Spinal Cord Functions & Spinal Reflexes

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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

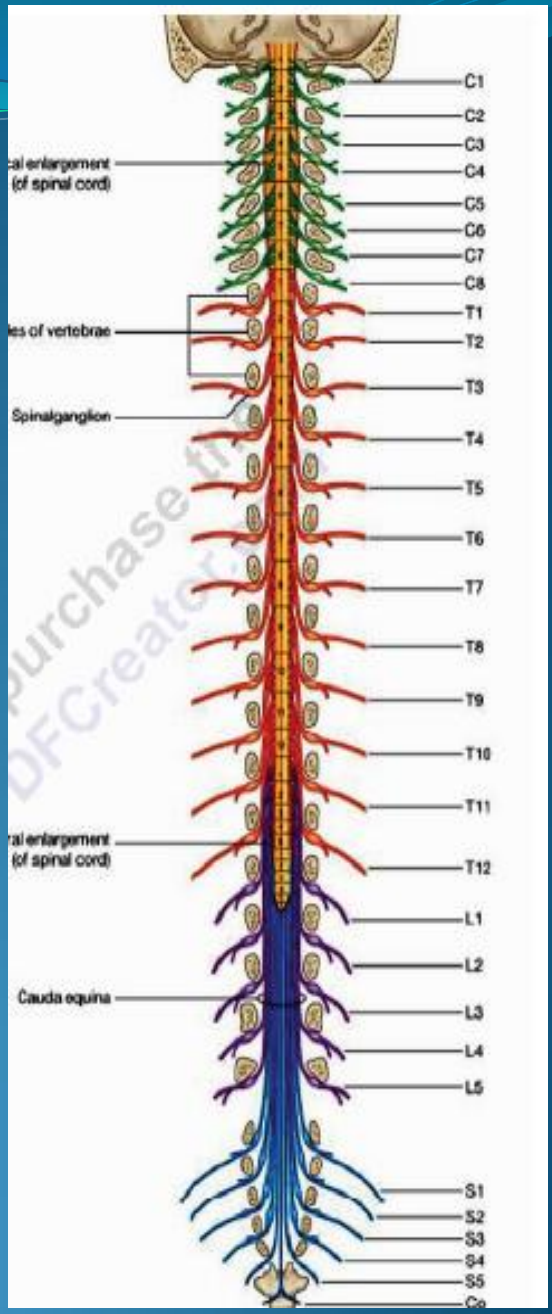
Describe properties of spinal cord reflexes as irradiation, recruitment and after discharge

