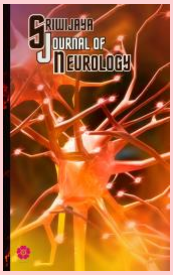

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Overview of Cellular Aspects of the Nervous System: A Narrative Literature Review

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A B S T R A C T

The structure of neurons varies so much that each neuron is adapted to perform a specific function. Although their functions may vary slightly, neurons have three common components, namely the cell body (soma), dendrites (thin branching fibers from the cell), and the axon. This literature review aimed to describe the cellular aspect of the system nerves in the human body. The cellular constituents of a typical neuron include microtubules (transporters within the cell), neurofibrils (thin supporting fibers extending throughout the neuron), microfilaments (proteins thought to be involved in the transport of cellular products), and Nissl bodies (endoplasmic reticulum and ribosomes). Involved in protein synthesis. Although most neurons are non-dividing cells, some continue to divide after birth; for example, the olfactory neurons in the nose continue to divide throughout life. In conclusion, there are two basic types of cells comprising nervous tissue: neurons and supporting neuroglia. Neurons are electrically excitable cells and transmit electrical or chemical information between other neurons or to effector organs. Neuroglial cells provide structural support, protection, and nutrition for neurons and facilitate neurotransmission.

1. Introduction

Two basic types of cells comprise nervous tissue: neurons and supporting neuroglia. Neurons are electrically excitable cells and transmit electrical or chemical information between other neurons or to effector organs. Neuroglial cells provide structural support, protection, and nutrition for neurons and facilitate neurotransmission. Neuroglial cells include astrocytes, microglia, and oligodendrocytes in the central nervous system (CNS); Schwann (neurilemma), and satellite cells in the peripheral nervous system (PNS).[1-5] This literature review aimed to describe the cellular aspect of the system nerves in the human body.

Neuron

Working alone or in units, neurons detect environmental changes and initiate body responses to maintain a dynamic steady state. The structure of neurons varies so much that each neuron is adapted to perform a specific function. Although their functions may vary slightly, neurons have three common components: the cell body (soma), dendrites (thin branching fibers from the cell), and the axon. The cell bodies for most neurons, even those extending axons to peripheral nerves, are located within the CNS. The tightly packed collection of cell bodies in the CNS is called the nucleus. In the PNS, cell bodies can be found in groups called ganglia or plexuses (groups of relay nerves). Extension dendrites carry nerve impulses going to body cells. The dendritic zone is part of the neuron that receives the stimulus and propagates or reduces conduction. The axon is the

long protrusion that carries nerve impulses avoid from the cell body. The axon hillock is the conical process where the axon leaves the cell body. The first part of the axon hillock has the lowest threshold for stimulation, so action potentials often start there. Principle Divergence Refers to the ability of the axonal branch to affect many different neurons. Convergence applies when branches of different numbers of neurons coalesce and affect one neuron.[6-8]

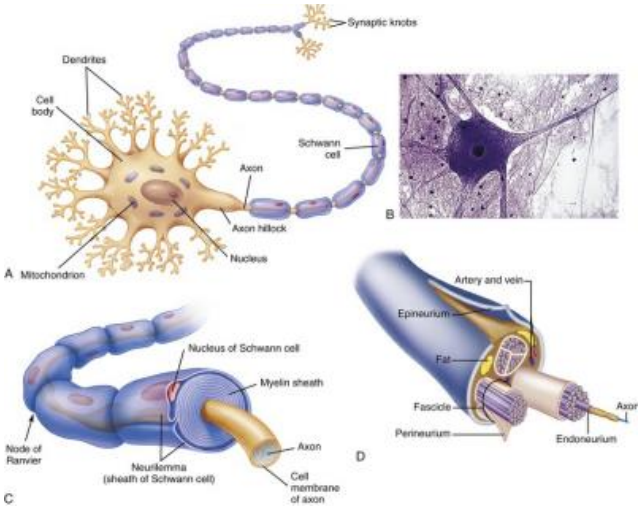

Figure 1. Structure of a special neuron. A) Several dendrites carry nerve impulses to the cell body, and one long axon carries nerve impulses away from the cell body. Long axons are encased at intervals by a myelin sheath. B) Photomicrograph of a neuron. C) a segment of a myelin fiber in a cross-section, showing the myelin sheath consisting of several layers of myelin, which encloses the axon. D) Axons are bundled into fascicles.

