FREE EDITION · NOTES + 3 SAMPLE MCQS

CUET · BIOLOGY · CLASS XI · CODE 304

Neural Control and Coordination

CUET unit: Human Physiology → Neural Control and Coordination

By **UniDrill** · NCERT-grounded study material

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📌 Snapshot

- Establishes how the neural system gives the body a fast, point-to-point coordination network, working alongside the endocrine system to maintain homeostasis (NCERT chapter intro, p. 230).
- Lays down the architecture of the human neural system — CNS (brain + spinal cord) and PNS (somatic + autonomic, plus visceral) — that CUET regularly tests through "which division" type MCQs.
- Builds the neuron as the structural-functional unit: cell body, dendrites, axon, Nissl's granules, myelin sheath, nodes of Ranvier, multipolar/bipolar/unipolar types (NCERT §18.3, pp. 231–232).
- Explains the electrical machinery of a nerve impulse — resting potential, Na+ influx → depolarisation, K+ efflux → repolarisation, and synaptic transmission (electrical vs chemical via neurotransmitters) — a CUET favourite for assertion-reason questions (NCERT §18.3.1–18.3.2, pp. 232–235).
- Maps the brain — forebrain (cerebrum, thalamus, hypothalamus, limbic system), midbrain (corpora quadrigemina, cerebral aqueduct), hindbrain (pons, cerebellum, medulla) — and notes the brainstem as the brain–spinal cord link (NCERT §18.4, pp. 235–237).

📖 Detailed Notes

2.1 Core concepts

- Coordination is the process by which two or more organs interact and complement each other's functions; the neural system and endocrine system jointly coordinate all organ activities in a synchronised fashion (NCERT chapter intro, p. 230).
- The neural system provides an organised network of point-to-point connections for quick coordination, while the endocrine system provides chemical integration through hormones (NCERT chapter intro, p. 230).
- Neural organisation is simple in lower invertebrates — Hydra has a network of neurons; insects have a brain with ganglia; vertebrates have a more developed neural system (NCERT §18.1, p. 231).
- The human neural system has two parts — the central neural system (CNS = brain + spinal cord), which is the site of information processing and control, and the

peripheral neural system (PNS), which comprises all nerves associated with the CNS (NCERT §18.2, p. 231).

- PNS nerve fibres are of two types — afferent fibres carry impulses from tissues/organs to the CNS; efferent fibres carry regulatory impulses from the CNS to peripheral tissues/organs (NCERT §18.2, p. 231).
- PNS is divided into the somatic neural system (relays impulses from CNS to skeletal muscles) and the autonomic neural system (transmits impulses from CNS to involuntary organs and smooth muscles); the autonomic is further split into sympathetic and parasympathetic (NCERT §18.2, p. 231).
- The visceral nervous system is the part of the PNS comprising nerves, fibres, ganglia and plexuses that carry impulses between the CNS and the viscera (NCERT §18.2, p. 231).
- A neuron has three major parts — cell body (with cytoplasm, organelles and granular Nissl's granules), dendrites (short branched fibres carrying impulses towards the cell body), and axon (long fibre carrying impulses away to a synapse or neuro-muscular junction; ends in synaptic knobs with synaptic vesicles containing neurotransmitters) (NCERT §18.3, pp. 231–232).
- Based on axon/dendrite number, neurons are multipolar (1 axon + $\geqslant$2 dendrites; cerebral cortex), bipolar (1 axon + 1 dendrite; retina of eye), and unipolar (cell body with only 1 axon; usually embryonic) (NCERT §18.3, p. 232).
- Axons are myelinated (Schwann cells form a myelin sheath; gaps = nodes of Ranvier; found in spinal and cranial nerves) or non-myelinated (Schwann cell encloses but no sheath; common in autonomic and somatic systems) (NCERT §18.3, p. 232).
- Neurons are excitable because their membranes are polarised — the resting axonal membrane is more permeable to K+, nearly impermeable to Na+, and impermeable to negatively charged proteins inside the axoplasm (NCERT §18.3.1, p. 232).
- The sodium-potassium pump actively transports 3 Na+ out for every 2 K+ in, maintaining the ionic gradient; the outer surface of the resting axonal membrane is positive and the inner surface is negative — this potential difference is the resting potential (NCERT §18.3.1, pp. 232–233).
- On stimulation at a site, the membrane becomes freely permeable to Na+, leading to rapid Na+ influx and reversal of polarity (outer surface negative, inner positive) — this depolarisation creates an action potential, i.e., a nerve impulse (NCERT §18.3.1, p. 233).
- The action potential at site A induces a current that depolarises the adjacent site B, propagating the impulse along the axon; the Na+ permeability rise is short-lived and is followed by a rise in K+ permeability — K+ diffuses out and restores the resting potential (repolarisation), making the fibre responsive again (NCERT §18.3.1, p. 233).
- A synapse is formed by the membranes of a pre-synaptic and post-synaptic neuron, which may or may not be separated by a synaptic cleft; synapses are of two types — electrical and chemical (NCERT §18.3.2, p. 234).

