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&crossed extensor reflex

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

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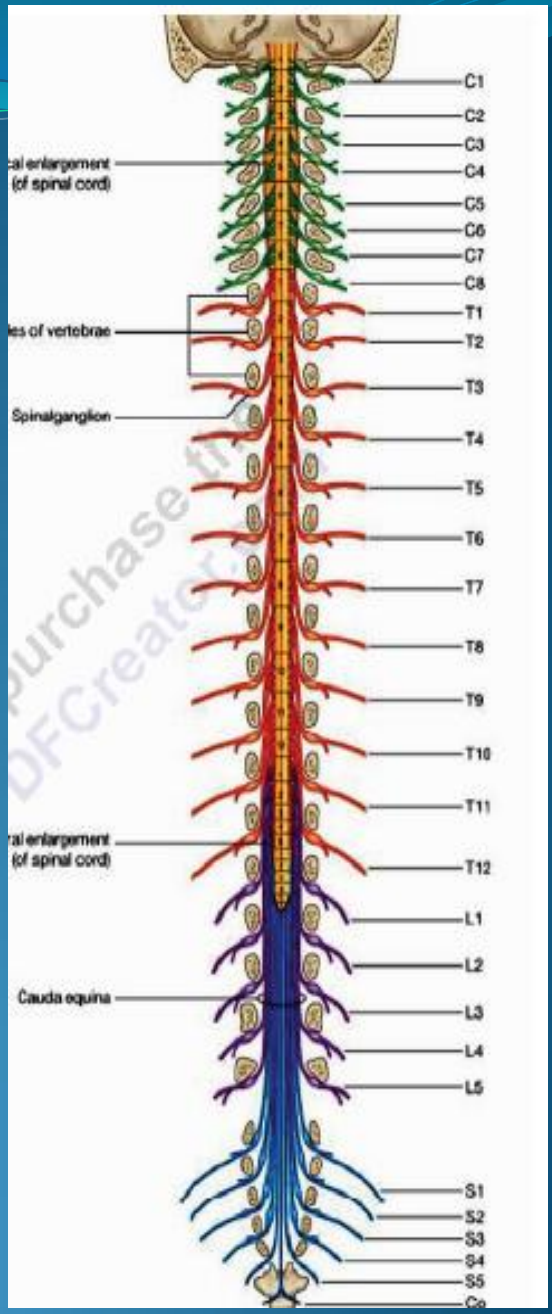
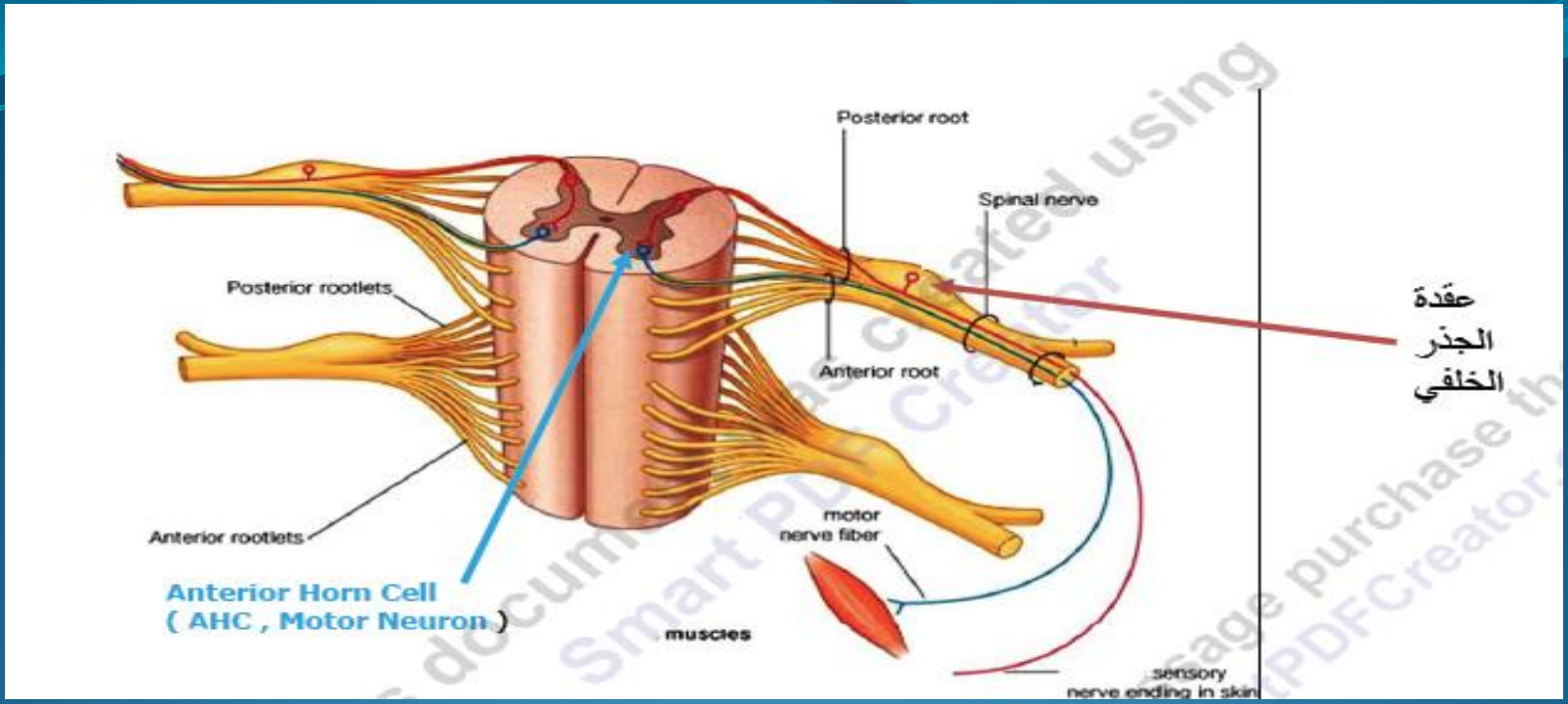
Spinal Nerves

