

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

Anatomy of the Spinal Cord

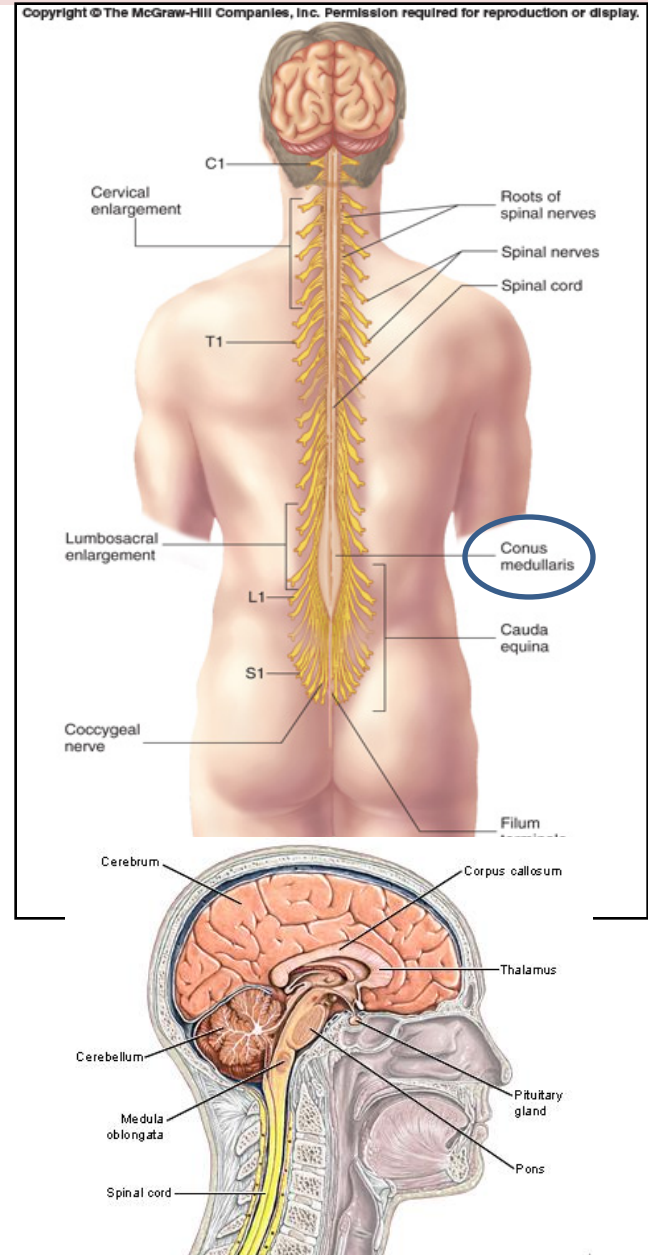
DR JAMILA EL MEDANY

OBJECTIVES

- *At the end of the 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.
- Define a reflex and reflex arc. Describe the components of the reflex arc.

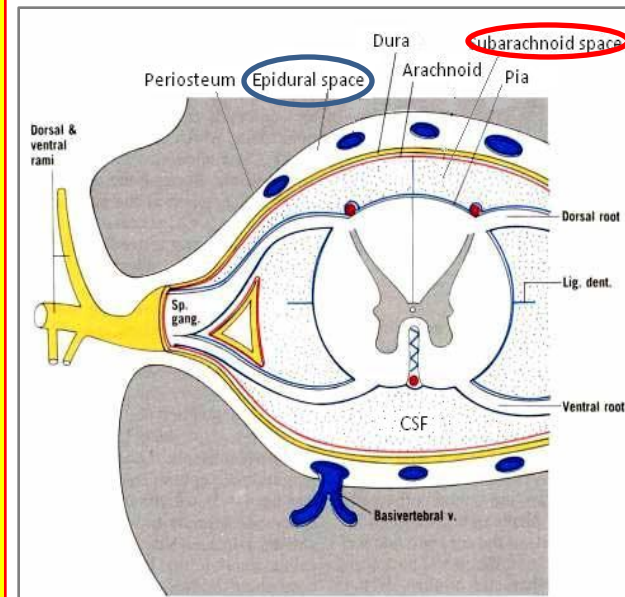
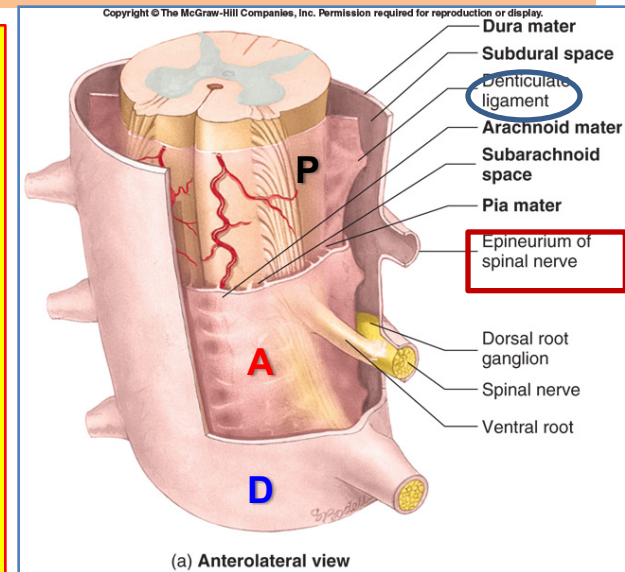
Spinal Cord

