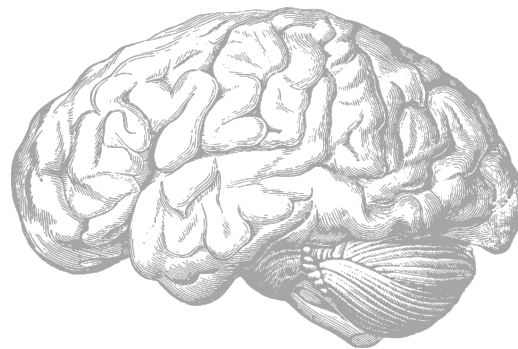




Anatomy of the Spinal Cord

CNS Block



Color Index








- ◆ Main Text
- ◆ Female Slides
- ◆ Male Slides
- ◆ Drs' Notes
- ◆ Important
- ◆ Extra info

[The Editing File](#)





Objectives

-  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.
-  **Clinical anatomy**



You can find Atlas by [Clicking HERE!](#)

Spinal Cord

Introduction

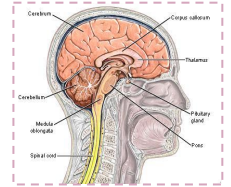
The spinal cord is the main pathway for information connecting the brain and peripheral nervous system.

It is elongated, almost cylindrical, suspended in the vertebral canal, and protected by vertebrae.

Surrounded by the meninges and cerebrospinal fluid (CSF).

The primary function of spinal cord is a transmission of neural signals between the brain and the rest of the body.

Approximately 45 cm long in adult males and is about the thickness of the little finger.



Sensory

Motor

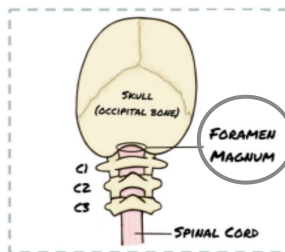
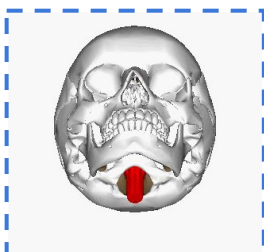
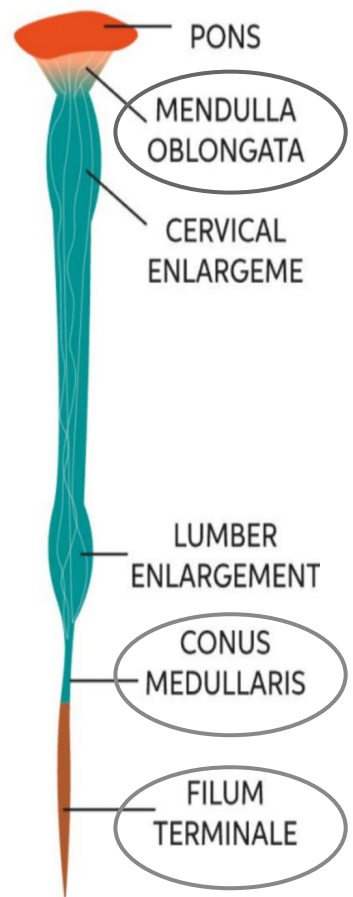
Local reflexes

Structures

Extends from foramen magnum to 2nd lumbar vertebra.

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**.

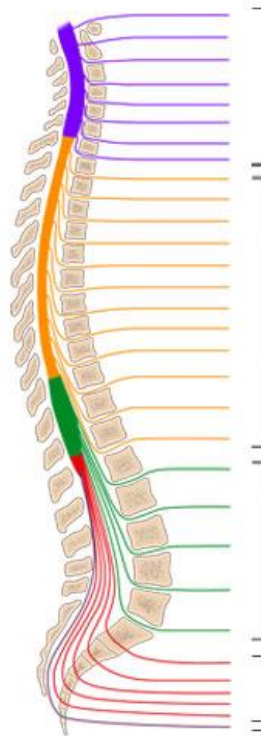


Spinal Cord

Features

Segmented structure, gives rise to 31 pairs of spinal nerves. Spinal nerves are part of the PNS, however the spinal cord is part of the CNS.

- ❖ First pair exit vertebral column between skull and atlas.
- ❖ Others exit through intervertebral foramina.
- ❖ Last four pairs exit via the sacral foramina.



