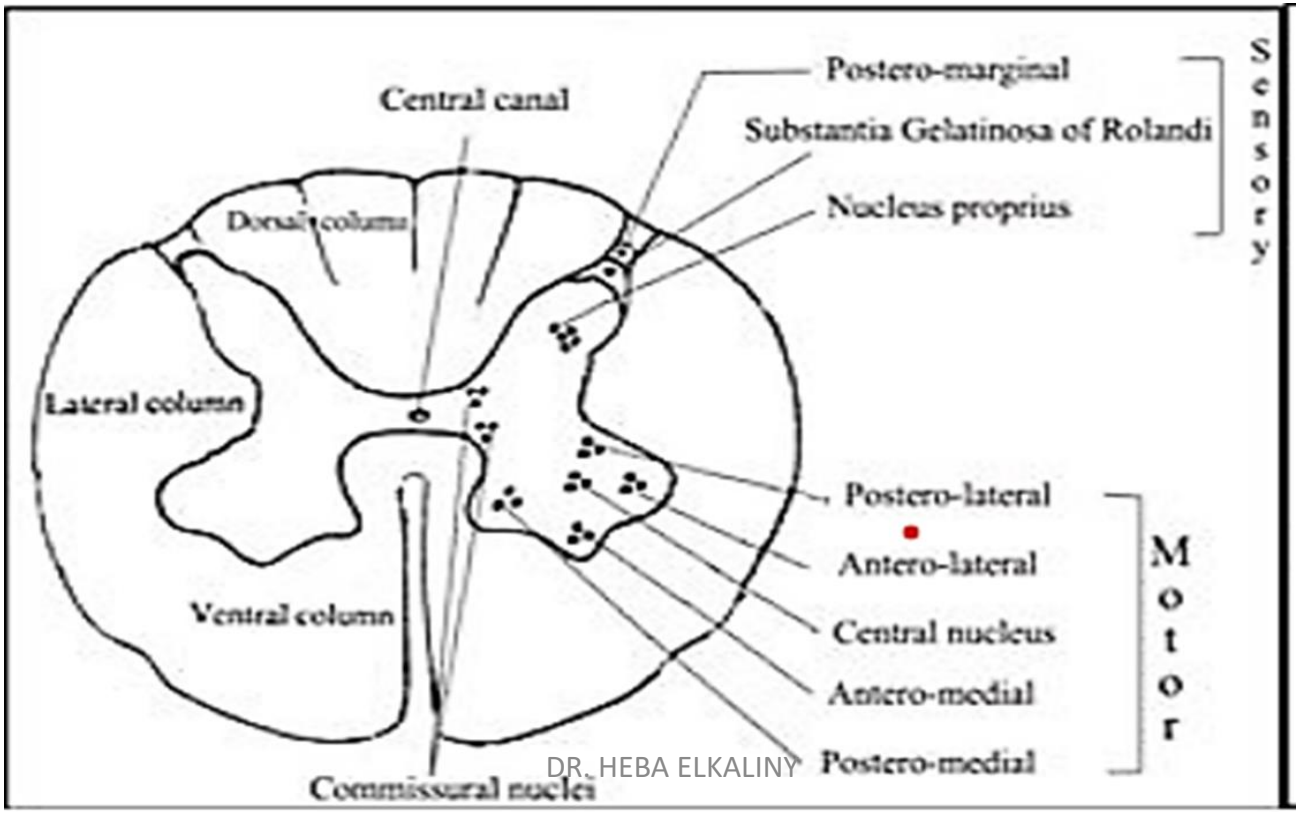


Internal structure of the spinal cord

- The spinal cord contains a central canal in the middle that is surrounded by central **grey matter** and outer **white matter**. The central canal runs longitudinally through the length of the entire spinal cord and contains cerebrospinal fluid (C.S.F.)
- On cross section, the spinal cord is oval in shape. It has grey matter as central H shaped with two anterior and two posterior horns connected by thin grey commissure containing small central canal.
- In thoracic and upper lumber segments two small lateral horns are seen.