- 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**

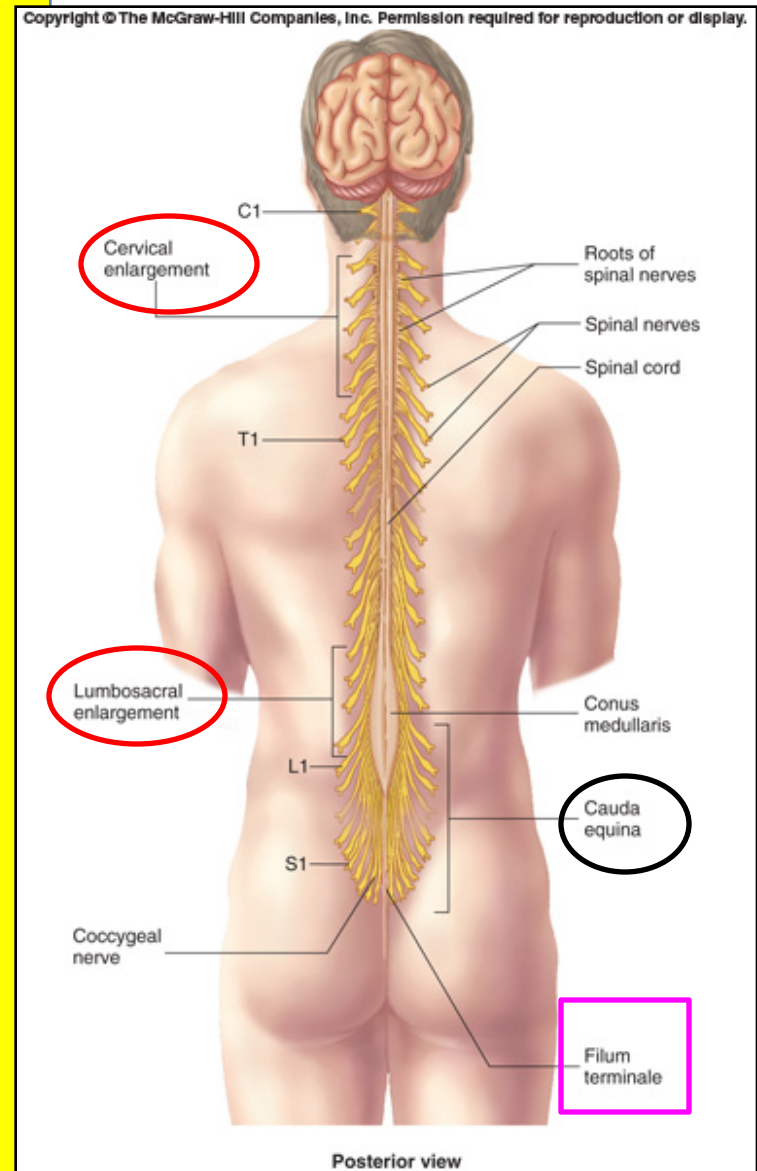


Spinal Meninges

- 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



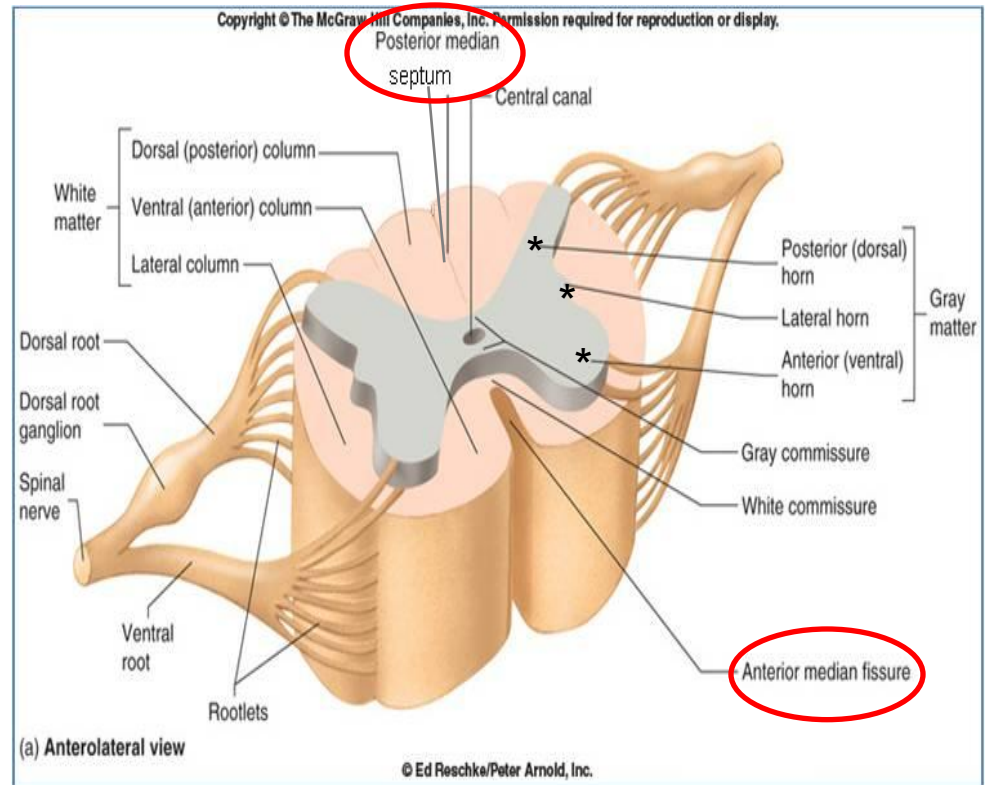
- The spinal cord is a **Segmented** structure, has
 - **Cervical**
 - **Thoracic**
 - **Lumbar**
 - **Sacral** segments
- Not uniform in diameter,
- Has **two enlargements**:
 - **Cervical enlargement**: supplies upper limbs
 - **Lumbosacral enlargement**: supplies lower limbs
- The bundle of spinal 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)



Cross Section of Spinal Cord

The spinal cord is:

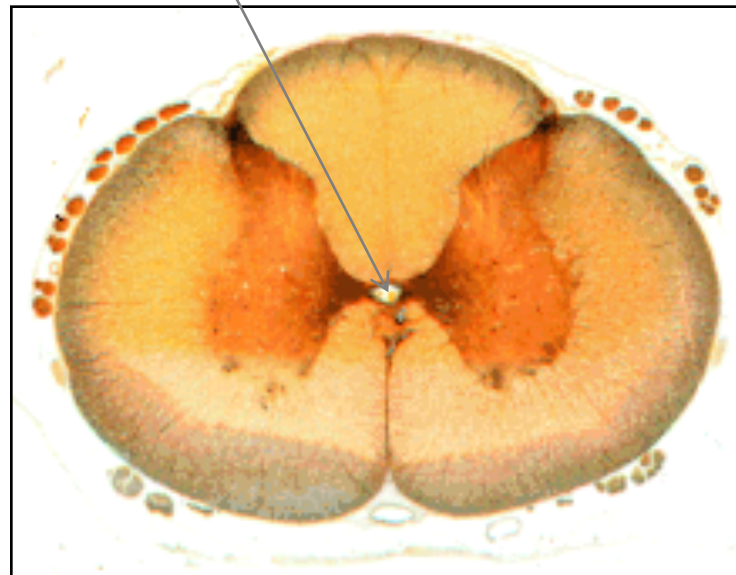
- Incompletely divided into two equal parts,
 - **anteriorly** by a short, shallow **median fissure** and
 - **posteriorly** by a deep narrow septum, the **posterior median septum**.
- Composed of **grey matter** in the centre surrounded by **white matter**



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



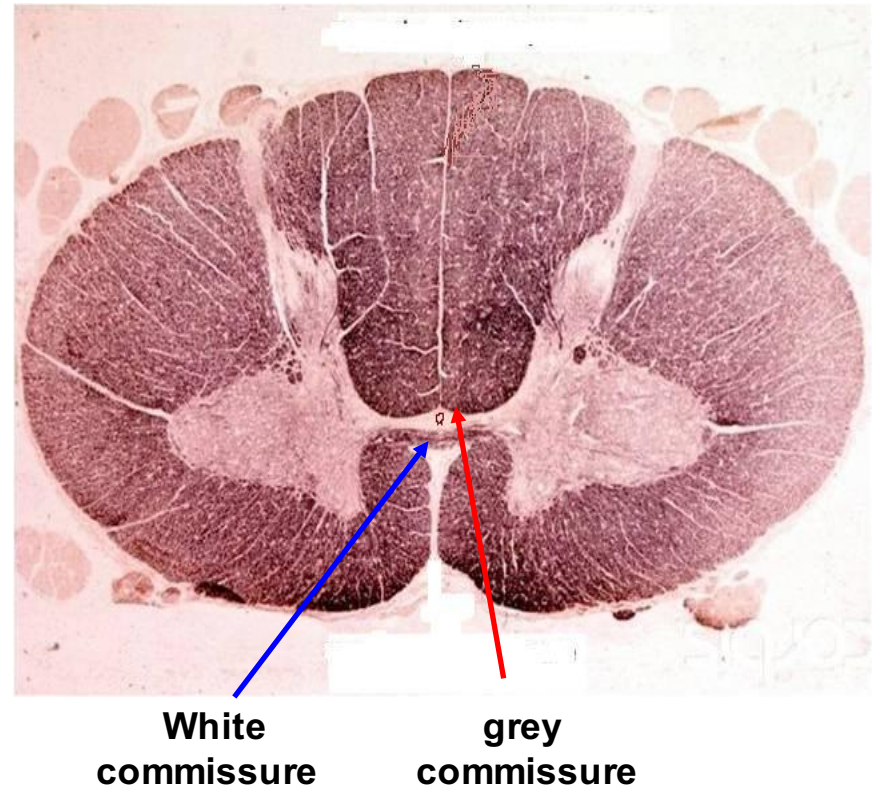
Commissures of the Spinal Cord

Grey commissure:

