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Reflex Arcs, Synapses & Peripheral Nerve Anatomy

Study Guide — Reflexes & Spinal Cord

High-school/Pre-med/IB questions on reflex arc components, synapses, nerve structure, and factors affecting speed of nervous transmission.

30 items — Study Guide with Answers

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1 Which sequence correctly represents the basic pathway of a spinal reflex arc from stimulus to response?

- A** Receptor → motor neuron → effector → sensory neuron → spinal cord
- B** Receptor → sensory (afferent) neuron → CNS integration → motor (efferent) neuron → effector ✓
- C** Effector → motor neuron → spinal cord → sensory neuron → receptor
- D** Receptor → interneuron → sensory neuron → motor neuron → effector
- E** Receptor → blood → brain → muscle → spinal cord

► **Explanation:** A reflex arc begins at a receptor, travels via a sensory (afferent) neuron to an integration center in the CNS (often spinal cord), then exits via a motor (efferent) neuron to an effector. The other options scramble the order or include incorrect routes (e.g., blood is not part of neural conduction).



2 Which statement correctly defines afferent vs efferent nerve pathways?

- A** Afferent nerves carry signals from the CNS to muscles; efferent nerves carry signals to the CNS
- B** Afferent nerves carry sensory information to the CNS; efferent nerves carry commands from the CNS to effectors ✓
- C** Afferent nerves are only autonomic; efferent nerves are only somatic
- D** Afferent and efferent both carry signals away from the CNS
- E** Afferent nerves always contain motor neurons, while efferent nerves never do

► **Explanation:** Afferent = toward the CNS (sensory input). Efferent = exiting the CNS (motor output to muscles/glands). The other options reverse directions or incorrectly restrict to autonomic/somatic only.





3 In the spinal cord, sensory fibers enter and motor fibers exit via which structures?

- A Sensory enter via ventral roots; motor exit via dorsal roots
- B Sensory enter via dorsal roots; motor exit via ventral roots ✓
- C Both sensory and motor enter via dorsal roots
- D Both sensory and motor exit via ventral roots
- E Sensory and motor both enter and exit via the same root only

► **Explanation:** Dorsal roots carry sensory (afferent) fibers into the spinal cord, while ventral roots carry motor (efferent) fibers out. The other options swap or incorrectly combine roles.



4 Where are the cell bodies of most sensory neurons supplying the spinal cord located?

- A Ventral horn of the spinal cord
- B Dorsal root ganglion ✓
- C Motor end plate
- D Inside skeletal muscle fibers
- E Cerebral cortex

► **Explanation:** Sensory neuron cell bodies cluster in the dorsal root ganglia (PNS). Motor neuron cell bodies are in the ventral horn, and the cortex is not where peripheral sensory neuron cell bodies sit.



5 Which statement about the patellar (knee-jerk) reflex is MOST accurate at Pre-med/IB level?

- A It is a voluntary movement controlled by the motor cortex





B It is a monosynaptic reflex with a direct sensory-to-motor synapse in the spinal cord ✓

- C** It requires multiple interneurons and is therefore the slowest reflex
- D** It occurs only if the brain first interprets pain
- E** It uses only autonomic nerves and glands as effectors

► **Explanation:** The core stretch reflex pathway is monosynaptic: a sensory neuron from the muscle spindle synapses directly onto a motor neuron to the same muscle. The other options confuse reflexes with voluntary movement, pain processing, or autonomic pathways.

6 Which change would MOST directly increase the speed of action potential conduction along an axon (all else equal)?



- A** Increasing the length of the axon
- B** Adding more chemical synapses along the pathway
- C Increasing myelination of the axon ✓**
- D** Decreasing the axon diameter
- E** Reducing the number of nodes of Ranvier to zero while keeping myelin

► **Explanation:** Myelination increases conduction speed by enabling saltatory conduction and reducing ion leakage. Longer axons do not inherently conduct faster, additional synapses slow transmission, smaller diameter slows conduction, and removing nodes would prevent proper regeneration of the signal.

7 Compared with electrical synapses, chemical synapses are generally slower mainly because chemical synapses:



- A Require diffusion of neurotransmitter and receptor activation steps ✓**
- B** Use myelin to transmit signals
- C** Allow ions to flow directly through gap junctions





- D Are always bidirectional
- E Do not involve ion channels in the postsynaptic cell

► **Explanation:** Chemical synapses include several time-consuming steps (vesicle fusion, neurotransmitter diffusion, receptor binding), causing synaptic delay. Gap junctions (electrical synapses) are faster, and chemical synapses are typically unidirectional and do involve postsynaptic ion channels.