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

Each spinal nerve has:

- (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 afferent sensory nerves to ascending sensory tracts).

A-Carring tracts Reaching Conscious Brain Level :

1- Dorsal Column Tracts (Gracile &Cuneate)

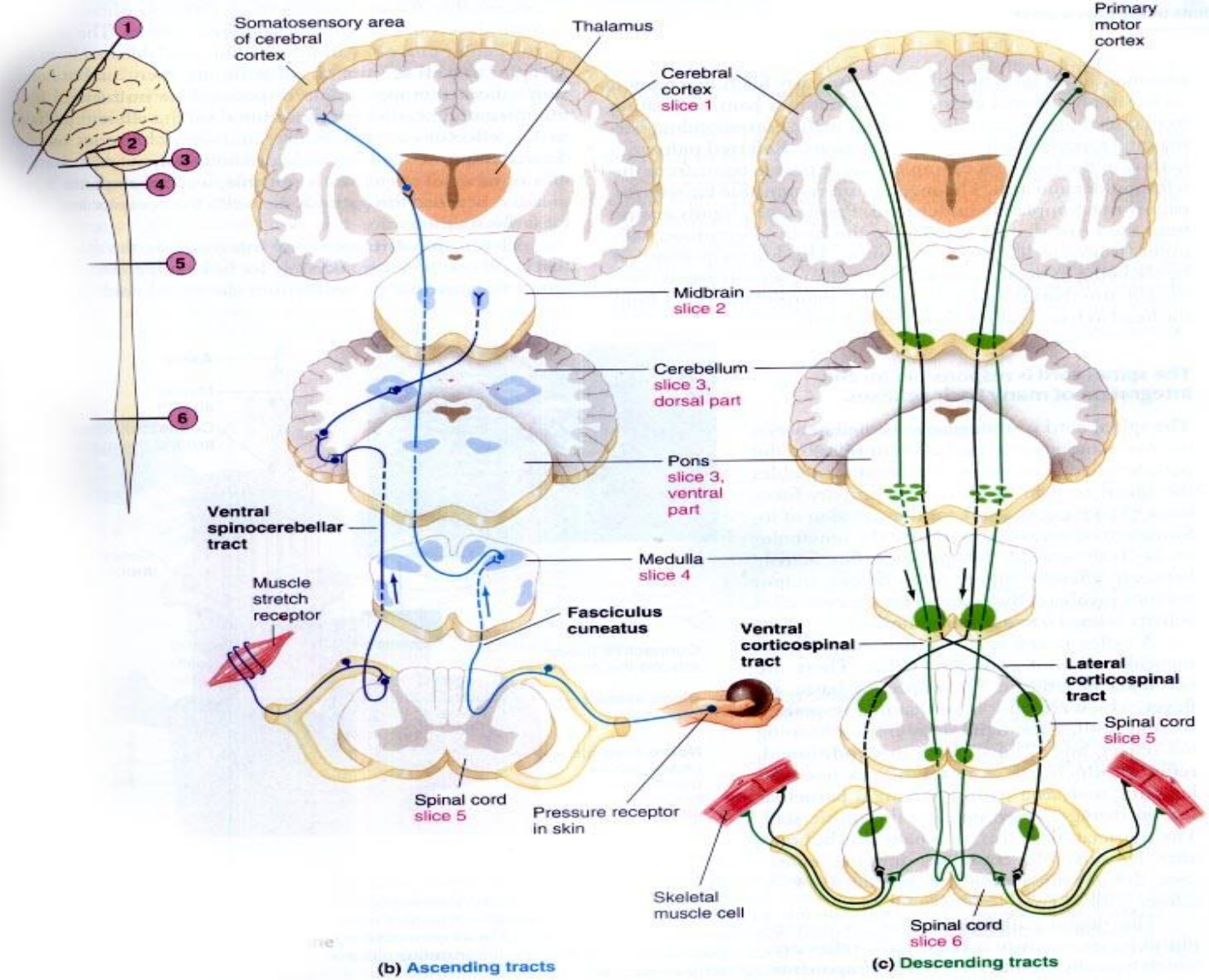
-Fine discriminative touch , vibration , position senses ,proprioception& stereognosis

2- Lateral Spinothalamic Tract for pain and temperature .

3- Anterior Spinothalamic Tract for crude touch , pressure .

B-Carring 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


1
2
3
4
5
6
Somatosensory area of cerebral cortex
Thalamus
Cerebral cortex slice 1
Primary motor cortex
Midbrain slice 2
Cerebellum slice 3, dorsal part
Pons slice 3, ventral part
Medulla slice 4
Ventral spinocerebellar tract
Muscle stretch receptor
Fasciculus cuneatus
Ventral corticospinal tract
Lateral corticospinal tract
Spinal cord slice 5
Spinal cord slice 5
Pressure receptor in skin
Skeletal muscle cell
Spinal cord slice 6
(b) Ascending tracts
(c) Descending tracts

Functions of the Spinal Cord

(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 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).

