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NERVOUS SYSTEM

Asadullayev Sobirjon Sodiq o'g'li
Scientific supervisor: **Asatullayev Rustamjon Bakhtiyarovich**
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Abstract: This article examines the structure and functions of the nervous system as an integral system. Beyond the classical anatomical classification, it pays special attention to the dynamic interaction between neurons and glial cells, the dual control logic of the autonomic nervous system, and modern concepts of neuroplasticity. The main purpose of the article is to outline the theoretical foundations for interpreting the nervous system not as a static "collection of divisions," but as a constantly adapting, multi-level control network.

Keywords: central nervous system, peripheral nervous system, neuroglia, autonomic nervous system, neuroplasticity

Introduction

Although the nervous system is one of the most complex and thoroughly studied systems of the organism, our understanding of its functional integrity has changed radically in recent decades. In traditional textbooks, the nervous system is usually divided into central and peripheral divisions, with the anatomical structure of each division highlighted separately. However, this approach cannot fully reflect the real working dynamics of the system, especially the active participation of glial cells, the dual logic of autonomic control, and the ability to reorganize after injury.

The central thesis of this article is that to understand the nervous system, it is not enough to list its "parts"; it is necessary to analyze the functional connections between the parts and the regularities of how these connections change over time. Based on this perspective, the main structural levels of the nervous system and their interrelations are discussed below.

The Functional Logic of Central and Peripheral Division

The central nervous system (CNS) consists of the brain and spinal cord, functioning as the integration center of the organism. The brain is divided into various regions: some areas process sensory information, others control movement or regulate hormonal secretion. The spinal cord is mainly composed of long nerve pathways, serving to transmit signals between the brain and the body.

The peripheral nervous system (PNS) consists of nerves emerging from the brain and spinal cord. Through these nerves, sensory signals from the external environment reach the center, while motor commands from the center are transmitted to the muscles. Importantly, the PNS is not protected by bone, making it more prone to injury. The functional consequence of this anatomical vulnerability is that when a peripheral nerve is damaged, it regenerates slower than the central nervous system—growing at a rate of only 1-2 mm per day.

Neurons and Neuroglia: Two-Way, Not One-Way, Communication

The neuron is considered the primary functional unit of the nervous system. Neurons receive signals via dendrites and transmit them over long distances via axons. Traditional views held that the neuron was the "main worker" and glia played only a "supportive" role. Modern research has radically changed this view.

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Neuroglial cells—astrocytes, oligodendrocytes, and microglia—not only perform structural support functions but also directly participate in the survival of neurons, the formation and reorganization of synaptic connections, myelination, and immune defense. Oligodendrocytes form myelin in the central nervous system, ensuring the speed of nerve impulses; Schwann cells perform the same function in peripheral nerves. Microglia actively participate in the synaptic "pruning" process, removing redundant or inefficient synaptic connections.

This means that the functional state of the nervous system is determined not only by the electrical activity of neurons, but also by how glial cells support and limit this activity. Dysfunction of neuroglia increases neuronal vulnerability and lays the groundwork for the development of various neurological diseases.

Autonomic Nervous System: The Balance of Two Opposing Forces The autonomic nervous system (ANS) controls the activity of internal organs, blood vessels, the heart, and glands independently of will. Its sympathetic and parasympathetic divisions exert opposite effects on the same organs: the sympathetic division triggers the "fight or flight" response during stress and emergencies—increasing blood pressure, accelerating heart rate, and slowing digestion. The parasympathetic division reverses these changes once the danger passes: heart rate slows down, blood pressure drops, and digestion is restored.

The balance of these two systems is crucial for ensuring the internal environment stability (homeostasis) of the organism. The enteric nervous system, which is part of the ANS and located in the walls of the digestive tract containing about 100 million neurons, is even called the "second brain" because it can autonomously control the basic functions of the digestive process.

Neuroplasticity: The Variability of the System

One of the most important properties of the nervous system is neuroplasticity, which is the ability to change structure and function as a result of external influences and experience. This property is preserved not only during the development period but throughout life. Neuroplasticity underlies the processes of learning and memory, and also determines recovery possibilities after injury.

However, there are limits to plasticity. In the central nervous system, neurons do not multiply—the number given at birth is preserved, and a dead neuron is not completely replaced by another. Peripheral nerves have a certain capacity for recovery, but this process is slow and not always complete. Therefore, nervous system disorders often lead to long-term consequences.

Conclusion

The key to understanding the nervous system is to view it not as a collection of independent divisions, but as an interconnected, constantly adapting, multi-level control network. The electrical signals of neurons, the supporting and regulatory activity of glial cells, the balanced control of the autonomic system, and the limited yet real possibilities of neuroplasticity—all of these together ensure the organism's ability to adapt to the external environment. Promising directions for future research include developing therapeutic strategies targeting glial cells and finding ways to artificially stimulate neuroplasticity.

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