

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

Anatomy of the Spinal Cord

DR JAMILA EL MEDANY

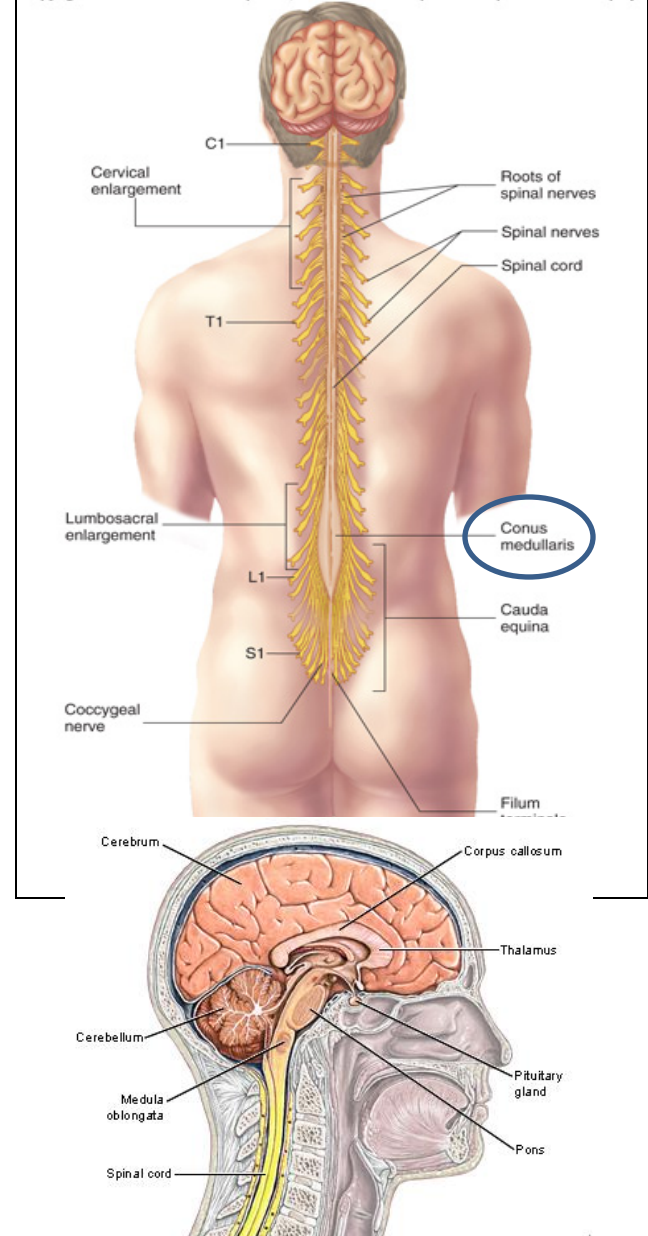
OBJECTIVES

- *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**

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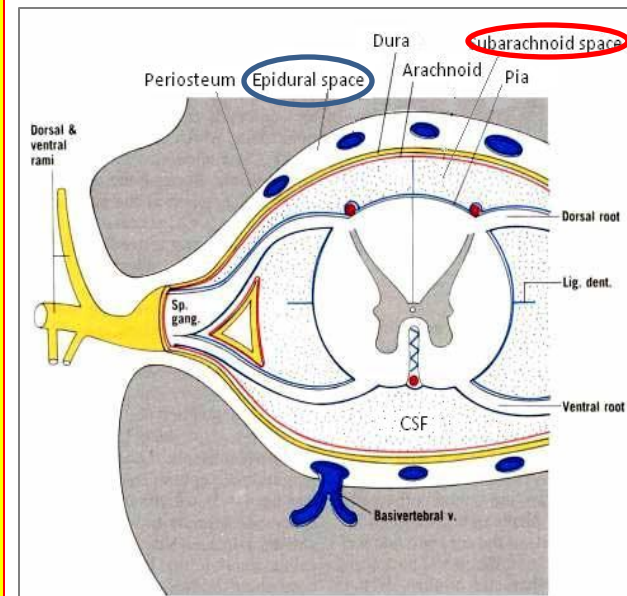
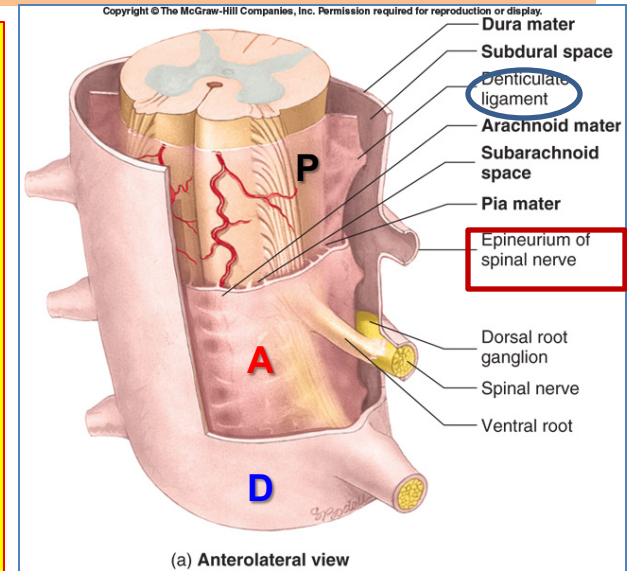


