Anatomy Team 435

Anatomy of the spinal cord

Done By:

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"GIRLS SLIDES"

Revised by

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Objectives:

At the end of this lecture, the students should be able to :

- Describe the external anatomy of the spinal cord.
- Describe the internal anatomy of the spinal cord.
- Describe the spinal nerves: formation, branches and distribution via plexuses.
- Define 'Dermatome' and describe its significance.
- Describe the meninges of the spinal cord.

Dr.Najeeb notes: Green

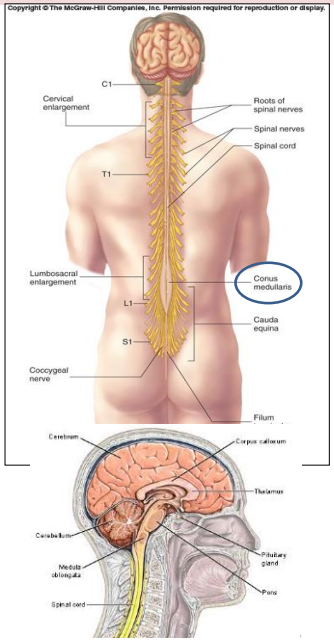
Doctors' notes: Red

Extra notes& Summaries: Blue

Editing File

Spinal Cord

- An **Elongated**, almost **Cylindrical structure**, about the thickness of the little finger.
- It is suspended in the vertebral canal & surrounded by the meninges and cerebrospinal fluid (CSF).
- In **adults**, its **Length** is approximately 45 cm
- Extends from foramen magnum to **L1-L2**
- (In **children** it extends to **L3**)
- Continuous above with the medulla oblongata.
- The tapered inferior end forms **conus medullaris,** which is connected to the coccyx by a non-neuronal cord called **filum terminale**.
- Gives rise to **31 pairs of spinal nerves**

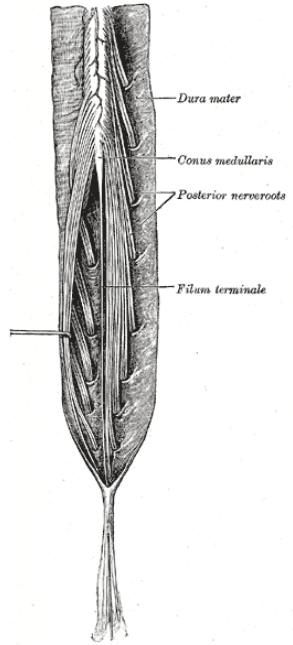


Terms:

- **Conus medullaris:** The most distal bulbous part of the spinal cord.
- **Filum terminale "Termenal thread":** is a delicate strand of fibrous tissue, about 20 cm in length, proceeding downward from the apex of the conus medullaris

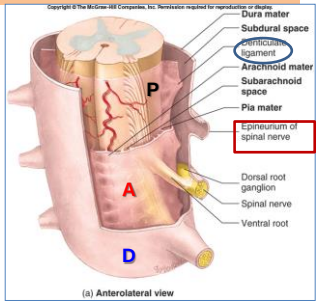
Notes:

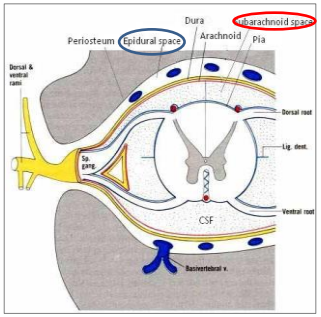
- In children it extends to L3 so, we cannot give children spinal Anastasia to prevent spinal cord injury.



Spinal Meninges

- Three connective tissue membranes surround spinal cord and brain
  - **Dura mater**: tough outer layer, continuous with epineurium of the spinal nerves
  - **Arachnoid mater:** thin membrane deeper to dura mater
  - **Pia mater**: delicate membrane bound tightly to surface of brain and spinal cord and carries blood vessels.
  - Forms the **filum terminale**, which anchors spinal cord to coccyx and the **denticulate ligaments** that attach the spinal cord to the dura mater
- **Spaces**
  - **Epidural**: Contains blood vessels, areolar connective tissue and fat.
  - **Subdural**: a potential cavity between the dura and arachnoid mater, contains a small volume of serous fluid.
  - **Subarachnoid**: Contains cerebrospinal fluid (CSF) and blood vessels



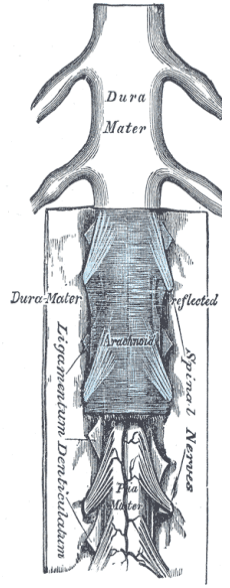


Terms:

