

Neural Control and Coordination - NCERT Exercise Answer Key

1. Briefly describe the...structure of the Brain

Answer: The human brain is protected by the skull and covered by three meningeal layers: dura mater (outer), arachnoid (middle), and pia mater (inner). The brain is divided into three major parts:

Forebrain: Contains cerebrum (divided into left and right hemispheres connected by corpus callosum), thalamus (sensory and motor relay center), and hypothalamus (controls temperature, hunger, thirst, and produces hormones).

Midbrain: Located between forebrain and hindbrain, contains corpora quadrigemina (four lobes for visual and auditory reflexes) and cerebral aqueduct.

Hindbrain: Comprises pons (fiber tracts connecting brain regions), cerebellum (motor coordination and balance), and medulla oblongata (controls respiration, cardiovascular reflexes, and gastric secretions).

2. Compare the following:

(a) Central neural system...Peripheral neural system

CNS:

- Components: Brain and spinal cord
- Function: Information processing and control
- Location: Protected by skull and vertebral column
- Cell bodies: Concentrated in gray matter

PNS:

- Components: All nerves connected to CNS
- Function: Communication between CNS and body parts
- Types: Afferent (sensory) and efferent (motor) fibers
- Divisions: Somatic and autonomic nervous systems

(b) Resting potential and...action potential

Resting Potential:

- Value: Approximately -70mV
- Condition: Membrane at rest, not conducting impulse
- Ion distribution: High K^+ inside, high Na^+ outside
- Permeability: More permeable to K^+ , less to Na^+

Action Potential:

- Value: Peak around +30mV
- Condition: Membrane conducting nerve impulse
- Process: Rapid Na^+ influx followed by K^+ efflux
- Duration: Lasts few milliseconds, then returns to resting state

3. Explain the following processes:

(a) Polarisation of the...nerve fibre

Polarization refers to the electrical charge difference across the neuron membrane at rest. The axonal membrane maintains higher K^+ concentration inside and higher Na^+ concentration outside through the sodium-potassium pump ($3Na^+$ out : $2K^+$ in). The membrane is selectively permeable to K^+ but impermeable to negatively charged proteins inside. This creates a negative charge inside (-70mV) relative to outside, establishing the resting potential.

(b) Depolarisation of the...nerve fibre

When a stimulus is applied, sodium channels open rapidly, making the membrane freely permeable to Na^+ . This causes massive Na^+ influx, reversing the membrane polarity - the inside becomes positive (+30mV) and outside becomes negative. This reversal of polarity is called depolarization, creating an action potential that propagates along the axon as a nerve impulse.

(c) Transmission of a...chemical synapse

At chemical synapses, when an action potential reaches the axon terminal, it triggers Ca^{2+} influx. This causes synaptic vesicles containing neurotransmitters to fuse with the presynaptic membrane and release neurotransmitters into the synaptic cleft. These neurotransmitters bind to specific receptors on the postsynaptic membrane, opening ion channels and generating either excitatory or inhibitory postsynaptic potentials.

4. Draw labelled diagrams...following:

(a) Neuron

Key structures to label:

- Cell body with nucleus and Nissl's granules
- Dendrites (receiving impulses)
- Axon (conducting impulses away)
- Myelin sheath with nodes of Ranvier
- Synaptic knobs with vesicles

(b) Brain

Key structures to label:

- Cerebrum (left and right hemispheres)

- Corpus callosum
- Thalamus and hypothalamus
- Midbrain with corpora quadrigemina
- Pons, cerebellum, and medulla oblongata
- Meningeal layers

5. Write short notes...following:

(a) Neural coordination

Neural coordination is the process by which the nervous system integrates and controls body functions through rapid electrical and chemical signals. It involves detection of stimuli, processing of information, and appropriate responses. The system works through neurons that form networks for point-to-point communication, enabling quick responses and maintaining homeostasis.

(b) Forebrain

The forebrain is the largest part of the brain consisting of cerebrum, thalamus, and hypothalamus. The cerebrum has gray matter (cell bodies) forming the cortex and white matter (myelinated fibers) inside. It contains motor, sensory, and association areas. The limbic system (including amygdala and hippocampus) regulates emotions, behavior, and memory formation.

(c) Midbrain

The midbrain connects the forebrain and hindbrain, containing the cerebral aqueduct for CSF flow. Its dorsal portion has corpora quadrigemina - four lobes that serve as reflex centers for visual and auditory stimuli. It integrates sensory inputs and helps coordinate reflexes and motor responses.