Spinal Meninges

- **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

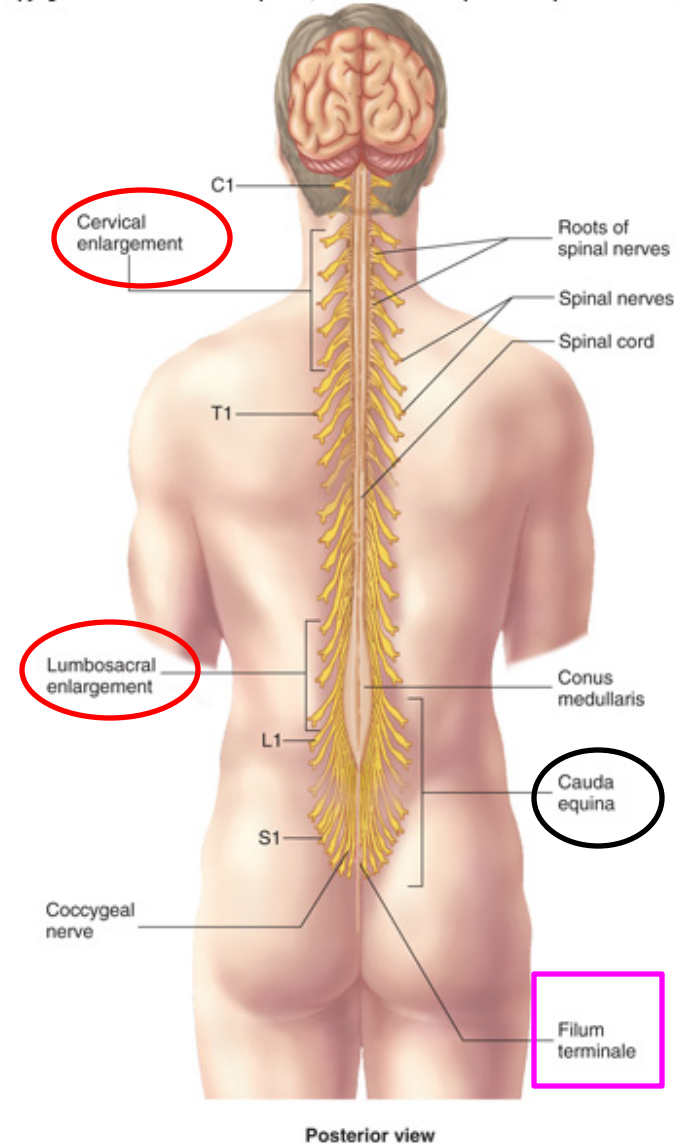
• Spaces

- **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**

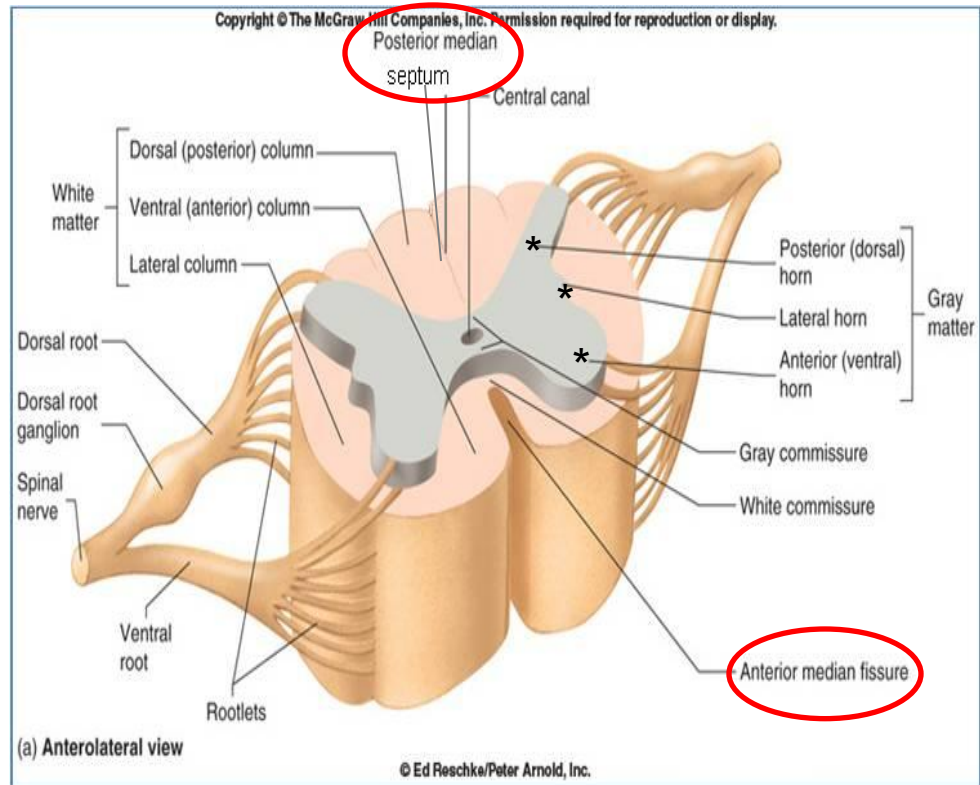
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Cross Section of Spinal Cord

The spinal cord is:

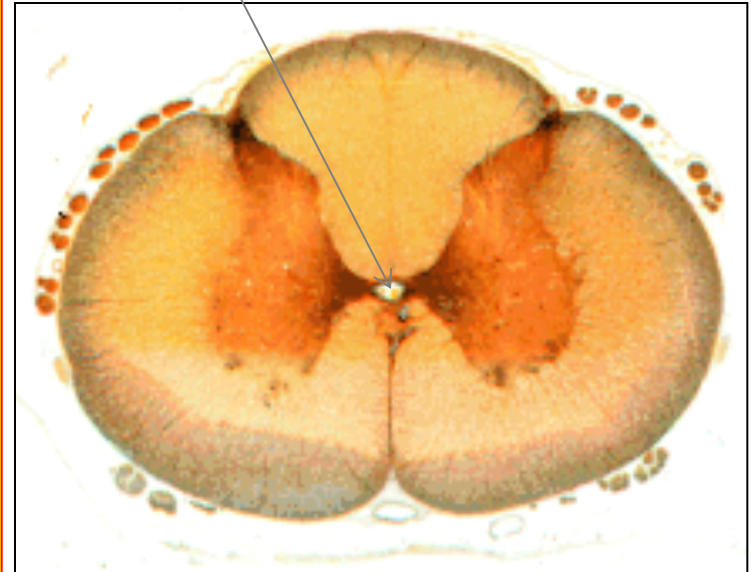
- Incompletely divided into two equal parts,
 - **anteriorly** by a short, shallow **median fissure** and
 - **posteriorly** by a deep narrow **septum**, the **posterior median septum**.
- **Composed of grey matter in the centre surrounded by white matter**



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



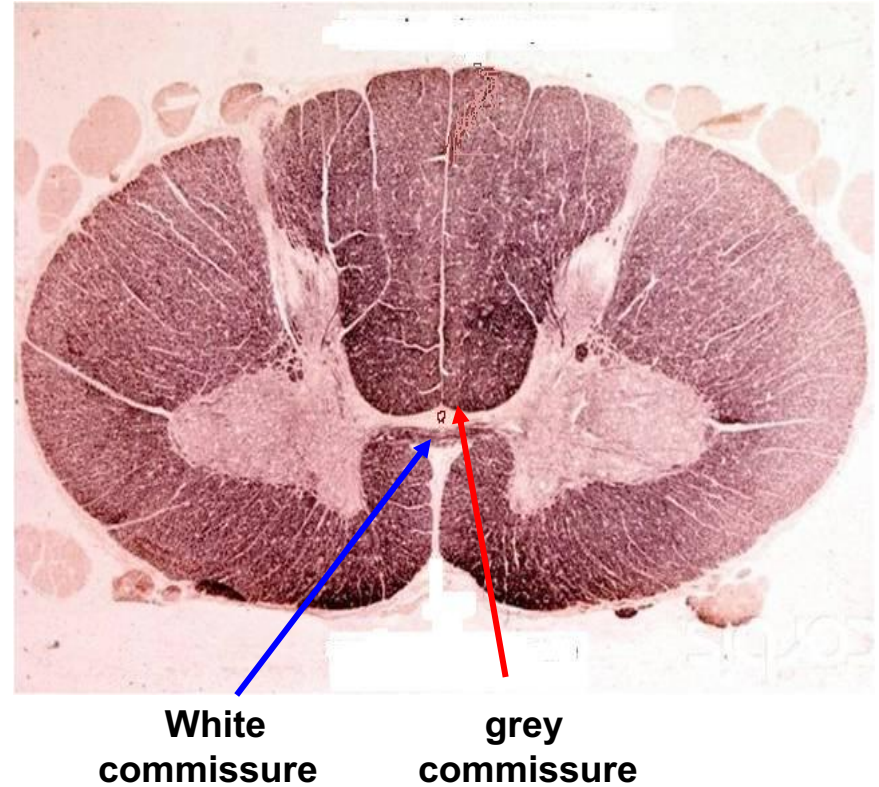
Commissures of the Spinal Cord

Grey commissure:

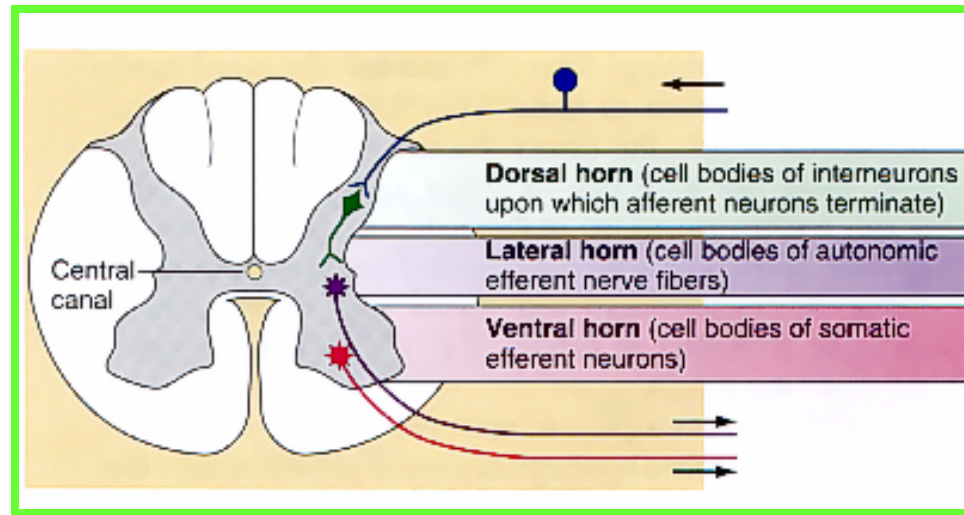
- A transverse bridge of grey matter connecting the anterior and posterior gray horns on each side
- Is pierced by the **central canal** that divides it into anterior and posterior parts

White Commissure:

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



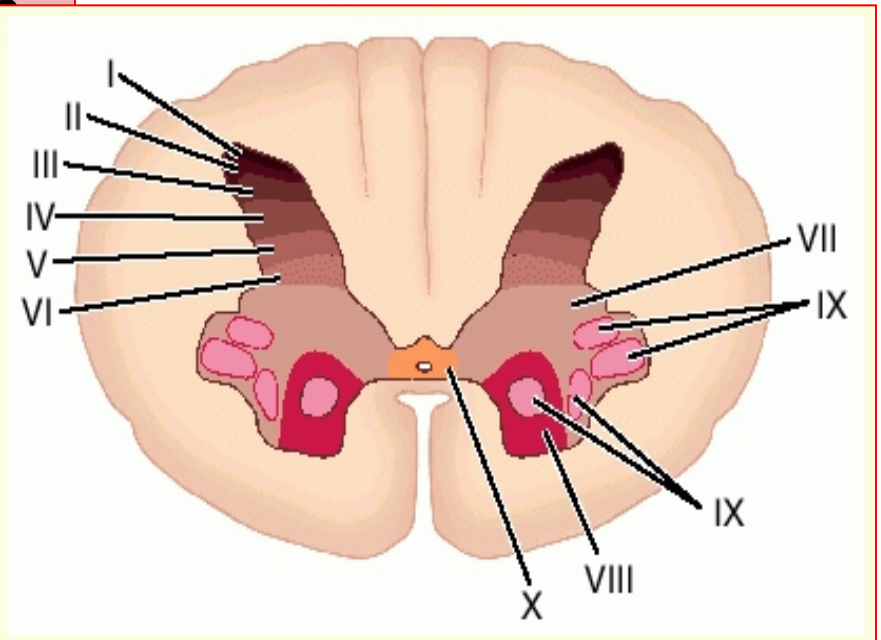
Grey matter



- **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

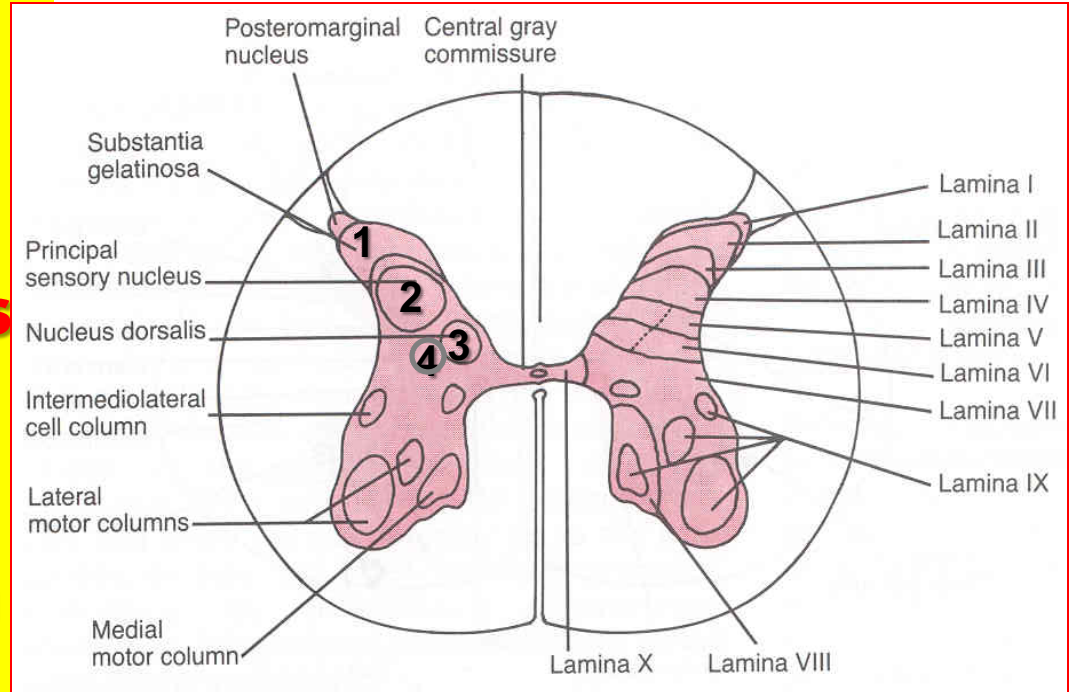
- Cells of the same type are clustered into groups, which occur in **long columns**
- In transverse section, these columns appear as **layers**, especially within the dorsal horn
- These layers are called the **Laminae of Rexed**, that are numbered consecutively by **Roman numerals**, starting from the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