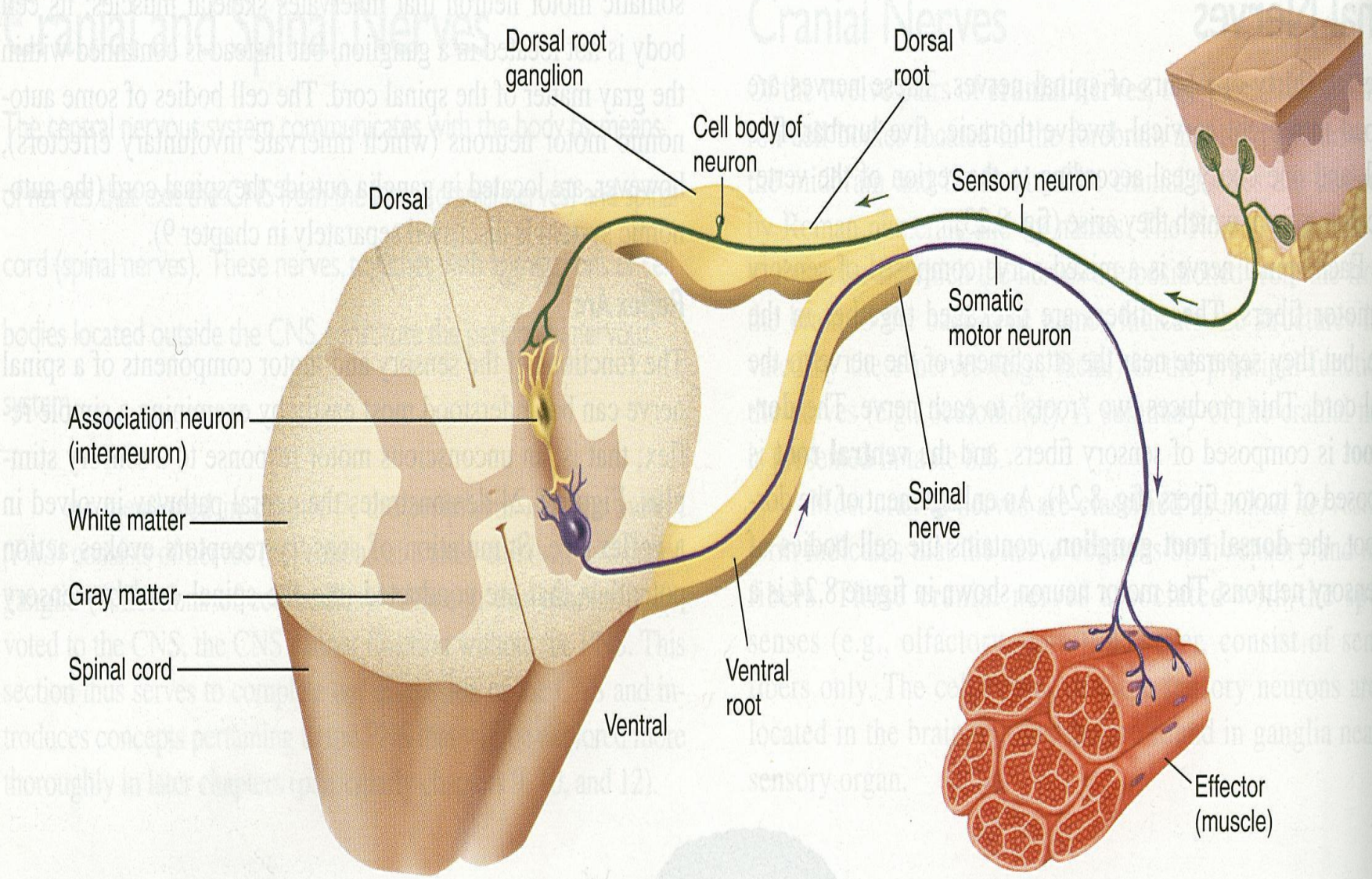


Figure 8.24 **A spinal reflex.** This reflex involves three types of neurons: a sensory neuron, an association neuron (interneuron), and a somatic mo neuron at the spinal cord level.

Components of reflex arc

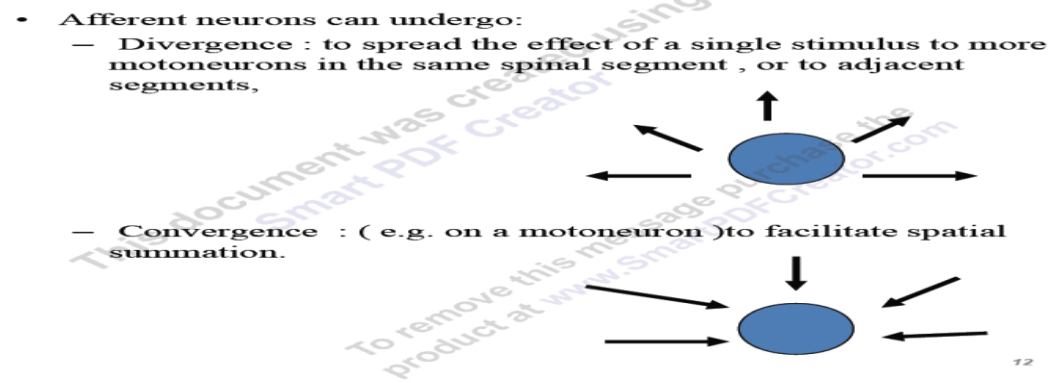
1-Afferent neuron

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

- - Afferent neurons undergo:

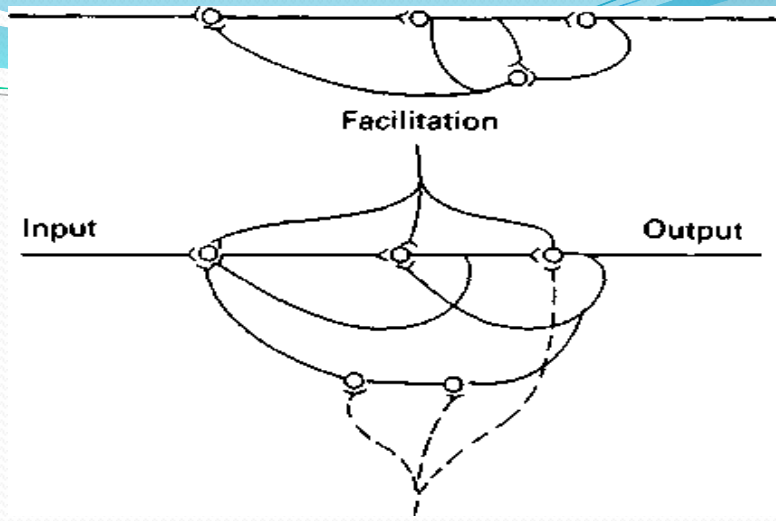
1- **Divergence** to help to spread a single stimulus to a wide area of the spinal cord,

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



2-Reverberating circuits

-Impulse from one neuron feed back to re-stimulate itself for long time as the fibers turn back on the same neurons

-What is its Value?

3-Efferent neuron

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

1. **alpha motor neurons :- large cells, with large mylinated fibres (axons) form 70% of ventral root – supply what?**
2. **Gamma motor neurons :- smaller cells- with small axons form 30 % of ventral root – supply what?**

The Alpha Motoneurons are called:-
the Final Common Pathway

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-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 (

2- excitatory and inhibitory signals from other segments 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 .What?

–What is Motor Unit ?

Types of reflexes

-According to number of neurons:-

- **Monosynaptic**
  - **Sensory axon (afferent)synapse directly with anterior horn cell-**

    Ex.Stretch reflex
- **Polysynaptic**
  - **Sensory axon (afferent)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 deep in muscle and tendons

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

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

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

(B) Superficial Reflexes

Are polysynaptic reflexes . The receptor are superficial in the skin .

Examples are Withdrawal, abdominal reflexes and plantar reflex

©Visceral:- by stimulation of receptors in wall of viscera

As Micturition, defecation

Properties of reflexes

1-Reciprocal inhibition

2-Irradiation

3-Recruitment

4-After discharge

5-**central delay&reflex time**

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 what?