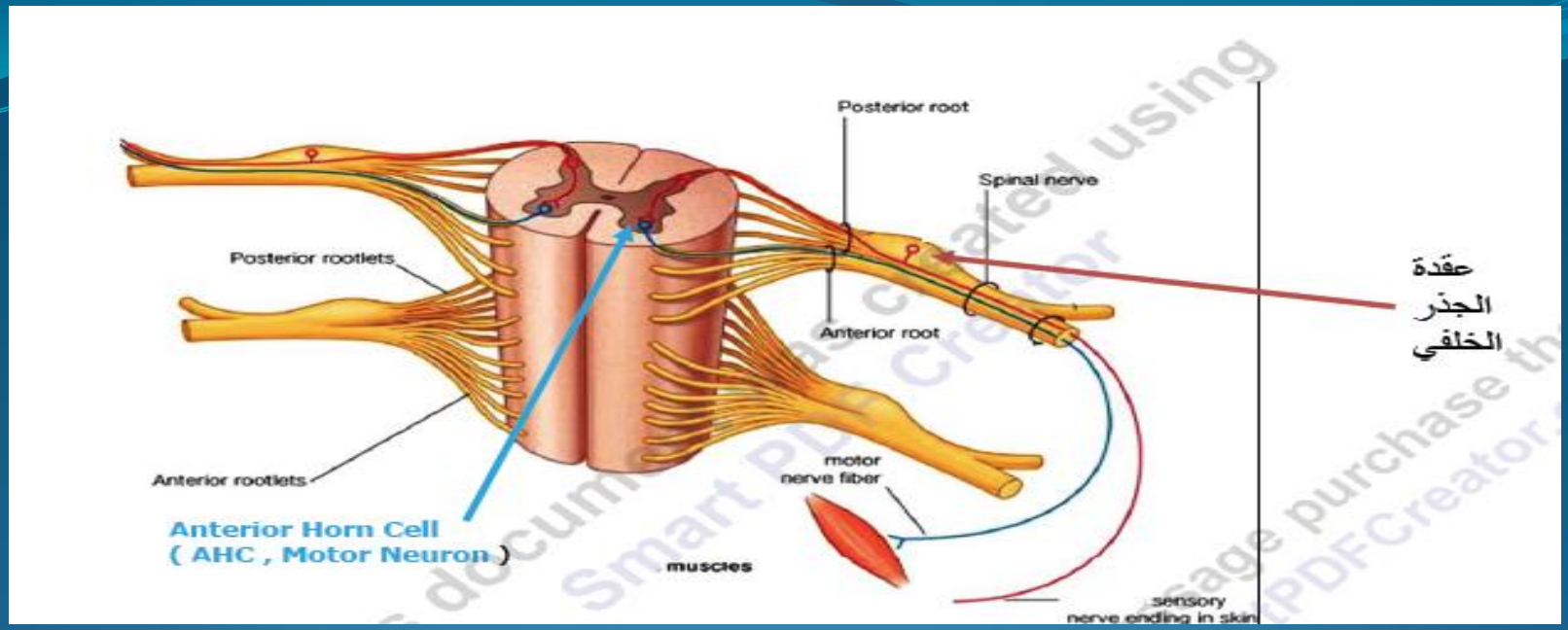
Spinal Nerve

- 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 .





- 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

Functions of the Spinal Cord

- (1) Carrying sensory information from the receptors to the brain
- (through spinal afferentsensory nerves & ascending/sensory tracts).
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A-Tracts Reaching Conscious Brain Level :

1- Dorsal Column Tracts (Gracile &Cuneate)

-Fine discriminative touch , vibration , position senses& stereognosis

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-Spinocerebellar Tracts carry fibers to the cerebellum for proproceptive information (sense of joint position& movements) for posture control & coordination of movement

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

- **Spinal reflexes**

- **What is a reflex?**

- **Functional unit of CNS, automatic ,involuntary response to a stimulus**
- **-example/pinprick causes withdrawal. R**

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).