Nerve Cell Groups in Dorsal Horn

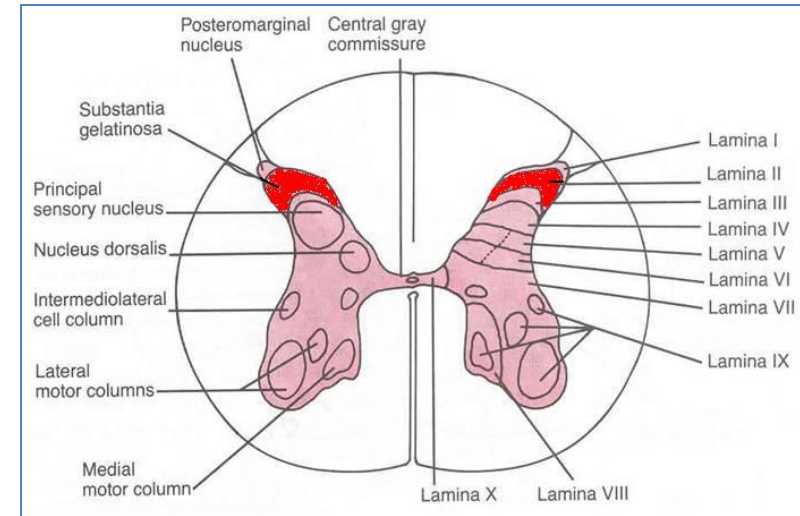
4 main groups

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



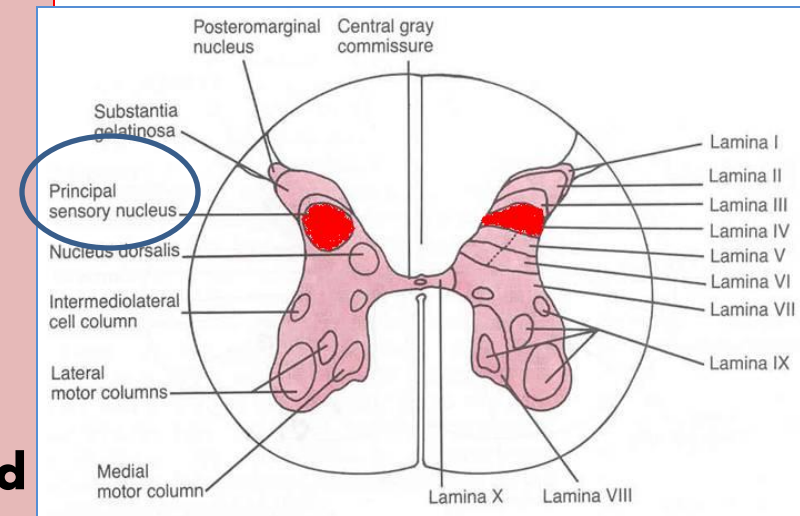
Substantia Gelatinosa

- **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.**



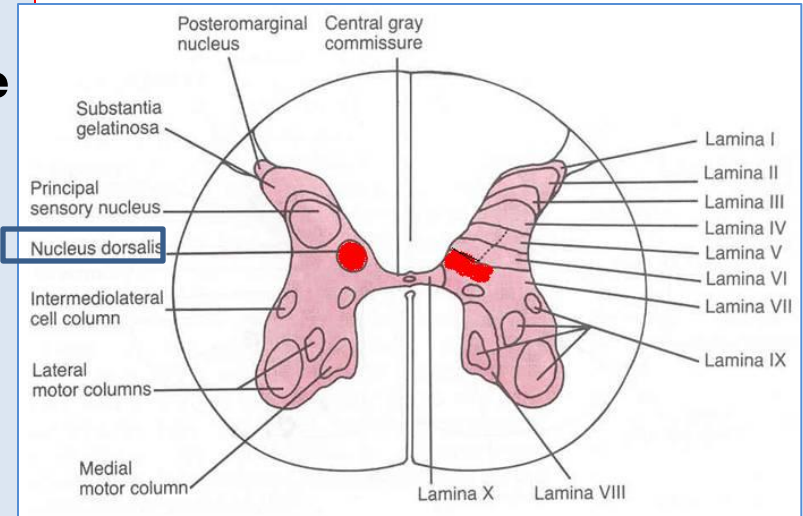
Nucleus Proprius (nucleus centralis) principal sensory nucleus

- **Rexed Lamina I** Located anterior to substantia gelatinosa
- **Composed of large neurons**
- **Extends throughout the length of spinal cord**
- **Afferents: dorsal root fibers concerned with half sense of Crude Touch.**



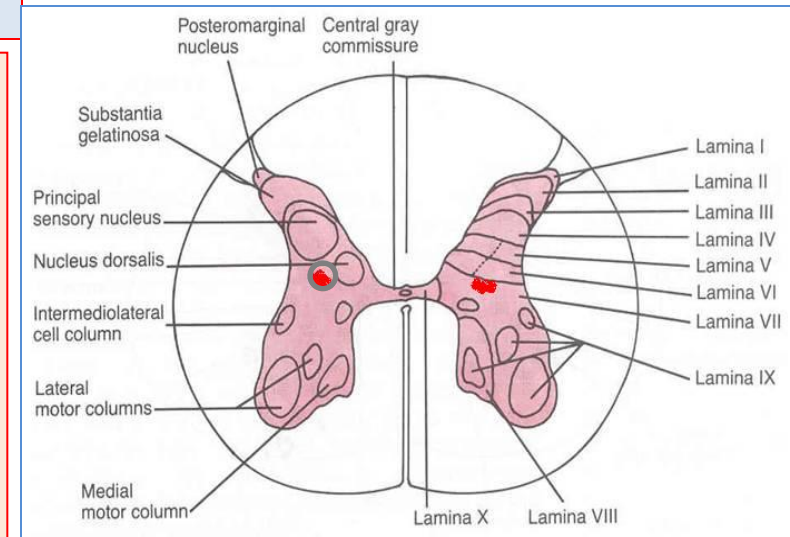
Nucleus Dorsalis (Clark's column, Nucleus thoracicus)

- **Rexed Lamina 1V** 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 V** Located lateral to nucleus dorsalis
- **Composed mostly of medium size neurons**
- **Extends from T1 to L3 segments**
- **Afferents: Visceral afferent information.**



Nerve Cell Groups in Ventral Horn

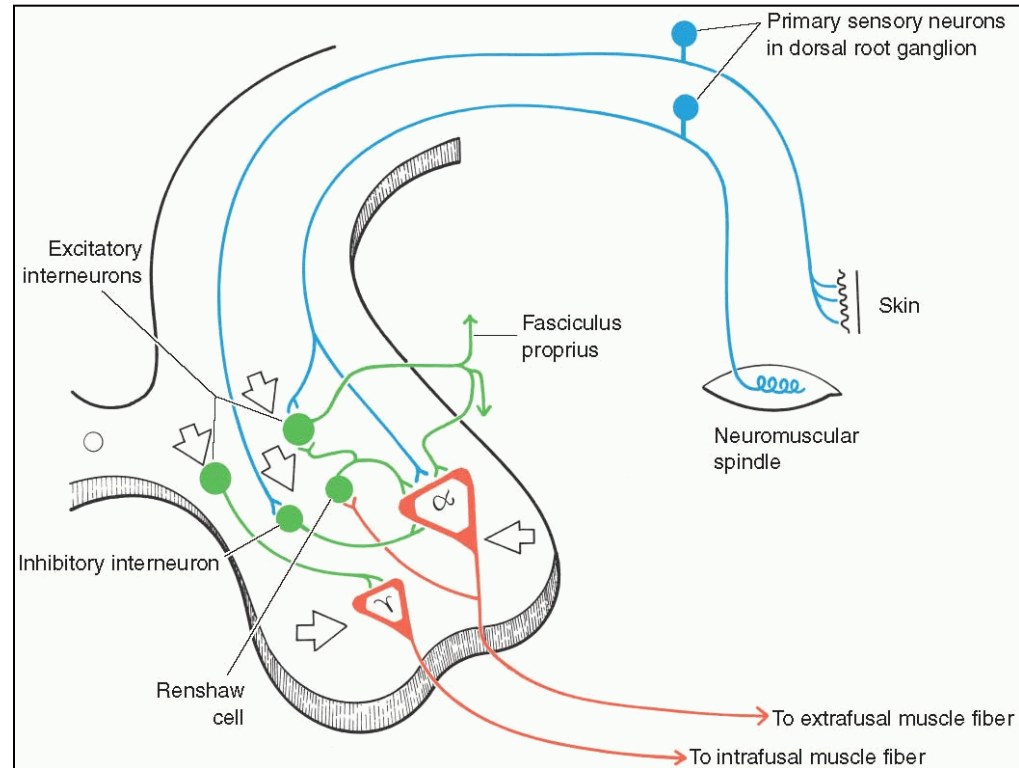
The ventral horns contain:

1. **Motor neurons, also called lower motor neurons.**

2. **Interneurons:**

Renshaw cells, whose branched axons form **Inhibitory synaptic junctions on motor neurons.**