***-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 also in crossed extensor reflex. How?

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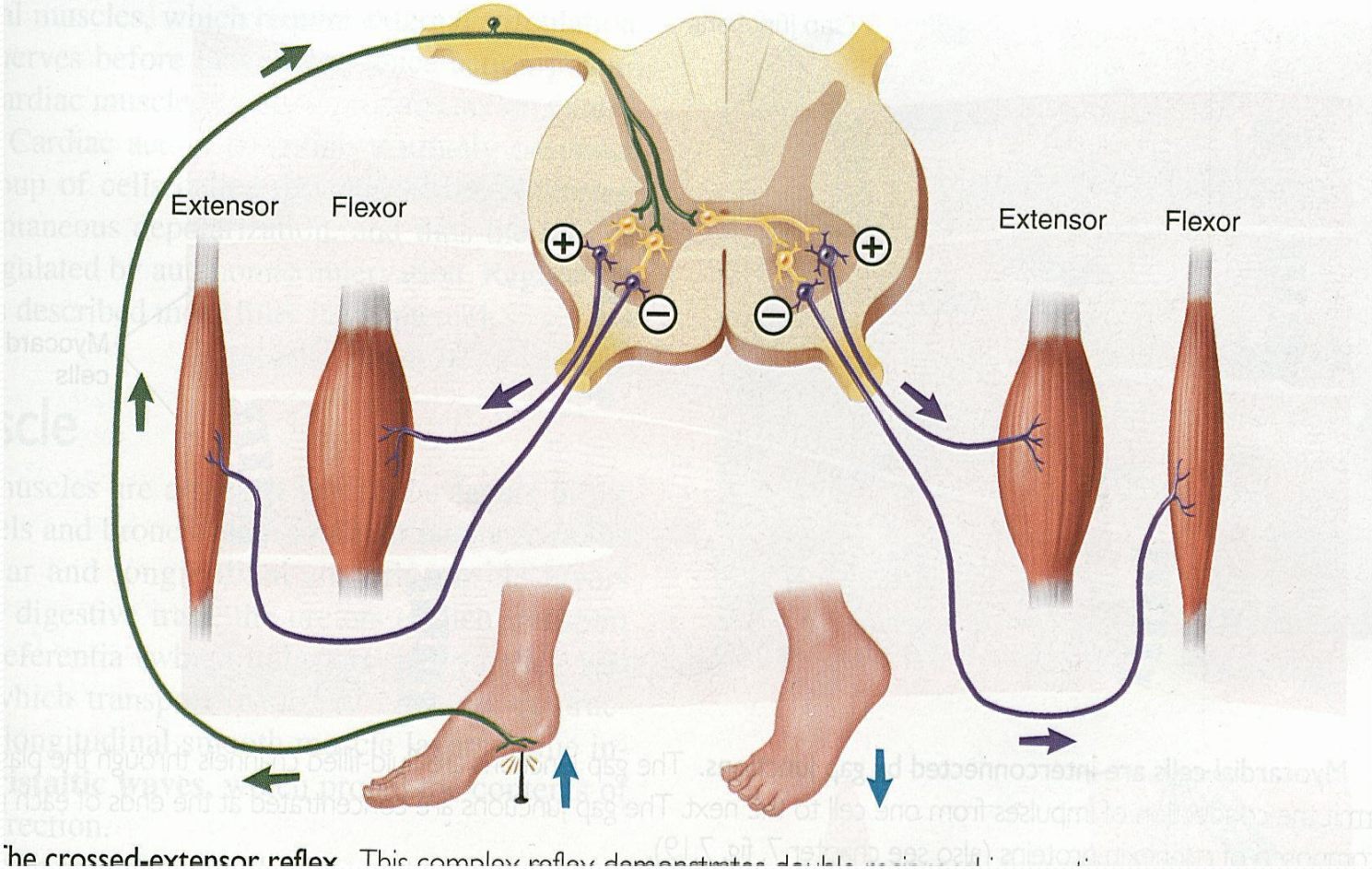
- hence it is an **Antigravity Reflex**

Crossed extensor reflex



The crossed-extensor reflex. This complex reflex demonstrates double

3- **IRRADIATION :-** - spread of impulses up & down to different segments and motor neurons in the S.C

A strong stim in sensory afferent irradiate to many segments of S.C due to WHAT?

****The extent of the response in a reflex depends on the intensity of the stimulus.**

-Weak stim----- weak flexion of limb

- Strong stim-----withdrawal of affected limb & extension of opposite limb.(as in crossed extensor reflex)

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4- RECRUITMENT :

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

Cause/ 1-different conduction velocities of afferents

2-different number of interneurons with short & long pathways to the motor neurons (AHCs)

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

5- After-discharge:-

- It means prolonged discharge of AHCs after stoppage of afferent stimulation.

(this cause maitained reflex action & response continue for some time after cessation of stimulus

What is the cause and value?

6-Central delay

Central delay/time of reflex to pass through neurons of CNS(S.C)

- equals 0.5 ms/synapse (SO it is long in polysynaptic R)

- **> 2 ms in the withdrawal R**

-Number of synapses= central delay /0.5ms

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