

# ★ Topic 1 :- Introduction.

• **The nervous system**:- A network of Billions of nerve cell linked together in a highly organized fashion to form the rapid control center of the body.

- **functions**
  - Sensation :- stimuli / Receptor
  - Integration :- processing & interpretation of sensory information → response.
  - Reaction (motor) :- muscles or glands via neurotransmitters.

• **Nervous Tissue (Histology)** :- highly cellular

- Types
  - Neurons :- functional, X divide, Long lived, ↑ metabolic activity, Electrically excitable
  - Neuroglia :- support & protect, Divide, smaller, 6 types
    - 4 CNS :- oligo, Astro, ependy, Microglia
    - 2 PNS :- Schwann, satellite.

• **Functional classification of Neurons**

- Sensory (Affrent) :- Dorsal (posterior) root.
- Interneuron
- Motor (Efferent) :- Ventral (Anterior) root.

• **Terminology**

- 1) White matter :- (Axons), aggregation of axons (myelinated & unmyelinated)
- 2) Gray matter :- (cell body).
- 3) Nerves :- Bundle of processes in PNS CT
  - epineurium
  - perineurium
  - endoneurium
- 4) Tracts :- Bundle of processes in CNS (no CT).
- 5) Ganglion :- cluster of nerve cell bodies in PNS.
- 6) Nucleus :- cluster of nerve cell bodies in CNS (surrounded by white matter).
- 7) Cortex :- cluster of nerve cell bodies in CNS, not surrounded by white matter.

• **Organization of Nervous system** → CNS

- PNS
  - 31 spinal nerves & 12 cranial
  - Sensory / motor
  - Somatic / Autonomic
- Embryology
  - Fore brain (P) :- cerebrum + Diencephalon
  - Midbrain :- Midbrain
  - Hindbrain (R) :- pons + medulla + cerebellum.

- First order neuron :- receptor → Spinal cord
  - Second order neuron :- spinal cord → Thalamus
  - Third order neuron :- Thalamus → Cortex
- } → modulation

- Motor** • upper motor neuron :- cerebrum → spinal cord.
- Somatic** • Lower motor neuron :- spinal cord → muscle.

- Motor** • preganglionic neuron
  - Autonomic** • Ganglionic neuron
  - postganglionic neuron
- } → Lateral horn → Sympathetic (T)
- parasympathetic (S)

External Anatomy of spinal Cord: through vertebral canal (foramen magnum → L2) (L1-L2), 42-45 cm

Regions (segments): 8C, 12T, 5L, 5S, 1 coccygeal

All are mixed, not uniform in diameter

Cervical enlargement → upper limb  
Lumbar enlargement → lower limb.

Conus medullaris: Tapered inferior end (conical structure)

cauda equina: spinal nerves extending inferiorly from conus medullaris (Lower 1/3 of the canal).

Meninges: connective tissue membranes

Dura mater: outermost, foramen magnum → S2

Filum terminale externum: closed caudal end is anchored to coccyx.

Arachnoid: web, adheres to inner surface of dura mater.

Pia mater: adhere to surface of spinal cord & brain.

Filum terminale internum

Denticulate ligament: spinal cord + arachnoid + inner surface of the dura mater.

Spaces

Epidural: Between Dura mater & wall of vertebral canal, Anesthetics & fat-fill.

Subdural space: Serous fluid.

Subarachnoid: Between pia mater & arachnoid, Lumbar puncture (L2-L4).