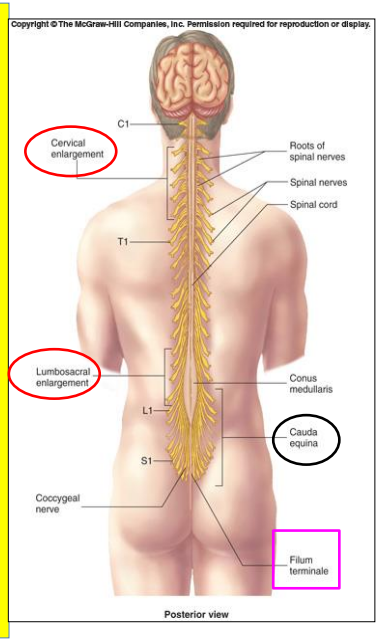
- **Epineurium:** is the outermost layer of dense irregular connective tissue surrounding a peripheral nerve. "Extension from the Dura mater"
- **Denticulate ligaments:** The Pia mater of the spinal cord form a pair of denticulate ligaments (one on each side of the spinal cord)."To fix the spinal cord in position"
- **Epidural:** The space between the bone and Dura mater.

Notes:

- Anastasia during delivery in "Epidural space"
- Spinal Anastasia in "Subarachnoid space"
- Two structures are responsible for fixation of the spinal cord in its position: Filum terminale & denticulate ligaments.

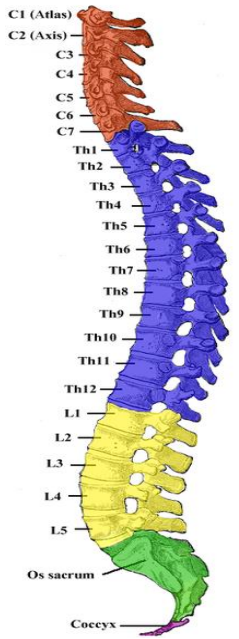


- The spinal cord is a **Segmented** structure, has
  - **Cervical**
  - **Thoracic**
  - **Lumbar**
  - **Sacral** segments
- Not uniform in diameter,
- Has **two enlargements:**
  - **Cervical enlargement**: supplies upper limbs
  - **Lumbosacral enlargement**: supplies lower limbs
- The bundle of spinal nerves extending inferiorly from lumbosacral enlargement and conus medullaris surround the filum terminale and form **cauda equina** (because of its resemblance to a horse's tail



Terms:

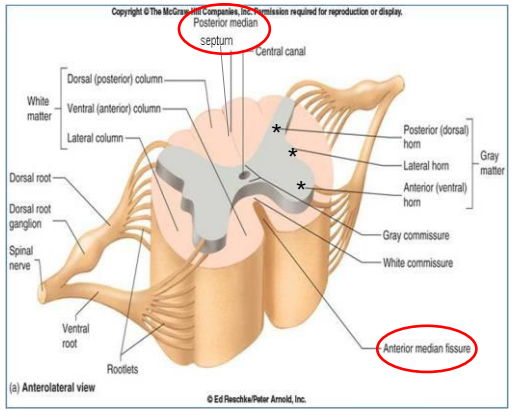
- **Cauda equine:** (Latin for "horse's tail") is a bundle of spinal nerves and spinal nerve roots all of which arise from dorsal root of lumbar,sacral and coccygeal spinal nerves.



Cross Section of Spinal Cord

The spinal cord is:

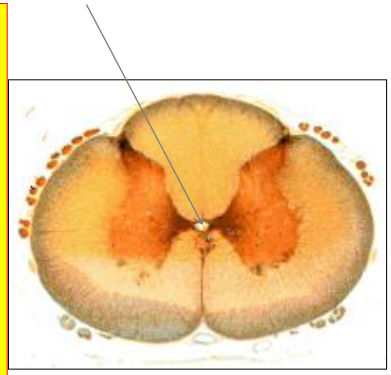
- Incompletely divided into two equal parts,
  - anteriorly by a short, shallow **median fissure** and
  - posteriorly by a deep narrow septum, the **posterior median septum.**
- Composed of **grey matter** in the centre surrounded by **white matter**



The arrangement of grey matter resembles the shape of the letter **H**, having two **posterior,** two **anterior** and two **lateral** horns/columns

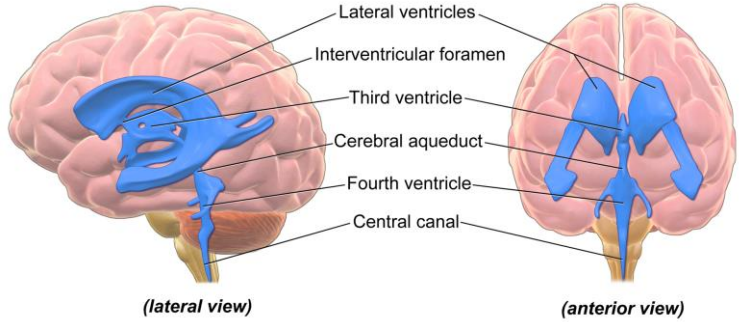
Central canal

- A cerebrospinal-filled space that runs longitudinally through the entire length of the spinal cord.
- Lined by ependyma (ciliated columnar epithelium)
- Continuous with the ventricular system of the brain
- Superiorly opens into the 4th ventricle
- Inferiorly in the conus medullaris, it expands into the fusiform **terminal ventricle** and terminates below at the root of filum terminale