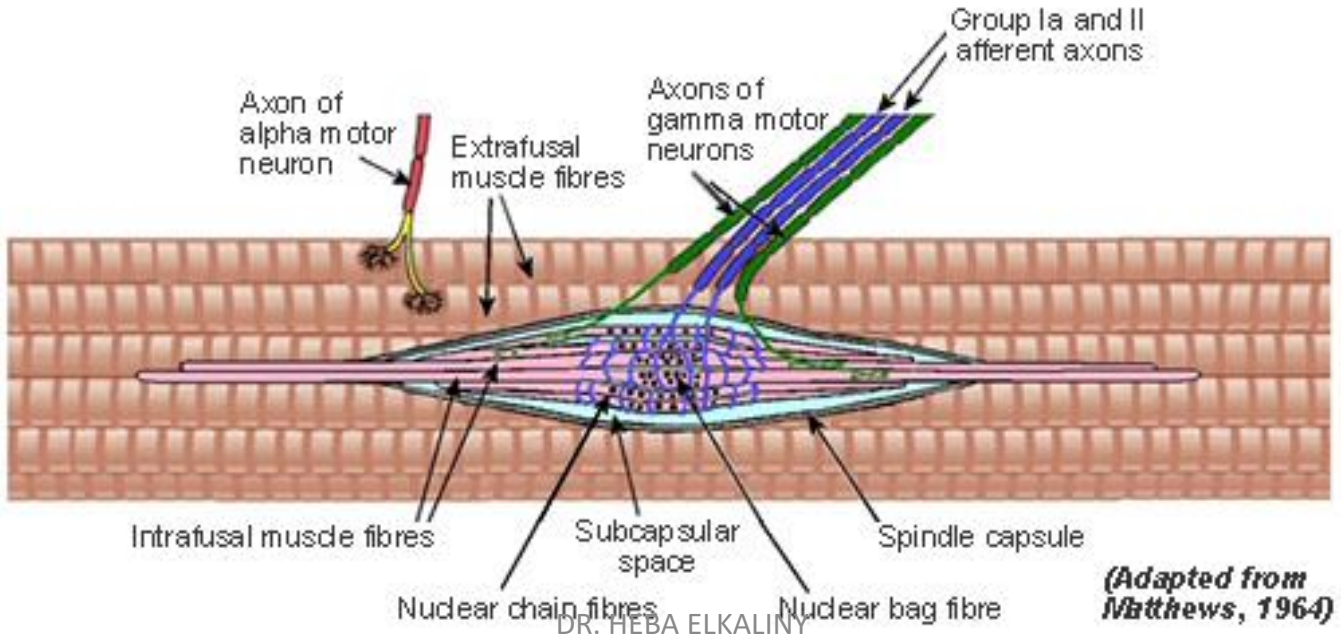
- **The grey matter** of the spinal cord consists of multipolar nerve cells with their naked fibers (no sheaths) and dendrites, neuroglial cells and blood vessels.

- The anterior horns (contain motor nuclei), posterior horns (contain sensory nuclei), and lateral horns (contain sympathetic nuclei) while grey commissure contains anterior and posterior commissural nuclei



A) Anterior horns` nuclei (motor nuclei): - Each nucleus of anterior horn contains:

- -Large multipolar nerve cells which give α-efferents that innervate extrafusal skeletal muscle.
- -Small multipolar nerve cells which give ϐ-efferents which innervate contractile elements of muscle spindles (intrafusal muscle fibers of neuromuscular spindles). the 2nd order neurons of the somatic motor pathway.



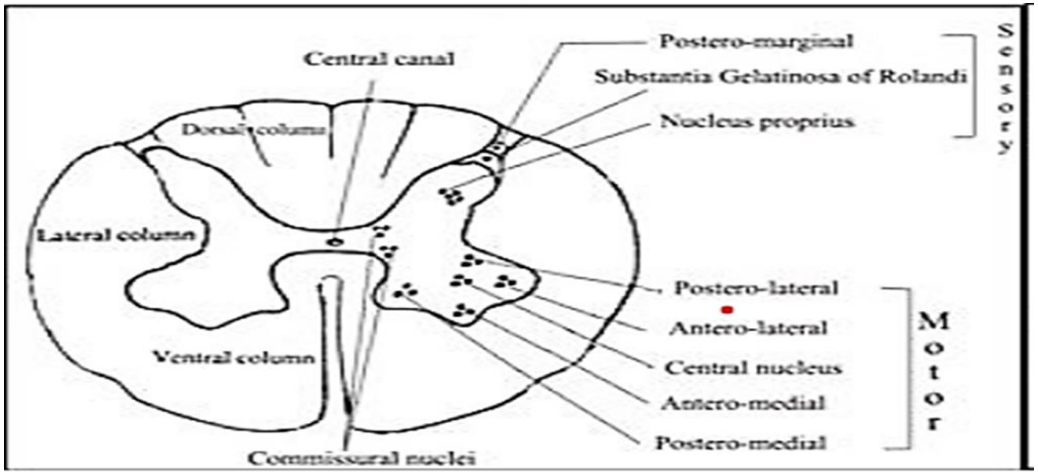
A) Anterior horns` nuclei (VIII, IX)

