CNS Block

3rd Lecture

Spinal Cord Functions & Spinal Reflexes

PHYSIOLOGY TEAM – 430

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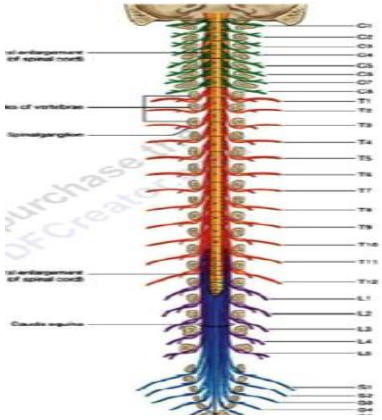
Spinal Cord Functions & Spinal Reflexes

- **Introduction:**



Spinal Nerves :

The spinal cord has 31 pairs of spinalNerves

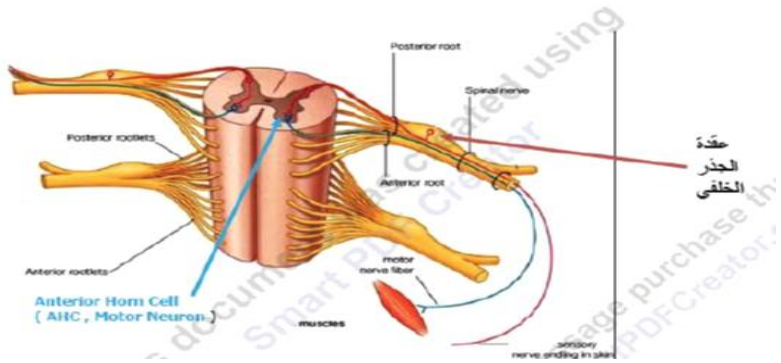
- 8 cervical,
- 12 thoracic,
- 5 lumbar,
- 5 sacral and 1 coccygeal

They contain :

(1) Afferent fibers bringing to the CNS sensory information from receptors of skin ,muscles & joints.

(2) Efferent fibers carrying motor commands from the CNS to muscles.

Cross section of the spinal cord



- **The spinal cord has 2 roots:**

The root	Location of the cell body
1-Dorsal (posterior) root: contains affrent(sensory) nerves coming from the recetors	In the DRG(dorsal root ganglion)
2- ventral (anterior) root: carries efferent fibers	Ventral (anterior) horn of 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) which are of two types:

A-Tracts Reaching Conscious Brain Level (i.e: reaching the cortex):

1-Dorsal Column Tracts (Gracile &Cuneate)
Responsible about : 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) " i.e : don't reach the cortex"

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

proprioception is the ability to recognize sence of movement and position

2) Executing brain motor commands (through descending/motor tracts & spinal efferent/motor nerves to skeletal muscles)

3) Generating Spinal Reflexes (they don't reach the brain)

- **Spinal reflexes :**

– **What is a reflex**?
It's a Functional unit of CNS, automatic ,involuntary response to a stimulus

it's invoulntary because that we don't think about the response we have done after exposing to the stimulus , and that what Distinguishes spinal reflexes from other actions

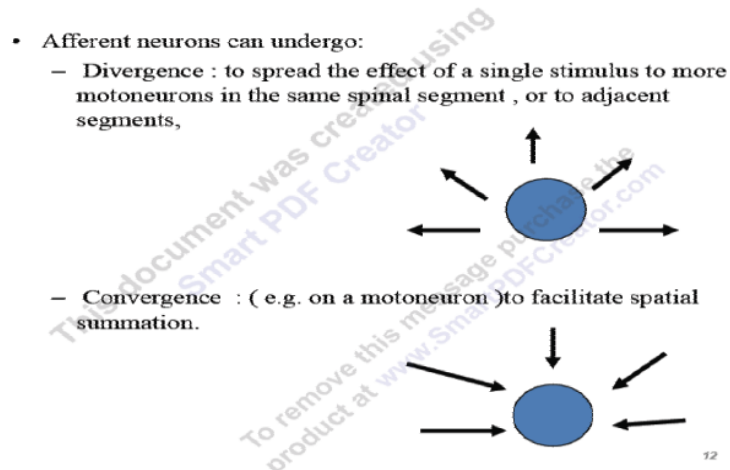
– **Example** :
pinprick causes withdrawal reflex (which is pulling the hand away from the stimuls "pinprick"

- **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)(coming from the receptors)
    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).

- **Components of the reflex arc:**



1)Afferent neurons :

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.
The benefit from this property: to have a strong stimulus

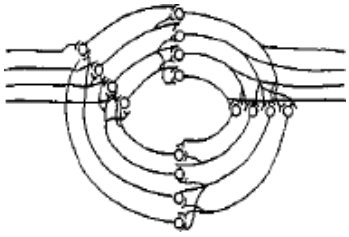
2- **Convergence** :
To help the process of spatial summation.(multiple stimuli summate& collect together at the same time)
The benefit : to have a localized response

2)Interneurons (cells that compose the center) :

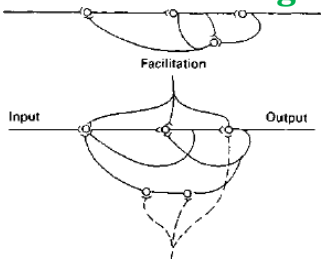
Interneurons are small cells in grey matter ofspinal cord connecting afferent to efferent(excitatory or inhibitory).
-Two types of circuits formed by inter neurons (parallel and reverberating circuits).

Reverberating circuits :

1- Parallel (the afferent is parallel to the eeferent)



2- Reverbrating



There is a neuron which gives an axon to another neuron to stimulate it . This other neuron will stimulate the first neuron back by sending a collateral axon .
Example: during studying and memorizing . this process will continoue untill the neurons become fatigue or when the neurotransmmitters are

Value//Allow prolonged discharge of the same motor neurons by a single stimulus . Why?
--Impulse from one neuron feed back to restimulate itself for long time as branches turn back on the same neurons → permitting activity to reverbrate untill it stops due to fatigue or inhibitory impulse

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

  - **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(the stimulus is PAIN"important")**

1- 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

2- IRRADIATION :-

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

-weak stimulation -- weak flexion of limb

- strong stimulation -- withdrawal of affected limb &extension of opposite limb. A strong stimulation in sensory afferent 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.

3- 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 stimulatioallow 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

4- after-discharge:-

- It means prolonged discharge of AHCs after stoppage of afferent stimulation this cause maintained reflex action & response continue for some time after cessation of stimulus Causes:
  - presence of reverberating circuit restimulate AHCs
  - Value /prolong the protective response of reflex

5-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