Terms:

- **Ependyma:** is the thin epithelial lining of the ventricular system of the brain and the central canal of the spinal cord, made up of ependymal cells



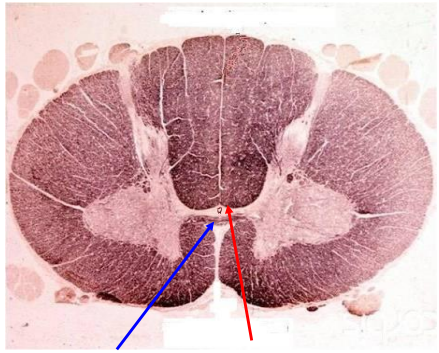
Commissures of the Spinal Cord

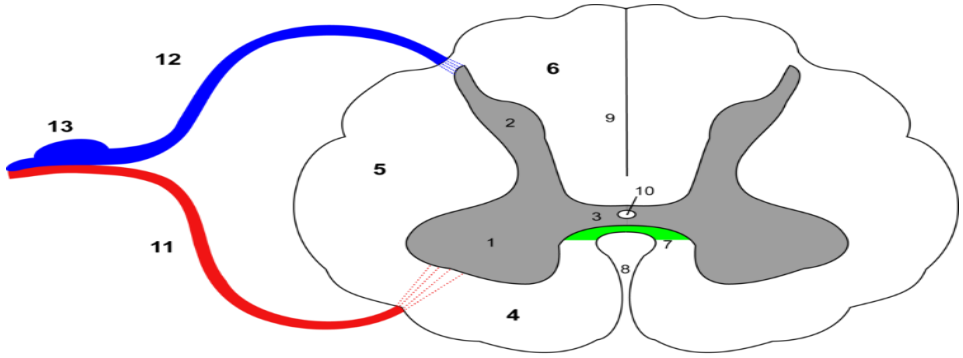
Grey commissure:

- A transverse bridge of grey matter connecting the anterior and posterior gray horns on each side
- Is pierced by the central canal that divides it into anterior and posterior parts

White Commissure:

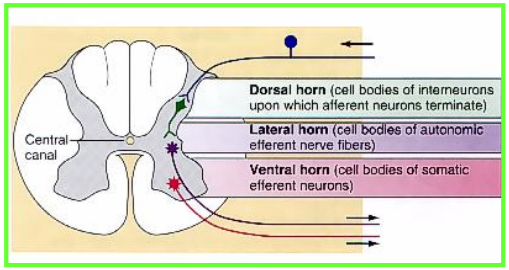
- Lies ventral to the gray commissure
- Mainly contains decussating nerve fibers





Gray matter	White matter	
1. Anterior horn	4. Anterior funiculus	10. Central canal
2. Posterior horn	5. Lateral funiculus	11. Anterior root
3. Gray commisure	6. Posterior funiculus	12. Posterior root
	7. Anterior commisure	13. Dorsal root ganglion
	8. Anterior median fissure	
	9. Posterior median sulcus	

Grey matter



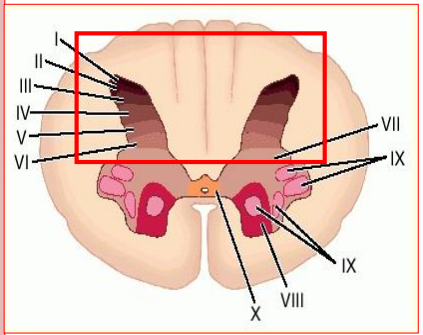
- Consists of nerve cell bodies and their processes, neuroglia, and blood vessels
- The nerve cells are multipolar and are of three main categories:
  1. **Sensory neurons (Tract cells)**, which receive impulses from the periphery of the body and whose axons constitute the ascending fasciculi of the white matter, are **located in the Dorsal horns.**
  2. **Lower motor neurons**, which transmit impulses to the skeletal muscles, are **located in the ventral horns** (similar neurons in the **lateral horn** are the preganglionic neurons of the autonomic system)
  3. **Interneurons (connector neurons)**: linking sensory and motor neurons, at the same or different levels, which form spinal reflex arcs.

