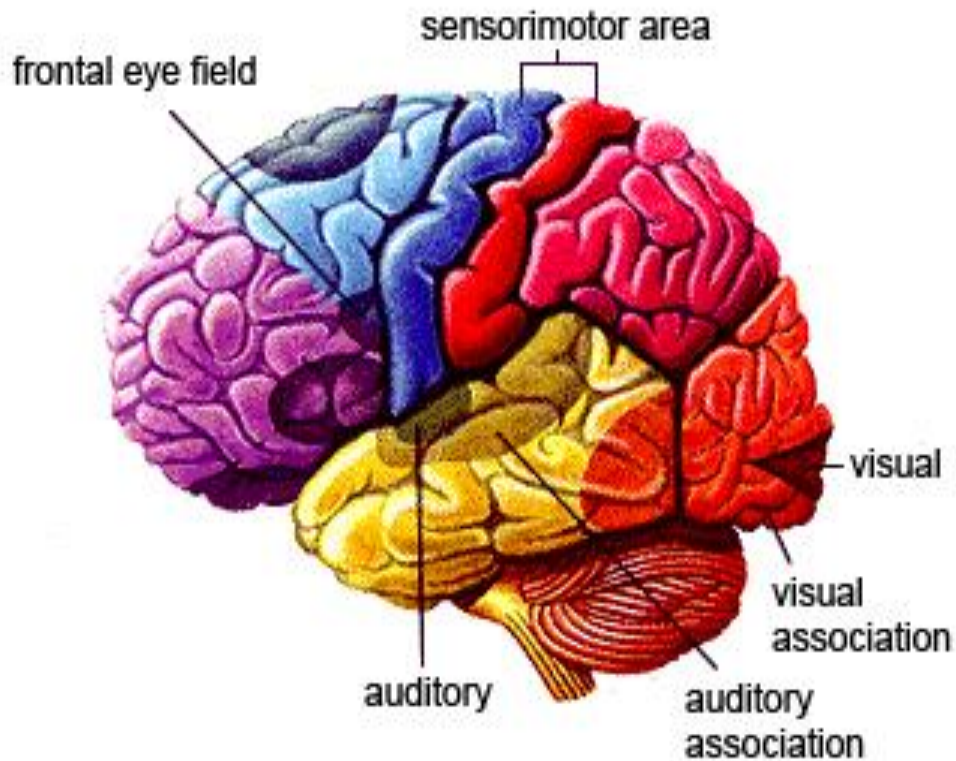


# Physiology Team



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( these notes are combination of female and male slides + our notes )

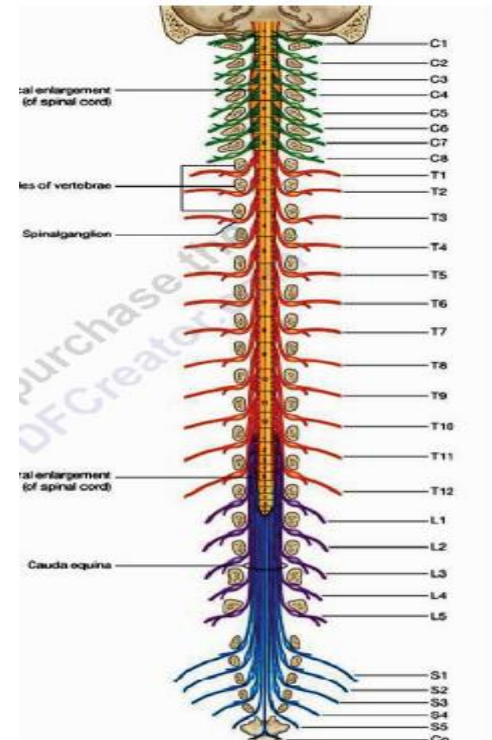
# Spinal Cord Functions & Spinal Reflexes

## 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 skin , muscles & joints
2. Efferent fibers carrying motor commands from the CNS to muscles .