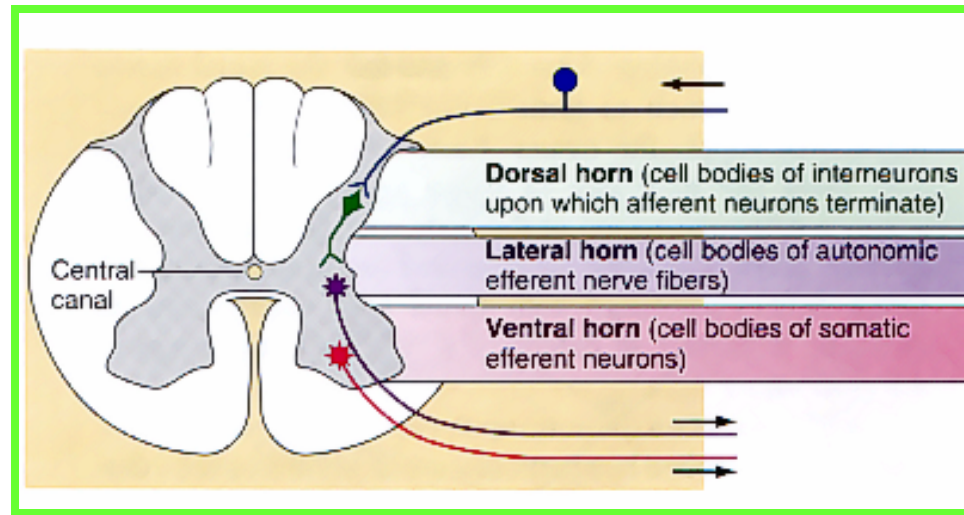
- A transverse bridge of grey matter connecting the anterior and posterior gray horns on each side
- Is pierced by the **central canal** that divides it into anterior and posterior parts

White Commissure:

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



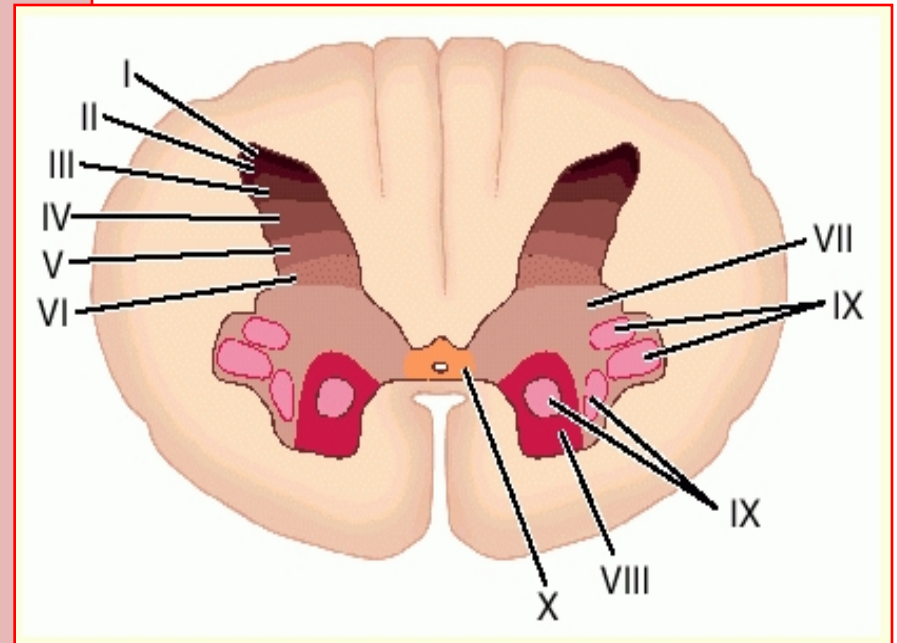
Grey matter



- 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.

Neuronal Architecture of Spinal Grey Matter

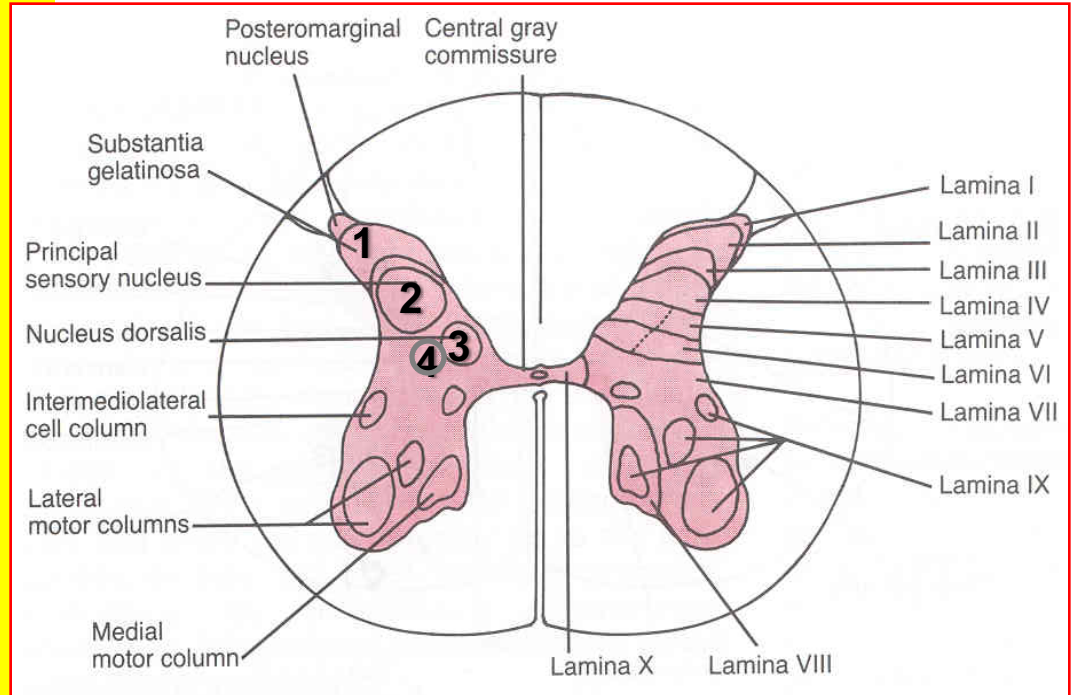
- Cells of the same type are clustered into groups, which occur in **long columns**
- In transverse section, these columns appear as **layers**, especially within the dorsal horn
- These layers are called the **Laminae of Rexed**, that are numbered consecutively by **Roman numerals**, starting from the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