• **Excitatory interneurons**



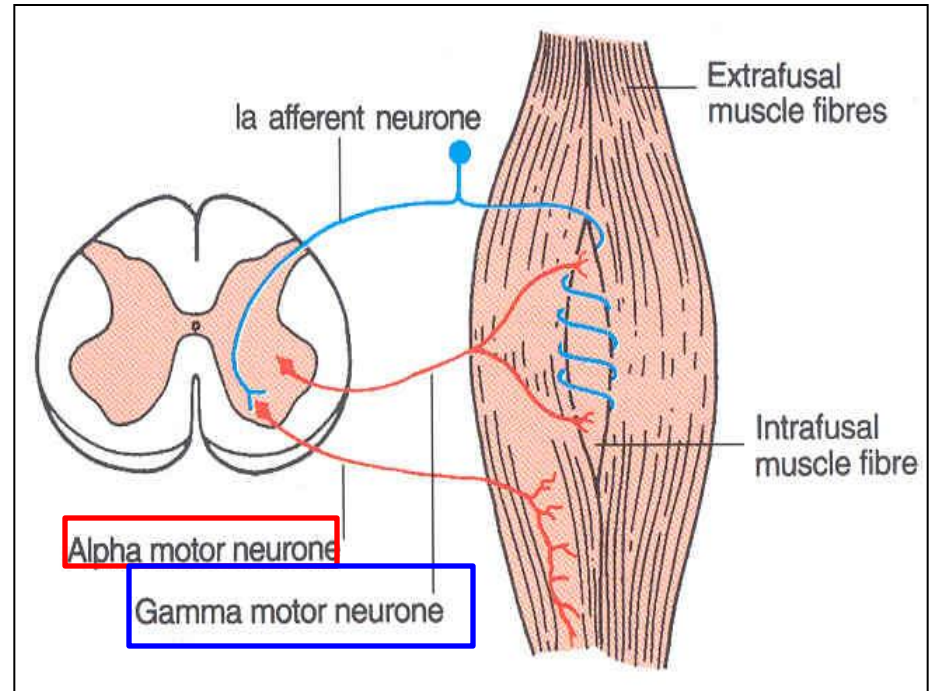
Types of Motor Neurons in Ventral Horn

- **Large multipolar cells**

- Numerous
- Axons pass out in the ventral roots of spinal nerves as **alpha** efferents
- Innervate **extrafusal muscle fibers**

- **Smaller multipolar cells**

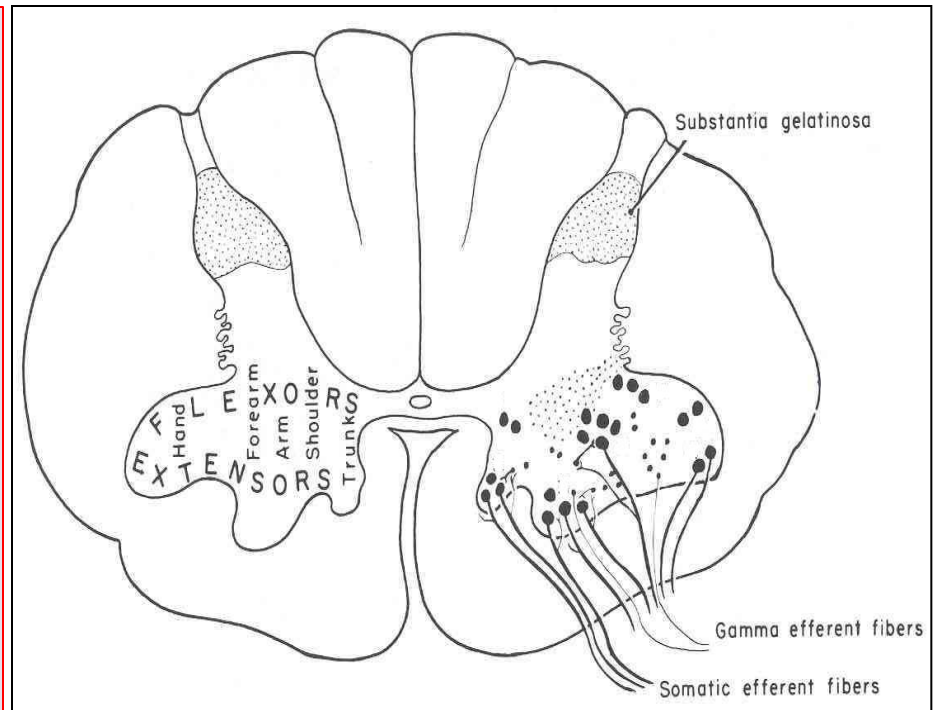
- Less numerous
- Axons pass out in the ventral roots of spinal nerves as **gamma** efferents
- Innervate **intrafusal muscle fibers** of neuromuscular spindles



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

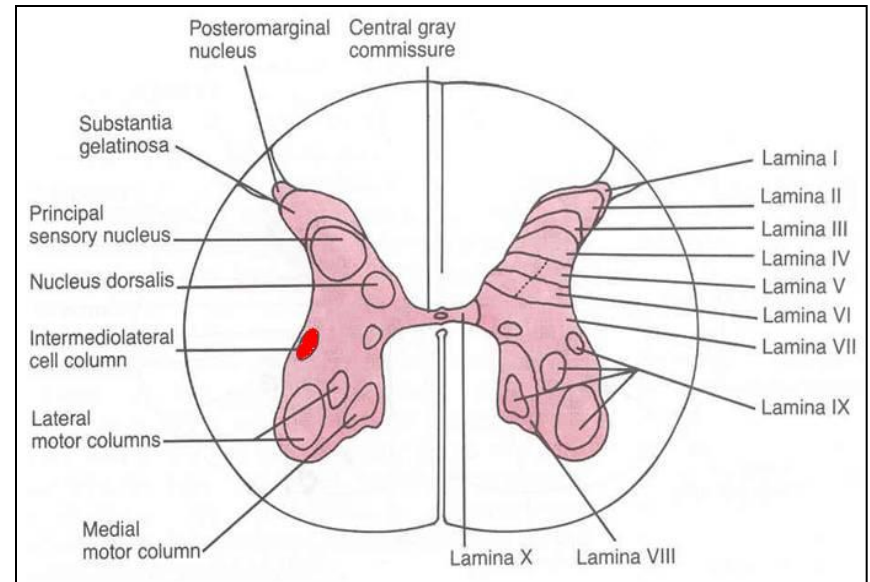
- Motor neurons are organized in 3 groups:
- Medial:
 - present in **most segments**
 - Innervate muscles of **Neck and Trunk** (including and abdominal muscles)
- Central:
 - smallest,
 - present in some segments: **cervical** (phrenic C3-5, spinal accessory C1-6) and **lumbosacral** (L2-S1)
- Lateral: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



