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Neural Control and Coordination

Class 11 Notes | CBSE Biology

Chapter 18

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Neural Control and Coordination Class 11 Notes | CBSE Biology Chapter 18

Neural Control and Coordination is Chapter 18 of CBSE Class 11 Biology — the chapter that explains how a single touch on a hot pan makes you pull your hand back before you even think about it. It is the story of the neuron, the nerve impulse, the synapse, and the master organ that runs the show: your brain. For NEET aspirants this is a high-yield chapter, and for boards it carries reliable, scoring questions.

By the end of these notes you will be able to label a neuron, explain resting and action potentials step by step, describe how impulses jump across a synapse, map the human neural system from spinal cord to forebrain, and trace a complete reflex arc. You will also know the working structure of the eye and ear well enough to answer any standard board or NEET question. This chapter connects directly with Chemical Coordination (hormones) and is foundational for human physiology.

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Key Concepts

1. Neural Coordination — Why We Need It

Coordination is the process through which two or more organs interact and complement the functions of one another. When you run, your muscles, lungs, and heart work together — that teamwork is coordination.

In animals this is achieved by two systems working together: the **neural system** (fast, electrical, short-lived) and the **endocrine system** (slow, chemical, long-lasting). This chapter deals with the neural system, made up of highly specialised cells called **neurons** that detect, receive, and transmit different kinds of stimuli.

2. Neuron — Structure and Types

A **neuron** is the structural and functional unit of the nervous system. It is a microscopic cell built to carry electrical messages over long distances. A neuron has three main parts.

- **Cell body (cyton):** contains the nucleus, cytoplasm, and granular bodies called **Nissl's granules**.
- **Dendrites:** short, branched fibres that receive impulses and carry them *towards* the cell body.
- **Axon:** a long fibre that carries impulses *away* from the cell body; its end branches into **axon terminals** ending in synaptic knobs containing neurotransmitters.

[DIAGRAM: A neuron — dendrites and cyton on the left, a long myelinated axon with nodes of Ranvier, ending in synaptic knobs on the right.]

Myelinated vs Non-myelinated Axons

- **Myelinated:** covered by a myelin sheath (Schwann cells) with gaps called **nodes of Ranvier**; found in spinal and cranial nerves. Conduct impulses fast.
- **Non-myelinated:** enclosed by a Schwann cell but without a myelin sheath; common in the autonomic system. Conduct impulses slowly.

Types of Neurons (by structure)

- **Multipolar:** one axon and many dendrites (e.g., cerebral cortex).
- **Bipolar:** one axon and one dendrite (e.g., retina of the eye).
- **Unipolar:** only the axon, cell body with no true dendrite (found in embryonic stage).

3. Generation of Nerve Impulse — Resting Potential

When a neuron is not conducting any impulse, it is in a **resting state**, and the electrical potential difference across its membrane is the **resting potential** (about -70 mV).

- The membrane is more permeable to **potassium (K^+)** and nearly impermeable to **sodium (Na^+)** at rest.
- The **sodium-potassium pump** pushes 3 Na^+ out for every 2 K^+ in, keeping Na^+ high outside and K^+ high inside.
- Result: the outer surface is **positively charged** and the inner surface is **negatively charged** — the membrane is said to be **polarised**.

4. Action Potential (Nerve Impulse)

When a stimulus is applied at a point, the membrane there suddenly becomes far more permeable to Na^+ . The events that follow are the action potential.

- **Depolarisation:** Na^+ rushes in, the inside becomes positive (about $+30$ mV) and the outside negative — the polarity reverses.
- **Repolarisation:** Na^+ channels close, K^+ channels open, K^+ moves out, and the resting polarity is restored.
- The potential difference across the membrane at the site of depolarisation is called the **action potential**, which acts as the **nerve impulse**.

[DIAGRAM: Action potential graph — resting -70 mV, sharp rise to $+30$ mV (depolarisation), fall back through -70 mV (repolarisation), brief dip (refractory period).]

Conduction of the Impulse

The depolarisation at one point triggers depolarisation in the next region, so the impulse travels along the axon like a wave. In myelinated fibres the impulse jumps from node to node — called **saltatory conduction** — which is much faster.

5. Transmission of Impulse Across a Synapse

A **synapse** is the junction between two neurons (or a neuron and a muscle). The impulse must cross from the axon terminal of one neuron to the dendrite of the next. There are two types.

- **Electrical synapse:** membranes of pre- and post-synaptic neurons are very close; impulse passes directly. Fast, but rare.
- **Chemical synapse:** separated by a fluid-filled **synaptic cleft**; impulse is carried by chemicals. Most synapses are of this type.

Steps at a Chemical Synapse

- The impulse reaches the axon terminal and opens Ca^{2+} channels.
 - Synaptic vesicles fuse with the membrane and release a **neurotransmitter** (e.g., acetylcholine) into the synaptic cleft.
 - The neurotransmitter binds to receptors on the post-synaptic membrane, opening ion channels and generating a new potential — the impulse continues.
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6. Human Neural System — Overview

The human neural system is divided into two main parts.