## The spinal cord has ventral & dorsal roots :

- The **DORSAL ROOT** contains afferent (sensory) nerves coming from receptors .
- The cell body of these neurons is located in dorsal (posterior) root ganglion ( DRG)
- The **VENTRAL ROOT** carries efferent (motor) fibers
- The cell-body of these motor fibers is located in the ventral (anterior )

horn of the spinal cord

## Functions of the Spinal Cord

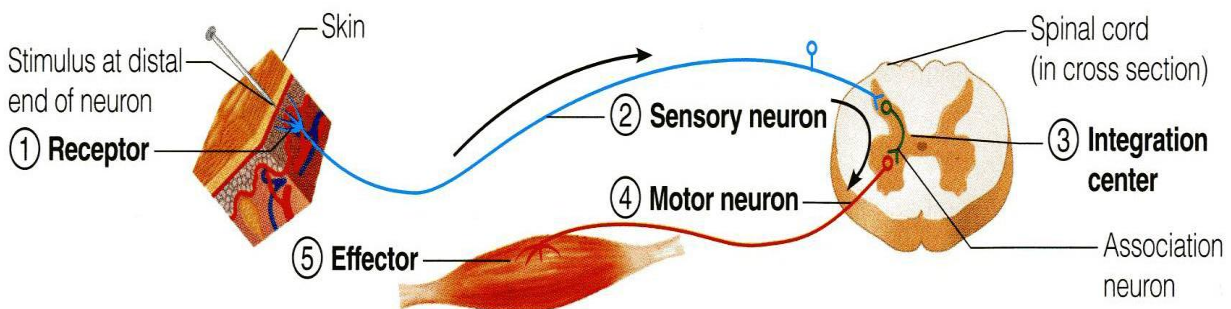
- (1) *Carrying sensory information from the receptors to the brain* ( through spinal afferent/sensory nerves & ascending/sensory tracts ).

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

1. Dorsal Column Tracts ( Gracile & Cuneate ) a Fine , discriminative touch , vibration & position senses
2. Lateral Spinothalamic Tract for pain and temperature .
3. Anterior Spinothalamic Tract for crude touch , pressure .

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

- (1) Spino cerebellar Tracts carry proprioceptive fibers to the cerebellum for posture control & coordination of movement
- (2) Executing brain motor commands ( through descending/motor tracts & spinal efferent/motor nerves to skeletal muscles)
- (3) Generating Spinal Reflexes



## Spinal reflexes

Is an automatic, voluntary neuromuscular action elected by a defined adequate stimulus (( No need for the brain ))

### Reflex Arc

- The basic unit of a reflex is the reflex arc
- Pathway of Sensory information to spinal cord to cause spinal reflex, it is formed of:

- Sense organ (receptor).
  - An afferent sensory neuron.
    - Center//One or more synapses (interneurons in S.C located in one or more spinal cord segments ).
      - Such interneurons can be excitatory or inhibitory.
- The " centre " of a spinal reflex consists of ending of the afferent nerve within the spinal cord + the motor neuron or interneurons
- An efferent motor neuron.
- An effector organ (skeletal muscle).

### Components of reflex arc :

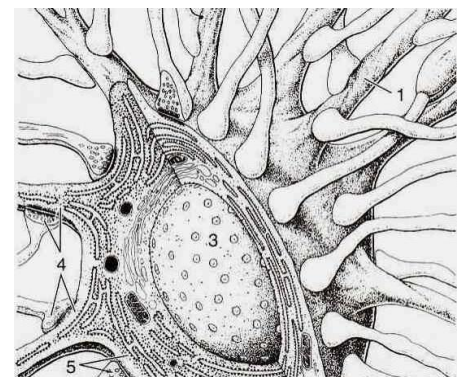
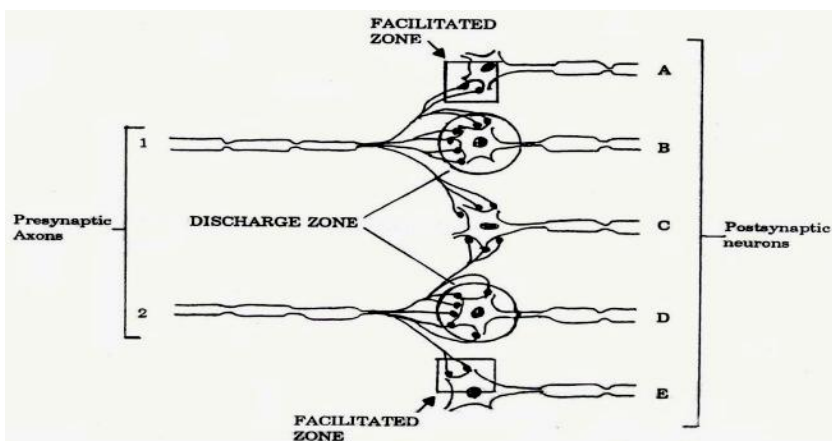
#### 1-AFFERENT NEURON

- Sensory afferent enter spinal cord via dorsal(posterior) root, ends at same segment or ascend to higher segments.
- AFFERENT NEURONS UNDERGO:

**Divergence:** to spread the effect of a single stimulus to more motoneurons in the same spinal segment or to adjacent segment  
 Ex: the axons of most presynaptic neurons divide into many branches that diverge to end on many postsynaptic neurons.