8 Cervical Pair

12 Thoracic Pair

5 Lumbar Pair

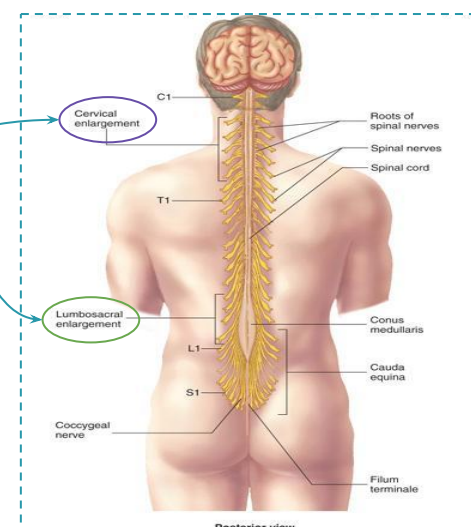
5 Sacral Pair

1 coccygeal Pair

Not uniform in diameter, has two enlargements:

- 1- **Cervical Enlargement:** Supplies upper limbs.
- 2- **Lumbosacral Enlargement:** Supplies lower limbs.

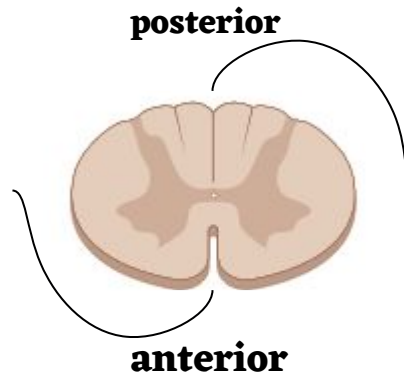
The bundle of spinal nerves extending inferiorly from **lumbosacral enlargement** and **conus medullaris** surround the filum terminale and form **cauda equina** (because of its resemblance to a horse's tail)



Cross section of the spinal cord

The Spinal cord is **incompletely** divided into two equal parts:

anteriorly:
by a short, shallow
median fissure

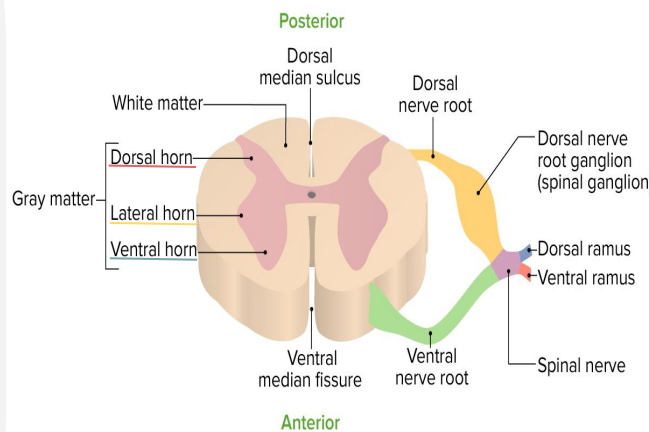


posteriorly;
by a deep narrow
septum, the **posterior
median septum/sulcus.**

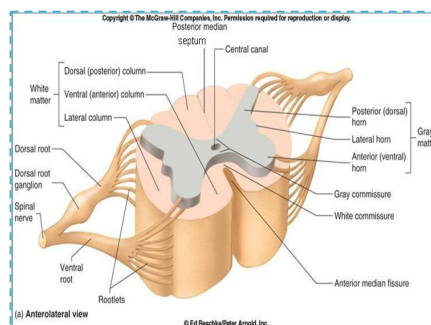
Composed of **grey matter** in the centre surrounded by **white matter**, and supported by neuroglia.

The arrangement of grey matter resembles the shape of the letter **H**, Having:

- **two posterior (Dorsal)**
- **two lateral**
- **two anterior (Ventral) horns/columns.**



Each spinal nerve arises as rootlets which then combine to form **dorsal (posterior) & ventral (anterior) roots**. Two roots merge laterally and form the spinal nerve. Dorsal (posterior) root has a **ganglion (dorsal root/sensory ganglion)** that contain the cell body of the sensory neurons.