- At electrical synapses, pre- and post-synaptic membranes are very close — current flows directly across; transmission is faster than at chemical synapses but electrical synapses are rare in our system (NCERT §18.3.2, p. 234).
- At chemical synapses, neurotransmitters stored in axon-terminal vesicles are released into the synaptic cleft when an action potential arrives; they bind specific receptors on the post-synaptic membrane, opening ion channels and generating a new potential that may be excitatory or inhibitory (NCERT §18.3.2, pp. 234–235).
- The brain is the central information processing organ — the 'command and control system' — controlling voluntary movement, balance, vital involuntary organs, thermoregulation, hunger and thirst, circadian rhythms, endocrine activity, behaviour, and processing of vision, hearing, speech, memory, intelligence, emotion and thought (NCERT §18.4, p. 235).
- The brain is protected by the skull and covered by cranial meninges — outer dura mater, thin middle arachnoid, and inner pia mater (in contact with brain tissue); the brain is divided into forebrain, midbrain and hindbrain (NCERT §18.4, p. 235).
- Forebrain = cerebrum + thalamus + hypothalamus; cerebrum is split by a deep cleft into left and right cerebral hemispheres connected by the corpus callosum (NCERT §18.4.1, p. 236).
- The cerebral cortex (grey matter, neuron cell bodies) covers the hemispheres in folds and contains motor areas, sensory areas and association areas (intersensory associations, memory, communication); myelinated tract fibres form the inner white matter (NCERT §18.4.1, p. 236).
- The thalamus is a major coordinating centre for sensory and motor signalling; the hypothalamus (at the base of the thalamus) controls body temperature, hunger, thirst, and secretes hypothalamic hormones via neurosecretory cells (NCERT §18.4.1, p. 236).
- The limbic system (inner cerebral hemisphere parts + amygdala, hippocampus, etc.) along with the hypothalamus regulates sexual behaviour, emotional expression (excitement, pleasure, rage, fear) and motivation, plus olfaction and autonomic responses (NCERT §18.4.1, p. 236; Summary, p. 237).
- The midbrain lies between the thalamus/hypothalamus and the pons; the cerebral aqueduct passes through it, and its dorsal portion bears four round swellings called corpora quadrigemina; it integrates visual, tactile and auditory inputs (NCERT §18.4.2, p. 236; Summary, p. 237).
- The hindbrain comprises pons (fibre tracts interconnecting brain regions), cerebellum (highly convoluted surface giving more space for neurons; integrates information from semicircular canals of the ear and the auditory system) and medulla oblongata (centres for respiration, cardiovascular reflexes and gastric secretions; connects to the spinal cord) (NCERT §18.4.3, p. 236; Summary, p. 237).
- The brainstem (midbrain + pons + medulla oblongata) forms the connection between the brain and the spinal cord (NCERT §18.4.3, p. 236).

