

431

**CNS** System  
central Nervous

**Block**

**Physiology Team**

Female Side

Male side

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# CNS System central Nervous

## Block

Slide No.( 2 )

### Objectives:

Upon completion of this lecture, students should be able to:

Describe the functions of spinal cord

Understand the physiological role of the spinal cord as a pathway for tracts.

Explain functional role of tracts pass in spinal cord

Describe the definition of a spinal reflex and reflex arc components

Describe the most important types of spinal cord reflexes as withdrawal reflex

Describe properties of spinal cord reflexes as irradiation, recruitment and after discharge

**Team Notes :**

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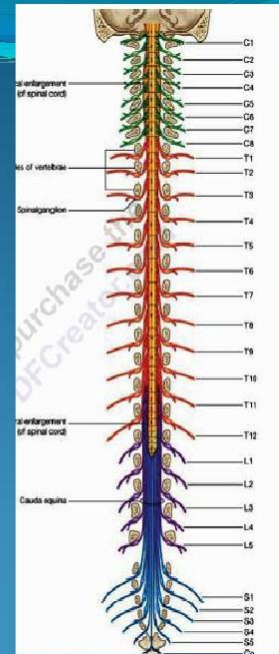
Slide No.( 3 )

### Spinal Nerve

- The spinal cord has 31 pairs of spinal nerves
- 8 cervical,
- 12 thoracic,
- 5 lumbar,
- 5 sacral and 1 coccygeal

### They contain

- (1) **Afferent** fibers bringing to the CNS **sensory** information from receptors of skin , muscles & joints and
- (2) **Efferent** fibers carrying **motor** commands from the CNS to muscles .

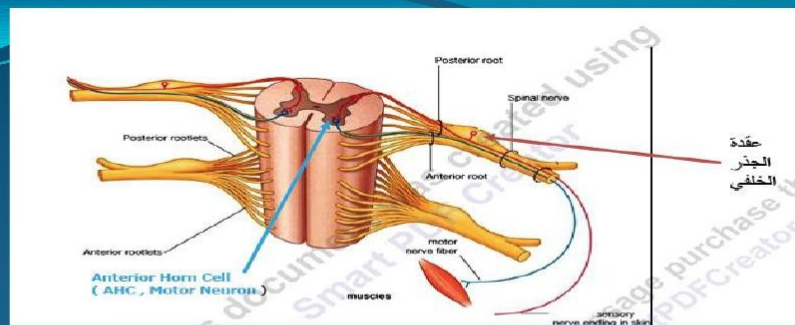


Team Notes :

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Slide No.( 4 )



- The spinal cord has ventral & dorsal roots :
- The dorsal (posterior) root contains afferent (sensory) nerves coming from receptors .
- The cell body of these neurons is located in dorsal ( posterior ) root ganglion ( DRG)
- The ventral (anterior) root carries efferent (motor) fibers
- The cell-body of these motor fibers is located in the ventral (anterior ) horn of the spinal cord

Team Notes :

Nothing else was mentioned about this slide.



# CNS System central Nervous

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Slide No.(5 )

### Functions of the Spinal Cord

- (1) Carrying sensory information from thereceptorstothe brain
- ( throughspinal afferentsensory nerves & ascending/sensory tracts ).

#### A-Tracts Reaching Conscious Brain Level :

- 1- Dorsal Column Tracts ( Gracile &Cuneate )
- 2- Finediscriminative touch , vibration , position senses& stereognosis
- 2- Lateral Spinothalamic Tractforpainand temperature .
- 3- Anterior Spinothalamic Tract forcrude touch , pressure .

#### B-Tracts Not Reaching Conscious Level ( Functioning at Subconscious Level ) :

- 1-SpinocerebellarTracts carry fibers tothe cerebellum forproproceptive information ( senseof jointposition& movements) forposturecontrol & coordinationof movement

### Team Notes :

**Stereognosis** : is the ability to perceive and recognize the form of an object using texture, size, spatial properties even when your eyes are closed.