Three groups of nuclei are present in the anterior horns:

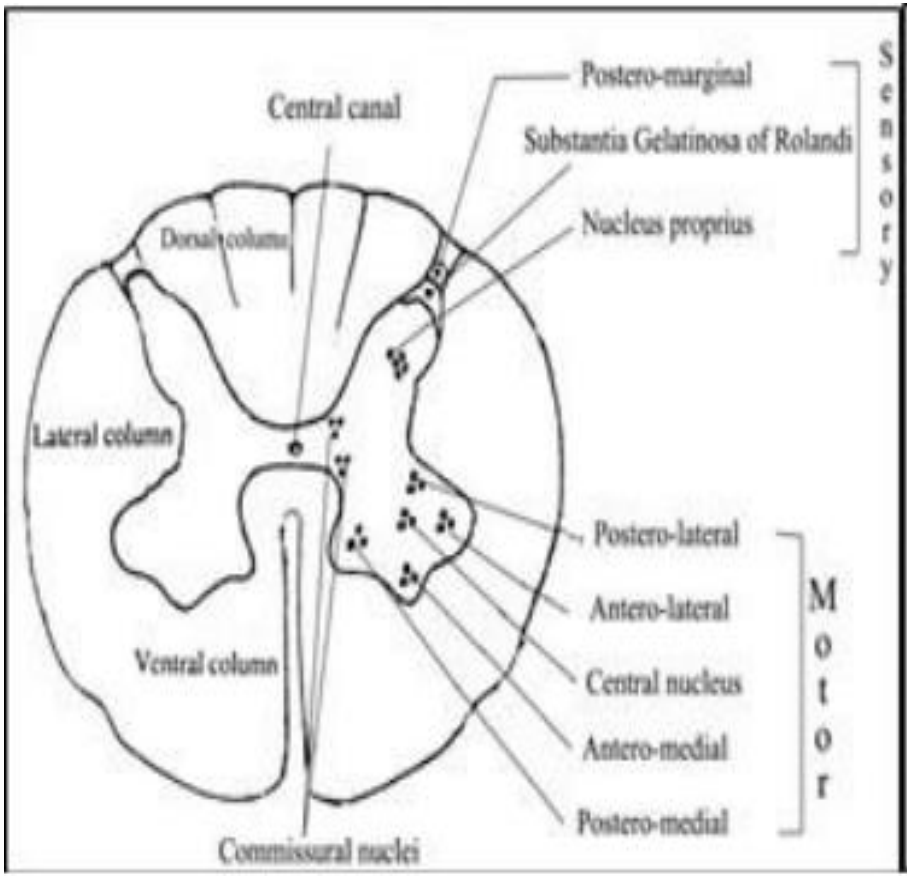
(1) **Medial group**: It includes: antero-medial group and postero-medial group. It is present in all segments of spinal cord. It innervates axial muscles (intercostal & abdominal).