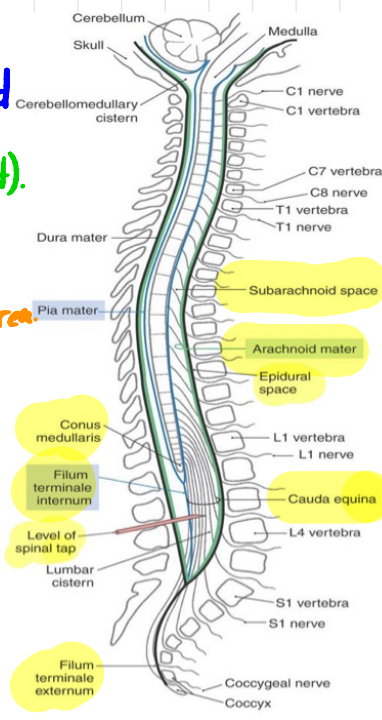
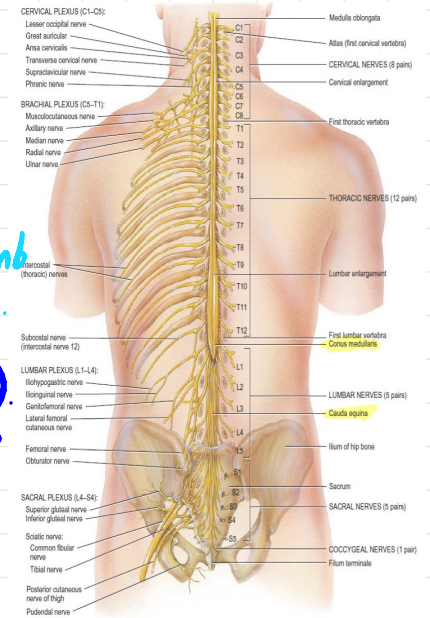
Spinal cord segment

Segments of the spinal cord are not in line with corresponded vertebrae & increases as we go downward.

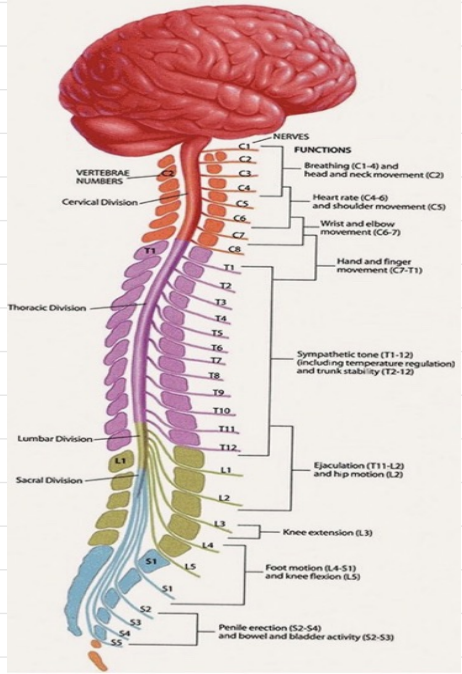
Root increase in length as you go downward. (spinal nerve length).

Every spinal nerve emerges from the spinal column through the vertebral foramen under its corresponding vertebra.

First 7 cervical nerves pass above their corresponding vertebra.



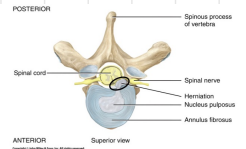
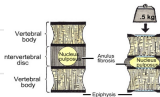
Spinous process	spinal cord segment
C7	C8
T3	T5
T9	T12
T10	L1-2
T11	L3-4
T12	L5
L1	S1-end



# ★ Topic 2 :- DISCS

• **Herniated Disc (Ruptured / Slipped):** Leakage of the gelatinous nucleus pulposus through annulus fibrosus of Intervertebral disc.

- Intervertebral disc
  - outer Annulus fibrosus
  - Inner nucleus pulposus



• Most common: posterolateral (Thinner annulus fibrosus), 95% in L4/L5 or L5/S1 (Lower)

- **Dermatome** :- Area of skin that rely on specific nerve connections on spinal cord.
- **myotome** :- A group of muscles which is innervated by single spinal nerve root.
- **Common Lumbar disc problems** :- ↑ sensitivity to sensory (↓ in motor).

Disc	Root Below	Percentage	Motor weakness	Sensory changes	Reflex affected
L3-L4	L4	3-10%	Knee extension (Quadriceps femoris)	Anteriomedial leg (saphenous)	Knee jerk
L4-L5	L5	40-45%	Big toe dorsiflexion (EHL) and TA	Big toe, anteriolateral leg (Common P)	Hamstring jerk
L5-S1	S1	45-50%	Foot planter flexion (Gastrocnemius)	Lateral border of foot (sural)	Ankle jerk

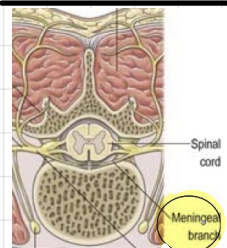
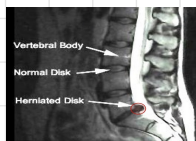


• **Tests**  
 Ask the patient to stand on his Heels  
 Ask the patient to stand on his tiptoes.