**Reaching Conscious level**= reaching **cerebral cortex**.

**Reaching subconscious level** = reaching only the **cerebellum**.



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### Functions of the Spinal Cord (2)

- (2) Executing brain motor commands ( through descending/motor tracts & spinal efferent/motor nerves to skeletal muscles)
- (3) Generating Spinal Reflexes

**Team Notes :**

Nothing else was mentioned about this slide.



# CNS System central Nervous

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Slide No.(7)

- **Spinal reflexes**
- **What is a reflex?**
- **Functional unit of CNS, automatic ,involuntary response to a stimulus**
- **-example/pinprick causes withdrawal. R**

**Team Notes :**

**Additional ( was Not mentioned by the doctor) :**

**What is the difference between Cranial And Spinal Reflex?**

A cranial reflex is one that is controlled by one of the cranial nerves and tend to take place in the facial or head area. These can include reflexes like the constriction of the pupils in response to light, etc. A spinal reflex, on the other hand, is a reflex that involves only the spinal nerves and is not processed by the brain. An example is the patellar reflex, like when the doctor hits your knee and it reflexively moves.

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## Reflex Arc

- The basic unit of a reflex is the reflex arc
- It is the pathway of Sensory information to spinal cord to cause spinal reflex, it is formed of :
  - 1-Sense organ (receptor).
  - 2-An afferent sensory nerve (neuron).
  - 3- Center// ending of the afferent sensory neuron within the spinal cord on one or more synapses (interneurons in S.C located in one or more spinal cord segments ).
    - Such interneurons can be excitatory or inhibitory.
  - 4-An efferent somatic motor neuron.
  - 5-An effector organ ( skeletal muscle).

### Team Notes :

- In case of monosynaptic reflexes the afferent neuron synapses directly on the AHC .
- in case of polysynaptic reflexes , one or more interneuron connects the afferent & efferent neurons

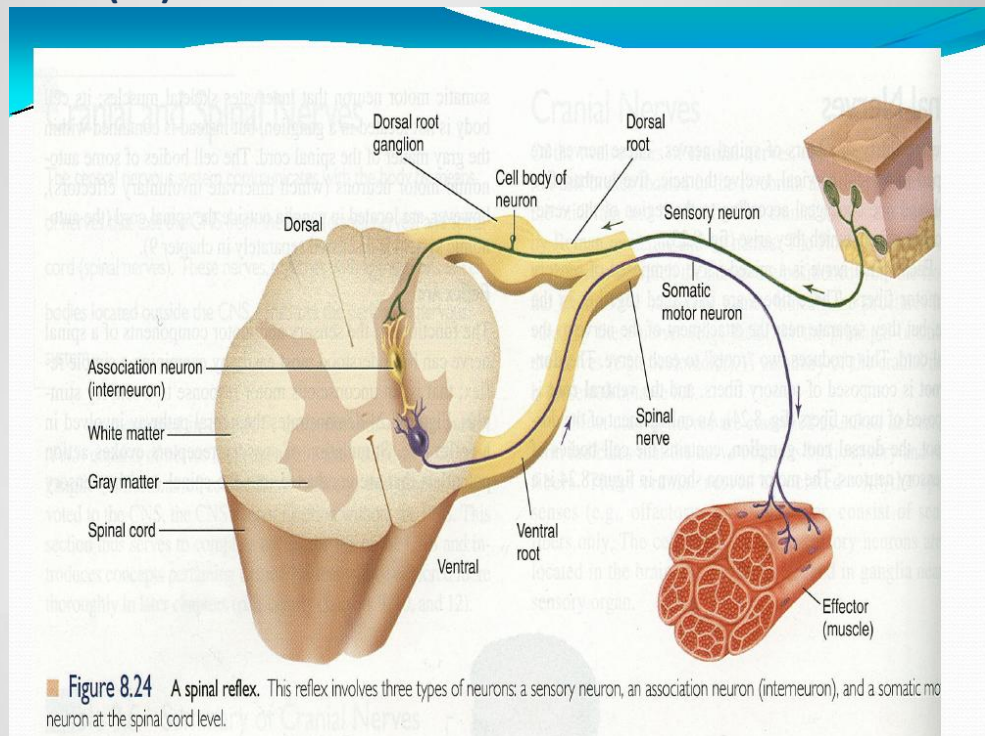


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### Team Notes :