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A typical neuron has only one axon, which may be tightly wrapped with a layer of segmented lipid material called myelin, an insulating substance. In the brain and spinal cord, myelin is formed by oligodendrocytes. Areas of the brain and spinal cord with a high degree of myelination constitute white matter, whereas areas that are not significantly myelinated (usually consisting mainly of cell bodies) are gray matter. In the CNS, the myelin sheaths of motor and sensory axons are formed by Schwann cells. The myelin sheath is interrupted periodically by the nodes of Ranvier. Axons can branch at the nodes of Ranvier.[9-11]

Exchange of nutrients is not possible through the myelin sheath, although it can occur at nodes of Ranvier where axons are not isolated. Myelin acts as an insulator allowing action potentials to jump between nodes of Ranvier rather than flowing along the entire length of the membrane, resulting in an increase in conduction velocity. This mechanism is known as saltatory conduction. Disorders of the myelin sheath (demyelinating diseases), such as multiple sclerosis, Guillain-Barré syndrome, and Charcot-Marie-Tooth disease, point to the important role of myelin in nerve conduction. The conduction velocity depends not only on the myelin layer but also on the diameter of the axon. Larger axons transmit impulses at a faster rate.

Neurons are structurally classified based on the number of processes (projections) that extend from the cell body. There are four basic types of cell configurations: (1) unipolar, (2) pseudounipolar, (3) bipolar, and (4) multipolar. Unipolar neurons have a single process that branches immediately after leaving

the cell body. One example is found in the retina. Pseudounipolar neurons (some authors call them unipolar) also have one process. The dendritic portion of each of these neurons extends from the CNS, and the axon portion projects into the CNS. Its configuration is typical of sensory neurons in cranial and spinal nerves. Bipolar neurons have two distinct processes that arise from the cell body. This type of neuron is connected to the rod and cone cells of the retina. Multipolar neurons are the most common and have many processes capable of extensive branching. A motor neuron is usually multipolar.[12-14]

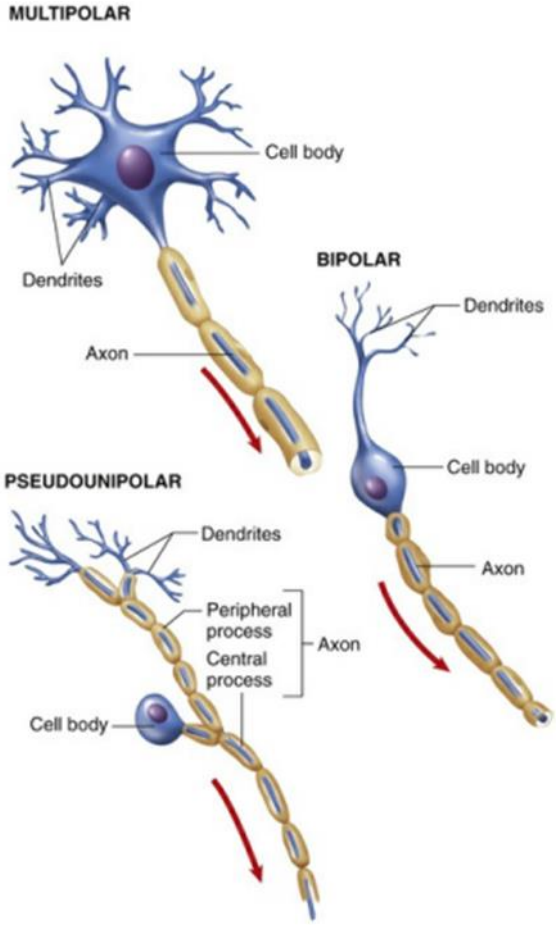

Figure 2. Structural classification of neurons.