• Major symptoms of disc herniation.

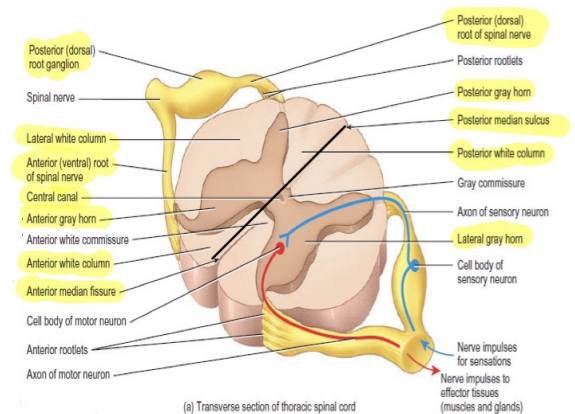
- Low Back pain :- meningeal branch :- A Branch from the spinal nerve that supply the Dura matter.
- Straight Leg Raise test (SLR) :- flexion → Sciatic nerve pulling.
- MRI

- pain is diffused due to overlapping dermatomes.



• **cross section of spinal cord.**

- 2 sulcus
  - Anterior median fissure.
  - posterior median sulcus.
- 3 horns (Grey)
  - Anterior (ventral) :- Motor
  - Lateral - Autonomic
  - posterior (dorsal) :- sensory
- 3 Column (white matter)
  - Anterior funiculus.
  - Lateral funiculus.
  - posterior funiculus.
- 2 Roots of the spinal nerve
  - Anterior
  - posterior
- Central canal :- CSF.



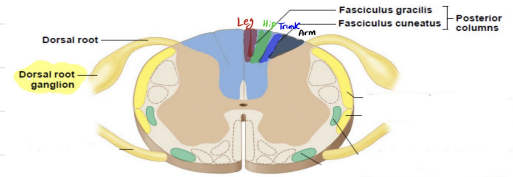
	ELECTROPHYSIOLOGIC CLASSIFICATION OF PERIPHERAL NERVES	CLASSIFICATION OF AFFERENT FIBERS ONLY (CLASS/GROUP)	FIBER DIAMETER (µm)	CONDUCTION VELOCITY (m/s)	RECEPTOR SUPPLIED
Bigger	Aα	Ia and Ib	13-20	80-120	Primary muscle spindles, Golgi tendon organ
	Aβ	II	6-12	35-75	Secondary muscle spindles, skin mechanoreceptors
	Aδ	III	1-5	5-30	Skin mechanoreceptors, thermal receptors, and nociceptors
	C	IV	0.2-1.5	0.5-2	Skin mechanoreceptors, thermal receptors, and nociceptors
smaller					

# \*Topic 3: PMLP & LPT



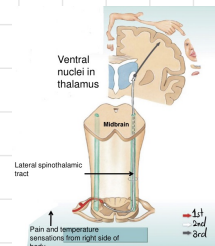
## 1 posterior white column-medial Lemniscal pathway.

- Modality (نوع الإحساس) → Discriminative touch sensation: - vibration.
- Receptor: - Most of Receptors except free nerve endings.
- 1st neuron: - Dorsal root ganglion: - Ascend ipsilateral to lower medulla oblongata.
- 2nd neuron
  - Dorsal column nuclei (cell body 2nd N)
    - Lateral nucleus gracilis (fasciculus gracilis: inferior to T<sub>6</sub> (Low))
    - medial nuclei cuneate (fasciculus cuneatus: Superior to T<sub>6</sub> (upper)).
  - Internal Arcuate Fibers: - cross to opposite side
  - Medial Lemniscus / Lemniscal Decussation: - To the thalamus.
- 3rd neuron
  - Thalamus (VPL: - ventroposterolateral nucleus): - cell body of 3rd N.
  - Internal capsule
  - corona radiata.
- Termination: - Primary Somesthetic Area (S<sub>1</sub>): - postcentral gyrus in parietal lobe.
  - 3a: - Spinal Spindles
  - 2: - Golgi tendon & Joint
  - 3b & 1: - cutaneous (meissner/merkel / pain & Temp).
- Fibers: - A $\alpha$  & AB: - fast fibers.