8 Which feature is MOST characteristic of an electrical synapse?



- A Uses neurotransmitter vesicles and receptors across a synaptic cleft
- B **Allows direct ionic current flow through gap junctions ✓**
- C Has a large synaptic delay due to diffusion
- D Is always slower than chemical synapses
- E Always produces inhibition and never excitation

► **Explanation:** Electrical synapses use gap junctions that directly connect the cytoplasm of two cells, allowing ions to pass quickly. Chemical synapses rely on neurotransmitter release and can be either excitatory or inhibitory.

9 Saltatory conduction occurs because action potentials are regenerated mainly at:



- A The myelin sheath itself
- B **Nodes of Ranvier ✓**
- C The nucleus of the neuron
- D The dendrites
- E The synaptic cleft





► **Explanation:** Nodes of Ranvier are gaps in myelin with high densities of voltage-gated Na^+ channels, where the action potential is regenerated. Myelin insulates but does not generate action potentials.

10 Damage to myelin around a peripheral axon would most likely cause which effect on nervous transmission?



- A Action potentials become larger in amplitude
- B Transmission becomes faster because ions leak out more easily
- C Transmission slows and may fail because current leaks and the next node may not reach threshold ✓**
- D Signals reverse direction along the axon
- E Chemical synapses stop using neurotransmitters

► **Explanation:** Myelin normally reduces current leakage and speeds conduction; loss of myelin slows conduction and can block propagation if depolarization cannot reach threshold at downstream regions. It does not reverse direction or change synapses to stop using neurotransmitters.

11 A 'nerve' in the peripheral nervous system is best defined as:



- A A single neuron cell body
- B A bundle of axons in the PNS surrounded by connective tissue ✓**
- C A bundle of axons in the CNS (brain or spinal cord)
- D A bundle of dendrites only
- E A cluster of cell bodies in the CNS

► **Explanation:** In the PNS, a nerve is a bundle of axons wrapped in connective tissue layers. In the CNS, bundles of axons are called tracts, and clusters of cell bodies are called nuclei (CNS) or ganglia (PNS).





12 Which connective tissue layer surrounds a FASCICLE (a bundle of axons) within a peripheral nerve?



- A Endoneurium
- B Perineurium ✓
- C Epineurium
- D Sarcolemma
- E Periosteum

► **Explanation:** Endoneurium wraps individual axons, perineurium wraps fascicles, and epineurium wraps the entire nerve. Sarcolemma is a muscle membrane, and periosteum surrounds bone.

13 In peripheral nerve anatomy, a 'fascicle' refers to:



- A A cluster of neuron cell bodies in the spinal cord
- B A bundle of axons grouped together within a nerve ✓
- C A synapse between two neurons
- D The gap between myelin segments
- E A bundle of dendrites only

► **Explanation:** A fascicle is a bundle of axons within a nerve, enclosed by perineurium. Clusters of cell bodies are ganglia (PNS) or nuclei (CNS), and nodes of Ranvier are gaps in myelin.

14 A typical spinal nerve (after dorsal and ventral roots merge) is classified as:



- A Purely sensory





- B Purely motor
- C Mixed (contains sensory and motor fibers) ✓
- D Purely autonomic only
- E Neither sensory nor motor

► **Explanation:** Dorsal roots carry sensory fibers and ventral roots carry motor fibers; once they merge, the spinal nerve contains both, making it mixed. The other options ignore this merging.

15 Monosynaptic reflexes are generally faster than polysynaptic reflexes mainly because monosynaptic reflexes:



- A Use electrical synapses only
- B Have fewer synapses and therefore less synaptic delay ✓
- C Use thicker bones to transmit signals
- D Do not require any neurons
- E Occur only in the brain cortex

► **Explanation:** Each chemical synapse introduces a synaptic delay. Monosynaptic reflexes have only one synapse in the core pathway, while polysynaptic reflexes have additional interneurons and synapses, slowing the response.

16 A person withdraws their hand from a hot object before consciously feeling pain. Which explanation best accounts for this?