Notes:

- **3 categories of nerve cells in the spinal cord:**
  1- **In the Dorsal horn > contains the axons of sensory neurons whole the cell bodies in the dorsal root ganglion.**
  2- **Two LMN**
  - **In the ventral horn > motor somatic. "muscles"**
  - **In the lateral horn > motor autonomic.**
  3- **Interneurons (connector neuron) > linking sensory & motor.**

Neuronal Architecture of Spinal Grey Matter

- Cells of the same type are clustered into groups, which occur in **long columns**
- In transverse section, these columns appear as **layers**, especially within the dorsal horn
- These layers are called the **Laminae of Rexed**, that are numbered consecutively by Roman numerals, starting from the tip of the dorsal horn and moving ventrally into the ventral horn



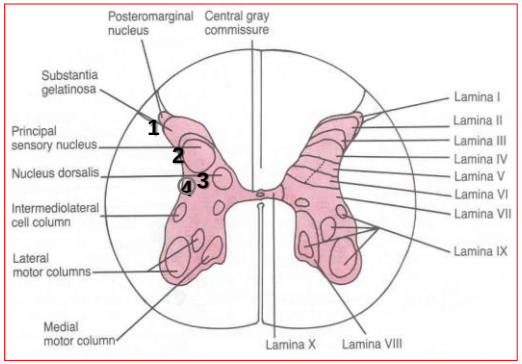
Notes:

- Called Rexed b/c it is identified in the early 1950s by Bror Rexed to label portions of the grey columns of the spinal cord.

Nerve Cell Groups in Dorsal Horn

4 main groups

1. Substantia gelatinosa
2. Nucleus proprius
3. Nucleus dorsalis (Clark's column, nucleus thoracis)
4. Visceral afferent nucleus

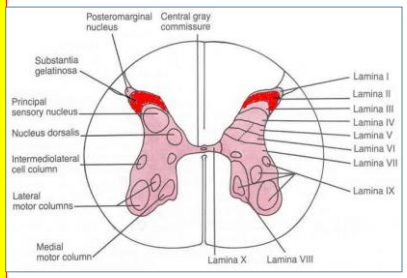


Notes:

- All of these groups are Sensory in function.

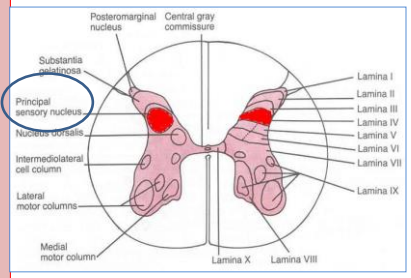
Substantia Gelatinosa

- Rexed Laminae II
- Located at the apex of the posterior horn
- Composed of large neurons
- Extends throughout the length of spinal cord
- Afferents: dorsal root fibers concerned with **pain**, **temperature** and crude **touch**



Nucleus Proprius

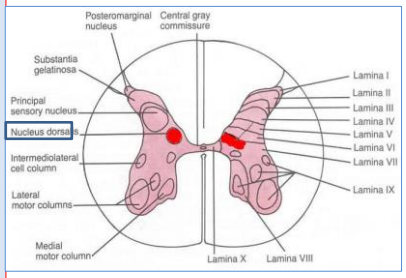
- Rexed Lamina IV
- Located anterior to substantia gelatinosa
- Composed of large neurons
- Extends throughout the length of spinal cord
- **Afferents**: dorsal root fibers concerned with **fine touch (senses of position & movement** (proprioception) and **two point discrimiation** & **vibration)**



Nucleus	Lamina	Located in:	Composed of:	Extends:
Substantia Gelatinosa	II	at the apex of the posterior horn	large neurons	throughout the length of spinal cord
Nucleus Proprius	IV	anterior to substantia gelatinosa	large neurons	throughout the length of spinal cord
Nucleus Dorsalis	VII	at the base of dorsal horn	mostly of large neurons	from **C8 to L3-4** segments
Visceral Afferent Nucleus	VII	lateral to nucleus dorsalis	mostly of medium size neurons	from **T1 to L3** segments

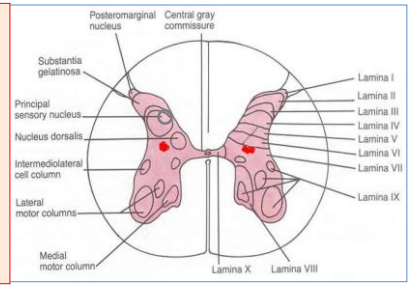
Nucleus Dorsalis (Clark's column, Nucleus thoracis)

- Rexed Lamina VII
- Located at the base of dorsal horn
- Composed mostly of large neurons
- Extends from **C8 to L3-4** segments
- Associated with **proprioceptive endings**
- Afferents: dorsal root fibers concerned with information from **muscle spindles and tendon organs.**



Visceral Afferent Nucleus

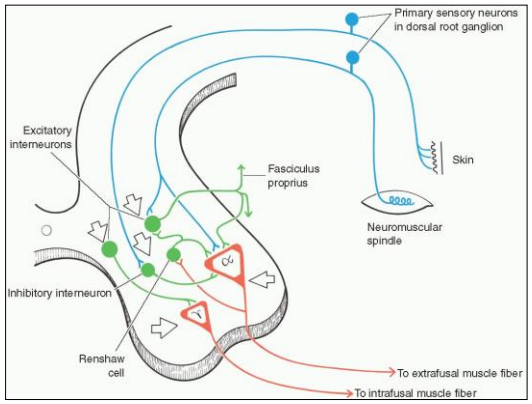
- Rexed Lamina VII
- Located lateral to nucleus dorsalis
- Composed mostly of medium size neurons
- Extends from **T1 to L3** segments
- **Afferents:** Visceral afferents