Nothing else was mentioned about this slide.



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### *Components of reflex arc*

**Team Notes :**

Nothing else was mentioned about this slide.

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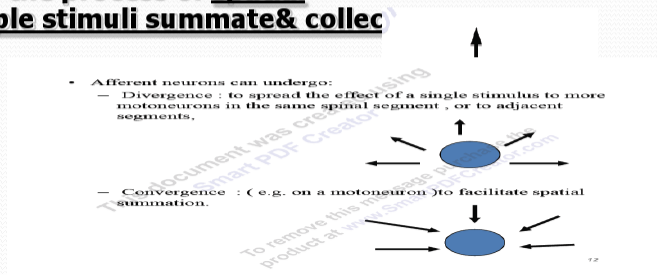
Slide No.( 11 )

## 1-Afferent neuron

- **Sensory afferent enter spinal cord via dorsal(posterior) root, ends at same segment or ascend to higher segments.**
- **- Afferent neurons undergo:**

1- **Divergence** to help to spread a single stimulus to a wide area of the spinal cord,

2- **Convergence** to help the process of spatial summation.(multiple stimuli summate& collect the same time)



Team Notes :

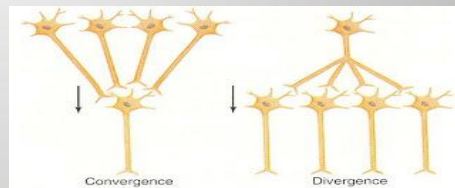
Clearer Picture:

What are the benefits of these 2 processes?

(Additional)

**Convergence** arrangement allows a neuron to be stimulated from various sources and also to strengthen the AP by summation.

**Divergence** (when taking place before parallel processing) : many responses occur simultaneously. For example, when you step on a sharp object, you withdraw your foot, shift your weight, move your arms, feel the pain, and even scream all at the same time.



## 2- Interneurons

- **Interneurons** are small cells in grey matter of spinal cord connecting afferent to efferent (**excitatory** or **inhibitory**).
- (Two types of circuits formed by inter neurons (parallel and reverberating circuits)).

### Team Notes :

(Additional)

#### Exapmle of one function of inhibitory interneuron in a reflex?

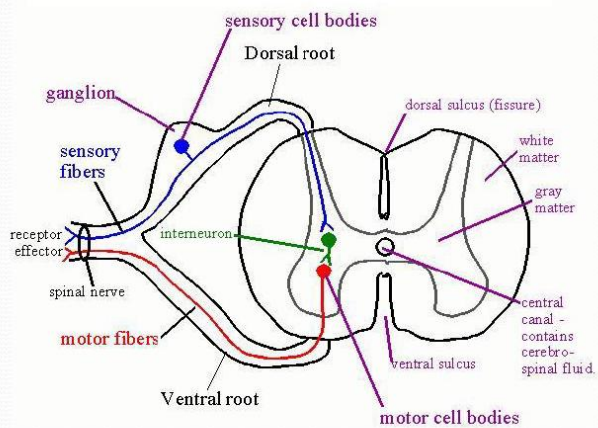
Joints are controlled by two opposing sets of muscles, extensors and flexors. when a muscle spindle is stretched and the stretch reflex is activated, the opposing muscle group must be inhibited to prevent it from working against the resulting contraction of muscle .This inhibition .is accomplished by an inhibitory interneuron in the spinal cord.