Grey Matter

The grey matter consists of:

1 Nerve cell bodies and their processes

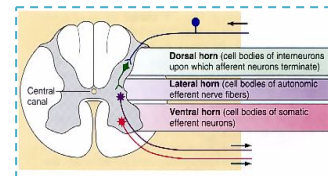
2 Neuroglia

3 Blood Vessels

The nerve cells are **multipolar**, and are of **three** main categories:

Sensory neurons (Tract cells)	receive impulses from the periphery of the body and whose axons constitute the ascending fasciculi of the white matter ,	located in the dorsal horns . <i>* حساسات خلفية *</i>
Lower motor neurons	which transmit impulses to the skeletal muscles,	located in the ventral horns (similar neurons in the lateral horn are the preganglionic neurons of the autonomic system)
Interneurons (connector neurons)	linking sensory and motor neurons, at the same or different levels, which form spinal reflex arcs . (more about it in the next slides)	

extra introduction, details on next slide



classification of the structure of the spinal cord

groups of neuron cell bodies

Rexed laminae

The prominent nuclei (groups of neuron cell bodies) in the spinal cord are:

cells are grouped according to their **Location**

comprise a system of ten layers of grey matter (I–X),

cells are grouped according to their **structure and function**,

Lateral motor neurons and medial motor neurons:

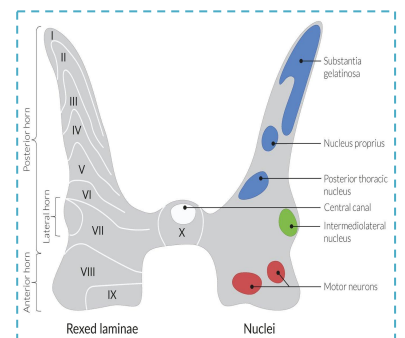
Intermediolateral nucleus

Dorsal nucleus of Clarke

Nucleus proprius

Substantia gelatinosa

Marginal zone



Grey Matter

Neuronal Architecture of Spinal Grey Matter:

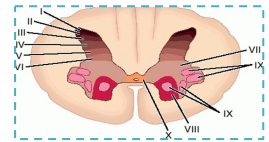
Cells of the same type are clustered into groups, which occur in long columns

In transverse section, these columns appear as layers, especially within dorsal horn

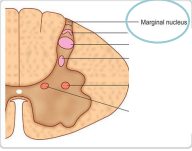
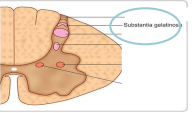
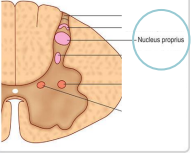
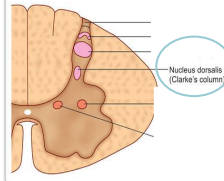
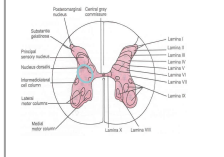
These layers are called the Laminae of Rexed, that are numbered consecutively by Roman numerals, starting from the tip of the dorsal horn and moving ventrally into the ventral horn.

It is an alternative to spinal cord nuclei where cells are grouped according to their structure and function, rather than solely on location.

I Identified in the early 1950s by Swedish neuroscientist.

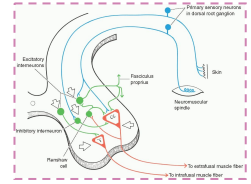


Nerve Cell Groups in Dorsal Horn

Nuclei	Rexed Laminae	Location	Composition	Extension	Function	Picture
Marginal zone <i>male's slides</i>	Rexed Laminae I	at the tip of the dorsal horn		-	Important for relaying pain (fast pain) and temperature sensation to the brain.	
Substantia gelatinosa	Rexed Laminae II	Top/apex of the horn	large neurons	throughout the length of spinal cord	Afferents: dorsal root fibers concerned with pain (slow pain), temperature and light touch	
Nucleus proprius	Rexed Lamina IV	in the neck of the horn anterior to substantia gelatinosa			Afferents: dorsal root fibers concerned with senses of position & movement (proprioception) and two-point discrimination & vibration	
Dorsal nucleus of Clarke Nucleus Dorsalis (Clark's column), Nucleus thoracis	Rexed Lamina VII	at the base of the horn the most dorso-medial nuclei	mostly large neurons	Its only found in C8 to L3-4 segments	-Associated with proprioceptive endings -Afferents: dorsal root fibers, concerned with information from muscle spindles and tendon organs . -it relays unconscious proprioceptive information to the brain.	
Visceral Afferent Nucleus <i>Female's slides</i>	Rexed Lamina VII	lateral to nucleus dorsalis	medium size neurons	T1 to L3 segments	Visceral afferents and autonomic signals from the brain to the visceral organs.	