Nerve Cell Groups in Ventral Horn

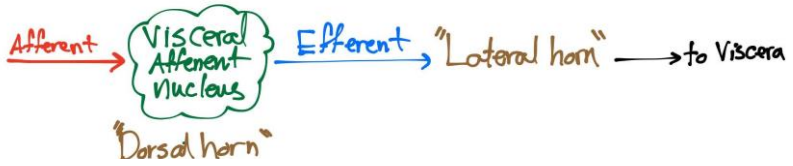
The ventral horns contain:

1. **Motor neurons**, also called lower motor neurons.
2. **Interneurons**, the (**Renshaw cells**), whose branched axons form **inhibitory** synaptic junctions on motor neurons

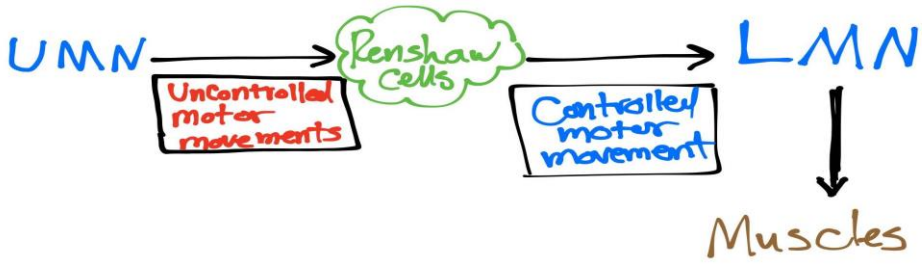


Notes:

- Autonomic Afferents (Sensory) inter the CNS Through the "Visceral Afferent Nucleus" at the base of **"Dorsal horn"**
- Autonomic Efferent (Motor) exit the CNS through the **"Lateral horn"**



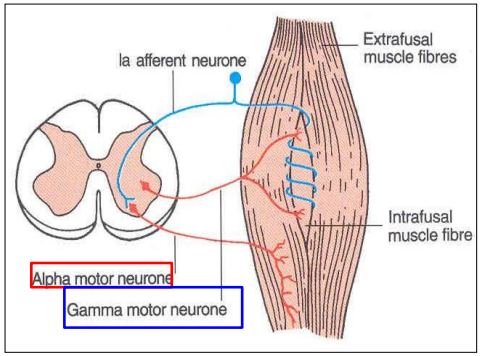
Nucleus	Afferent action:
Substantia Gelatinosa	Dorsal root fibers concerned with **pain, temperature** and crude **touch**.
Nucleus Proprius	Dorsal root fibers concerned with **fine touch (senses of position & movement** (proprioception) and **two point discrimiation & vibration)**
Nucleus Dorsalis	Dorsal root fibers concerned with information from **muscle spindles and tendon organs.**
Visceral Afferent Nucleus	**Visceral afferents.**



Types of Motor Neurons in Ventral Horn

Are of **Two types**

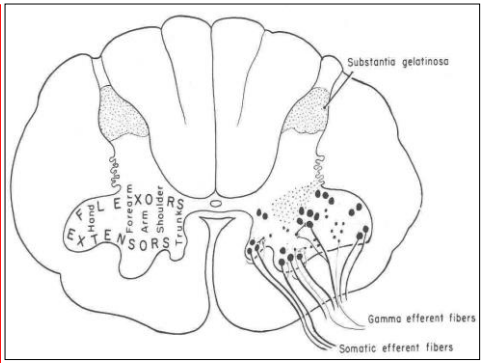
- **Large** multipolar cells
  - **Numerous**
  - Axons pass out in the ventral roots of spinal nerves as **alpha** efferents
  - Innervate **extrafusal muscle fibers**
- **Smaller** multipolar cells
  - **Less numerous**
  - Axons pass out in the ventral roots of spinal nerves as **gamma** efferents
  - Innervate **intrafusal muscle fibers** of neuromuscular spindles



Both alpha and gamma motor neurons are under the influence of descending pathways (upper motor neurons) from brain

Organization of Motor Neurons in Ventral Horn

- Motor neurons are organized in **3 groups**:
- **Medial**:
  - present in **most segments**
  - Innervate muscles of **Neck and Trunk** (including intercostal and abdominal muscles)
- **Central**:
  - smallest,
  - present in some segments: **cervical** (phrenic C3-5, spinal accessory C1-6) and **lumbosacral** (L2-S1)
- **Lateral**:
  - present in cervical and lumbosacral segments
  - innervates muscles of the **Limbs**



Neurons supplying flexor muscles are located dorsal to neurons for extensor muscles