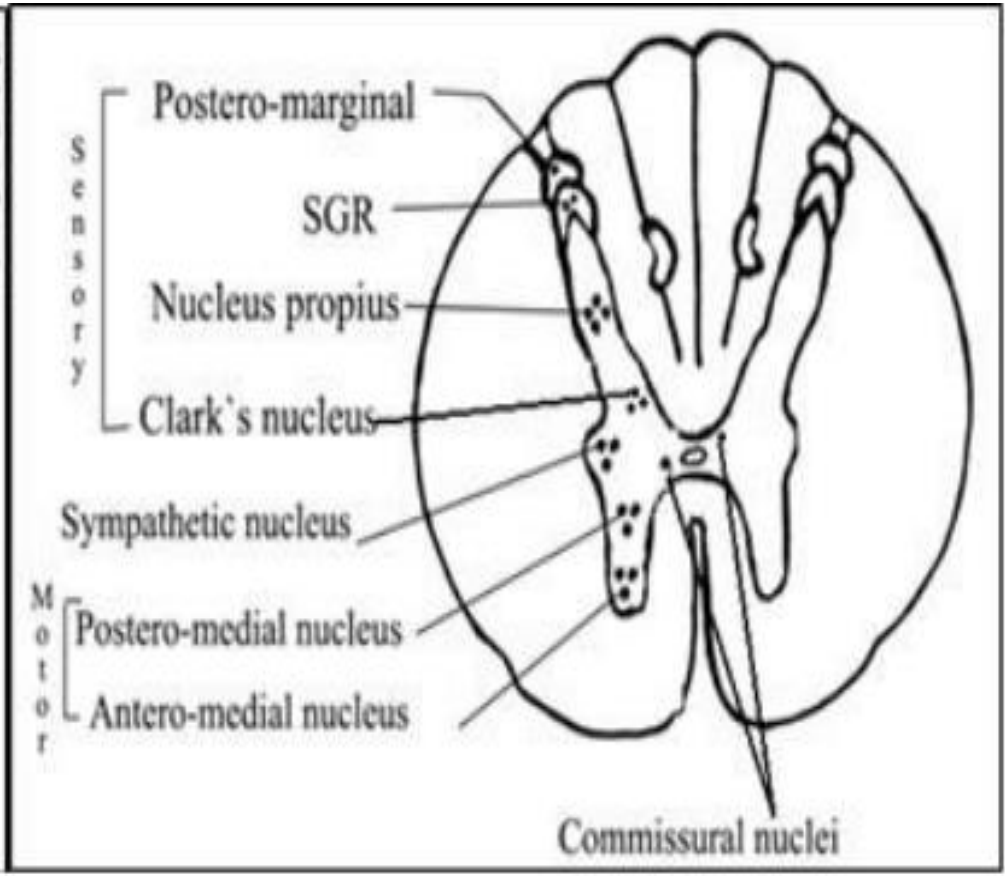
(2) **Central group:** Present in all the segments except thoracic segments. It innervates some muscle of the neck, diaphragm & external anal and urethral sphincters.

(3) **Lateral group:** It includes antero-lateral and postero-lateral. Present in all the segments except thoracic segments It innervates the skeletal muscles of upper and lower limbs.



B) Posterior horns nuclei (sensory nuclei): They contain medium sized cells and are the 2nd order neurons of the sensory pathway.





(1) **Posteromarginal nucleus(I):** It covers the tip of posterior horn In all levels of spinal segments. It mediates pain and temperature sensation.

(2) **Substantia gelatinosa of Rolandi (II):** Its nerve cells are present at the apex of the posterior horns beneath the posteromarginal nucleus. Present in all levels of spinal segments. Its cells form the 2nd order neurons in the pathway of pain and temperature sensations

(3) **Main sensory nucleus (Nucleus proprius)(III,IV):** Its cells are present in the centre of the posterior horns. Present in all levels of spinal segments. Its cells form the 2nd order neurons in the pathway of crude (light) touch

(4) **Clark's nucleus (nucleus dorsalis)(VII):** Its cells present at the base of posterior horn. Present in 8 th cervical and all thoracic up to 3rd lumbar (C8 – L3). Its cells form the 2nd order neurons of (unconscious proprioception).

C) Lateral horns nuclei (VII) contain: (1) Sympathetic nuclei: The thoracic and upper two lumbar segments contain intermediolateral sympathetic nuclei. They give preganglionic fibers which pass in anterior root of spinal nerve. (2)Parasympathetic nuclei: Present in sacral segments (S.2,3&4).

D) Commissural nuclei (X): Present in all segments of spinal cord They surround the central canal. They act as interneurons between sensory and motor nuclei. There are anterior and posterior commissural nuclei.

N. B. Some segments contain some specific nuclei as:

- **Phrenic nucleus:** Is a part of central nucleus of anterior horn of C2- C5 for innervations of diaphragm.
- **Spinal accessory nucleus:** Is a part of central nucleus of anterior horn of C1- C5 for innervations of trapezoid and sternomastoid muscles.