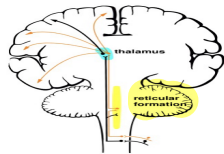


## 2 Lateral spinothalamic tract

- Modality: - pain & Temperature
- Receptors: - free nerve ending.
- 1st neuron: - Dorsal root ganglia.
- 2nd neuron: - posterior gray column (substantia gelatinosa Lamina 1 & 2): - cross opposite side to anterior horn → ascends contralateral as Lateral spinothalamic tract.
- 3rd neuron: - Thalamus (VPL) → Internal capsule → Corona radiata.
- Termination
  - Primary Somesthetic Area (S<sub>1</sub>): - Area 3
  - Widespread cortical Region
  - Reticular formation: - slow pain, awareness or consciousness of pain (switch the cortex on.)
  - Cingulate gyrus: - interpretation of the emotional aspect of pain.
  - Insular gyrus: - pain from internal organs (visceral pain) & Autonomic response.
- Fibers
  - Fast pain (Lamina 1 + 5): - A $\delta$  (delta) fibers
  - Slow pain (Lamina 1 + 2): - C fibers.
- Rexed Laminae: - Lamina 1 + Lamina 2 (substantia gelatinosa) + Lamina 5.

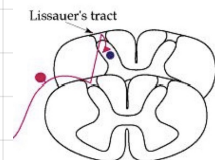


Lamina 1  
Lamina 2



## - posterolateral tract of Lissauer. (not necessary in the same segment).

- Located between the posterior white column & Lateral white column of other segment.
- projects up or down across one or two spinal segments.

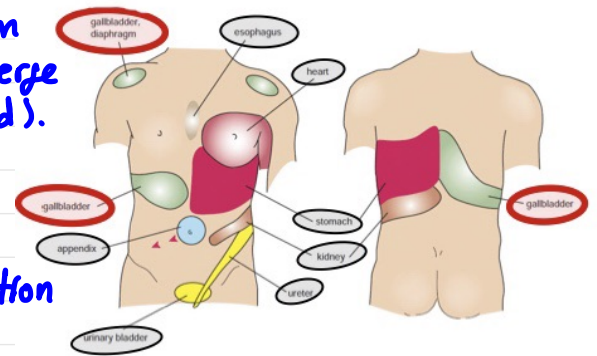


# \* Topic 4 :- pain / spinothalamic / spinocerebellar.

Fast Pain	Slow Pain
Sharp, pricking (initial injury, knife)	Dull, burning (inflammation, chronic pain)
(Aδ) fiber (faster)	(C) fiber (slower)
Short latency	Slower onset
Well localized (synapse with 1, 2nd order)	Diffuse (synapse with more than one 2nd order neuron)
Short duration	Long duration
Less emotional	Emotional, autonomic response (chronic pain → emotional)
Mostly from superficial structures	Superficial & deep structures
Spinothalamic	Spinoreticular (Reticular formation)
lamina I & V	lamina I & II
VPL nucleus	VPL & intralaminar nucleus (related to Reticular formation)

## • Referred pain mechanism (convergence theory).

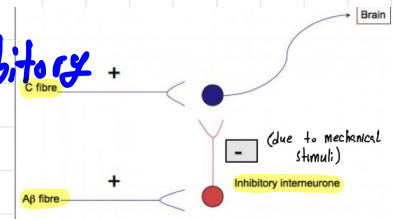
↳ pain referred because the information from multiple nociceptor afferents (visceral & skin) converge onto individual spinothalamic tract neurons (2nd).



- The brain therefore interprets the information coming from visceral receptors as having arisen from receptors on the skin.

## • Pain control in CNS

I) Gating theory:- where the pain fibers enter the CNS, inhibitory may occur by Aβ fibers (large) carrying information of non-painful touch & pressure.



II) Descending control of pain (our analgesic system).

spinoreticular fibers → periaqueductal gray (in mid brain, PAG) around cerebral aqueduct  
 → Excitatory neurons → Nucleus raphe magnus (NRM, part of Reticular formation) → Serotonin  
 → Inhibitory neurons secrete enkephalin & endorphin (morphine-like) → Substantia gelatinosa (Lamina I & II).