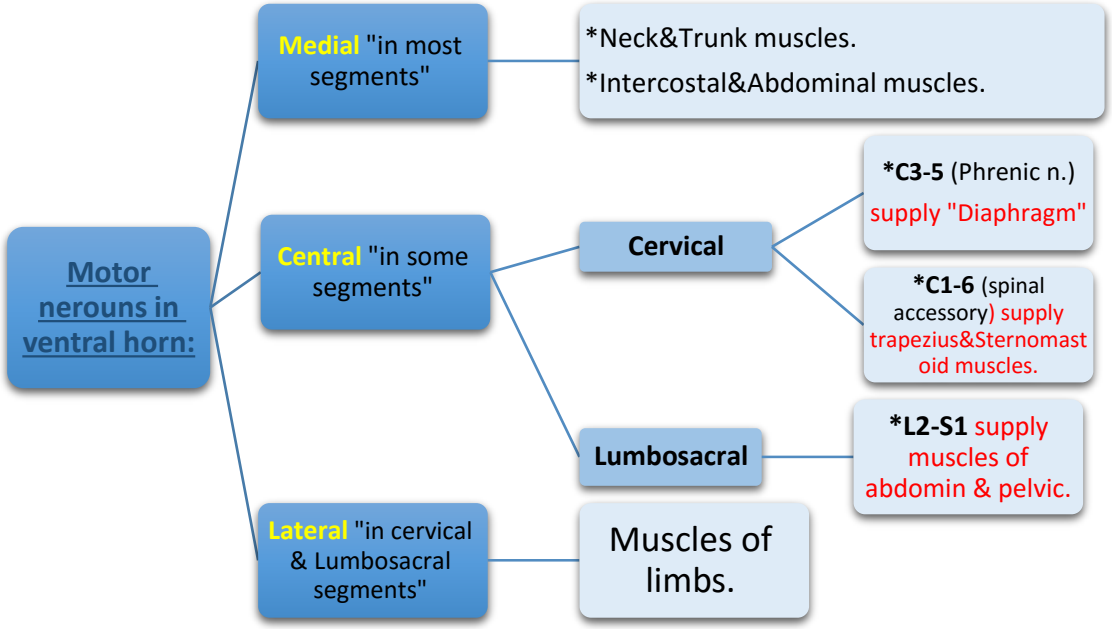
Notes:

- If the **UMN** is not working & **LMN** is working > Nothing will happen.
  B/c the main control is UMN from the brain.

Dr.Najeeb:

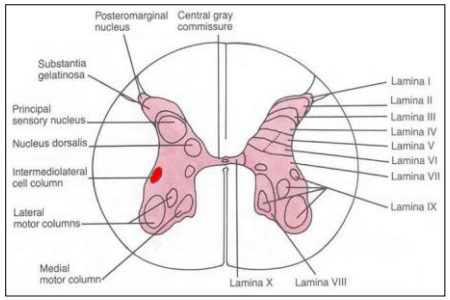
- **UMN lesion > Spastic muscles & Hyper-reflexia.**
- **LMN lesion > paralysis muscles.**

Large cells	Small cells
Numerous	Numerous
Alpha efferents	Gamma efferents
Innervates "Extrafusal muscle fibers"	Innervate "Intrafusal muscle fibers"
Both in the "Ventral horn"	
Both are under influence of "Descending pathways UMN"	



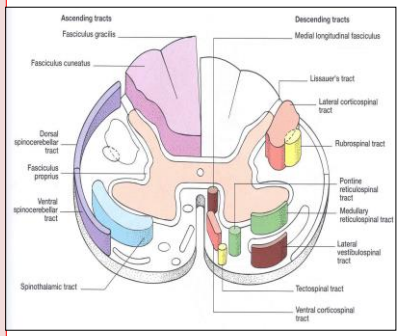
Nerve Cell Groups in Lateral Horn

- Small column composed of small neurons extend from:
- **T1 to L2-3** segments, give rise to pre-ganglionic **sympathetic fibers**
- **S2-4** segments, give rise to preganglionic **parasympathetic fibers**



White Matter

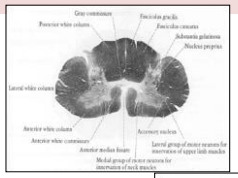
- Consists of mixture of nerve fibers, neuroglia and blood vessels. White color is due to high proportion of myelinated nerve fibers
- Arranged in columns/funiculi; **anterior, posterior and lateral**.
- The nerve fibers are arranged as bundles, running vertically through the cord. A group of nerve fibers (axons) that share a common origin, termination and function form a tract or fasciculus
- Tracts are often named according to their points of origin and destination, e.g. spinothalamic, corticospinal.



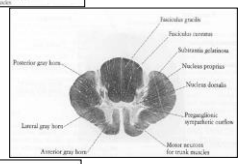
Depending on their function, the spinal tracts are divided into ascending and descending tracts

Regional Differences

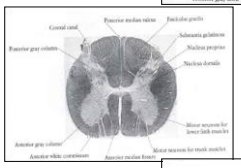
- Although the general pattern of gray matter is the same throughout spinal cord, regional differences are apparent in transverse sections
- The **amount of white matter** increases in a caudal-to-cranial direction because fibers are added to ascending tracts
- The **gray matter** is increased in volume in **cervical & lumbosacral enlargements** for innervation of upper & lower limbs
- The **lateral horn** is characteristics of **thoracic and upper lumbar segments**