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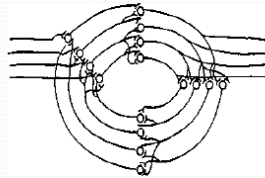


**Team Notes :**

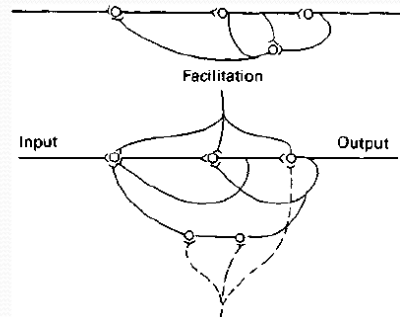
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### Reverberating circuits

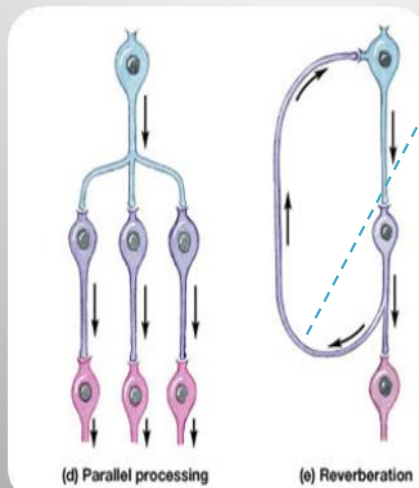
#### 1- Parallel




#### 2-Reverbrating



### Team Notes :



collateral branches of axons somewhere along the sequence extend back toward the source of an impulse and further stimulate the presynaptic neurons. Once a reverberating circuit has been activated, it will continue to function until synaptic fatigue or inhibitory stimuli break the cycle.



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**1-Parallel circuits //afferent and efferent are parallel to each other**

**2-Reverberating circuits**

**-Value//Allow prolonged discharge of the same motor neurons by a single stimulus . Why?**

**-Impulse from one neuron feed back to re-stimulate itself for long time as branches turn back on the same neurons>>>>>permitting activity to reverbrate untill it stops due to fatigue or stop by inhibitory impuls**

**Team Notes :**

**(Additional)**

**Divergence** should take place before parallel processing , this is very helpful because many responses can occur simultaneously. For example, when you step on a sharp object, you withdraw your foot, shift your weight, move your arms, feel the pain, and even scream all at the same time.

### **3-Efferent neuron**

-Anterior Horn Cells (Motoneurons)  
of spinal cord supplying skeletal muscle:

1. **alpha motor neurons** :- large cells, with large myelinated fibres (axons) form **70%** of ventral root - supply **extrafusal muscle fibres (2/3 Of skeletal muscle fibers)**
2. **Gamma motor neurons** :- smaller cells- with small axons form **30 %** of ventral root - supply **intrafusal muscle fibres (1/3 Of skeletal muscle fibers)**

#### Team Notes :

##### Extrafusal Muscle Fibers :

muscle responsible for contraction, extrafusal muscle fibers that are associated alpha motor neurons are called a **motor unit**

##### Intrafusal Muscle Fibers:

specialized sensory organs served by 2 axons, one sensory and one motor - also called **muscle spindles**





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The Alpha Motoneurons are called the Final Common Pathway

--alpha motor neurons supply extrafusal muscle fibers are efferent side of many reflex arcs & many inputs converge on them to adjust their level of activity

- The alpha motoneuron synapses directly on the muscle , therefore it directly controls muscle movement

- inputs come from spinal & supraspinal centers converge on them ( up to 10000 synapses can be present on one alpha motoneuron )

They receive signals from:

1- excitatory and inhibitory signals from same segment of S.C (muscle spindle, golgi tendon organ, pain receptors as withdrawal reflex)


2- excitatory and inhibitory signals from other levels of S.C

3- supraspinal descending tracts from brainstem and cerebral cortex

### Team Notes :


**Motor neurons** are called **the final common pathway** because all the subtle signals converging from several descending tracts as well as afferent input from the periphery are somehow integrated on the motor neuron

which subsequently conducts the appropriate signal out to the muscle.