Functionally, there are three types of neurons (with their directions of transmission and typical configuration noted in parentheses): (1) sensory (afferent, mostly pseudounipolar), (2) association (interneurons, multipolar), and (3) motor (efferent, multipolar). Sensory neurons carry impulses from peripheral sensory receptors to the CNS. Association neurons (interneurons) transmit impulses from neuron to neuron and are located only in the CNS. Motor neurons transmit impulses away from the CNS to effector organs (i.e., skeletal muscles or organs). In skeletal muscle, the axon terminal processes form special structures called neuromuscular junctions.[15-17]

Neuroglia and Schwann cells

Neuroglia ("nerve glue") is a general classification of non-neuronal cells that support CNS neurons. Conduction velocity depends not only on the myelin sheath and nodes of Ranvier but also on the axon diameter. Larger axons transmit impulses at a faster rate. Oligodendroglia (oligodendrocytes) form the myelin sheaths within the brain and spinal cord. Areas of the brain and spinal cord with a high degree of myelination constitute white matter, whereas areas that are not significantly myelinated (usually consisting mainly of cell bodies) are gray matter. Schwann cells form myelin sheaths around axons in the peripheral nervous system and direct axonal regrowth and functional restoration of injured

neurons. Schwann cell non-myelinating provides metabolic support.

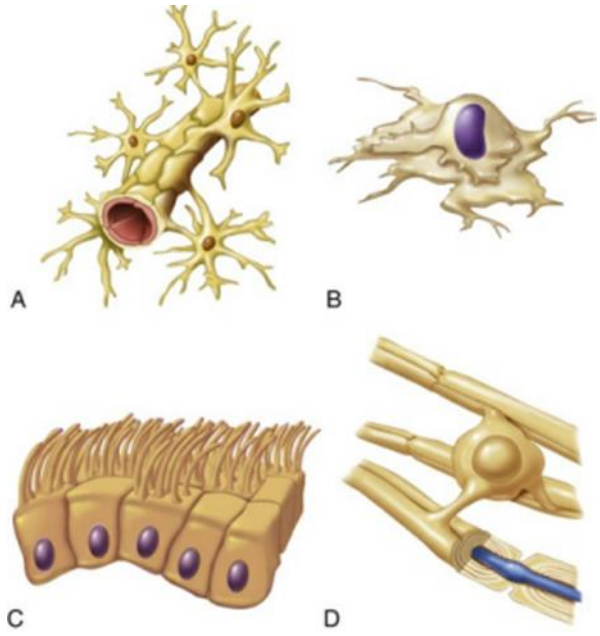

Figure 3. Types of neuroglial cells. A) Astrocytes attached to brain capillaries, B) Microglial cells, C) ependymal cells that form sheets to line the fluid cavities in the brain, D) Oligodendrocytes are wrapped around CNS nerve fibers, forming myelin.

Table 1. Support cells (glial cells) of the nervous system.

Cell type	Main function
Astrocytes	Forms a special contact between the surface of the nerves and blood vessels Provides fast transport for nutrients and metabolites It is believed to form an important component of the blood-brain barrier It appears to be the scar tissue-forming cells of the CNS, which may be the focus of seizures Participates in CNS immune function It appears to work with neurons in processing information and storing memory
Oligodendroglia (oligodendrocyte)	Formation of the myelin sheath and neurilemma in the CNS
Schwann cell	Formation of the myelin sheath and neurilemma in PNS
Microglia	Responsible for clearing cellular debris (phagocytosis property)
Ependymal cell	Serves as a lining for the ventricles and the choroid plexus involved in CSF production

CNS, central nerve system; CSF, cerebrospinal fluid; PNS, peripheral nervous system.

Nerve injury and regeneration

Mature neurons do not divide, and injury to the CNS results in permanent loss of the damaged neuron. Peripheral nerves can repair themselves through local, anterograde, and retrograde changes. This is known as an axonal reaction. Local changes occur when an axon is severed. The truncated ends are retracted, and the axolemma covers the truncated ends, reducing the passage of the axoplasm. Macrophages and Schwann cells begin to phagocytize damaged tissue. The cell bodies undergo chromatolysis with swelling, loss of Nissl bodies, and lateral migration of the nucleus. Antegrade degeneration (Wallerian) occurs in the distal axon: (1) characteristic swelling appears at the axon terminal and degenerates and loses contact with the postsynaptic membrane within 7 days; (2) macrophages and Schwann cells phagocytize the remnants of axon terminals; and (3) Schwann cells