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

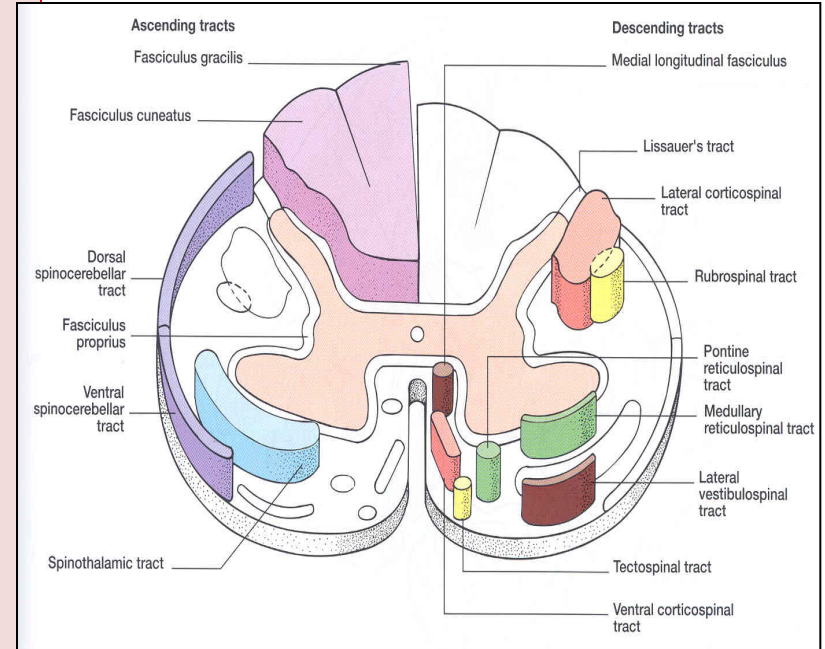
Nerve Cell Groups in Lateral Horn

- **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

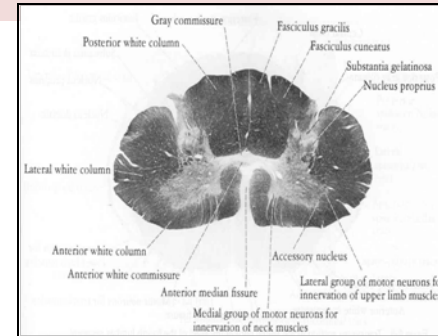
- Consists of mixture of **nerve fibers, neuroglia** and **blood vessels**. White color is due to high proportion of **myelinated nerve fibers**
- Arranged in **columns/funiculi**; anterior, posterior and lateral.
- The nerve fibers are arranged as **bundles**, running vertically through the cord. A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



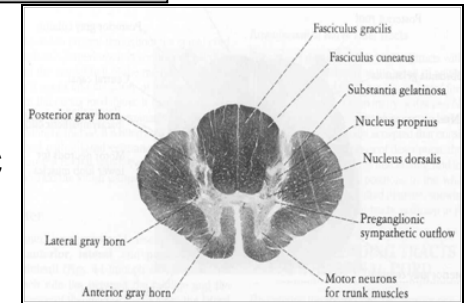
Depending on their function, the spinal tracts are divided into **Ascending and Descending tracts**

Regional Differences

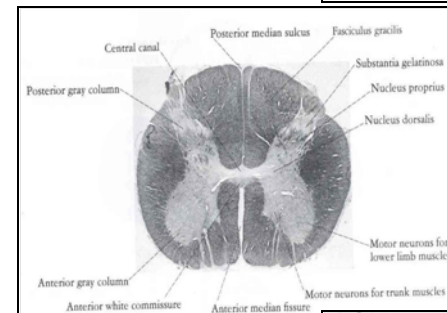
- Although the general pattern of gray matter is the same throughout spinal cord, **regional differences** are apparent in transverse sections
- The **amount of white matter** increases in a caudal-to-cranial direction because fibers are added to ascending tracts
- The **gray matter** is increased in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



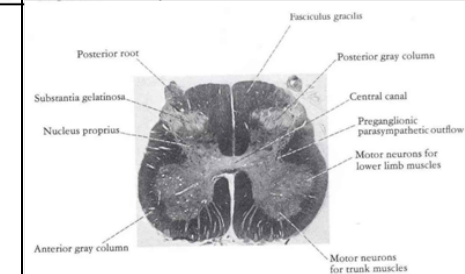
Cervical



Thoracic



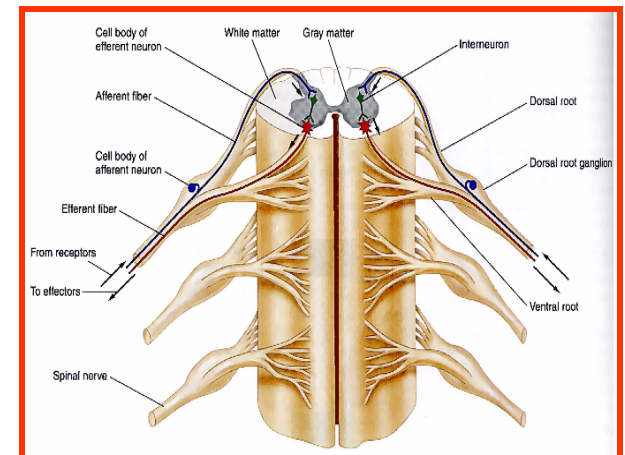
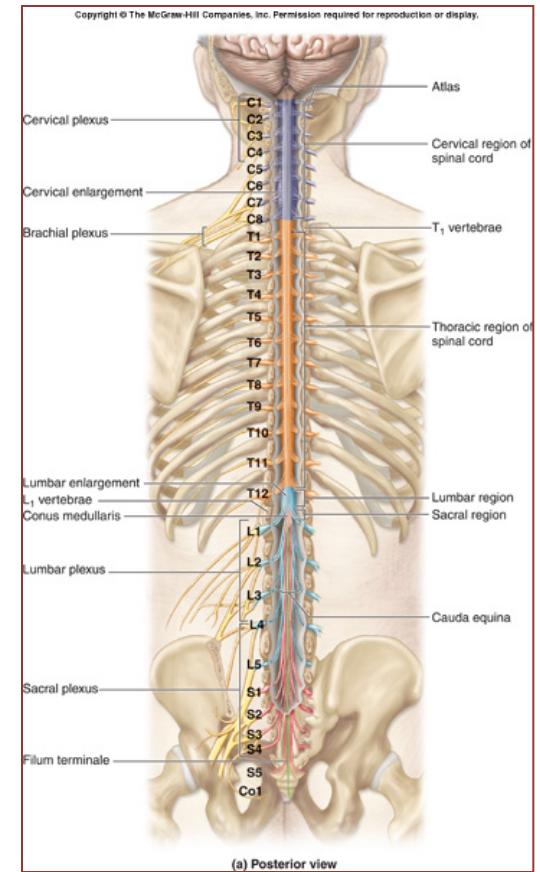
Lumbar