(d) Hindbrain

The hindbrain comprises medulla oblongata (controls vital functions like respiration and heart rate), pons (contains fiber tracts connecting brain regions), and cerebellum (coordinates motor activities

and maintains balance). These structures are essential for survival and motor coordination.

(e) Synapse

A synapse is the junction between two neurons where impulse transmission occurs. Chemical synapses have a synaptic cleft filled with neurotransmitters that bind to postsynaptic receptors. This allows one-way transmission, signal modulation, and integration of multiple inputs, forming the basis of neural computation.

6. Give a brief...synaptic transmission

Synaptic transmission occurs when an action potential reaches the presynaptic terminal, causing voltage-gated calcium channels to open. Ca^{2+} influx triggers fusion of neurotransmitter-filled vesicles with the membrane. Released neurotransmitters diffuse across the synaptic cleft and bind to specific receptors on the postsynaptic membrane, opening ion channels. This generates postsynaptic potentials that may be excitatory (EPSP) or inhibitory (IPSP), depending on the ions involved.

7. Explain the role...action potential

Na^+ plays a crucial role in action potential generation through rapid influx during depolarization. When threshold stimulus is reached, voltage-gated Na^+ channels open, allowing massive Na^+ entry down its concentration gradient. This influx reverses membrane polarity from -70mV to $+30\text{mV}$, creating the rising phase of action potential. The brief opening of Na^+ channels initiates the wave of depolarization that propagates along the axon as a nerve impulse.

8. Differentiate between:

(a) Myelinated and non-myelinated axons

Myelinated:

- Wrapped by Schwann cells forming myelin sheath

- Have nodes of Ranvier between sheaths
- Faster conduction (saltatory)
- Found in spinal and cranial nerves

Non-myelinated:

- Enclosed by Schwann cells without myelin
- No nodes of Ranvier
- Slower, continuous conduction
- Found in autonomic nervous system

(b) Dendrites and axons

Dendrites:

- Short, branched fibers from cell body
- Contain Nissl's granules
- Receive and conduct impulses toward cell body
- Multiple per neuron

Axons:

- Single, long fiber from cell body
- No Nissl's granules
- Conduct impulses away from cell body
- End in synaptic knobs

(c) Thalamus and Hypothalamus

Thalamus:

- Relay station for sensory and motor signals
- Located centrally, wrapped by cerebrum
- Integrates and processes information
- Role in consciousness and sleep-wake cycles

Hypothalamus:

- Controls homeostatic functions
- Located below thalamus
- Regulates temperature, hunger, thirst
- Produces hormones and controls pituitary

(d) Cerebrum and Cerebellum

Cerebrum:

- Largest brain part with two hemispheres
- Contains motor, sensory, and association areas
- Responsible for consciousness and higher functions
- Has gray matter cortex and white matter inside

Cerebellum:

- Highly folded structure in hindbrain
- Coordinates motor activities and balance
- Processes input from semicircular canals
- Important for motor learning

9. Answer the following:

(a) Which part of...most developed?

The cerebrum is the most developed part of the human brain, forming the major portion and containing the highly folded cerebral cortex with motor, sensory, and association areas responsible for higher cognitive functions.

(b) Which part of...master clock?

The hypothalamus acts as the master clock of our central nervous system, regulating circadian rhythms, body temperature, sleep-wake cycles, and coordinating various homeostatic functions.

10. Distinguish between:

(a) afferent neurons and...efferent neurons

Afferent (Sensory) Neurons:

- Carry impulses from tissues/organs to CNS
- Transmit sensory information
- Part of sensory pathways
- Detect external and internal stimuli

Efferent (Motor) Neurons:

- Carry regulatory impulses from CNS to organs
- Control muscle contraction and gland secretion
- Part of motor pathways
- Execute responses to stimuli

(b) impulse conduction in...unmyelinated nerve fibre

Myelinated Conduction:

- Saltatory conduction (jumping between nodes)
- Fast speed (up to 120 m/s)
- Energy efficient
- Action potentials only at nodes of Ranvier

Unmyelinated Conduction:

- Continuous conduction along entire membrane
- Slower speed (0.5-2 m/s)
- Higher energy consumption
- Action potentials propagate continuously

(f) cranial nerves and...spinal nerves

Cranial Nerves:

- 12 pairs arising directly from brain
- Serve head and neck regions mainly
- Include sensory, motor, and mixed types
- Examples: optic, facial, vagus nerves

Spinal Nerves:

- 31 pairs arising from spinal cord
- Serve trunk and limbs
- All are mixed nerves (sensory and motor)

- Named according to vertebral regions