Nerve Cell Groups in Dorsal Horn

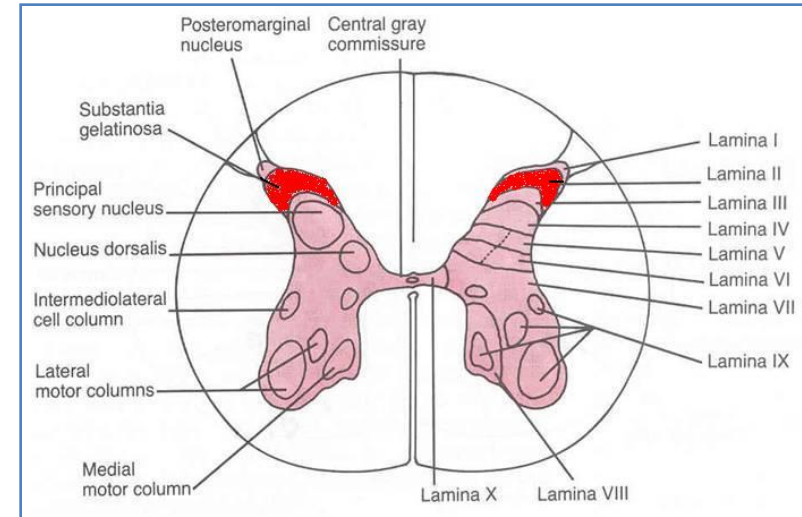
4 main groups

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



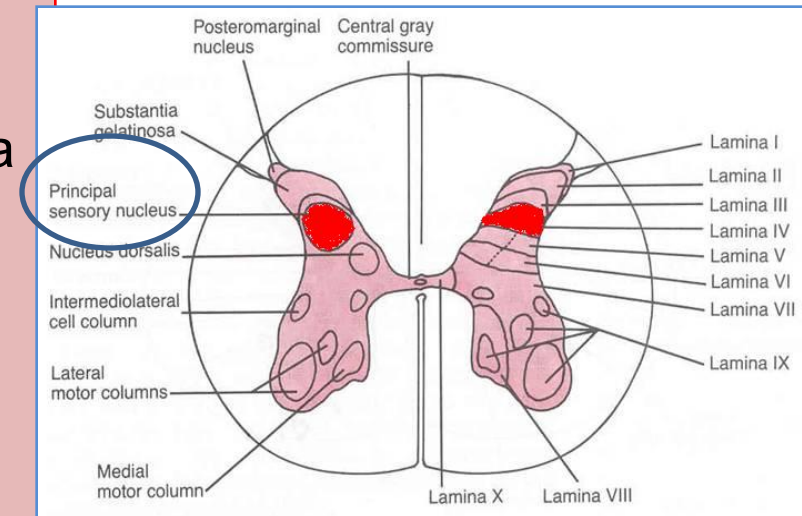
Substantia Gelatinosa

- 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**



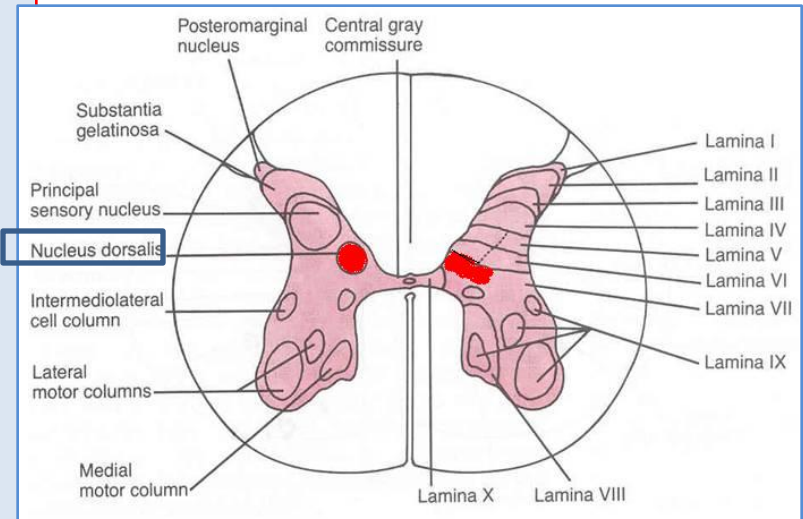
Nucleus Proprius

- 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 discrimination & vibration**



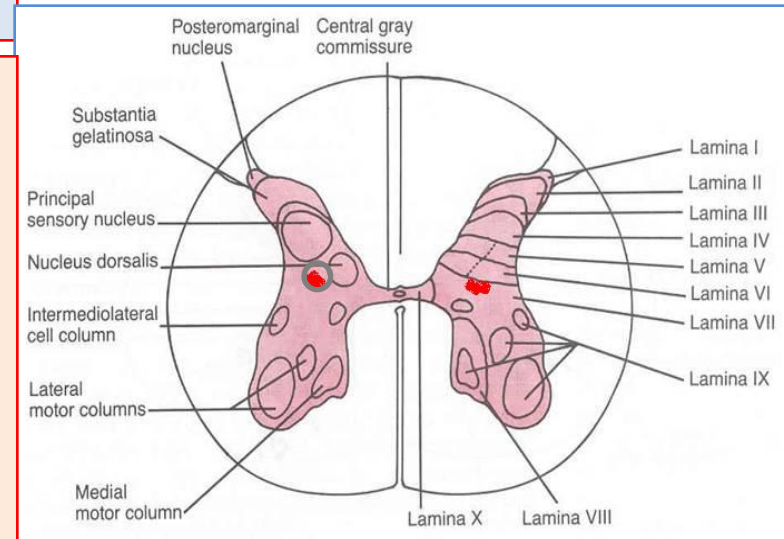
Nucleus Dorsalis (Clark's column, Nucleus thoracis)

- 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

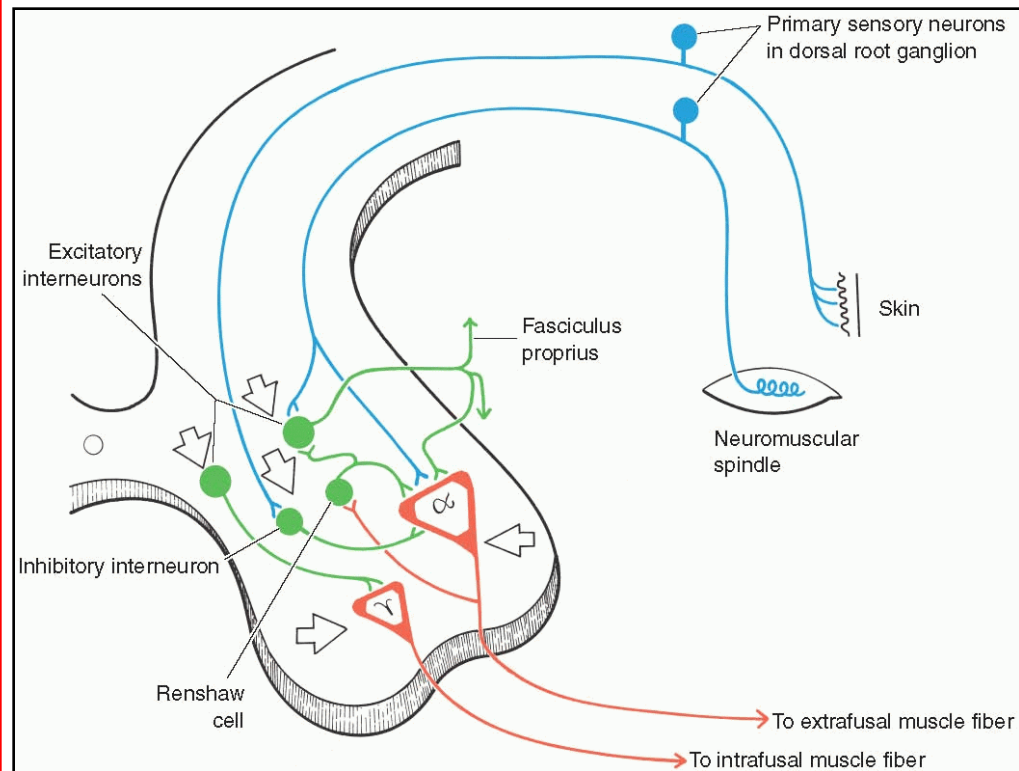
- Rexed Lamina VII
- Located lateral to nucleus dorsalis
- Composed mostly of **medium size neurons**
- Extends from T1 to L3 segments
- Afferents: **Visceral afferents**



Nerve Cell Groups in Ventral Horn

The ventral horns contain:

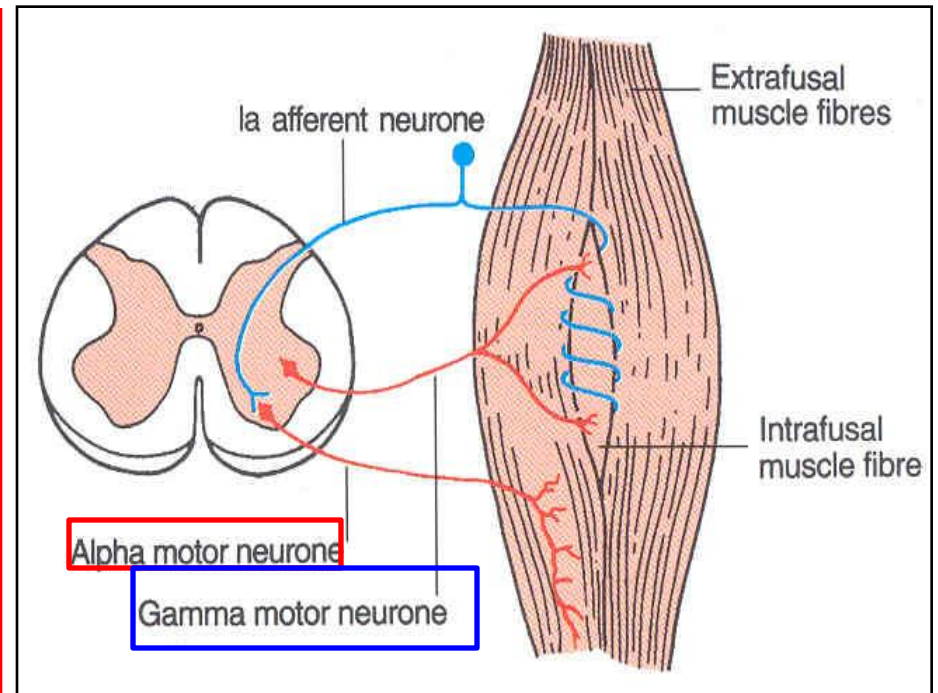
1. **Motor neurons**, also called **lower motor neurons**.
2. **Interneurons**, the (**Renshaw cells**), whose branched axons form **inhibitory** synaptic junctions on motor neurons



Types of Motor Neurons in Ventral Horn

Are of Two types

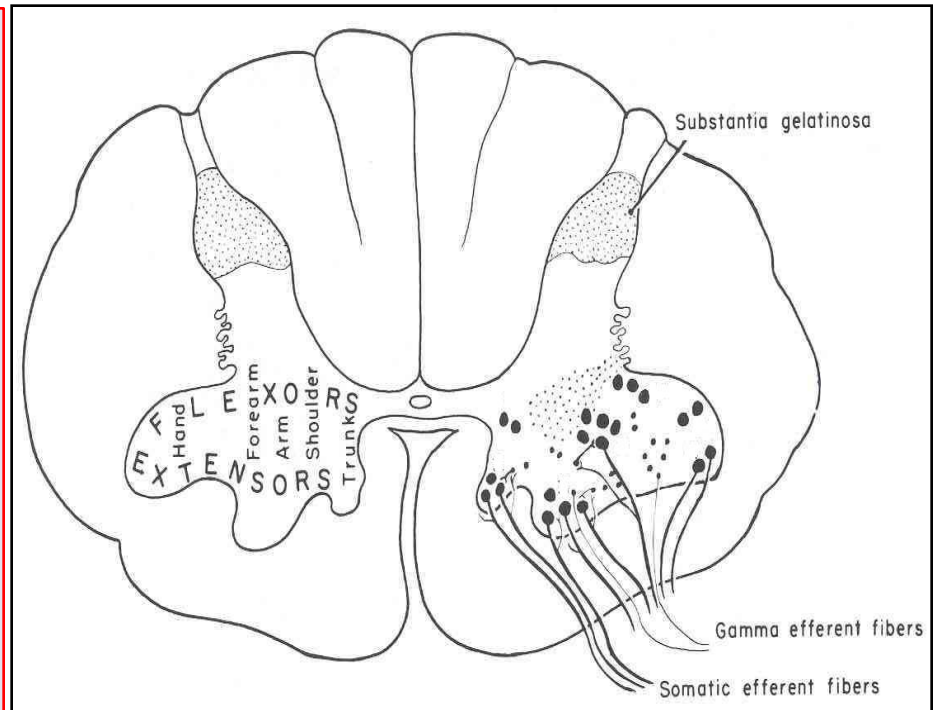
- **Large multipolar cells**
 - **Numerous**
 - Axons pass out in the ventral roots of spinal nerves as **alpha** efferents
 - Innervate **extrafusal muscle fibers**
- **Smaller multipolar cells**
 - **Less numerous**
 - Axons pass out in the ventral roots of spinal nerves as **gamma** efferents
 - Innervate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

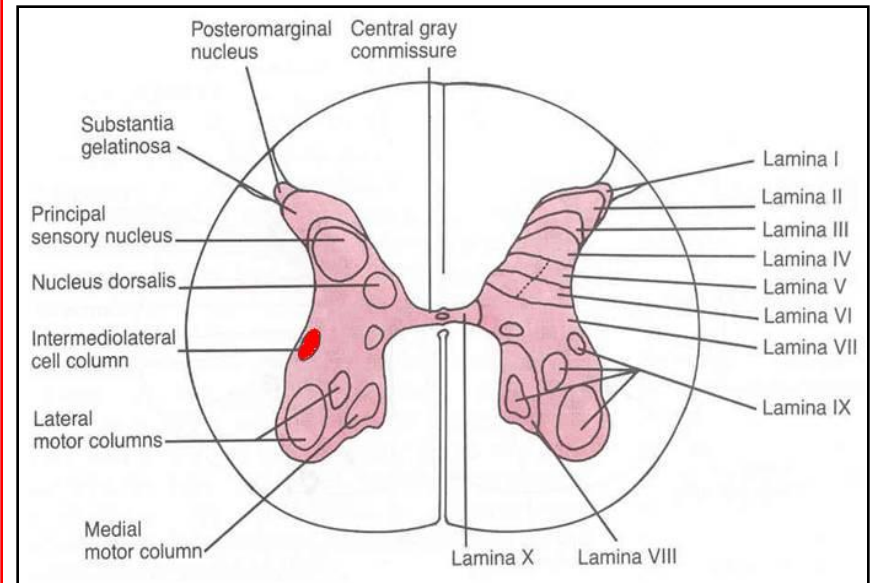
- Motor neurons are organized in **3 groups**:
- **Medial:**
 - present in **most segments**
 - Innervate muscles of **Neck and Trunk** (including intercostal and abdominal muscles)
- **Central:**
 - smallest,
 - present in some segments: **cervical** (phrenic C3-5, spinal accessory C1-6) and **lumbosacral**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