- A The signal never reaches the brain
- B The reflex is integrated in the spinal cord, allowing a rapid motor response before conscious perception ✓
- C Heat directly contracts skeletal muscle without nerves





- D The motor cortex always reacts faster than the spinal cord
- E Chemical synapses are faster than electrical synapses

► **Explanation:** Withdrawal reflexes are processed in the spinal cord, producing a rapid protective response. Pain information still travels to the brain, but conscious perception takes longer than spinal reflex processing.

17 When stepping on a sharp object, the withdrawal reflex causes the injured leg to flex. Often, the opposite leg extends at the same time. This opposite-leg extension mainly helps to:



- A Stop neurotransmitter release at the synapse
- B Maintain balance by supporting body weight on the opposite leg ✓**
- C Decrease oxygen delivery to muscles
- D Increase the pain signal reaching the brain
- E Convert the reflex into a voluntary action

► **Explanation:** The crossed extensor reflex extends the opposite limb to help maintain posture and balance while the injured limb withdraws. It is not about stopping synaptic transmission or increasing pain.

18 An inhibitory postsynaptic potential (IPSP) is most commonly produced when a neurotransmitter causes:



- A Na^+ influx that depolarizes the postsynaptic membrane
- B Ca^{2+} influx into the postsynaptic membrane to trigger vesicle release
- C Cl^- influx or K^+ efflux that hyperpolarizes the postsynaptic membrane ✓**
- D Closure of all ion channels so the membrane potential becomes 0 mV
- E Direct ATP production at the synapse





► **Explanation:** IPSPs make the postsynaptic cell less likely to fire by hyperpolarizing it, commonly via Cl^- entry or K^+ exit. Na^+ entry typically causes excitation (EPSP).

19 A neuron receives several weak excitatory inputs that are each insufficient alone to reach threshold. The neuron fires only when **MANY** different presynaptic neurons activate at the **SAME** time. This is best described as:



- A Temporal summation
- B Spatial summation ✓**
- C Refractory period
- D Saltatory conduction
- E Osmosis

► **Explanation:** Spatial summation is the combining of inputs from multiple presynaptic neurons at once. Temporal summation is repeated firing from the same synapse over time.

20 Where are the cell bodies of somatic motor neurons that innervate skeletal muscle typically located?



- A Dorsal root ganglion
- B Ventral horn of the spinal cord ✓**
- C Synaptic cleft
- D White matter tracts only
- E Inside the muscle fiber

► **Explanation:** Somatic motor neuron cell bodies are located in the ventral horn (gray matter) of the spinal cord. Dorsal root ganglia contain sensory neuron cell bodies.





21 A lesion cuts the **DORSAL** root of a spinal nerve but leaves the ventral root intact. Which outcome is most expected for that spinal segment?

- A** Loss of motor output with normal sensation
- B** Loss of sensation and loss of the reflex response, but motor pathways can still carry signals out if directly activated ✓
- C** Normal sensation but exaggerated reflexes
- D** Loss of all autonomic functions only
- E** Improved conduction speed due to reduced sensory load

► **Explanation:** Dorsal roots carry sensory input; cutting them prevents the CNS from receiving the stimulus, so reflexes dependent on that input are lost. Ventral roots still carry motor output, so motor pathways remain structurally present even though reflex triggering is disrupted.



22 A lesion cuts the **VENTRAL** root of a spinal nerve but leaves the dorsal root intact. Which outcome is most expected?

- A** Loss of motor output (weakness/paralysis) with preserved sensation; reflex response is absent because the efferent limb is broken ✓
- B** Loss of sensation with preserved motor output
- C** Normal reflexes and normal movement
- D** Only pain sensation is lost; touch and pressure remain
- E** Only brain function changes; spinal cord function is unaffected

► **Explanation:** Ventral roots carry motor (efferent) fibers; cutting them prevents motor commands from reaching muscles. Sensory input can still enter via the dorsal root, but reflex output fails because the efferent limb is interrupted.





23 A local anesthetic blocks voltage-gated Na^+ channels in the skin near a painful stimulus. Which immediate effect is **MOST** likely on the reflex withdrawal response?