**Convergence:** to facilitate spatial summation

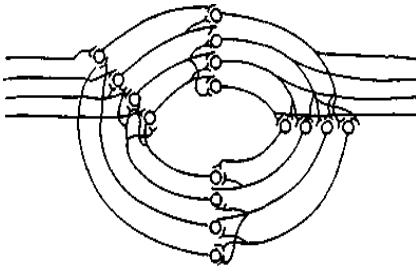
Ex : many presynaptic neurons converge on any single postsynaptic neuron



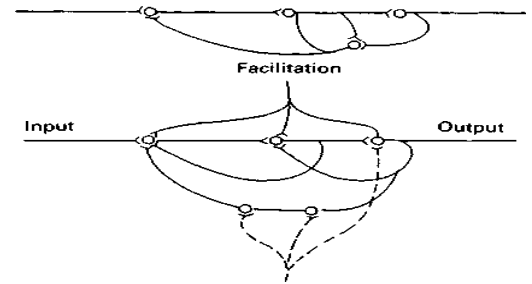
## 2- INTERNEURONS

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

### Parallel circuit



### Reverberating circuit



Some of the branch pathways turn back on themselves, permitting activity to reverberate allowing prolonged discharge by a single stimulus

## 3- EFFERENT NEURON ( 2 types )

1. **alpha motor neurons** :- large cells, large **myelinated** fibres (axons) form 70% of ventral root - supply extrafusal muscle fibres (2/3)
2. **Gamma motor neurons** :- smaller cells- small axons form 30 % of ventral root - supply intrafusal fibres.(1/3) " **less myelinated** than the alpha → slower in transmission "

• **The Alpha Motoneuron is also called the ( Final Common Pathway )**

- supply extrafusal muscle fibers
- are efferent side of many reflex arcs & many inputs converge on them from spinal & supraspinal centres ( brain ) " ( up to 10000 synapses can be present on one alpha motoneuron )

1- sensory neurons in same segment of S.C (muscle spindle, golgi tendon organ, pain receptors as withdrawal reflex)

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

3- supraspinal descending tracts from brainstem and cerebral cortex

- 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** "