2.2 Definitions to memorise

Term	Definition	Page
Coordination	The process through which two or more organs interact and complement each other's functions.	230
Neuron	The highly specialised, excitable cell of the neural system that detects, receives and transmits stimuli; the structural and functional unit.	231
Afferent nerve fibres	Nerve fibres that transmit impulses from tissues/organs to the CNS.	231
Efferent nerve fibres	Nerve fibres that transmit regulatory impulses from the CNS to peripheral tissues/organs.	231
Somatic neural system	Part of PNS that relays impulses from the CNS to skeletal muscles.	231
Autonomic neural system	Part of PNS that transmits impulses from the CNS to involuntary organs and smooth muscles; split into sympathetic and parasympathetic.	231
Visceral nervous system	Part of PNS — complex of nerves, fibres, ganglia and plexuses carrying impulses between the CNS and viscera.	231
Nissl's granules	Granular bodies in the cytoplasm of the neuron cell body and dendrites.	231–232
Synaptic knob	Bulb-like terminal of an axon branch containing synaptic vesicles filled with neurotransmitters.	232
Nodes of Ranvier	Gaps between two adjacent myelin sheaths along a myelinated axon.	232
Resting potential	The electrical potential difference across the resting (polarised) plasma membrane of a neuron.	233
Action potential	The electrical potential difference produced across the plasma membrane after depolarisation; this is the nerve impulse.	233
Synapse	Junction formed by the membranes of a pre-synaptic and a post-synaptic neuron, which may or may not be separated by a synaptic cleft.	234
Synaptic cleft	The fluid-filled space between pre- and post-synaptic membranes at a chemical synapse.	234
Neurotransmitters	Chemicals (stored in synaptic vesicles) released into the synaptic cleft to transmit impulses across a chemical synapse.	234
Cranial meninges	The three protective membranes around the brain — dura mater, arachnoid, pia mater.	235
Corpus callosum	Tract of nerve fibres connecting the left and right cerebral hemispheres.	236

Term	Definition	Page
Cerebral cortex	The folded grey-matter layer covering the cerebral hemispheres; contains motor, sensory and association areas.	236
Association areas	Cortical regions responsible for complex functions like intersensory association, memory and communication.	236
Limbic system	Complex formed by inner parts of cerebral hemispheres plus amygdala, hippocampus, etc.; regulates sexual behaviour, emotional reactions, motivation (and olfaction/autonomic responses).	236–237
Corpora quadrigemina	Four round swellings on the dorsal portion of the midbrain.	236
Cerebral aqueduct	Canal passing through the midbrain.	236
Brainstem	Midbrain + pons + medulla oblongata; connects brain to spinal cord.	236

2.3 Diagrams / processes to remember

- **Figure 18.1 — Structure of a neuron (p. 232):** labelled dendrites, Nissl's granules, cell body, nucleus, Schwann cell, axon, myelin sheath, node of Ranvier, axon terminal, synaptic knob.
- **Figure 18.2 — Impulse conduction along an axon (p. 233):** shows depolarised site A (Na+ influx, polarity reversed — outer negative, inner positive) and current loops that depolarise the adjacent site B; useful for understanding the propagation of action potential.
- **Figure 18.3 — Axon terminal and synapse (p. 234):** labelled axon, axon terminal, synaptic vesicles, pre-synaptic membrane, synaptic cleft, post-synaptic membrane, receptors and neurotransmitters — the canonical chemical-synapse diagram.
- **Figure 18.4 — Sagittal section of the human brain (p. 235):** labelled cerebrum, cerebral hemisphere, corpus callosum, thalamus, hypothalamus, midbrain, cerebral aqueduct, pons, cerebellum, medulla, spinal cord (forebrain bracketed).
- **Process — Generation and conduction of a nerve impulse (§18.3.1, pp. 232–233):** resting (K+ permeable, Na+ impermeable, Na+/K+ pump 3 Na+ out : 2 K+ in, outer +, inner –) → stimulus → Na+ influx, depolarisation, action potential → local current depolarises next site → K+ efflux restores resting potential (repolarisation).
- **Process — Chemical synaptic transmission (§18.3.2, pp. 234–235):** action potential arrives at axon terminal → synaptic vesicles fuse with pre-synaptic membrane → neurotransmitter released into synaptic cleft → binds receptors on post-synaptic membrane → opens ion channels → new (excitatory or inhibitory) potential generated.