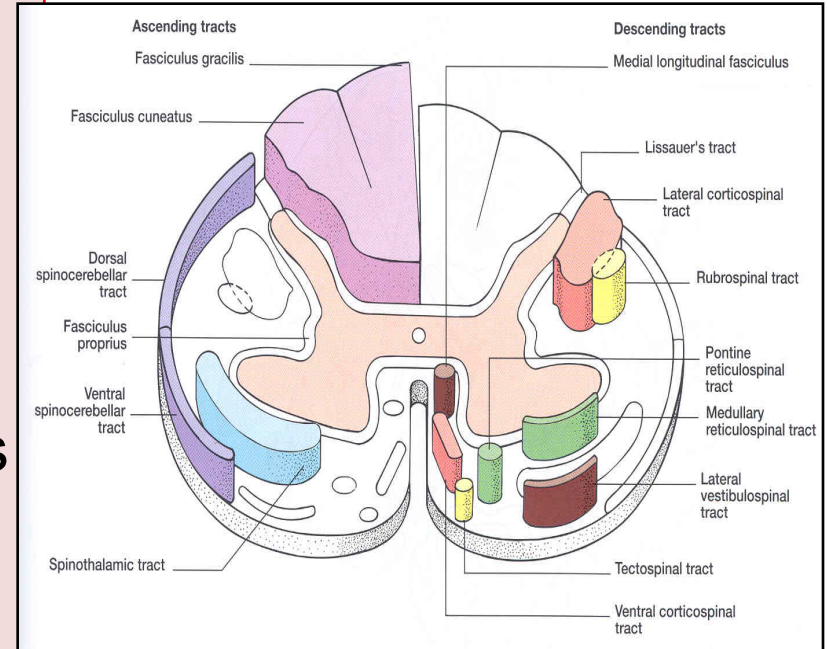
Nerve Cell Groups in Lateral Horn

- 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

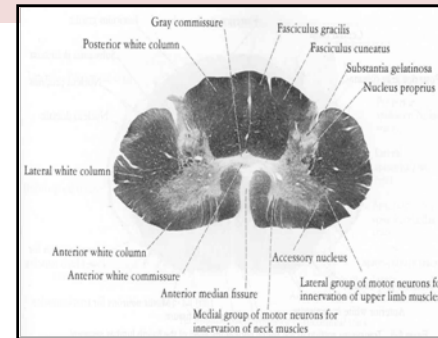
- Consists of mixture of **nerve fibers**, **neuroglia** and **blood vessels**. White color is due to high proportion of **myelinated nerve fibers**
- Arranged in columns/funiculi; **anterior, posterior and lateral**.
- The nerve fibers are arranged as bundles, running vertically through the cord. A 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.



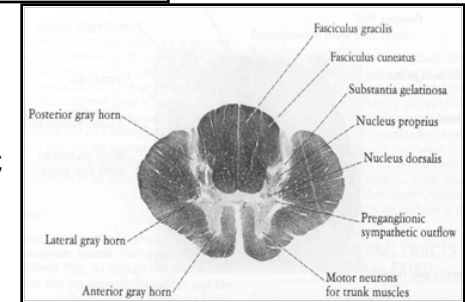
Depending on their function, the spinal tracts are divided into ascending and descending tracts

Regional Differences

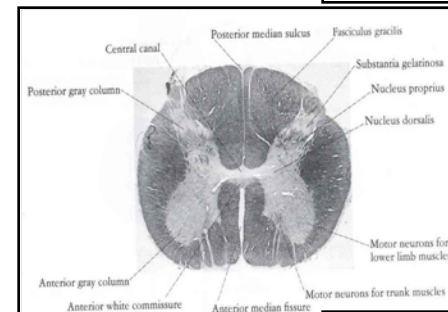
- Although the general pattern of gray matter is the same throughout spinal cord, **regional differences** are apparent in transverse sections
- The **amount of white matter** increases in a caudal-to-cranial direction because fibers are added to ascending tracts
- The **gray matter** is increased in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



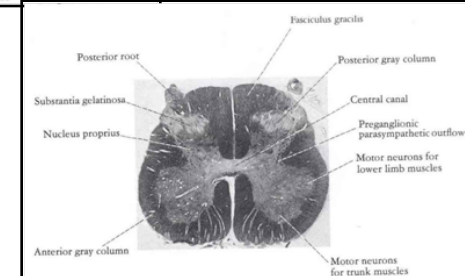
Cervical



Thoracic



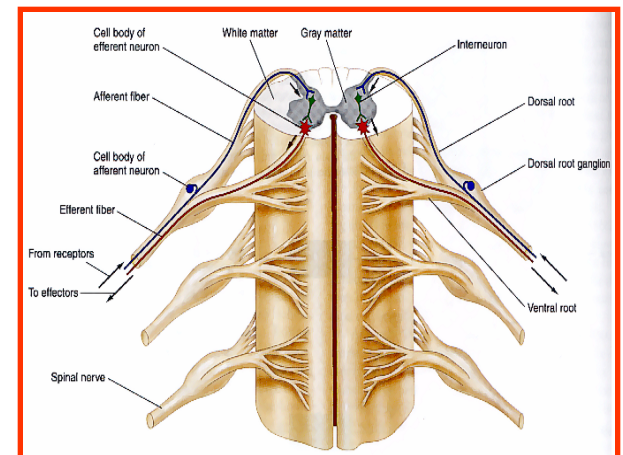
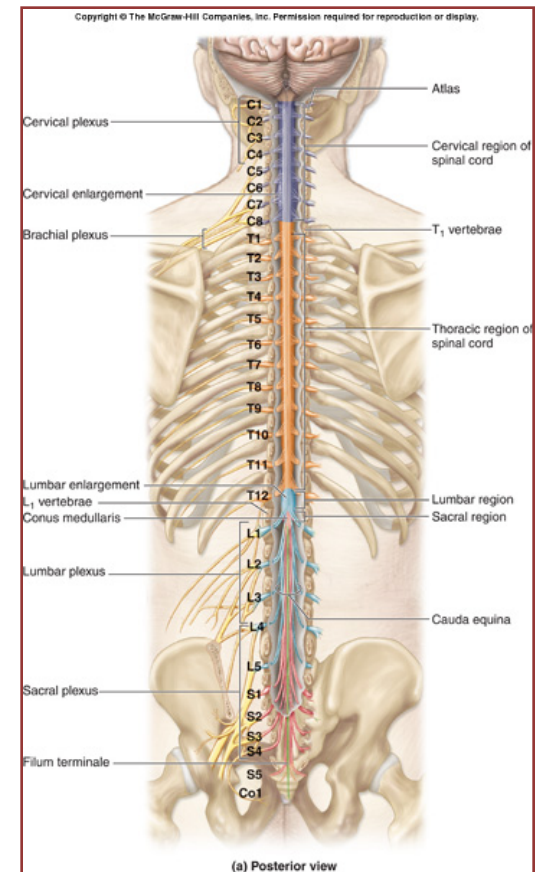
Lumbar