Grey Matter

Ventral Horns



Motor neurons
Lower motor neurons (LMN)

Interneurons
(Renshaw cells)

Large multipolar cells

Smaller multipolar cells

Numerous

Axons pass out in the ventral roots of spinal nerves as **alpha** efferents

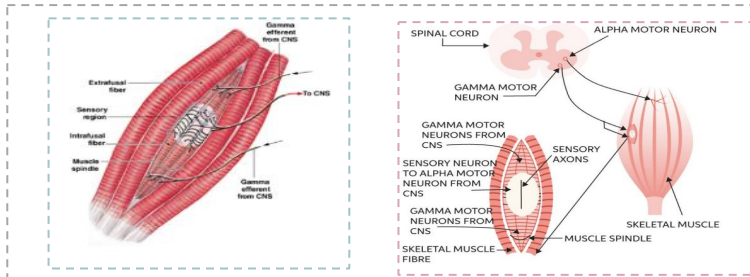
Innervates extrafusal muscle fibers

Less Numerous

Axons pass out in the ventral roots of spinal nerves as **gamma** efferents

Innervates intrafusal muscle fibers of neuro-muscular spindles

whose branched axons form **inhibitory** synaptic junctions on motor neurons



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

Medial	Laminae VIII & IX	present in <u>most</u> segments	innervates muscles of neck and trunk (including intercostal and abdominal muscles)
Lateral		present in cervical and lumbosacral segments	innervates muscles of the limbs
Central	present in some cervical <ul style="list-style-type: none"> • phrenic C3-5 • spinal accessory C1-6 • lumbosacral (L2-S1) segments 		Smallest

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

Nerve Cell Groups in **Lateral** Horn consist of visceral motor neuron cell bodies

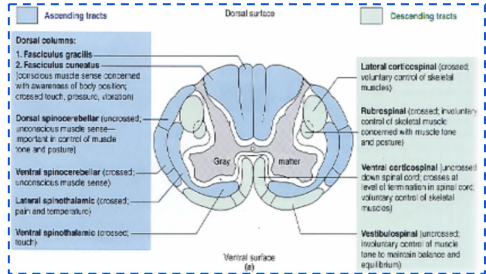
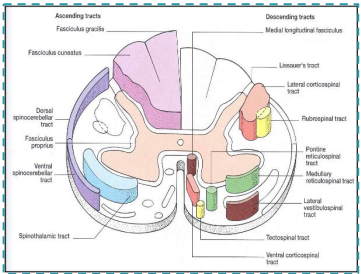
Small column composed of small neurons extend from: Female Slides	T1 to L2-3 segments, give rise to preganglionic sympathetic fibers
	S2-4 segments, give rise to preganglionic parasympathetic fibers
Intermediolateral nucleus Male Slides	Laminae VII located in the intermediate column and lateral horn , and it relays sensory information from viscera to the brain, and autonomic signals from the brain to the visceral organs.

White Matter

The white matter consists of:

- 1 Nerve Fibers
- 2 Neuroglia
- 3 Blood Vessels

White matter colour is due to the high proportion of myelinated nerve fibers



1 White matter is arranged in columns or **funiculi**:

- Anterior column
- Posterior column
- Lateral column

2 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**. Depending on their function, the spinal tracts are divided into:

1. ascending (sensory nerve fibers to the brain,)
2. descending tracts (motor nerve fibers from the brain)

3 Tracts are often named according to their points of **origin** and **destination**,

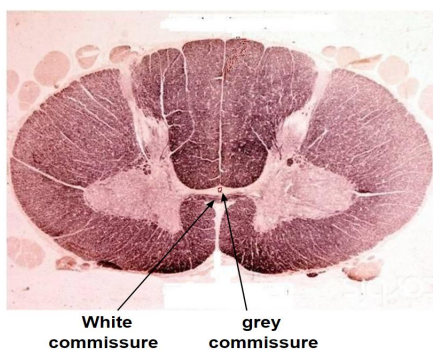
- Spinothalamic
 - Spine/ thalamus
- Corticospinal
 - Spine/Cortex

Commissures:

connections between left and right halves:
 -Gray with central canal in the center
 -White

White Commissure:

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



Grey commissure:

- 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

Cross section of the spinal cord

Central Canal:

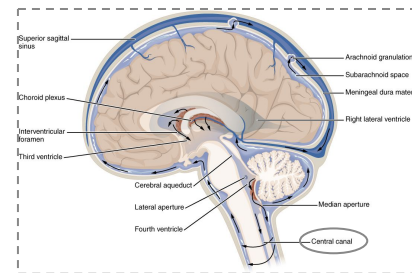
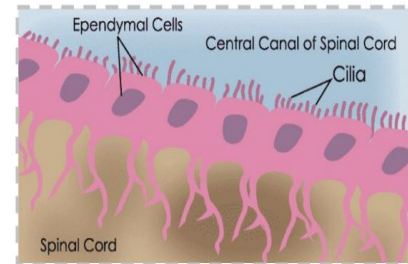
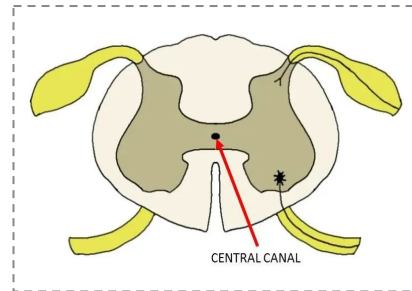
The cerebrospinal-filled space that runs longitudinally through the entire length of the spinal cord.

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.



Regional Differences:

Grey matter:

1- Although the **general pattern of gray matter** is the same throughout spinal cord, **regional differences** are apparent in transverse sections.

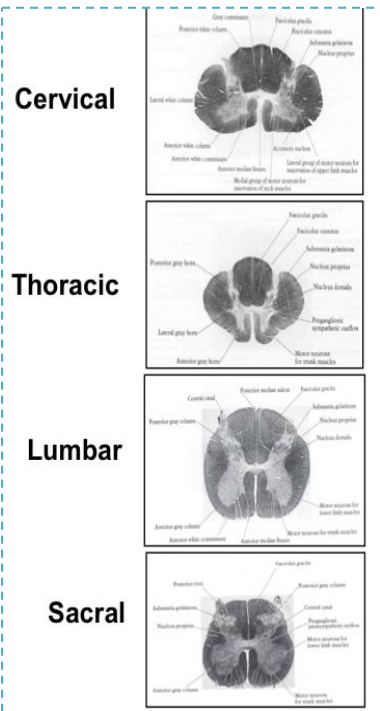
2- The **gray matter** is in **increased volume** in cervical & lumbosacral enlargements for **innervation** of upper & lower limbs.

White Matter:

The **amount of white matter increases** in a **caudal-to-cranial direction** because **fibers are added** to ascending tracts and **fibers leave descending tracts**.

The lateral horn:

is characteristic of thoracic and upper lumbar segments.



Spinal Nerves

31 pairs of spinal nerves:

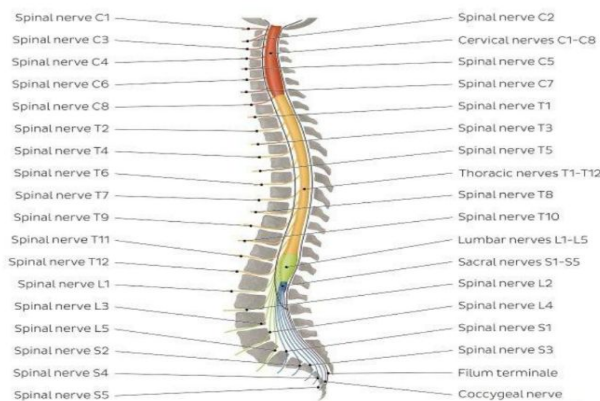
8 Cervical Pair

12 Thoracic Pair

5 Lumbar Pair

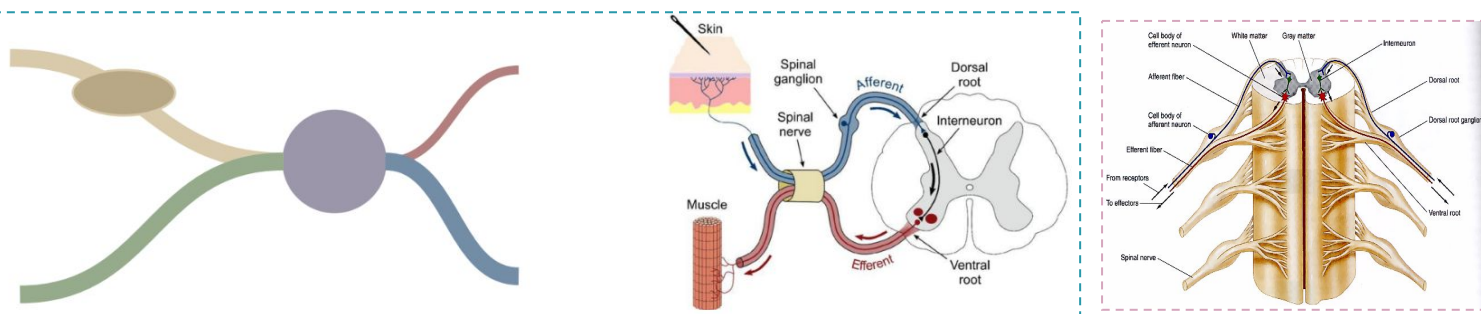
5 Sacral Pair

1 Coccygeal Pair



First pair exit vertebral column between skull and atlas, last four pairs exit via the sacral foramina and others exit through intervertebral foramina.

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



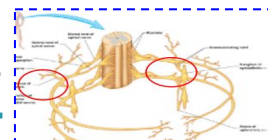
Each spinal nerve arises as rootlets which then combine to form dorsal (posterior) & ventral (anterior) roots.

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 smaller dorsal and a larger ventral ramus

Branches of Spinal Nerves



Dorsal Rami

1. Deep muscles of the trunk responsible for movements of the vertebral column
2. Skin near the midline of the back.

Ventral Rami

(what they innervate depends upon which part of the spinal cord is considered.)

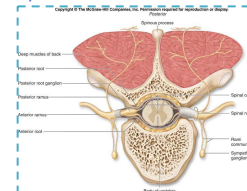
Thoracic region

- form intercostal nerves that innervate the :
1. intercostal muscles
 2. Skin over the thorax

Remaining ventral rami (roots of the plexus)

form five plexuse (intermingling of nerves):

1. C1 - C4= Cervical plexus
2. C5 - T1= Brachial plexus
3. L1 - L4/L5= Lumbar plexus
4. L4 - S4= Sacral plexus
5. S5 & Co / S4&S5= Coccygeal plexus



Dermatomes & Spinal Meninges

Dermatome

a segment of skin supplied by one spinal nerve

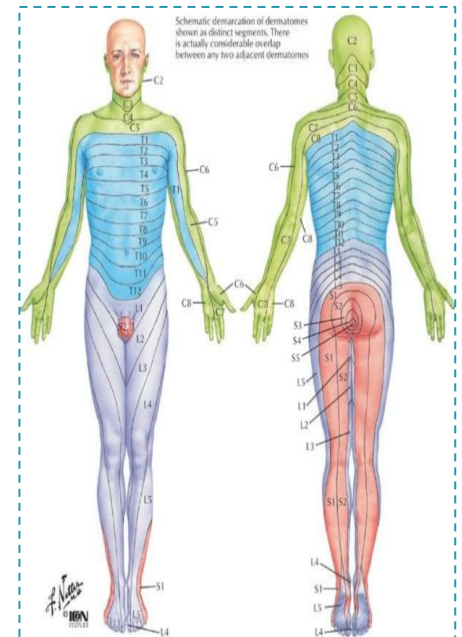
(Derma comes from skin and tome comes from cut)

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

Each of these spinal nerves relay sensation from a particular region of skin to the brain.

The nerves from the upper cervical spine supply the skin of the neck.

- C5 to T1 nerves supply the arms.
- T2 to L2 nerves supply the chest and abdomen.
- L3 to S1 nerves supply the skin of the legs.
- S1-C1 nerves go to the groin.

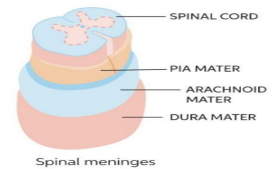
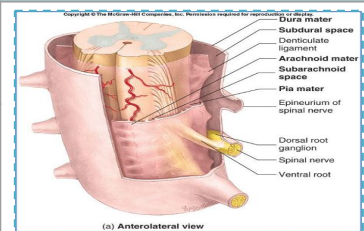


Testing of dermatomes is part of the neurological examination looking for sensation changes within a specific dermatome that may help in determining the pathological disc level.