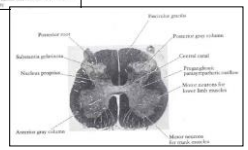
Cervical



Thoracic



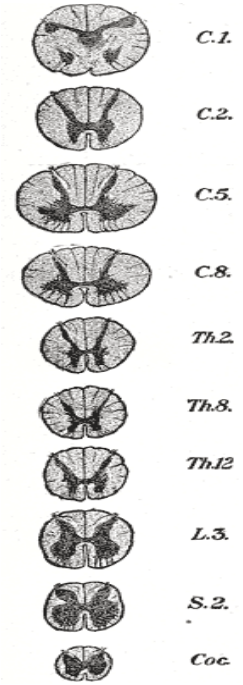
Lumbar



Sacral

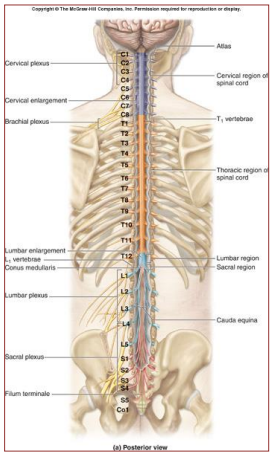
Notes:

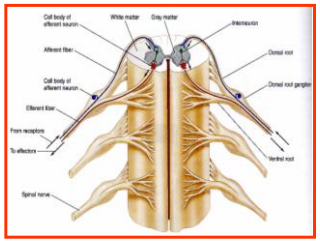
- More White matter > in Cervical region.
- Less White matter > in Sacral region.
- More Gray matter > in cervical & Lumbosacral enlargements.
- Less Gray matter > in Thoracic region.
- More Lateral Horn > is characteristics of thoracic & upper lumbar regions.



Spinal Nerves

- **Thirty-one pairs** of spinal nerves
- First pair exit vertebral column between skull and atlas, last four pair exit via the sacral foramina and others exit through intervertebral foramina
- **Eight pair cervical**, **twelve pair thoracic**, **five pair lumbar**, **five pair sacral**, **one pair coccygeal**
- Each spinal nerve arises as rootlets which then combine to form dorsal (posterior) **purely sensory** & ventral (anterior) **purely motor Roots.**
- Two roots merge laterally and form the spinal nerve.
- Dorsal (posterior) root has a ganglion (dorsal root/sensory ganglion) that contains the cell bodies of the sensory neurons
- Each spinal nerve then divides into a **MIXED smaller dorsal** and a **larger ventral Ramus**



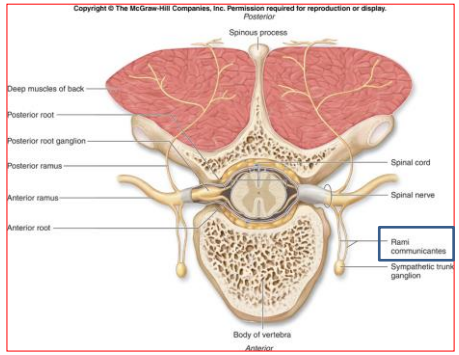


Notes:

- We have 33 vertebra & 31 Spinal nerves.
- We have 7 cervical segments & 8 cervical nerves.

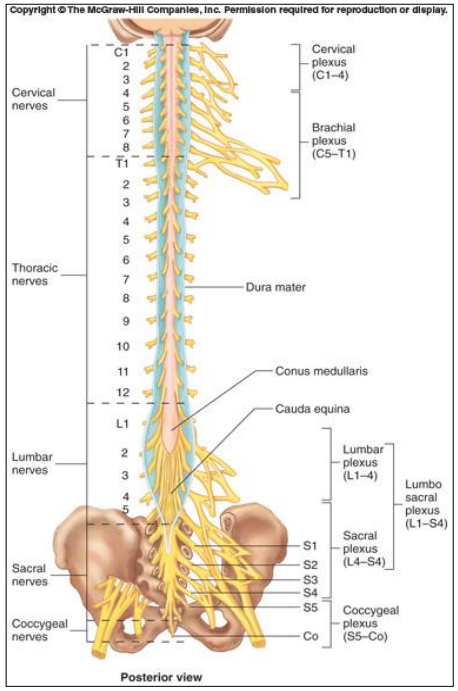
Branches of Spinal Nerves

- **Dorsal Rami** innervate:
  - Deep muscles of the trunk responsible for movements of the vertebral column
  - Skin near the midline of the back.
- **Ventral Rami**:
  - In the thoracic region form **intercostal nerves** that innervate the intercostal muscles and the skin over the thorax
  - Remaining ventral rami form **five plexuses:**
    - C1 - C4= **Cervical** plexus
    - C5 - T1= **Brachial** plexus
    - L1 - L4= **Lumbar** plexus
    - L4 - S4= **Sacral** plexus
    - S5 & Co= **Coccygeal** plexus