Sacral

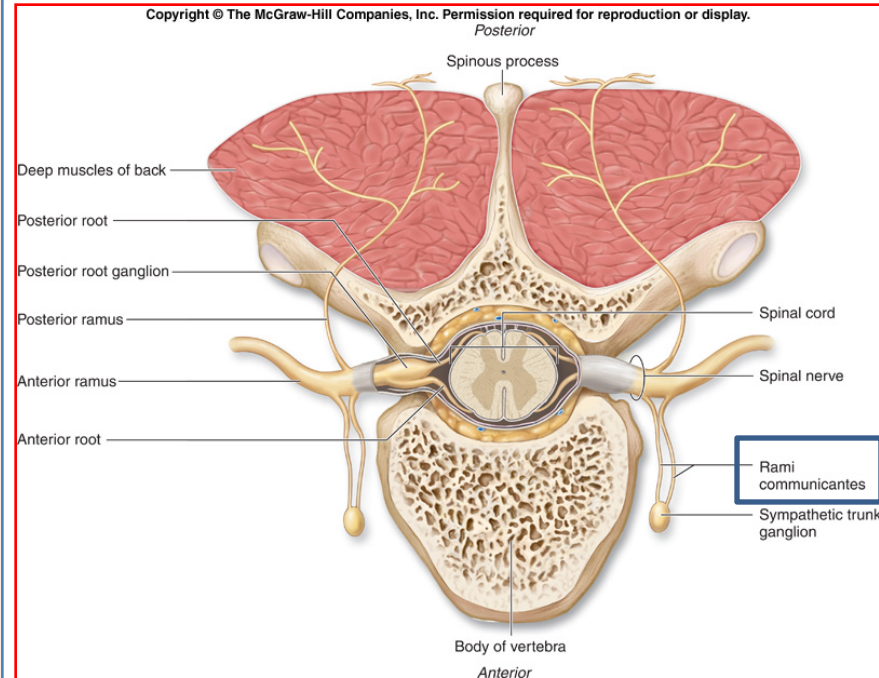
Spinal Nerves

- **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**

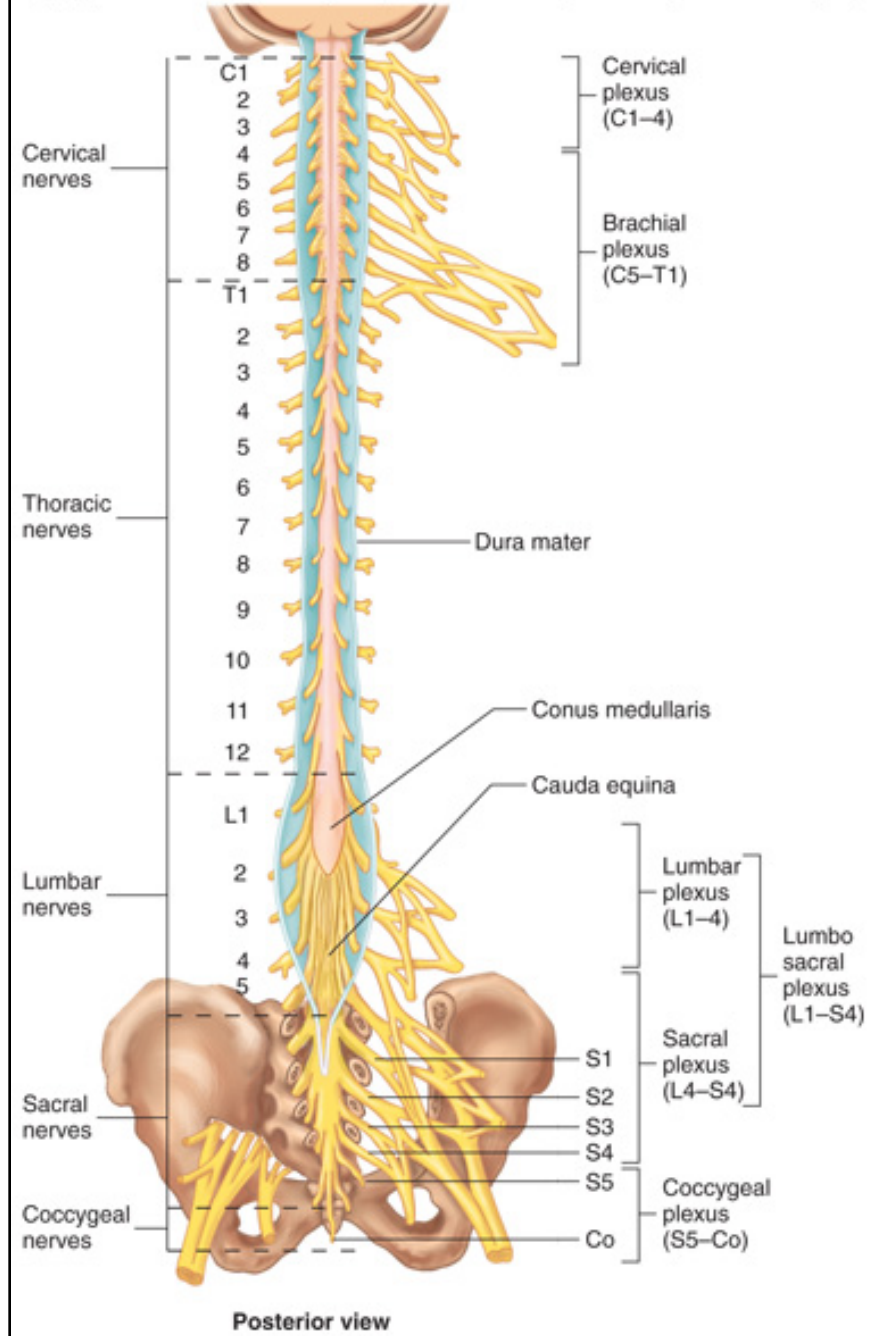


Branches of Spinal Nerves

- **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

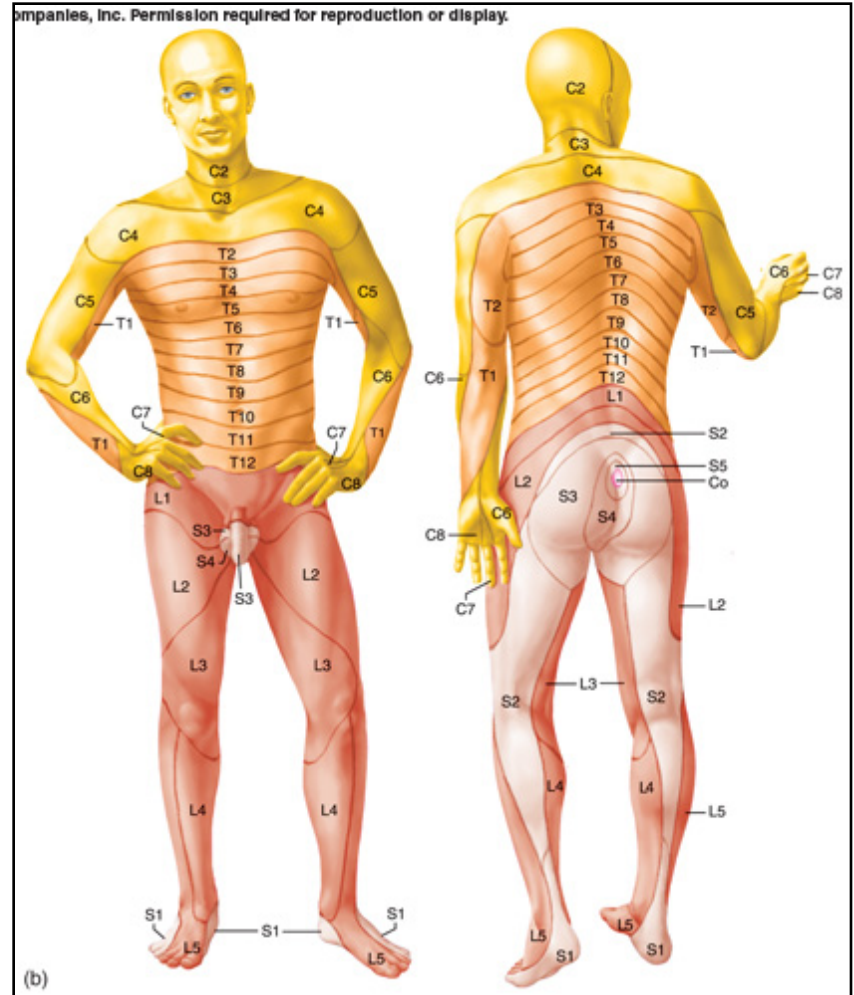


The spinal nerves are connected to sympathetic chain of ganglia by **communicating rami**