2.4 Common confusions / NTA trap points

- **CNS vs PNS components:** NTA likes to slip "spinal nerves" into the CNS or "brain" into the PNS — remember CNS = brain + spinal cord only; everything else is PNS (NCERT §18.2, p. 231).
- **Somatic vs autonomic:** somatic → skeletal (voluntary) muscles; autonomic → involuntary organs/smooth muscles. The autonomic, NOT the somatic, splits into sympathetic and parasympathetic (NCERT §18.2, p. 231).
- **Na+/K+ pump stoichiometry:** 3 Na+ out for 2 K+ in — distractors flip the ratio or the direction (NCERT §18.3.1, p. 232).
- **Depolarisation polarity reversal:** during the action potential the outer surface becomes negative and the inner surface positive — NTA distractors often retain the resting polarity (NCERT §18.3.1, p. 233).
- **Myelinated locations:** myelinated fibres are found in spinal and cranial nerves; non-myelinated fibres in autonomic and somatic systems — students often misremember this (NCERT §18.3, p. 232).
- **Neuron types vs location:** multipolar = cerebral cortex; bipolar = retina of eye; unipolar = usually embryonic. Watch for "bipolar in cerebral cortex" type swaps (NCERT §18.3, p. 232).
- **Electrical vs chemical synapse speed:** electrical synapses are faster, but they are rare in the human system — students often pick "chemical = faster" because chemical are more common (NCERT §18.3.2, p. 234).
- **Midbrain landmarks:** corpora quadrigemina is on the dorsal midbrain (not hindbrain); cerebral aqueduct passes through the midbrain — common confusion with hindbrain structures (NCERT §18.4.2, p. 236).
- **Meninges order:** outer → inner is dura mater → arachnoid → pia mater. NTA often reverses this (NCERT §18.4, p. 235).
- **Resting membrane potential value** — ~ −70 mV; outside is positive, inside negative. Action potential reverses this momentarily to ~ +30 mV (NCERT §18.3.1, p. 232–233).
- **Synaptic delay** — Chemical synapses involve neurotransmitter diffusion across the cleft, hence a measurable delay; electrical synapses (gap junctions) effectively have none (p. 234).

2.5 Quick reference — neural control & coordination

#	Item	Detail (NCERT)	Page
1	CNS	Brain + spinal cord	231
2	PNS divisions	Somatic + autonomic	231
3	Autonomic subdivisions	Sympathetic + parasympathetic	231

#	Item	Detail (NCERT)	Page
4	Neuron types (structure)	Multipolar, bipolar, unipolar	232
5	Resting potential	~ −70 mV (inside negative)	232
6	Action potential peak	~ +30 mV	233
7	Na+/K+ pump ratio	3 Na+ out : 2 K+ in	232
8	Synapse types	Electrical (fast) and chemical (most common)	234
9	Major brain divisions	Forebrain, midbrain, hindbrain	235
10	Forebrain parts	Cerebrum, thalamus, hypothalamus	235
11	Cerebral lobes	Frontal, parietal, temporal, occipital	235
12	Midbrain	Corpora quadrigemina, cerebral aqueduct	236
13	Hindbrain	Pons, cerebellum, medulla	236
14	Meninges (outer→inner)	Dura → arachnoid → pia mater	235
15	Limbic system role	Olfaction, behaviour, emotion, motivation	237

🎯 Practice MCQs

Q1. The peripheral neural system (PNS) is divided into somatic and autonomic neural systems. The autonomic neural system is further classified into which of the following?

A. Sympathetic and visceral

B. Somatic and sympathetic

C. Sympathetic and parasympathetic

D. Parasympathetic and visceral

Q2. In a resting neuron, the sodium-potassium pump transports:

A. 2 Na+ outwards for every 3 K+ inwards

B. 3 Na+ outwards for every 2 K+ inwards

C. 3 K+ outwards for every 2 Na+ inwards

D. 2 K+ outwards for every 3 Na+ inwards

Q3. Match the neuron type with its location and structural feature, as per NCERT: | Neuron type | Feature / Location | |---|---| | (i) Multipolar | (1) One axon, one dendrite; retina of eye | | (ii) Bipolar | (2) One axon only; usually embryonic stage | | (iii) Unipolar | (3) One axon, two or more dendrites; cerebral cortex |

A. (i)-(3), (ii)-(1), (iii)-(2)

B. (i)-(1), (ii)-(2), (iii)-(3)

C. (i)-(2), (ii)-(3), (iii)-(1)

D. (i)-(3), (ii)-(2), (iii)-(1)

📊 PYQ Alignment

Neural control and coordination is a staple of CUET (UG) Biology — CUET 2023–25 papers have consistently carried questions on the CNS/PNS subdivisions, neuron structure, Na+/K+ pump ratio, resting vs action potential, chemical synapse mechanism, and brain anatomy (corpus callosum, corpora quadrigemina, medulla functions). Expect roughly 1–2 direct factual MCQs from this chapter every year, with assertion-reason and statement-based "which of the following is correct" formats dominating.