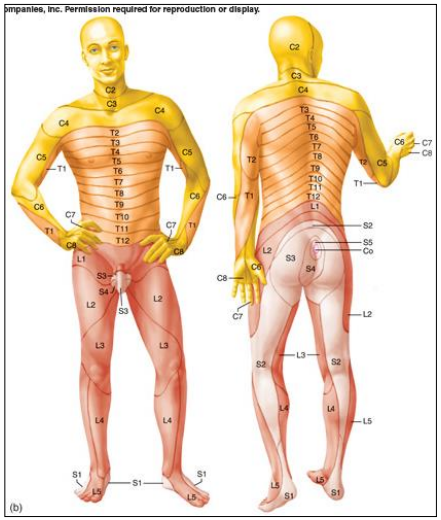
The spinal nerves are connected to sympathetic chain of ganglia by **communicating rami**

Dorsal Rami	Ventral Rami
• **Deep muscles of the trunk.** • **Responsible for movements of the vertebral column.** • **Skin near the midline of the back.**	**Intercostal nerves** that innervate: • Intercostal muscles. • Skin over the thorax. **Plexuses：** C1 - C4= Cervical plexus C5 - T1= Brachial plexus L1 - L4= Lumbar plexus L4 - S4= Sacral plexus S5&Co= Coccygeal plexus



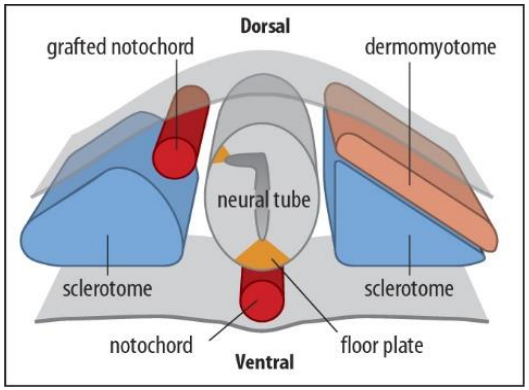
Dermatomes

- 'Dermatome' is a **segment** of skin supplied by a specific segment of the spinal cord (**segmental spinal nerve)**
- Cutaneous areas supplied by adjacent spinal nerves overlap. There is therefore little or no sensory loss after interruption of a single spinal nerve or dorsal root



Notes:

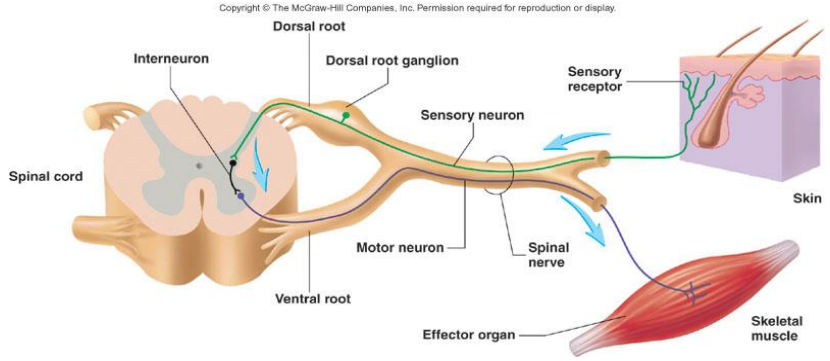
- Dermatome: related to skin.
- Myotome: related to muscles.



Reflex & Reflex Arc

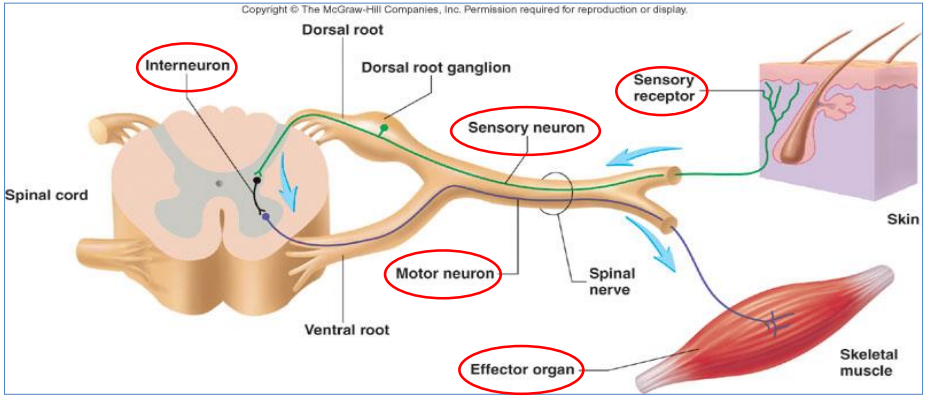
A reflex is a rapid, involuntary, predictable response brought by a **sensory stimulus**

The neural pathway mediating the reflex actions is called reflex arc.



Components of a Reflex Arc

Action potentials produced in **Sensory receptor** → **Sensory neuron** → **Interneuron** → **Motor neuron** → **Effector organ** which responds with a **reflex**



Variety of Reflexes

- Some integrated within spinal cord; some within brain
- Some involve excitatory neurons yielding a response; some involve inhibitory neurons that prevent an action
- Higher brain centers can influence, suppress, or exaggerate reflex responses