Sacral

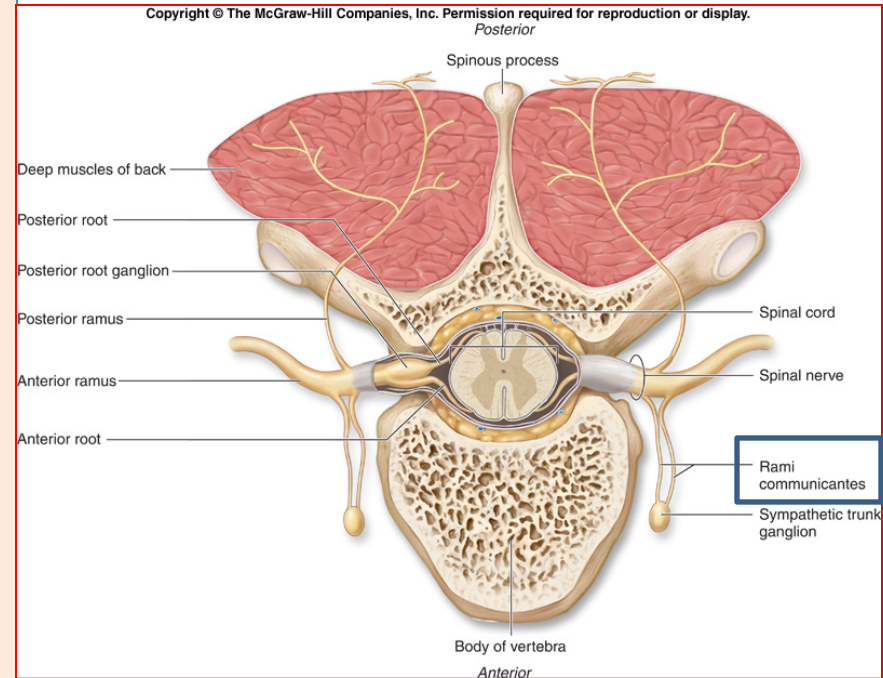
Spinal Nerves

- **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****

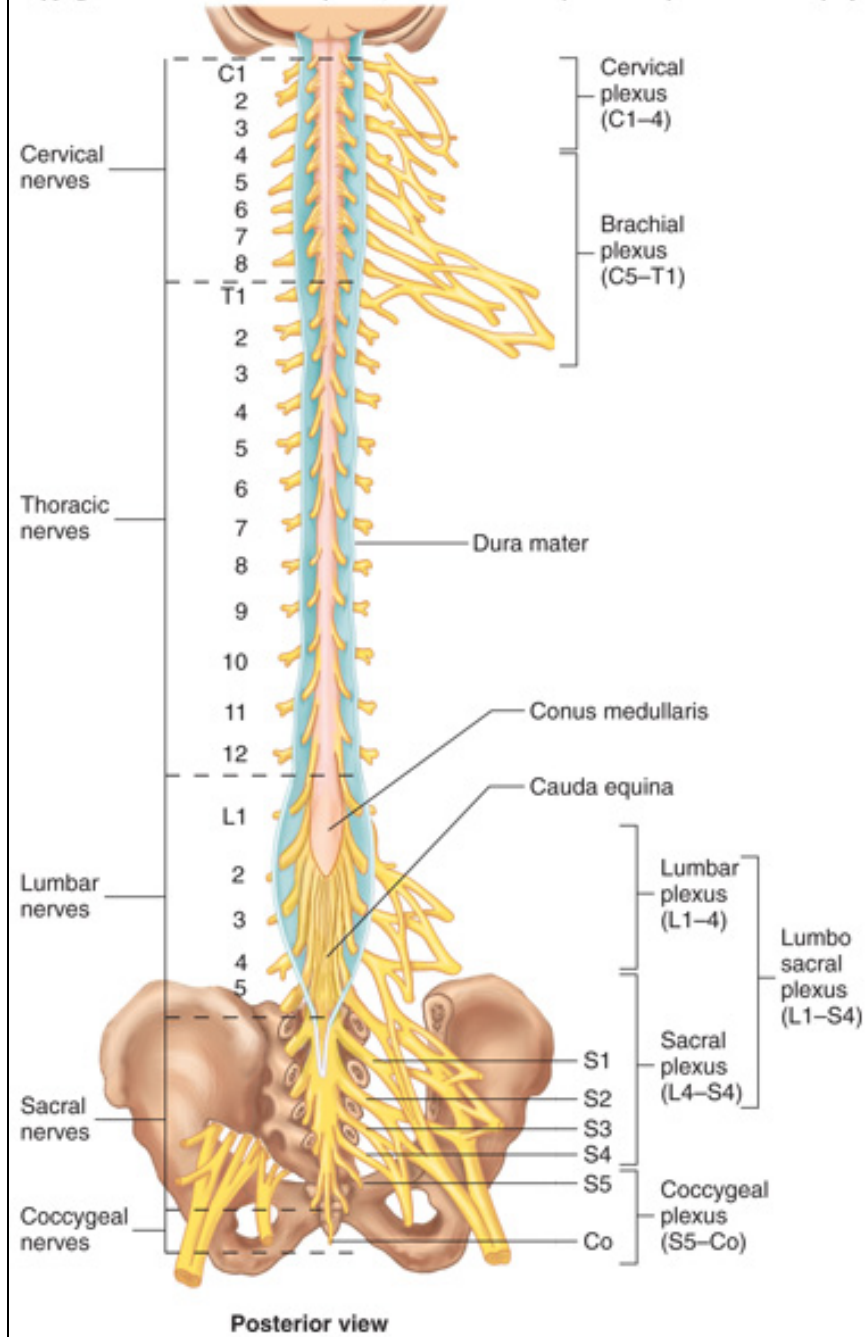


Branches of Spinal Nerves

- **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**

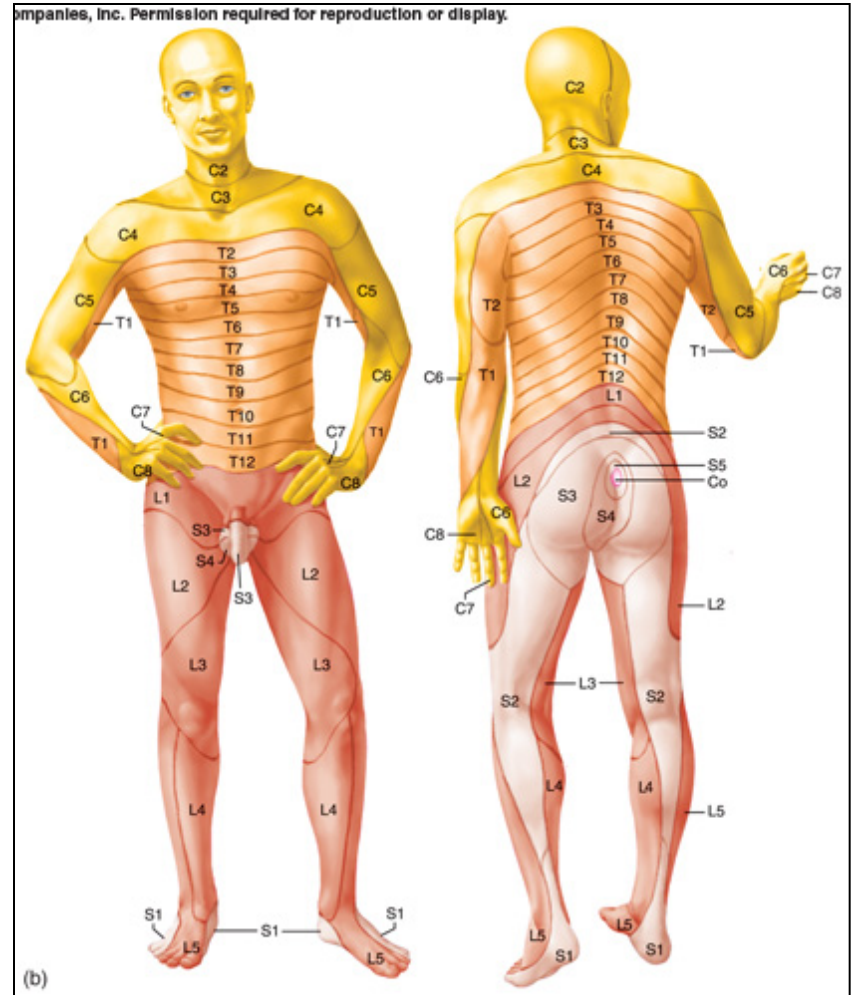


The spinal nerves are connected to sympathetic chain of ganglia by communicating rami