Rexed Laminae

As an alternative to spinal cord nuclei, Bror Rexed (1950s) identified layers, or laminae, within the spinal cord grey matter where cells were grouped according to their structure and function, rather than location

Lamina I

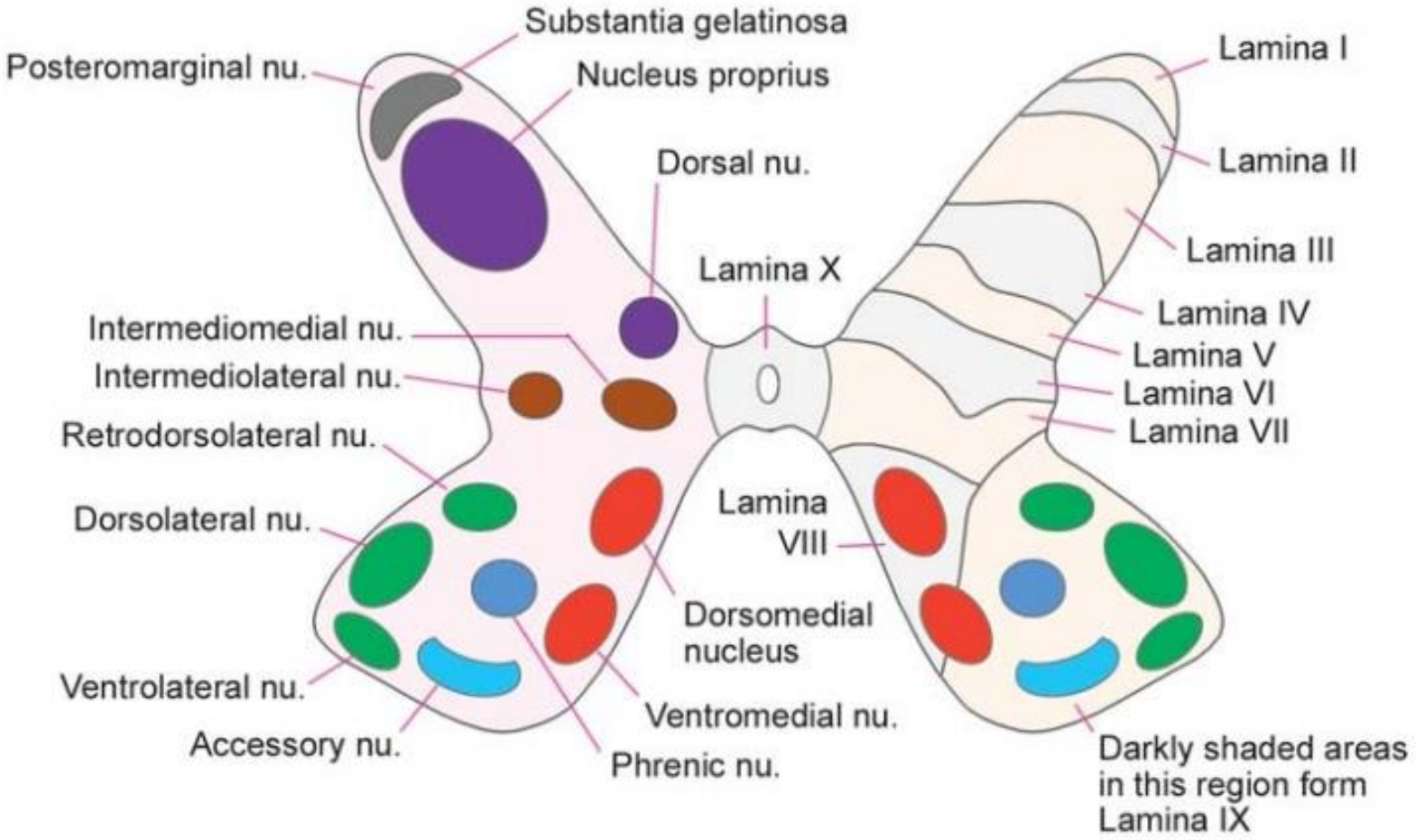
- It receives pain, temperature
- corresponds to the posteromarginal nucleus

Lamina II

- It receives pain, temperature and sexual sensation
- Corresponds to substantia gelatinosa
- Sends information to Lamina III and IV

Lamina III

- Involved in proprioception and sensation of light touch.
- Partially corresponds to nucleus proprius



Subdivisions of the grey matter of the spinal cord. The left half of the figure shows the cell groups usually described. The right half shows the newer concept of laminae.

Lamina IV

- Cells connect with those in lamina II
- Partially corresponds to nucleus proprius

Lamina V

- Relays sensory, including nociceptive (potentially painful), information to the brain via spinothalamic tracts
- Receives descending information from the brain via the corticospinal and rubrospinal tracts.