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- all these signals are integrated at the Alpha Motoneurons then they send integrated activity to muscles to adjust:-
  - posture, voluntary activity & coordinate actions of muscle
  - Each motor neuron + the group of skeletal muscle fibers it controls are together called a “ Motor Unit ”

### Team Notes :

- Each muscle fiber is innervated by one motor neuron.
- Each motor neuron innervate more than one muscle fiber.

Types of reflexes

-According to number of neurons:-

● Monosynaptic

- Sensory axon synapse directly with anterior horn cell- (No interneuron )

Ex.Stretch reflex

● Polysynaptic

- Sensory axon synapse with one or more interneuron

Ex.Withdarwal,abdominal reflexes, visceral

Team Notes :

- Stretch reflex also called tendon jerk
- Plantar reflex is polysynaptic reflex

## Types of reflexes

-According to site of the receptor:-

**(A) Deep Reflexes:-** by stimulation of receptors in muscle and tendons

(1) Stretch Reflexes (Tendon jerks) , monosynaptic : such as knee-jerk ( patellar reflex ) and ankle jerk .

The receptor for all these is the muscle spindle ( is located within the muscle itself

(2) Inverse Stretch Reflex ( Golgi Tendon organ reflex ) , polysynaptic : The receptor is called Golgi Tendon Organ present in the muscle tendon

**(B) Superficial Reflexes**

Are polysynaptic reflexes . The receptor is in the skin . Examples are Withdrawal, abdominal reflexes and plantar reflex

**©Visceral:-**by stimulation of receptors in wall of viscera  
As Micturition, defecation

### Team Notes :

**(Additional)**

The harder a muscle is stretched , the stronger is the reflex contraction However ,when the tension becomes great enough ,contraction suddenly ceases and muscle is relaxes . this relaxation in response to strong stretch called Inverse stretch reflex.



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Withdrawal reflex

**Team Notes :**

Nothing else was mentioned about this slide.

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## Withdrawal reflex(flexor reflex)

-A **superficial polysynaptic** reflex

- Stimulation of **pain receptors** of hand>>>>>> impulses to SC in **A delta or C fibres** >>>>>> interneurons >> anterior horn cells >> stimulate hand flexor muscles >> **move the hand away from the injurious stimulus.**

characterised by :

1-(**reciprocal inhibition or reciprocal innervation**), stimulation of **flexors muscle** accompanied by **inhibition of extensors**.through **inhibitory interneurons**  
(Reflex contraction of an agonist muscle is accompanied by inhibition of the antagonist.)

### Team Notes :

Withdarwel Reflex	Strech Reflex
Initiated by a painful stimulus and It is protective reflex	Intiated by a stretch
Polysynaptic	monosynaptic
Superficial	deep
Presence of interneuron	No interneuron
Inhibition or excitation by neurotransmitter produced by the interneurons :	
<b>Inhibitory neurotransmitter:</b> GABA and Glycine.	
<b>Excitatory Neurotransmitter:</b> Glutamate	

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## Withdrawal reflex

2- Accompanied with **crossed extensor reflex**:-  
Flexion and withdrawal of the stimulated limb  
>> extension of the opposite limb >> occurs  
with strong stimulus **why?**

-**Reciprocal innervations** occurs in **crossed extensor reflex. How?**

-flexors in the opposite limb are inhibited while extensors are excited because while pushing the body away from the injurious agent by withdrawal R, the **crossed extensor reflex** supporting the body weight against gravity

- hence it is an Antigravity Reflex

### Team Notes :

**Crossed extensor reflex** is not a general property of reflexes , it happens only in lower limb.

When you withdraw your leg , your limb will be flexed and the other limb will **be extended** to help you balance your body against gravity