- **Central Nervous System (CNS):** the brain and the spinal cord — the site of information processing and control.
- **Peripheral Nervous System (PNS):** all the nerves outside the CNS that connect it to the rest of the body.

Divisions of the PNS

- **Afferent (sensory) fibres:** carry impulses from tissues/organs to the CNS.
 - **Efferent (motor) fibres:** carry impulses *from* the CNS to muscles and glands.
 - **Somatic nervous system:** relays impulses to skeletal muscles (voluntary).
 - **Autonomic nervous system:** relays impulses to smooth muscles and glands; split into **sympathetic** (fight-or-flight) and **parasympathetic** (rest-and-digest).
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7. The Brain — Forebrain, Midbrain, Hindbrain

The brain is the central information-processing organ, protected by the skull and three membranes called **meninges** (dura mater, arachnoid, pia mater). It is divided into three regions.

Forebrain

- **Cerebrum:** the largest part; controls thinking, memory, voluntary movement, and intelligence. Its two hemispheres are joined by the **corpus callosum**.
- **Thalamus:** a major relay centre for sensory and motor signals.
- **Hypothalamus:** controls body temperature, hunger, thirst, and links to the endocrine system.

Midbrain

Located between the thalamus and the pons; the dorsal portion has four rounded swellings (**corpora quadrigemina**) that control visual and auditory reflexes.

Hindbrain

- **Cerebellum:** coordinates movement, posture, and balance.
- **Pons:** a band of fibres connecting brain regions; helps regulate breathing.
- **Medulla oblongata:** controls respiration, heartbeat, and other involuntary actions; connects to the spinal cord.

[DIAGRAM: Sagittal section of the human brain showing cerebrum, corpus callosum, thalamus, hypothalamus, midbrain, cerebellum, pons, and medulla oblongata.]

8. Reflex Action and Reflex Arc

A **reflex action** is a rapid, automatic, involuntary response to a stimulus that does not need conscious thought — like jerking your hand off a hot object. It is the body's protective shortcut.

The path travelled by the impulse during a reflex action is the **reflex arc**. It involves five components.

- **Receptor:** the sense organ (e.g., skin) that detects the stimulus.
- **Afferent (sensory) neuron:** carries the impulse to the spinal cord.
- **Interneuron:** processes the signal within the CNS (often the spinal cord, not the brain).
- **Efferent (motor) neuron:** carries the response to the effector.
- **Effector:** the muscle or gland that responds.

[DIAGRAM: Reflex arc — receptor in skin → sensory neuron → spinal cord (interneuron) → motor neuron → effector muscle.]

Key idea: Most reflexes are processed by the spinal cord directly, which is why the response is so fast — the brain is informed afterwards.

9. Sensory Reception — The Eye

The eye is the photoreceptor organ that converts light into nerve impulses. Its wall has three layers.

- **Sclera (outer):** tough white coat; its transparent front part is the **cornea**.
- **Choroid (middle):** pigmented, blood-rich layer; forms the **iris** and the muscular **ciliary body**. The hole in the iris is the **pupil**.
- **Retina (inner):** contains the photoreceptor cells — **rods** (dim light, black-and-white) and **cones** (bright light, colour vision).

How We See

- Light passes through the cornea and lens, which focus it onto the retina.
- The **fovea** (in the yellow spot/macula lutea) has the highest density of cones — sharpest vision.
- The point where the optic nerve leaves has no photoreceptors — the **blind spot**.
- The visual pigment **rhodopsin** in rods breaks down in light, generating impulses sent via the optic nerve to the brain.

[DIAGRAM: Horizontal section of the eye showing cornea, iris, pupil, lens, ciliary body, retina, fovea, blind spot, and optic nerve.]

10. Sensory Reception — The Ear

The ear performs two functions: **hearing** and **maintaining body balance**. It has three regions.

- **Outer ear:** the pinna collects sound and the auditory canal directs it to the **tympanic membrane (eardrum)**.
- **Middle ear:** three small bones — **malleus, incus, and stapes** (ear ossicles) — amplify and transmit vibrations to the oval window.
- **Inner ear:** the fluid-filled **cochlea** (hearing) and the **vestibular apparatus** with semicircular canals (balance).

How We Hear

- Sound vibrates the eardrum; the ossicles amplify and pass it to the oval window.
- Vibrations create waves in the cochlear fluid, bending hair cells of the **organ of Corti**.
- Hair cells generate nerve impulses sent via the auditory nerve to the brain, which interprets them as sound.

[DIAGRAM: The human ear showing pinna, auditory canal, eardrum, malleus-incus-stapes, cochlea, and semicircular canals.]