## Types of reflexes

### **1. 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. Withdrawal, abdominal reflexes, visceral

### **2. -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

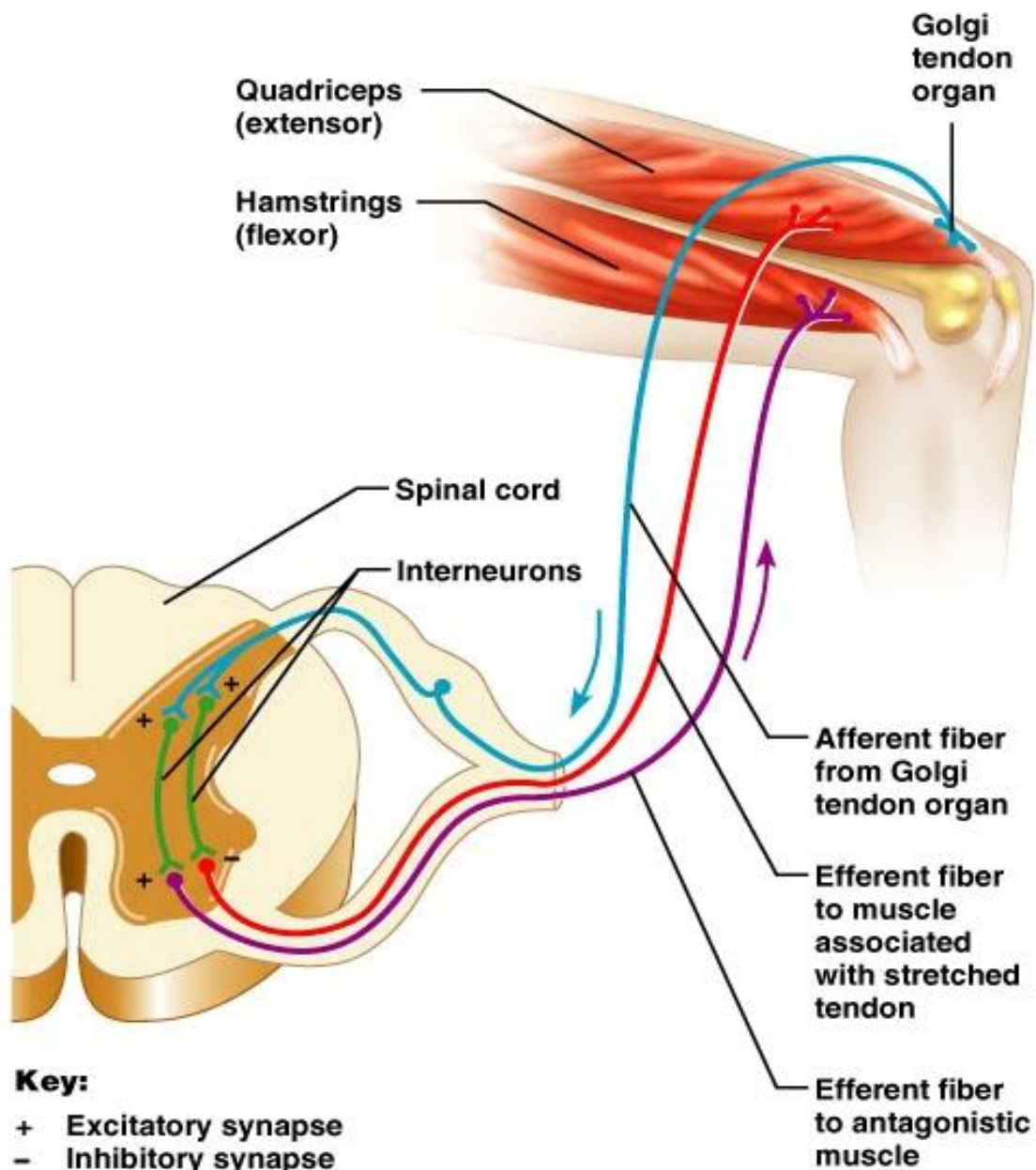
#### **(C )Visceral:**

by stimulation of receptors in wall of viscera as Micturition, defecation



## 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.



## Properties of reflexes :-

### 1. RECIPROCAL INHIBITION OR RECIPROCAL INNERVATIONS.

stimulation of flexors muscle accompanied by inhibition of extensors through inhibitory interneurons

### 2- THE CROSSED EXTENSOR REFLEX

- If a stronger stimulus ( than that needed to elicit the Withdrawal Reflex is delivered) then flexion withdrawal of the stimulated limb will be accompanied by extension of the opposite limb
- The latter response is called [Crossed Extensor reflex](#)
- Reciprocal innervations occurs in extensor reflex : flexors in the opposite limb are inhibited while extensors are excited to push the entire body away from the injurious agent and supporting the body weight against gravity.

### 3- IRRADIATION :-

spread of impulses up & down to different motor neurons in the S.C

- [weak stimulus](#) ----- weak flexion of limb  
Ex: when the sole of the foot is stimulated by a weak painful stimulus, only the big toe is flexed
- [strong stimulus](#) ----- withdrawal of affected limb & extension of opposite limb.

### 4- RECRUITMENT :

Gradual increase of activation of more number of motor neurons on stimulation of afferent nerve in a reflex arc by maintained, repetitive stimulus

#### Cause of gradual increase

- ✚ different conduction velocities of afferents
- ✚ different number of interneuron with short & long pathways to the anterior horn cells

### 5- AFTER-DISCHARGE:-

Means prolonged discharge of AHCs after stoppage of afferent stimulation causing maintained reflex action & response continue for some time after cessation of stimulus due to sustained activity in reverberating circuit

### 6-CENTRAL DELAY > 2MILLISECONDS

Time of reflex to pass through neurons of the spinal cord

- Number of synapses = central delay / time spent in each synapse (0.5 ms)
- Reflex Time = Central Delay + Time spent in conduction of impulses along the afferent and efferent nerves