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- 3- **IRRADIATION** :- spread of impulses up & down to different motor neurons in the S.C
- weak stim----- weak flexion of limb
  - strong stim-----withdrawal of affected limb & extension of opposite limb. **A strong stim in sensory aff irradiate to many segments of S.C due to divergence**
  - The extent of the response in a reflex depends on the intensity of the stimulus.** The more intense the stimulus >>>> greater spread of activity in the spinal cord >>>>involving more & more motor neurons>>>>more response

### Team Notes :

Not necessary irradiate to other segment of the spinal cord. It can irradiate to the other side of the same segment of spinal cord .

**Example:** when the impulses irradiate to the other side to stimulate the other limb to be extended in the crossed extensor reflex.



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### + RECRUITMENT :

- **Gradual** activation of more number of motor neurons on stim of afferent nerve in a reflex arc by **maintained, repetitive stimulus**

**Cause/** 1-different conduction velocities of afferents some are slowly & others are rapidly conducting fibres  
2-different number of interneurons with short & long pathways to AHCs

(impulses do not reach AHCs at same time, so maintained stimulation allow more neurones to be stimulated)

Motor unit recruitment : If a repetitive & stronger stimulus is maintained, there will be gradual increase in the force of the muscle contraction until the maximum force is reached .

- The slow build-up in force of muscle contraction is due to gradual recruitment/activation of more and more motor neurons

### Team Notes :

Nothing else was mentioned about this slide.

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### 5- after-discharge:-

- It means prolonged discharge of AHCs after stoppage of afferent stim. (this cause maintained reflex action & response continue for some time after cessation of stimulus)

#### Cause/

- presence of reverberating circuit restimulate AHCs
- Value /prolong the protective response of reflex

### 6-central delay > 2ms in the withdrawal R

Central delay/time of reflex to pass through neurons of CNS(S.C) ,equals 0.5 ms/synapse (it is long in polysynaptic R)

-Number of synapses= central delay/0.5ms

-Reflex Time = Central Delay + Time spent in conduction of impulses along the afferent and efferent nerves

### Team Notes :

- Central delay is time taken in spinal cord synapses
- Minimal Synaptic delay : is time taken in one synapse

#### Mathematical problems

If you have 20 interneuron, what is the total central delay?

$$20 \times 0.5 = 10 \text{ ms}$$

If the total central delay is 200 ms , how many neuron do you have?

$$200 / 0.5 = 100 \text{ interneuron}$$

Properties of reflexes

- 1-Reciprocal inhibition
- 2-Irradiation
- 3-Recruitmant
- 4-After discharge
- 5-central delay

Team Notes :

Nothing else was mentioned about this slide.

## Questions

**1. Reciprocal inhibition means:**

- A. Gradual activation of motor neurons by maintained stimulation
- B. Slight stimulus to the sole causes extension of the other limb
- C. A strong stimulus in an afferent irradiates to many segments of spinal cord
- D. Contraction of agonist and relaxation of antagonist muscle

**2. An example of polysynaptic reflex is**

- A. Withdrawal reflex
- B. Biceps reflex
- C. Triceps reflex
- D. Ankle jerk

**3. The knee jerk is:**

- A. A deep reflex
- B. Polysynaptic
- C. Initiated by painful stimulus
- D. Does not follow reciprocal inhibition

**4. Tendon jerks:**

- A. Are transmitted through flower spray (Secondary afferents)
- B. Stimulated by maintained muscle stretch
- C. Can be induced by a sudden muscle stretch
- D. Are static stretch reflexes

**• 5. Which one of the following is the receptor for the withdrawal flexor reflex:**

- A. Touch receptor
- B. Pain receptor
- C. Pressure receptor
- D. Muscle spindle

Answers :-

1-D

2- A

3- A

4- C

5- B