

SPINAL CORD FUNCTIONS & SPINAL REFLEXES

- **Team Members:** Ola Alnuhayer - Jwaher AlHarbi - Ammar AlMansour

OBJECTIVE SUMMARY - QUICK REVIEW

1. Appreciate the two-way traffic along the spinal cord

❖ Sensory signals from receptors enter the cord through the sensory roots, then every sensory signal travels to two separate destinations:

1. One branch of the sensory nerve terminates in the **gray matter of the spinal cord and elicits local segmental cord reflexes**
2. Another branch transmits signals to higher levels in the spinal cord, or to the brain stem, or even to the cerebral cortex through spinal **"ascending"**

Motor signals & brain motor commands pass through **descending motor tracts & spinal efferent motor nerves to skeletal muscles** to execute motor functions

2. Describe the role of the spinal cord as an initiator of spinal reflexes

The spinal cord & its associated spinal nerves contain neural circuits that control reflexes

3. Describe the organization of the spinal cord for motor functions

Anterior horn cells	<ul style="list-style-type: none"> ◆ Alpha motor neurons: <ul style="list-style-type: none"> ○ They give rise to large type A alpha motor nerve fibers ○ Form 70% of ventral root ○ Supply 2/3 Of the skeletal muscle fibers "extrafusal fibers" ◆ Gamma motor neurons: <ul style="list-style-type: none"> ○ They transmit impulses through type A gamma motor nerve fibers ○ Form 30% of ventral root ○ Supply 1/3 of the skeletal muscle fibers "intrafusal fibers"
Interneurons & interneuron pool	<ul style="list-style-type: none"> ○ They are excitatory or inhibitory. ○ highly excitable cells, often exhibiting spontaneous activity ○ Different types of neuronal circuits are found in the interneuron pool ◆ Renshaw cells: <ul style="list-style-type: none"> ○ <u>Inhibitory</u> cells inhibit → the surrounding motor neurons by <u>lateral inhibition</u> to help <u>focusing or sharpening</u> the signals from each motor neuron "it allows transmission of the primary signal in the desired direction while suppressing the tendency for signals to spread laterally"

4. Describe the spinal reflex and reflex arc components

Spinal reflex	rapid autonomic response to a stimuli that involve neurons in the spinal nerves & spinal cord	
Reflex arc	The pathway followed by nerve impulses that produce a reflex is a reflex arc	
Reflex arc components	Sensory receptor	<ul style="list-style-type: none"> ● It responds to a specific stimulus by producing generator potential. ● If generator potential reaches the threshold level of depolarization, it will trigger nerve impulses in the sensory neuron
	Sensory neuron	<ul style="list-style-type: none"> ● The nerve impulses propagate from the sensory receptor → the axon of the sensory neuron → the axon terminals ● Relay neurons send nerve impulses to the area of the brain that allows conscious awareness or it send to motor neuron or interneuron
	Integrating	<ul style="list-style-type: none"> ● Monosynaptic: single synapse between sensory & motor neurons

	center	<ul style="list-style-type: none"> Polysynaptic: contains one or more interneurons
	Motor neuron	<ul style="list-style-type: none"> Impulses triggered by the integrating center propagate out of the CNS along a motor neuron to the effector organ They are anterior horn cells (alpha/gamma)
	Effector	<ul style="list-style-type: none"> The part that responds to the motor nerve impulse. Its action is called reflex. <ul style="list-style-type: none"> If it is a skeletal muscle → somatic reflex If it is smooth muscle / cardiac muscle / gland → autonomic reflex

5. Classify reflexes

According to number of neurons	Monosynaptic "Ex.Stretch reflex"	Polysynaptic "Ex.Withdrawal,abdominal reflexes, visceral"	
According to site of the receptor	Superficial Reflexes	Deep Reflexes	Visceral reflexes
	<ul style="list-style-type: none"> ◆ The receptor are superficial in the skin <ul style="list-style-type: none"> Withdrawal reflex abdominal reflex plantar reflex 	<ul style="list-style-type: none"> ◆ Receptors are deep in muscle & tendons <ul style="list-style-type: none"> Stretch Reflexes (Tendon jerks) receptor → muscle spindle Inverse Stretch Reflex receptor → Golgi tendon organ 	<ul style="list-style-type: none"> ◆ receptors in wall of viscera <ul style="list-style-type: none"> Micturition defecation