Spinal Meninges:

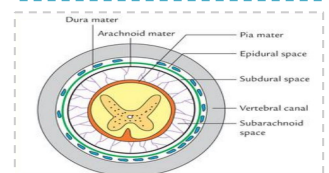
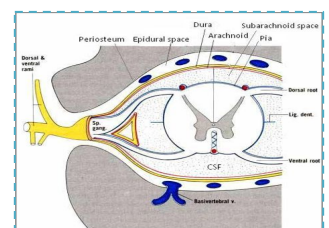
Three connective tissue membranes surrounding spinal cord and brain

Dura mater	tough outer layer, continuous with epineurium of the spinal nerves	
Arachnoid mater	thin membrane deeper to dura mater, thin and wispy	
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

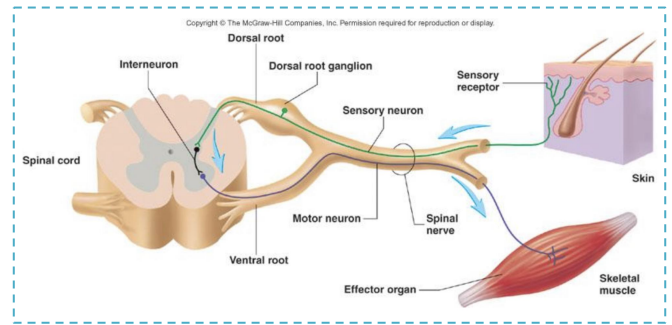
Epidural	1. blood vessels, 2. Areolar connective tissue 3. Fat.
Subdural	a potential cavity between the dura and arachnoid mater 1. contains a small volume of serous fluid .
Subarachnoid	1. Contains cerebrospinal fluid (CSF) 2. blood vessels 3. web-like strands of arachnoid tissue



Reflex arc & Applied Anatomy

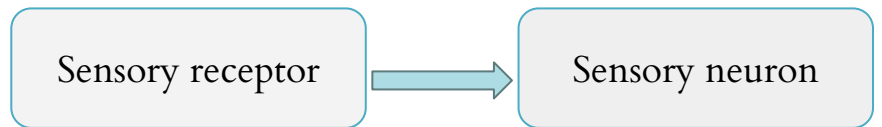
A reflex is a **rapid, involuntary, predictable** response brought by a **sensory stimulus**

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

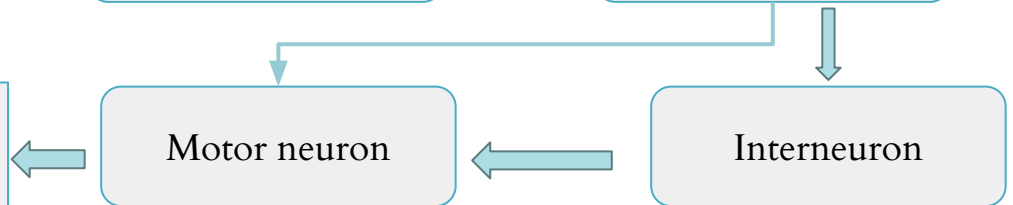


Components of a Reflex Arc

Action potentials produced in



Effector organ which responds with a reflex



Variety of Reflexes

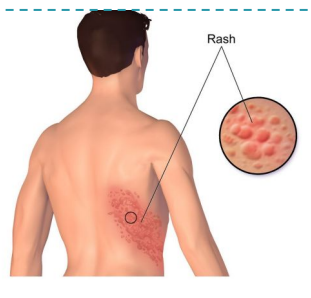
- Some integrated within spinal cord; some within brain
- Some involve excitatory neurons yielding a response; some involve inhibitory neurons that prevent an action
- Higher brain centers can influence, suppress, or exaggerate reflex responses

Applied anatomy: Herpes Zoster (Shingles)

Female slide

1

Common infection caused by Reactivation of **Varicella-Zoster Virus** (chickenpox) in the **sensory dorsal root or cranial nerve ganglion**



2

Characterized by **Unilateral vesicular rash** -> ulcerate, crust over 10 days

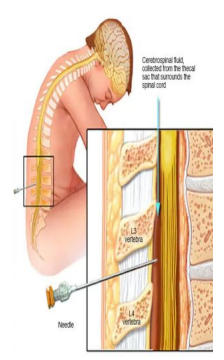
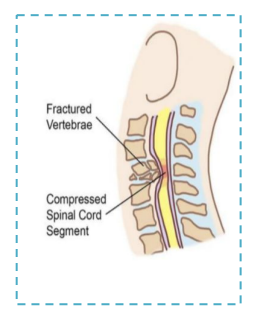