Weightage in Board & Entrance Exams

Exam	Typical Weightage	Most-Tested Areas
CBSE Board (Class 11)	5–7 marks	Neuron structure, reflex arc, brain parts, eye & ear structure
NEET	2–4 questions	Resting/action potential, synapse, CNS divisions, eye & ear
Other Medical Entrances	1–3 questions	Neurotransmitters, saltatory conduction, brain functions

[TABLE: Question-type split — VSA (1 mark): definitions & labelling; SA (2–3 marks): resting vs action potential, reflex arc, ear ossicles; LA (5 marks): brain structure & functions, mechanism of impulse transmission.]

Important Definitions

Term	Definition
Neuron	Structural and functional unit of the nervous system; carries impulses
Nissl's granules	Granular bodies in the cell body (cyton) of a neuron
Resting potential	Membrane potential (~ -70 mV) of a neuron not conducting an impulse
Action potential	Reversal of membrane polarity on stimulation; the nerve impulse
Saltatory conduction	Impulse jumping node to node in a myelinated axon (fast)
Synapse	Junction between two neurons across which an impulse passes
Neurotransmitter	Chemical (e.g., acetylcholine) carrying impulse across a chemical synapse
Reflex action	Rapid, automatic, involuntary response to a stimulus
Reflex arc	Path of the impulse during a reflex: receptor $\rightarrow$ CNS $\rightarrow$ effector
Blind spot	Region on the retina with no photoreceptors where the optic nerve exits

Solved Examples

Example 1

Why is the resting membrane of a neuron called “polarised”?

Answer: Because the outer surface carries a net **positive** charge and the inner surface a net **negative** charge, creating a potential difference of about -70 mV across the membrane.

Example 2

An impulse travels faster in a myelinated neuron than in a non-myelinated one. Why?

Answer: In a myelinated axon the impulse jumps from one node of Ranvier to the next (**saltatory conduction**), skipping the insulated regions, so it travels much faster.

Example 3

Name the neurotransmitter most commonly released at a chemical synapse and the ion that triggers its release.

Answer: The neurotransmitter is **acetylcholine**; its release is triggered by the inflow of **calcium ions (Ca^{2+})** into the axon terminal.

Example 4

A person touches a hot object and instantly withdraws the hand. Identify the type of action and the part of the CNS that controls it.

Answer: It is a **reflex action**, controlled by the **spinal cord** through a reflex arc — not the brain — which is why it is so fast.

Example 5

Which part of the brain controls heartbeat and breathing, and which controls balance and posture?

Answer: The **medulla oblongata** controls heartbeat and breathing; the **cerebellum** controls balance and posture.

Example 6

Name the photoreceptor cells of the retina and state the function of each.

Answer: **Rods** work in dim light and give black-and-white (twilight) vision; **cones** work in bright light and give colour vision and sharp detail.

Important Questions for Board Exams

1-Mark Questions (VSA)

1. What is the resting potential of a neuron?
2. Name the granular bodies present in the cell body of a neuron.
3. What is a synaptic cleft?

4. Name the part of the eye with the highest concentration of cones.

5. Name the three ear ossicles in order.

2–3-Mark Questions (SA)

1. Differentiate between resting potential and action potential.

2. Draw a labelled diagram of a neuron and name its three main parts.

3. Describe the five components of a reflex arc.

4. Distinguish between the sympathetic and parasympathetic nervous systems.

5-Mark Questions (LA)

1. Explain the generation and conduction of a nerve impulse along an axon.

2. Describe the structure of the human brain under forebrain, midbrain, and hindbrain with the function of each part.

3. Explain the mechanism of impulse transmission across a chemical synapse.

Quick Revision Points

- Neuron = structural and functional unit; parts — dendrites, cyton (Nissl's granules), axon
 - Myelinated axons conduct fast via saltatory conduction (node to node)
 - Resting potential ≈ -70 mV; membrane polarised (+ outside, – inside)
 - Action potential: depolarisation (Na^+ in) $\rightarrow$ repolarisation (K^+ out)
 - Sodium-potassium pump: 3 Na^+ out, 2 K^+ in
 - Chemical synapse: Ca^{2+} in $\rightarrow$ neurotransmitter (acetylcholine) released $\rightarrow$ binds receptors
 - CNS = brain + spinal cord; PNS = somatic + autonomic (sympathetic/parasympathetic)
 - Brain: forebrain (cerebrum, thalamus, hypothalamus), midbrain, hindbrain (cerebellum, pons, medulla)
 - Reflex arc: receptor $\rightarrow$ sensory neuron $\rightarrow$ spinal cord $\rightarrow$ motor neuron $\rightarrow$ effector
 - Eye: rods (dim light), cones (colour); fovea = sharpest vision; blind spot = no receptors
 - Ear: ossicles (malleus, incus, stapes); cochlea = hearing; semicircular canals = balance
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Next Chapter: Chapter 19 — Chemical Coordination and Integration



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