6. Recognize the general properties of spinal cord reflexes

Convergence	Divergence	Reciprocal inhibition circuits	
signals from multiple inputs uniting to excite a single neuron	signals from single input spread to excite multiple neurons	<ul style="list-style-type: none"> Reflex contraction of an agonist muscle is accompanied by inhibition of the antagonist. 	
After-discharge		Reverberating circuits	
<ul style="list-style-type: none"> A signal entering a pool causes a prolonged output discharge of AHCs, lasting a few time after the incoming signal is over. Occurs due to: <ol style="list-style-type: none"> Synaptic After-discharge. Reverberating circuits. 		<ul style="list-style-type: none"> simple → involves a single neuron the output neuron sends a collateral nerve fiber to restimulate the input neuron itself "the circuit may discharge repetitively for a long time and causes signal prolongation" Complex → involves facilitatory & inhibitory fibers 	
Irradiation	Recruitment		
<ul style="list-style-type: none"> ◆ spread of sensory impulses up & down to different segments and motor neurons in the spinal cord "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 motor neurons → more response 	<ul style="list-style-type: none"> ◆ Gradual activation of more number of motor neurons ◆ Cause: <ol style="list-style-type: none"> different conduction velocities of afferents different number of interneurons with short & long pathways to the motor neurons 		Reflex time (reaction time)
	Central delay (synaptic delay) = 0.5ms/synapse		<ul style="list-style-type: none"> ◆ The time between the application of the stimulus and the response ◆ = Central Delay + Time spent in conduction of impulses along the afferent and efferent nerves
	The minimal period of time required for transmission of a neuronal signal from presynaptic to postsynaptic neurons Number of synapses in a reflex = $\frac{\text{central delay}}{0.5ms}$		

7. Describe the most important types of spinal cord reflexes

Function	Protective "withdrawal from painful stimulus"	Stimulus	Sharp painful stimulus
response	Limb is rapidly withdrawn	Sensory receptor	Cutaneous skin and pain receptor
Synapses involved	Polysynaptic	Effects on muscle	Contract flexor muscle
Other effects	<ol style="list-style-type: none"> Relaxes extensor muscle of the same limb (reciprocal inhibition) Reverse effect on the opposite limb (cross extensor reflex) 		
	<ul style="list-style-type: none"> Diverging circuits to spread the reflex to the necessary muscles for withdrawal 		

Characterized by	<ul style="list-style-type: none"> • Reciprocal inhibition circuits / recruitment / irradiation to enhance the response • after-discharge circuits to prolong the protective response • The pattern of withdrawal follows the “local sign” principle
Crossed extensor reflex	
Function	Supporting the body weight against gravity (mostly in the lower limb)
Characterized by	<ul style="list-style-type: none"> • It begins lately (200 to 500 ms after onset of the initial pain stimulus) & it has longer period of after-discharge • Reciprocal innervations occurs also in crossed extensor reflex

Check your understanding!

1- Which neurotransmitter could be released from inhibitory interneuron:		2- what is the type of withdrawal reflex:	
A	Adrenaline and noradrenaline.	A	Superficial polysynaptic reflex.
B	Dopamine.	B	Deep monosynaptic reflex.
C	GABA and Glycine.	C	Superficial monosynaptic reflex.
D	Aspartate.	D	Deep polysynaptic reflex.
3- If the central delay = 0.6s, how many the number of synapses?		4- From the following statements, choose the accurate one:	
A	1	A	Alpha and gamma neurons are both motor neurons.
B	2	B	Gamma give rise to large motor nerve.
C	3	C	Alpha form 30% of the ventral horn.
D	4	D	Intrafusal fibers are innervated by alpha neuron.

5- When a pain stimulus targets the inward side of the arm causes not only contraction of the flexor muscles of the arm, but also contraction of abductor muscles to pull the arm outward. This is termed as:		6- cell body of interneuron is located in :	
A	Recruitment.	A	Lateral grey horn.
B	Crossed extensor reflex.	B	Anterior grey horn.
C	Local Sign.	C	Dorsal grey horn.
D	Irradiation.	D	Ventral grey horn.
7- cell body (SOMA) of sensory neurons is located in:		8- what kind of muscle fiber is supplied by Alpha motor neurons :	
A	Dorsal horn of grey matter.	A	Intrafusal.
B	Ventral horn of grey matter.	B	Extrafusal.
C	Dorsal root ganglion.	C	Subfusal
D	Lateral horn of grey matter.	D	Intrafusal and Extrafusal.
9- Sensory receptor responds to a specific stimulus by a potential named as:		10- One of the following features is important in terminating epileptic seizures (stops it)?	
A	Generator potential.	A	After discharge.
B	Graded potential.	B	Synaptic delay (Central delay).
C	Receptor potential.	C	Reverberating circuits.
D	A + C.	D	Fatigue of synaptic transmission.

Answers :

1- C	2- A	3- A	4- A	5- C	6- C	7- C	8- B	9- D	10- D
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