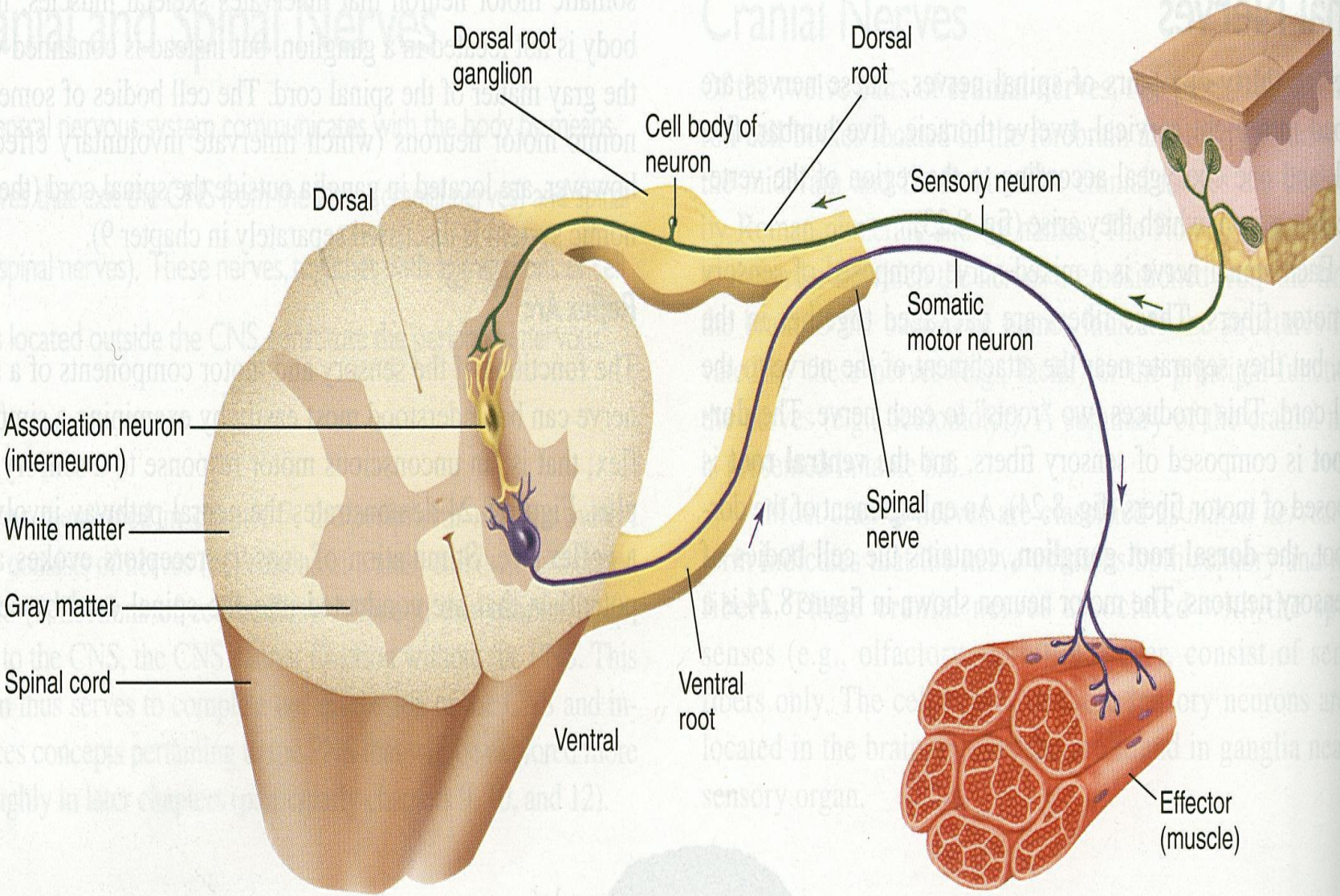


Figure 8.24 **A spinal reflex.** This reflex involves three types of neurons: a sensory neuron, an association neuron (interneuron), and a somatic mo neuron at the spinal cord level.

Components of reflex arc

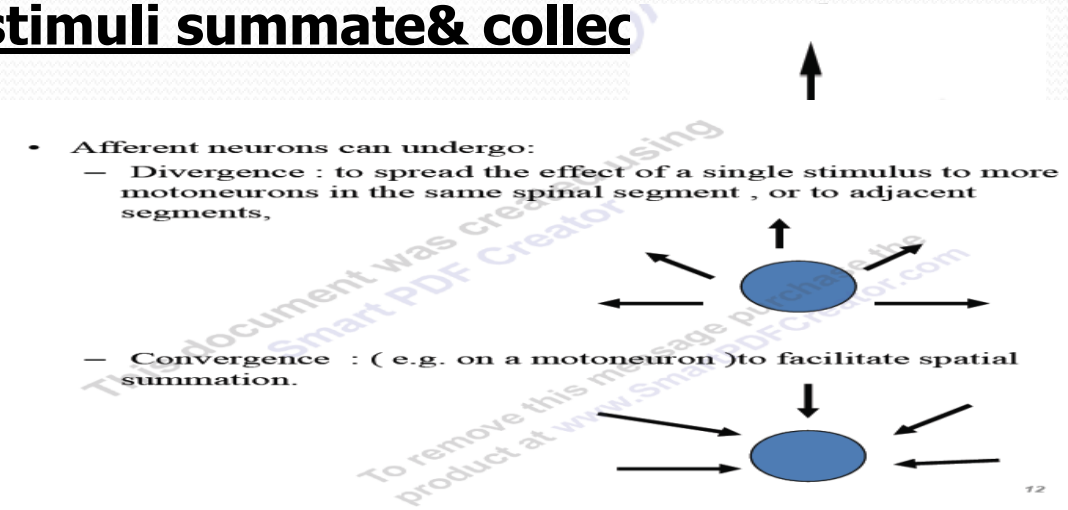
1-Afferent neuron

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

- - Afferent neurons undergo:

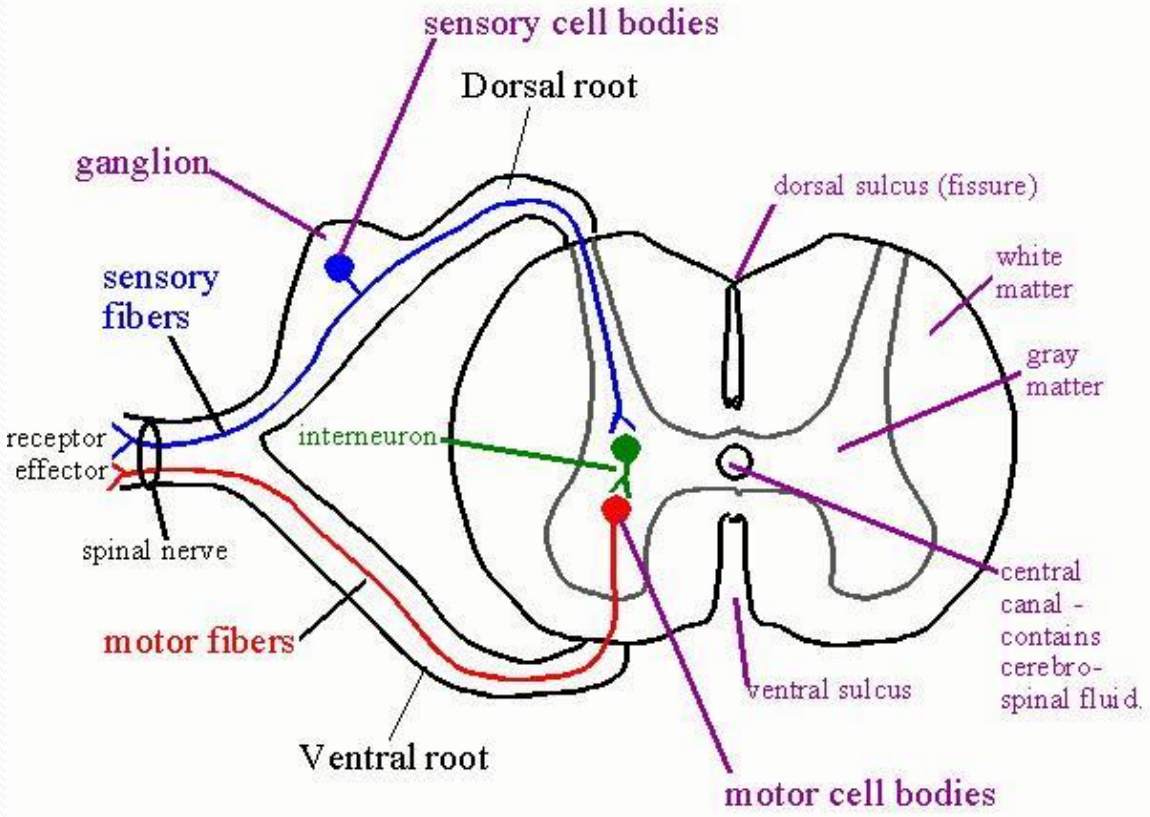
1- **Divergence** to help to spread a single stimulus to a wide area of the spinal cord,