Dermatomes

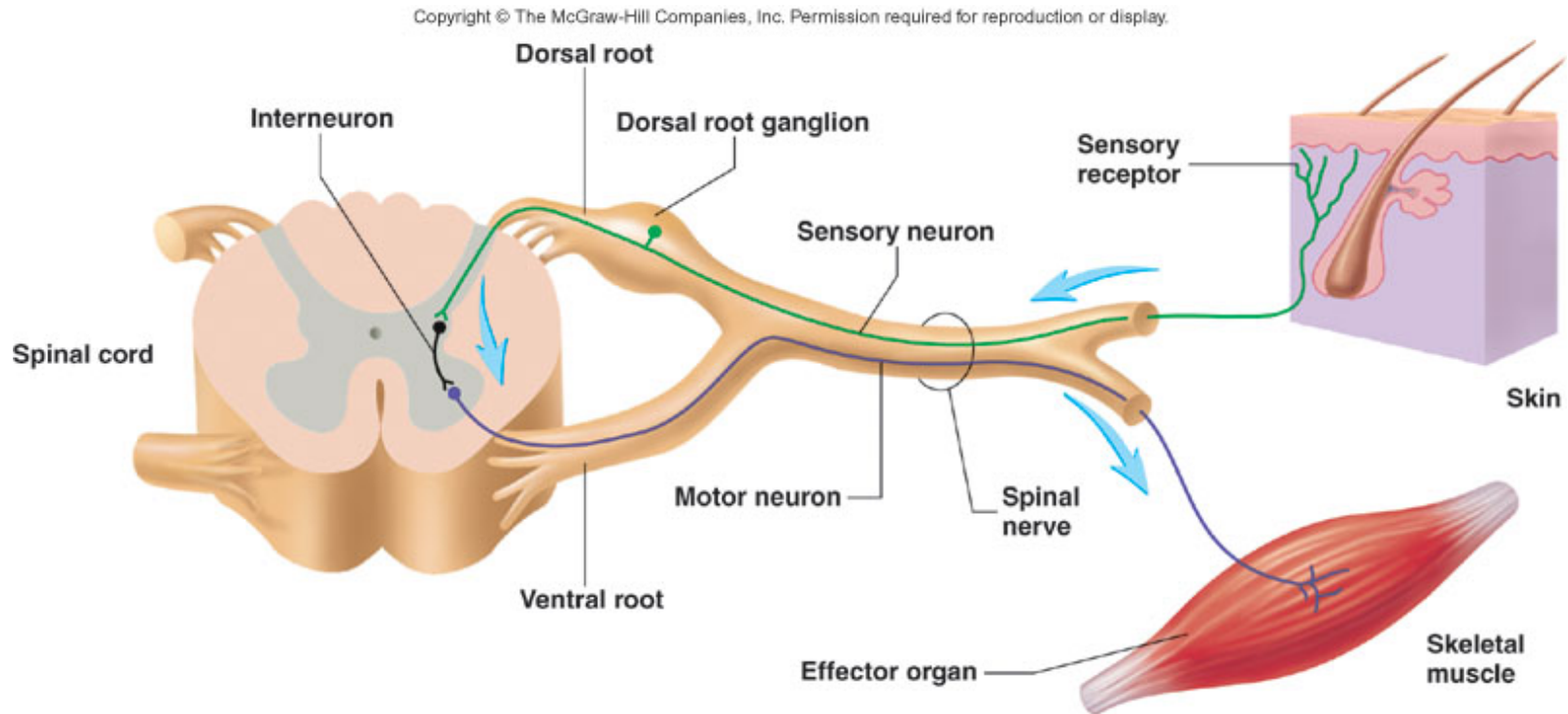
- ‘Dermatome’ is a **segment** of skin supplied by a specific segment of the spinal cord (**segmental spinal nerve**)
- Cutaneous areas supplied by adjacent spinal nerves **overlap**. There is therefore little or no sensory loss after interruption of a single spinal nerve or dorsal root



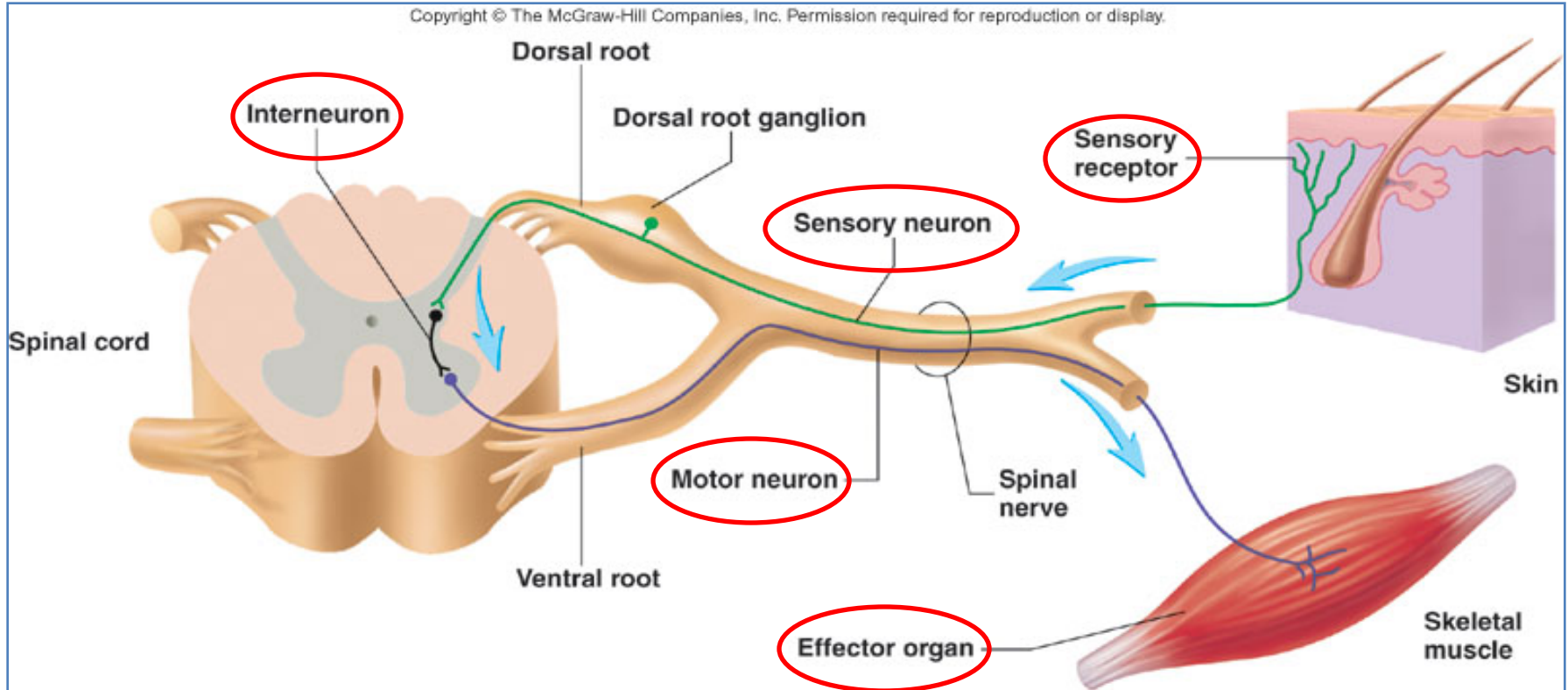
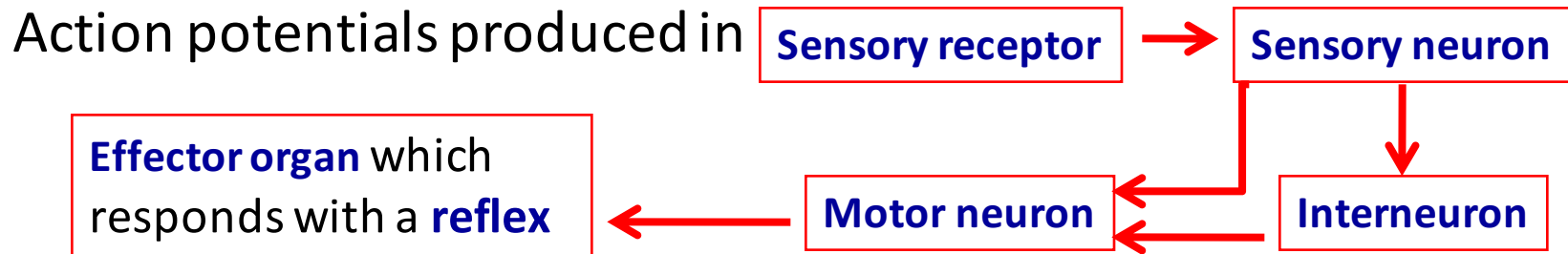
Reflex & Reflex Arc

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



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

Thank You