proliferate, forming columns or tubes of Schwann cells that are covered by the endoneurium's native basal lamina. Retrograde change occurs at the proximal end of the injured axon and is similar to antegrade changes but only returns to the next node of Ranvier. Approximately 7 to 14 days after injury, the new terminal bud protrudes from the proximal segment guided by Schwann cells and enters the Schwann cell column support substrate or tube for axonal regrowth. This process is very slow (about 1 mm per day) and is limited to the myelinated fibers in the PNS. Regeneration of axonal constituents in the CNS is limited by the increased incidence of glial scar formation (gliosis) and the distinct nature of myelin formed by oligodendrocytes

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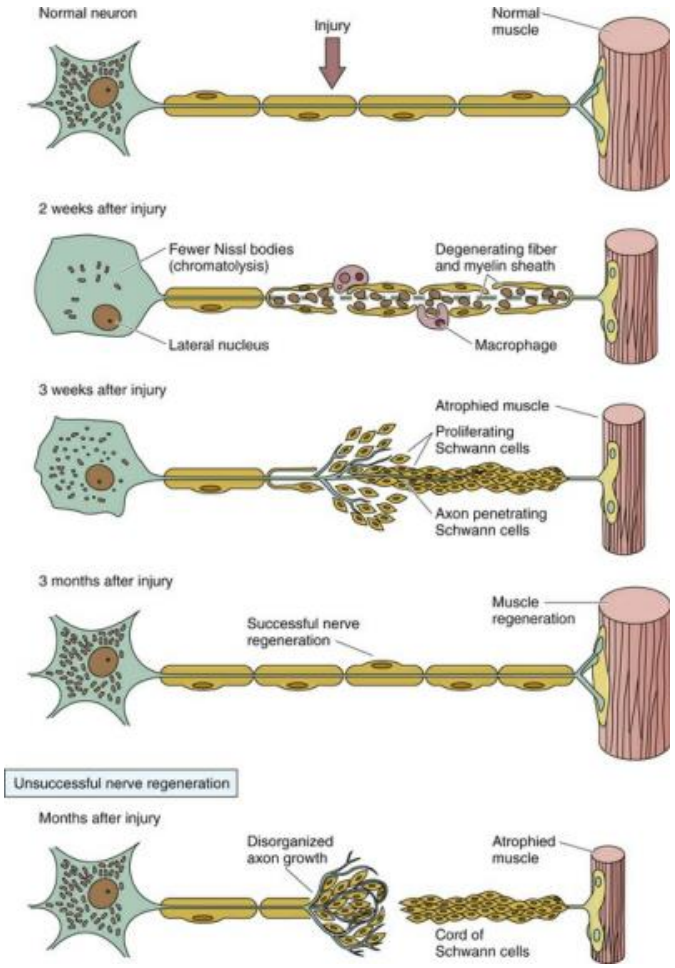

Figure 4. Peripheral nerve regeneration after injury. Schwann cells detach from the axon, proliferate, and, by recruiting macrophages, help clear cellular debris and myelin. At the same time, growth factor expression by Schwann cells creates a favorable environment for nerve regrowth to target organs. Damaged motor axons can grow back into their distal junctions only if the neurilemma remains intact (to form a guiding tunnel) and if scar tissue does not block its passage.

Nerve regeneration depends on many factors, such as the location of the injury, the type of injury, the presence of an inflammatory response, and the process by which scar tissue forms. The closer the injury is to the nerve cell body, the greater the chance that the nerve cell will die and not regenerate. Crush injuries allow for more complete recovery than cuts. Nerves that are destroyed sometimes recover completely, while nerves that are cut often form connective tissue that blocks or slows the regeneration of the axonal branches. Peripheral nerves injured close

to the spinal cord recover poorly and slowly because of the large distance between the cell body and the peripheral ends of the axons.[18-20]

2. Conclusion

Two basic types of cells comprise nervous tissue: neurons and supporting neuroglia. Neurons are electrically excitable cells and transmit electrical or chemical information between other neurons or to effector organs. Neuroglial cells provide structural support, protection, and nutrition for neurons and facilitate neurotransmission.

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