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



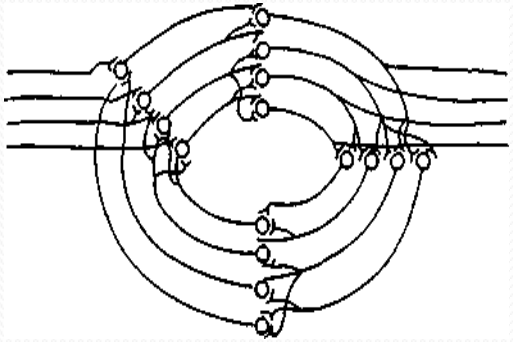
2- Interneurons

- 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).**

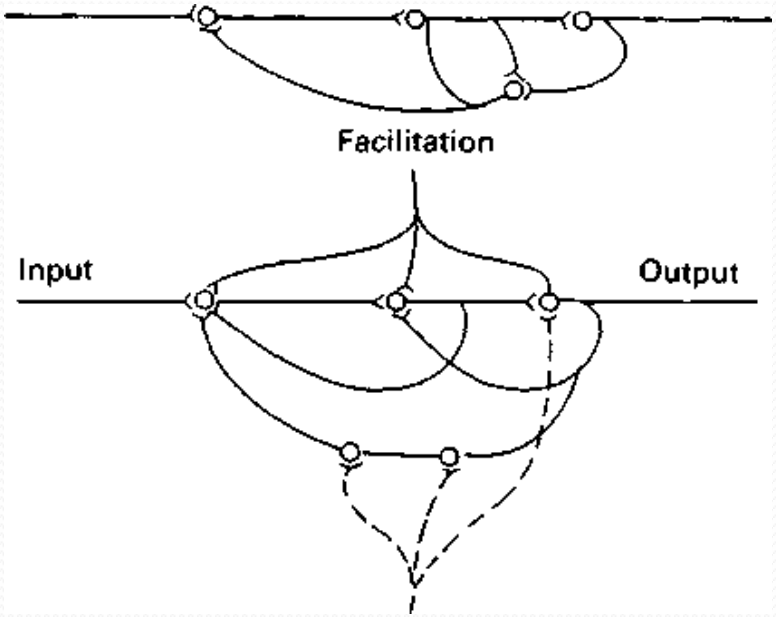

sensory cell bodies
Dorsal root
ganglion
dorsal sulcus (fissure)
white matter
sensory fibers
gray matter
receptor
effector
interneuron
spinal nerve
central canal - contains cerebro-spinal fluid
motor fibers
ventral sulcus
Ventral root
motor cell bodies

Reverberating circuits

1- Parallel



2-Reverbrating



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

--

3-Efferent neuron

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

1. **alpha motor neurons :- large cells, with large mylinated 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)**

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 &s upraspinal 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

-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 "

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

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

Withdrawal reflex

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.)

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

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

4- 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 begradual 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

5- after-discharge:-

- It means prolonged discharge of AHCs after stoppage of afferent stim. (this cause maitained 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

Properties of reflexes

1-Reciprocal inhibition

2-Irradiation

3-Recruitmant

4-After discharge

5-central delay