Dermatomes

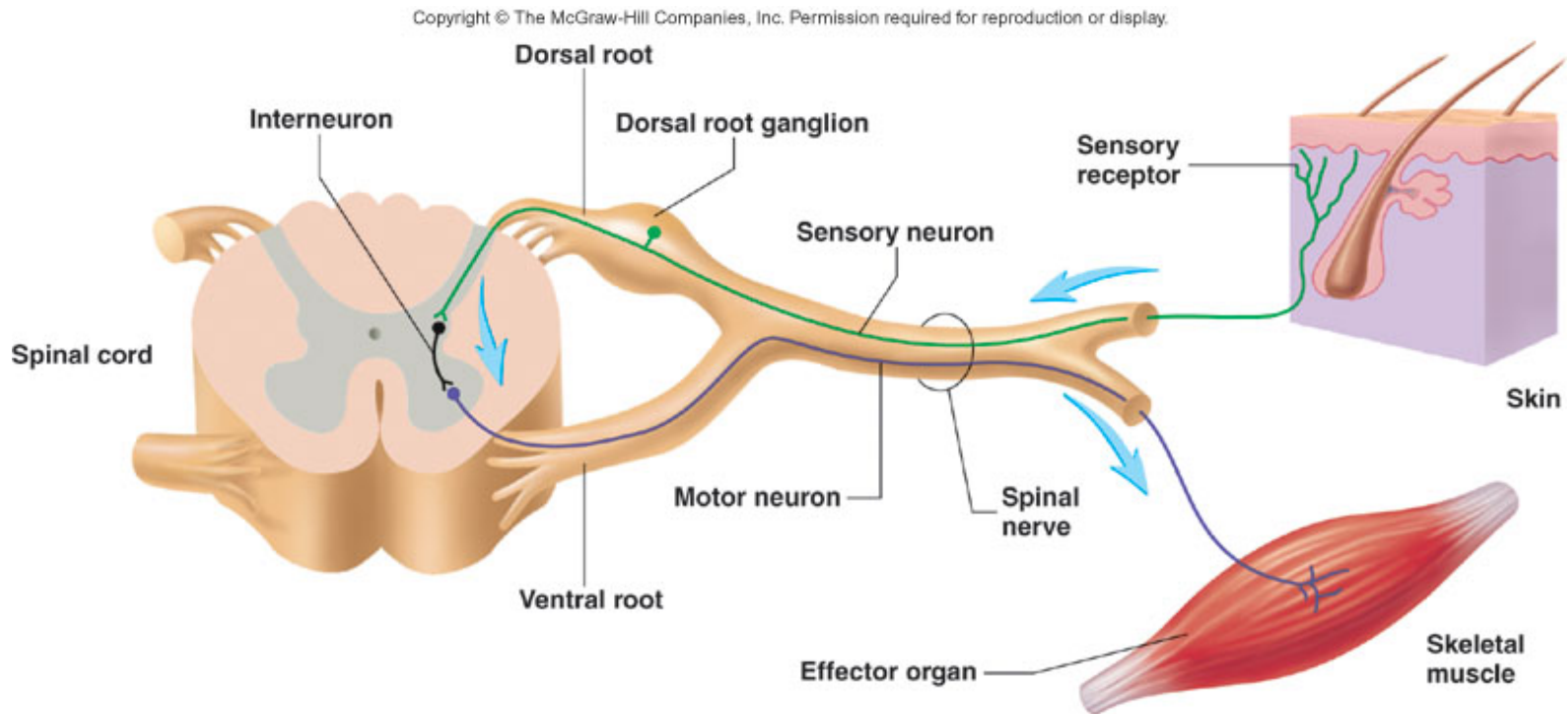
- 'Dermatome' is a segment of skin supplied by a specific segment of the spinal cord (**segmental spinal nerve**)
- Cutaneous areas supplied by adjacent spinal nerves **overlap**. There is therefore little or no sensory loss after interruption of a single spinal nerve or dorsal root



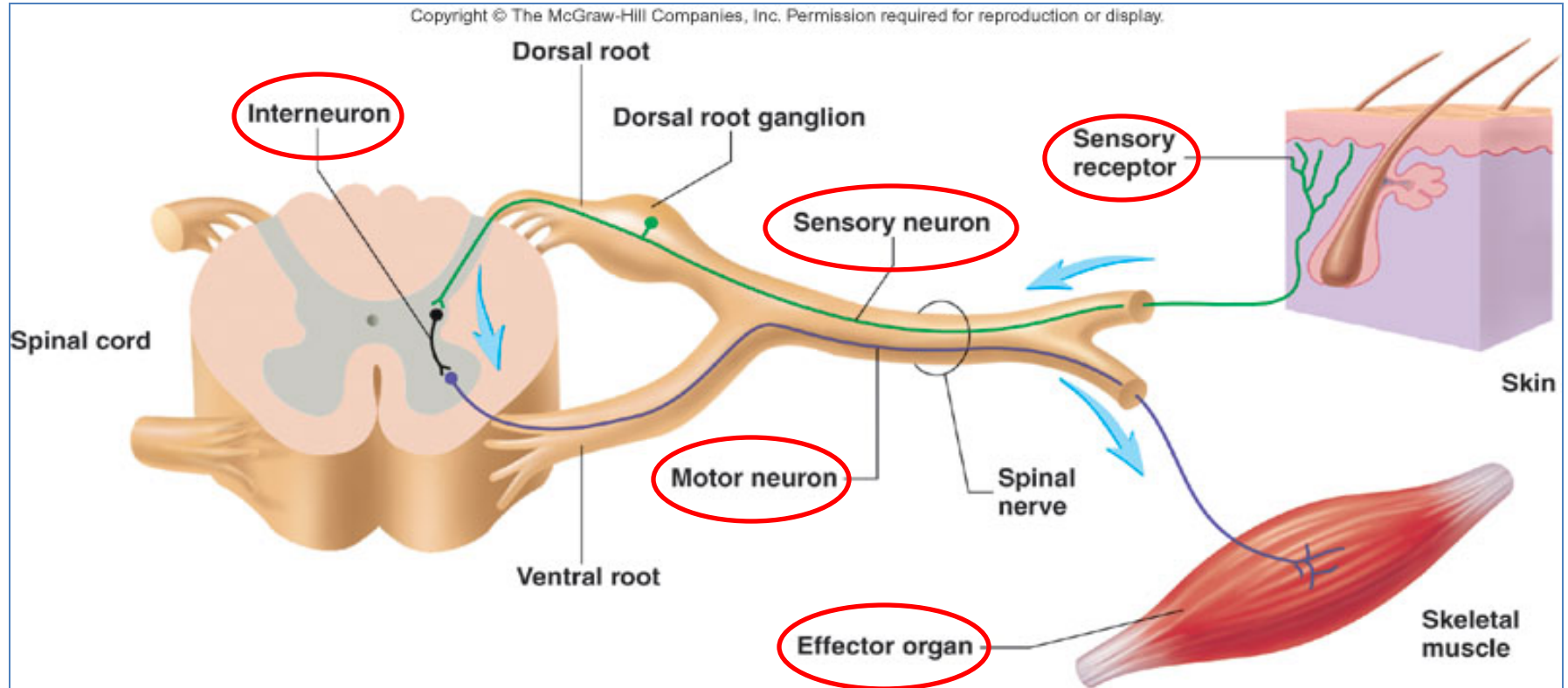
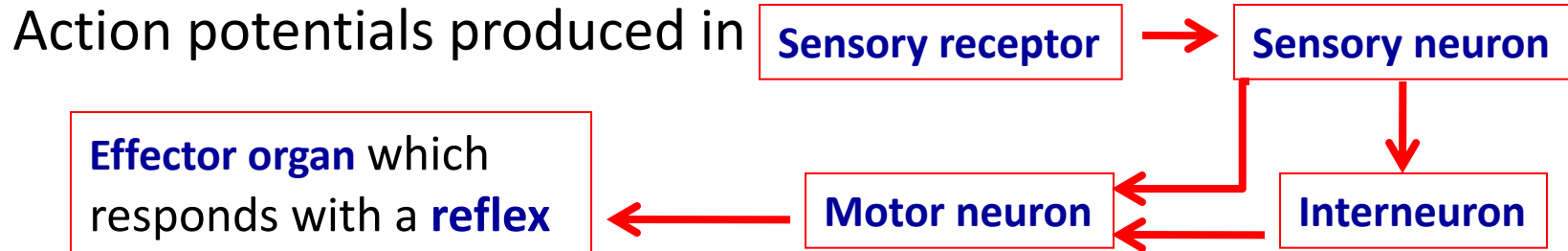
Reflex & Reflex Arc

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