

THE PHYSIOLOGY OF NERVE FIBERS AND SYNAPSES

Yusupova Mohira To'laganovna

Tashkent State Medical University, Teacher

e-mail: yusupovamohira@gmail.com +99893-243-00-36

Student: **Abiramatova Dilnura Farhod qizi**

Tashkent State Medical University

e-mail: abiramatovadilnura@gmail.com

Abstract. This article examines the fundamental physiological mechanisms of nerve fibers and synapses, focusing on their structural organization, electrophysiological properties, and roles in neural communication. By integrating classical neurophysiology with modern experimental findings, the study analyzes the conduction of action potentials, the functional differences between myelinated and unmyelinated fibers, and the molecular events underlying synaptic transmission. Special attention is given to the generation and propagation of electrical impulses, synaptic vesicle cycling, neurotransmitter release, receptor activation, and synaptic plasticity. The paper highlights the importance of nerve fiber and synapse physiology in maintaining neural network function and its implications for understanding neurological disorders, neural development, and therapeutic interventions. The findings demonstrate that nerve fibers and synapses form the core communication system of the nervous system, allowing rapid, precise, and adaptable information transfer throughout the organism.¹

Keywords: Nerve fibers; synapses; action potential; myelin; neurotransmitters; synaptic plasticity; axonal conduction; ion channels; neural communication; electrophysiology; neurobiology.

Introduction. The nervous system relies on highly specialized structures—nerve fibers and synapses—to coordinate sensory perception, motor control, cognition, and homeostasis. Nerve fibers transmit electrical impulses, whereas synapses mediate communication between neurons or between neurons and effector tissues.² Together, they

form an integrated signaling network that enables rapid and precise information transfer across the body. The aim of this study is to analyze the physiological principles of nerve fibers and synapses, exploring their structure, electrophysiological properties, and roles in neural communication as well as their significance in health and disease.

Main Body. Nerve fibers, also known as axons, conduct electrical signals called action potentials. These impulses are generated by rapid shifts in membrane potential produced by voltage-gated ion channels.³ The process begins with depolarization mediated by sodium influx, followed by repolarization driven by potassium efflux, establishing the characteristic action potential waveform.⁴ The speed and efficiency of impulse conduction vary depending on axon diameter and myelination. Myelinated fibers, wrapped by Schwann cells or oligodendrocytes, exhibit saltatory conduction, where impulses jump between nodes of Ranvier, significantly increasing conduction velocity.⁵ In contrast, unmyelinated fibers conduct impulses continuously along the membrane, resulting in slower transmission. This structural-functional relationship is essential for differentiating between rapid reflex pathways and slower autonomic responses. Nerve fibers contain molecular transport systems, including kinesin- and dynein-mediated axonal transport, which deliver neurotransmitters, vesicles, and organelles to synaptic terminals.⁶ Disruption of axonal transport contributes to neurodegenerative conditions such as Alzheimer's, ALS, and peripheral neuropathies. Synapses are specialized junctions that allow neurons to communicate with each other or with muscles and glands. Most synapses are chemical, relying on neurotransmitter release, though some are electrical, enabling direct ionic flow through gap junctions. Chemical synapses involve a multistep process: action potential arrival, calcium influx through voltage-gated Ca^{2+} channels, vesicle docking, exocytosis of neurotransmitters, receptor activation on the postsynaptic membrane, and termination through reuptake or enzymatic degradation.⁷ Acetylcholine, glutamate, GABA, dopamine, serotonin, and norepinephrine are among the key neurotransmitters influencing excitatory or inhibitory responses. Synaptic integration occurs when postsynaptic potentials—excitatory (EPSPs) or inhibitory (IPSPs)—combine spatially or temporally to determine neuronal firing.⁸ Synaptic plasticity, characterized by long-term potentiation (LTP) and long-term depression (LTD), underlies learning, memory, and adaptation of neural

circuits.⁹ This plasticity depends on receptor sensitivity, neurotransmitter release probability, and structural remodeling of synapses. In neuromuscular synapses, acetylcholine triggers muscle contraction through nicotinic receptors, linking neural activity to motor behavior.¹⁰ The physiology of nerve fibers and synapses is central to understanding various neurological disorders such as epilepsy (excessive synaptic excitation), Parkinson's disease (dopamine deficiency), multiple sclerosis (demyelination), and synaptopathies involving impaired synaptic transmission.¹¹ Thus, the coordinated function of nerve fibers and synapses ensures rapid, regulated, and adaptive communication necessary for organismal function.

Conclusion. Nerve fibers and synapses are the essential functional units of neural communication, providing the electrical and chemical basis of nervous system activity. Their physiological properties—action potential conduction, synaptic transmission, and plasticity—enable the nervous system to function with speed, precision, and adaptability. Understanding their mechanisms is crucial for interpreting normal neural function and for diagnosing and treating neurological disorders. As research advances, insights into synaptic signaling, ion channel dynamics, and myelin biology continue to inform the development of new therapeutic approaches and enhance our understanding of neural complexity.

References

1. Kandel E., Schwartz J., Jessell T. Principles of Neural Science. McGraw-Hill, 2021.
2. Bear M., Connors B., Paradiso M. Neuroscience: Exploring the Brain. Wolters Kluwer, 2020.
3. Hille B. Ion Channels of Excitable Membranes. Sinauer Associates, 2022.
4. Johnston D., Wu S. Foundations of Cellular Neurophysiology. MIT Press, 1995.
5. Zalc B., Fields R. Myelination and Axonal Conduction. Nature Reviews Neuroscience, 2020.
6. Maday S., Holzbaur E. Axonal Transport and Neurodegeneration. Neuron, 2016.
7. Südhof T. The Molecular Machinery of Neurotransmitter Release. Science, 2013.
8. Shepherd G. Neurobiology. Oxford University Press, 2019.

9. Bliss T., Collingridge G. Synaptic Plasticity and Memory. Nature, 2013.
10. Katz B. The Release of Neural Transmitter Substances. Liverpool Univ. Press, 1969.
11. Purves D. Et al. Neuroscience. Oxford Univ. Press, 2020.