Lamina VI

- Contains many small interneurons involved in spinal reflexes
- Receives sensory information from muscle spindles (involved in proprioception).
- Sends information to the brain via ipsilateral spinocerebellar pathways

Lamina VII

- Large, heterogenous zone that varies through the length of the spinal cord.
- Receives information from Lamina II to VI, and from viscera
- Relays motor information to the viscera
- Gives rise to cells involved in the autonomic system
- Dorsal nucleus of Clarke is part of Lamina VII

Lamina VIII

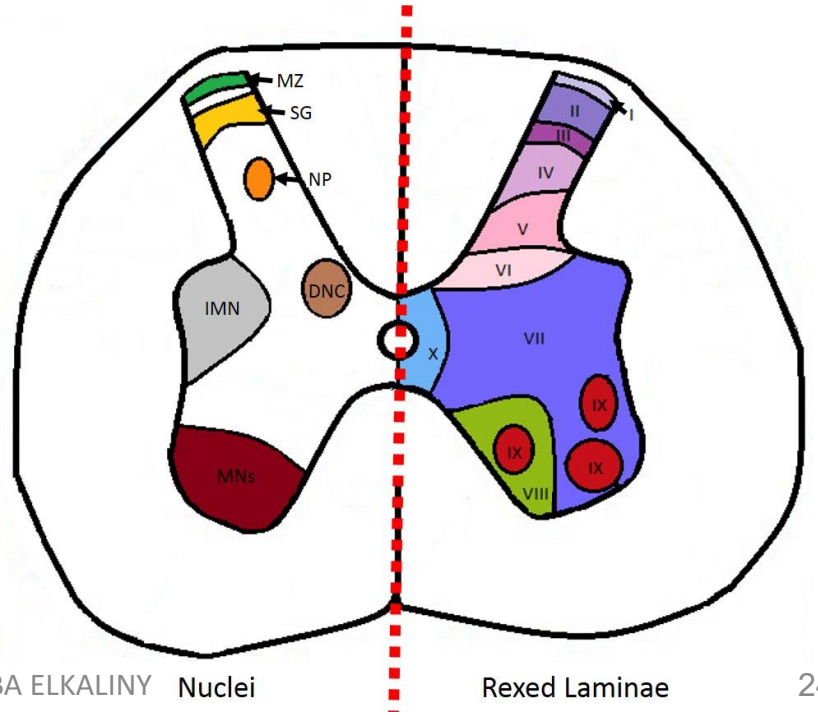
- Varies depending on spinal cord level, but is most prominent in cervical and lumbar enlargements
- Cells are involved in modulating motor output to skeletal muscle

Lamina IX

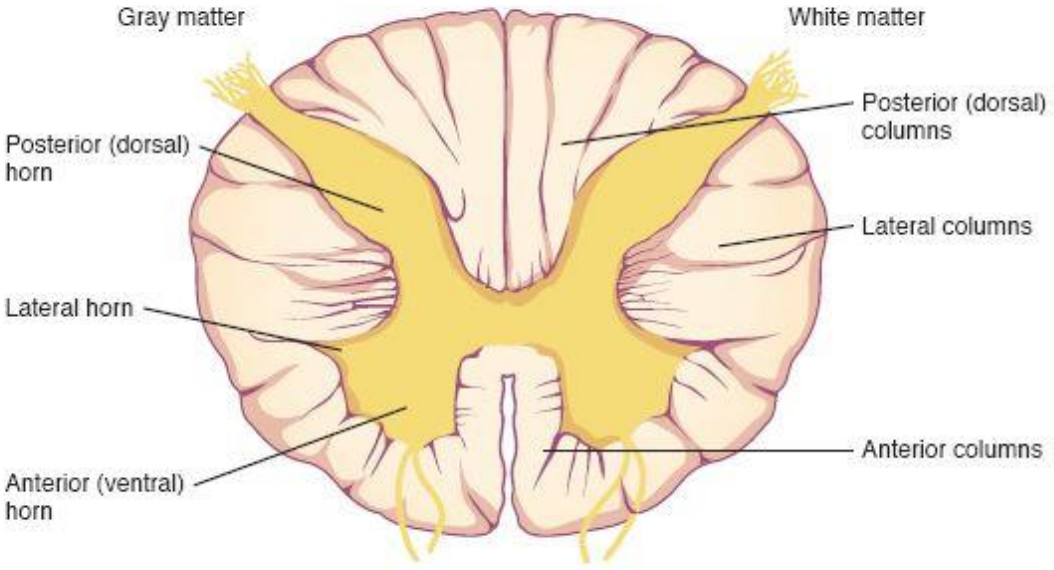
- Size and shape varies between spinal cord levels
- Distinct groups of motor neurons that innervate skeletal muscle.