III) Locus coeruleus (Pons):- Directly inhibit substantia gelatinosa neurons.

### 3 Anterior spinothalamic tract:- overlap with lateral spinothalamic tract.

- ↳ modality:- crude touch & pressure.
- ↳ 2nd neuron:- nucleus proprius:- Lamina 3 & 4 :- have many interneurons.
- ↳ Termination:- primary somesthetic Area (S1) only.
- ↳ others:- similar to lateral spinothalamic tract.

### 4 Spinotectal tract:-

- Tectum:- posterior aspect of midbrain → 4 colliculi (2 superior / 2 inferior)
- ↳ ascends:- close to lateral spinothalamic tract.
- ↳ Terminate:- superior colliculus.
- ↳ function:- spinovisual reflex (head, neck, eyeball movement to site of stimuli).

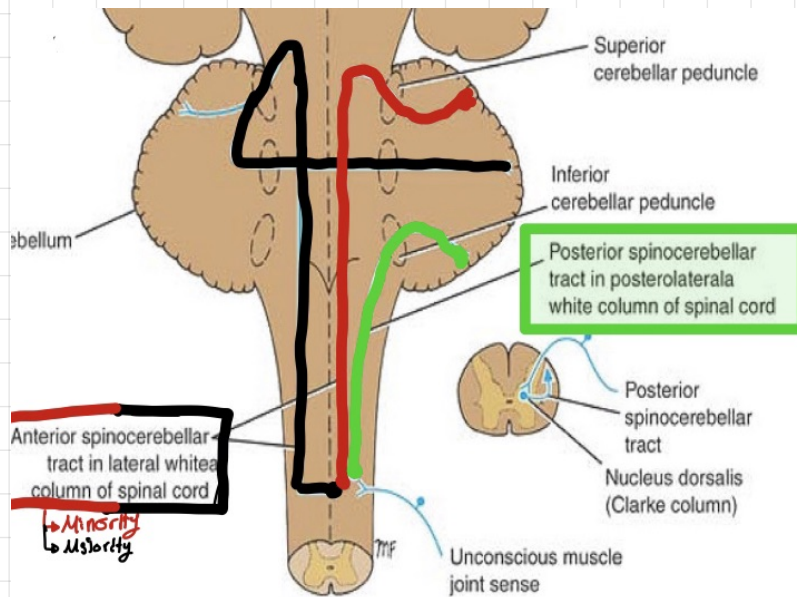
• **Spinal Lemniscus** = Ant & Lateral spinothalamic + spinothalamic tracts. (in medulla).

**5 Posterior spinocerebellar tract.**

- modality:- muscle & joint sensation :- **unconscious proprioception**
- 1st neuron:- terminates in Dorsal nucleus of clark's (Lamina 7):- **Fibers from lower part → L3-L4**
- 2nd neuron:- ascends on the same side in the posterolateral part of lateral column.
- Termination:- **cerebellar cortex:- through inferior cerebellar peduncle.**

**6 Anterior spinocerebellar tract.**

- modality & 1st neuron:- same as posterior spinocerebellar tract.
- 2nd order
  - ↳ Majority\*:- cross to opposite side in the contralateral column (**Double Crossing**)
  - ↳ Minority\*:- ascend in the lateral column of same side
- Termination:- **cerebellar cortex:- through superior cerebellar peduncle.**



- **Lamina 7** → Intermedio - Lateral nucleus :- preganglionic fibers of sympathetic (T<sub>1</sub>-L<sub>2</sub>).
- **Ant & posterior spinocerebellar** → Intermedio - medial nucleus :- visceral pain all over the spinal cord
- **Ant & posterior spinocerebellar** → Dorsal nucleus of clark's :- (C<sub>8</sub>-L<sub>2</sub> or T<sub>1</sub>-L<sub>4</sub>, it's not present in the segments lower than L<sub>3</sub>-L<sub>4</sub>), unconscious proprioception.

**Revision for Rexed Laminae**

- Lamina 1 & 2 (substantia gelatinosa) + Lamina 5 :- **pain & Temp.**  
Lateral spinothalamic tract.
- Lamina 3 & 4 (nucleus proprius) :- **having many interneurons.**  
Anterior spinothalamic tract.
- Lamina 6 :- **in cervical & lumbar enlargements & receives proprioception.**