- A The reflex becomes stronger because inhibition is blocked
- B The reflex is reduced or absent because sensory action potentials cannot propagate to the spinal cord ✓
- C The reflex is unchanged because reflexes do not use action potentials
- D Only motor neurons are affected; sensory neurons are not
- E Only neurotransmitter diffusion in the synapse is blocked, not conduction

► **Explanation:** Blocking voltage-gated Na^+ channels prevents action potentials in sensory neurons, so the afferent signal cannot reach the spinal cord to trigger the reflex. Reflexes depend on action potential conduction and synaptic transmission.



24 Which reflex is **MOST** likely to require one or more interneurons and therefore be polysynaptic?

- A Knee-jerk (stretch) reflex
- B Withdrawal reflex from pain ✓
- C A single action potential traveling along an axon
- D Passive recoil of the lungs
- E Diffusion of oxygen in alveoli

► **Explanation:** Withdrawal reflexes are typically polysynaptic because they involve interneurons to coordinate flexors and inhibit extensors (and may include crossed extensor pathways). Stretch reflexes are classically monosynaptic in their core pathway.





25 Which pairing of myelinating cell type and nervous system location is correct?



- A Schwann cell – CNS
- B Oligodendrocyte – PNS
- C Schwann cell – PNS; oligodendrocyte – CNS ✓**
- D Astrocyte – PNS; microglia – CNS
- E Neurons myelinate themselves in both PNS and CNS

► **Explanation:** Schwann cells myelinate axons in the peripheral nervous system, while oligodendrocytes myelinate axons in the central nervous system. Astrocytes and microglia have other support/immune roles.

26 Which statement best distinguishes gray matter from white matter in the nervous system?



- A Gray matter is mostly myelinated axons; white matter is mostly cell bodies
- B Gray matter contains many cell bodies and synapses; white matter contains many myelinated axons ✓**
- C Gray matter exists only in the PNS; white matter only in the CNS
- D White matter is where neurotransmitters are stored; gray matter is where oxygen is stored
- E There is no structural difference; the colors are only artistic labels

► **Explanation:** Gray matter is rich in neuron cell bodies, dendrites and synapses. White matter is rich in myelinated axons, giving it a lighter appearance due to lipid-rich myelin.

27 In a stretch reflex, what structure most directly detects muscle stretch and initiates the afferent signal?





- A Muscle spindle (stretch receptor) ✓**
- B Golgi tendon organ (tension receptor) only
- C Myelin sheath
- D Neuromuscular junction
- E Ribosomes in the muscle fiber

► **Explanation:** Muscle spindles detect stretch (length change) and send sensory signals to the spinal cord to trigger the stretch reflex. Golgi tendon organs primarily detect tension, and neuromuscular junctions are where motor neurons activate muscle.

28 At the neuromuscular junction, what MOST directly terminates the signal so the muscle does not contract continuously?



- A Diffusion of acetylcholine into the bloodstream
- B Breakdown of acetylcholine by acetylcholinesterase in the synaptic cleft ✓**
- C Closure of the dorsal root ganglion
- D Conversion of acetylcholine into glucose inside the muscle
- E Immediate reuptake of acetylcholine into the nucleus of the neuron

► **Explanation:** Acetylcholinesterase rapidly breaks down acetylcholine in the synaptic cleft, ending receptor stimulation and allowing the muscle to relax. The other options describe incorrect locations or processes.

29 Which axon type would generally conduct action potentials the FASTEST?



- A Small-diameter unmyelinated axon
- B Small-diameter myelinated axon
- C Large-diameter unmyelinated axon





- D Large-diameter myelinated axon ✓**
- E Any axon conducts at the same speed regardless of diameter or myelination**

► **Explanation:** Conduction velocity increases with both larger diameter (lower internal resistance) and myelination (saltatory conduction). Therefore, large-diameter myelinated fibers are fastest.

30 During repeated rapid stimulation of a reflex pathway, the response may weaken over time even if the axons are intact. This 'fatigue' most directly suggests that:



- A Axons cannot conduct more than one action potential**
- B Synapses can become temporarily less effective due to neurotransmitter depletion or receptor changes ✓**
- C Myelin is destroyed by repeated use within seconds**
- D The action potential amplitude gradually decreases along the axon**
- E The dorsal root ganglion stops producing neurons during stimulation**

► **Explanation:** Axons propagate all-or-nothing action potentials without gradually shrinking in amplitude, but chemical synapses can fatigue if neurotransmitter release cannot keep up or receptors desensitize. Rapid fatigue points to synaptic limitations rather than axonal conduction failure.