Lamina X

- Surrounds the central canal – the grey commissure
- Axons decussate (cross over) from one side of the spinal cord to the other



- **The white matter:** - In fresh state, it appears grossly white in colour because it contains many myelinated nerve fibers which are grouped to form tracts and few unmyelinated nerve fibers, neuroglia and few blood capillaries. - For simple description, the white matter of each half of the spinal cord is divided into three longitudinal columns (funiculi).



- **The white matter:**

1. Posterior column between the posterior horn of grey matter and the dorsal median septum in the midline. It contains mainly ascending tracts.

2. Anterior column between the anterior median fissure & the point of emergence of anterior nerve roots. It contains ascending & descending tracts.

3. Lateral column between the emergence of the anterior nerve roots and the entry of the posterior nerve roots. It contains ascending & descending tracts.

The tracts in white matter of spinal cord

I-Short associative tracts:

- ascending or descending tracts that begin and terminate in the spinal cord. Their functions are association and coordination of the different movements of the body with each other.

- There are four short tracts in spinal cord (Fasciculi proprii, Lissauer's, Comma shaped and Septo–marginal)

II - Long tracts: * Long ascending tracts (sensory)

* Long descending tracts (motor)

Short associative tracts

Between gracile& cuneate tracts

Comma - shaped Tr

Gracil Tr

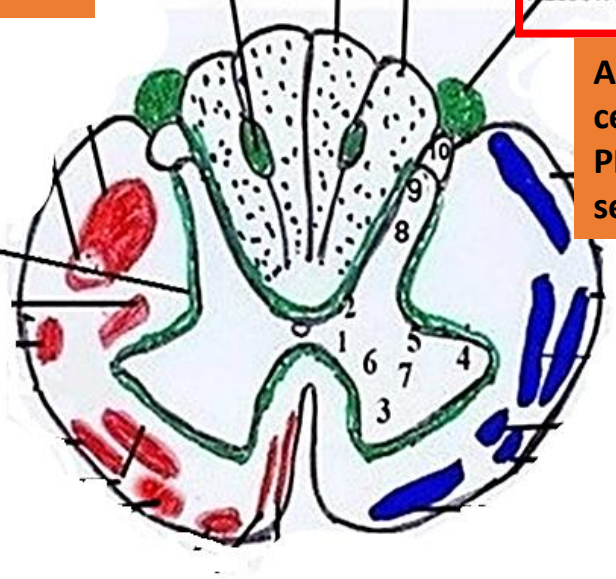
Cuneate Tr

Lissauer's Tr

Axons of cells of PRG in all segments

Fasciculi proprii

Around the grey matter of **all segments**



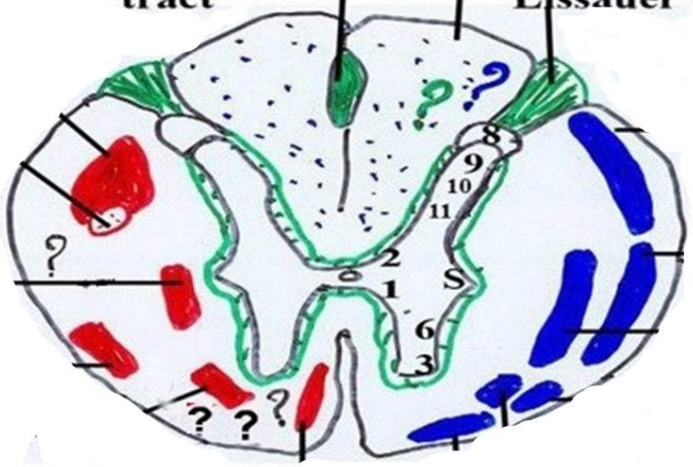
Cervical
Upper thoracic

Around the posterior septum

Septomarginal tract

Gracil tract

Lissauer's tract



Lower thoracic
Lumbar
Sacral

THANK YOU