

Neurons and Neurotransmission

Neurons & Neurotransmission – Study Notes

1. Overview of the Nervous System

Component	Main Function
Central Nervous System (CNS)	Brain + spinal cord; integrates information and generates responses.
Peripheral Nervous System (PNS)	Sensory (afferent) and motor (efferent) nerves that connect the CNS to the rest of the body.
Neurons	Specialized cells that transmit electrical and chemical signals.

2. Neuron Anatomy

Structure	Description	Key Role in Transmission
Cell Body (Soma)	Contains nucleus, organelles, and most cytoplasm.	Generates the resting membrane potential ; integrates incoming signals.
Dendrites	Branch-like extensions (often many).	Receive excitatory or inhibitory inputs from other neurons.
Axon	Long, thin process that can be myelinated.	Conducts action potentials away from the soma toward terminals.
Myelin Sheath	Lipid-rich layers formed by Schwann cells (PNS) or oligodendrocytes (CNS).	Increases conduction speed via saltatory propagation.
Nodes of Ranvier	Gaps in myelin.	Concentrate voltage-gated Na ⁺ channels; allow regeneration of the action potential.
Axon Terminals (Synaptic Boutons)	Swellings at the end of the axon.	Release neurotransmitter into the synaptic cleft.
Synapse	Junction between a presynaptic terminal and a postsynaptic element (neuron, muscle, gland).	Site of chemical communication.

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3. Resting Membrane Potential (RMP)

- **Typical value:** -70 mV (inside negative).
- **Main contributors:**
 - **$\text{Na}^+/\text{K}^+ \text{ ATPase}$** – pumps 3 Na^+ out, 2 K^+ in (maintains ion gradients).
 - **Leak channels** – primarily K^+ (makes interior negative).
 - **Permeability differences:** $P_{\text{K}^+} \gg P_{\text{Na}^+} \gg P_{\text{Cl}^-}$.
- **Nernst equation** (for a single ion):

$$[E_{\text{ion}} = \frac{RT}{zF} \ln \frac{[\text{ion}]_{\text{out}}}{[\text{ion}]_{\text{in}}}]$$

- **Goldman-Hodgkin-Katz (GHK) equation** (multiple ions):

$$[V_m = \frac{RT}{F} \ln \frac{P_{\text{K}^+}[\text{K}^+]_{\text{out}} + P_{\text{Na}^+}[\text{Na}^+]_{\text{out}} + P_{\text{Cl}^-}[\text{Cl}^-]_{\text{in}}}{P_{\text{K}^+}[\text{K}^+]_{\text{in}} + P_{\text{Na}^+}[\text{Na}^+]_{\text{in}} + P_{\text{Cl}^-}[\text{Cl}^-]_{\text{out}}}]$$

4. Generation of an Action Potential

Phase	Membrane Change	Ion Movements	Key Channels
Depolarization	Membrane potential rises toward 0 mV .	Voltage-gated Na^+ channels open Na^+ influx.	Na^+ channels (fast, inactivating).
Repolarization	Return toward negative values.	Voltage-gated K^+ channels open K^+ efflux; Na^+ channels inactivate.	