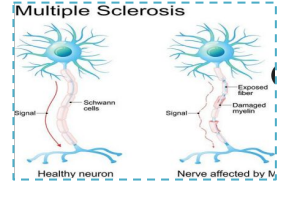
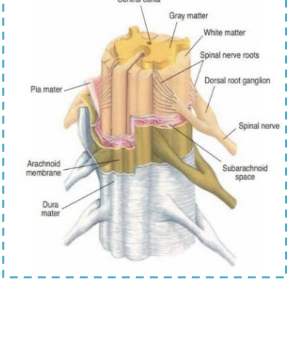
3

The rash is along a specific **dermatomal distribution**
Ex: at T7 spinal cord level which innervates the T7 dermatome segments of the skin which is basically the upper abdomen

4

Prodrome phase:
● pain (burn, sharp),
● itch,
● tingling

Applied Anatomy Conc.

<p>Lumbar Puncture</p>	<ul style="list-style-type: none"> ● Procedure of collecting CSF from the spinal canal ● The needle is typically inserted between L4-L5 vertebral level ● both diagnostic & therapeutic 	<p>Therapeutic</p>	<ul style="list-style-type: none"> ● allows intrathecal administration of chemotherapy & antibiotics 	
<p>Spinal cord lesions or syndromes</p>	<p>Spinal cord lesions can be divided into a few classic types:</p>			
<p>Spinal Nerve Injury Male's Slides</p>	<p>Complete transection: <i>Quadriplegia, Paraplegia</i></p>	<p>hemisection</p>	<p>posterior lesion and anterior lesion</p>	<p>central lesion</p> 
<p>Paralysis Male's Slides</p>	<ul style="list-style-type: none"> ● The spinal cord injury is the damage to the spinal cord that causes temporary or permanent changes in the functions. ● Symptoms may include loss of muscle function, sensation, or autonomic function. ● Injury can occur at any level of the spinal cord and can be complete injury with a total loss of sensation and muscle function, or it can be incomplete injury. ● Depending on the location and the severity of damage, the symptoms could include numbness, paralysis or incontinence. ● Long term outcomes ranges widely from full recovery to permanent quadriplegia or paraplegia. ● Complications can include muscle atrophy, pressure sores, infections, and breathing problems. 			
<p>Multiple Sclerosis Male's Slides</p>	<ul style="list-style-type: none"> ● Paralysis is loss of the ability to move one or more muscles. ● It may be associated with loss of feeling and other bodily functions. ● Paralysis may be partial or complete, and temporary or permanent. ● It is not usually caused by problems with the muscles, but by problems with the spinal cord or nerves that control muscles. ● A person with paralysis will usually have some form of nerve damage. ● Most paralysis results from cerebrovascular accidents and spinal cord injuries. ● Other causes of paralysis include Bell's palsy, multiple sclerosis, and Guillain-Barré syndrome. 			
<p>Spinal Meningitis Male's Slides</p> <p>Males Slides</p>	<ul style="list-style-type: none"> ● It is a progressive degenerative neurological disease with scattered patches of demyelination of nerve fibres of the brain and spinal cord. ● Common symptoms include tingling, numbness, muscle weakness or spasm, ataxia, dysarthria, dysphagia, visual problems (such as diplopia), fatigue, pain and bladder and bowel incontinence. 			
<p>Cerebrospinal Fluid Analysis Males Slides</p>	<ul style="list-style-type: none"> ● Meningitis is an inflammation in the meninges. ● Bacteria or virus usually cause this condition. ● The infection takes 10 days to two weeks before the symptoms appear. ● Symptoms include severe headache, Fatigue, neck stiffness, irritability, fever, nausea, vomiting and delirium and weight loss. ● A particular type of meningitis, meningococcal meningitis, is characterized by a rapidly spreading rash. ● Meningitis can be life threatening because of the proximity to the brain and spinal cord; therefore, the condition is classified as a medical emergency. ● A lumbar puncture is performed to diagnose the condition. ● This disease needs emergency treatment in a hospital. Treatment includes intravenous or oral antibiotics with bed rest. 			<ul style="list-style-type: none"> ● Cerebrospinal fluid (CSF) analysis is a test that is undertaken to diagnose a range of diseases and conditions affecting the CNS. ● Conditions include infectious diseases such as meningitis and encephalitis, haemorrhaging from the brain and tumours within the CNS.
<p>Computed Tomography</p>	<ul style="list-style-type: none"> ● A CT is a diagnostic test that can be used to identify disorders of the brain and spinal cord. 			



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