

Neuronal membrane and Mechanisms Appeared on the Membrane Surface

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Abstract. Most mechanisms involved in neuronal maintenance and function are activated at the neuronal membrane. Membrane-related molecular agents, which interact in protein/lipid clusters to begin molecular processing and signal transduction, are required for these functions. Furthermore, many neuropathological disorders originate in this structure and/or are the result of membrane malfunction. Although the precise molecular mechanisms for maintaining "membrane health" are unknown in most cases, it appears that the effects of different lipids on the microstructural and stoichiometric properties of the membrane influence the behavior and association of proteins within the lipid environment, which determines the final cell response. This review is mainly focused on the function of neuronal membrane like substance exchange, cell signaling, etc.

Keywords: Nerve cell, neuronal membrane, neuropathological disorders.

1. Introduction

All electrical activity in neurobiology occurs via voltages across the cell's membrane. The research of the cell membrane began in 1895, but it wasn't until 1972 that there was a general understanding of the cell membrane. This article will cover the fundamentals of cell membrane construction and electrical activity on nerve cell membranes.

This page covers the fundamental model of all biological membranes, the anatomy of nerve cells, and some unique nerve cell attributes such as the Na/K pump, myelin sheath, dendrites, and axons. The page also discusses the functions of these organelles and how they work, including resting potential. The chemical signal created at synapses will be discussed in the pages that follow.

2. Fundamental properties of biological membranes

Membranes are permeable to non-polar particles but impenetrable to most charged particles and polar compounds. When proteins projecting on both sides are included, they are 5 to 8 nm (50 to 80) thick. The evidence from electron microscopy and chemical composition studies, as well as a plethora of physical studies of permeability and the movement of individual lipid and protein molecules within membranes, led to the development of the fluid mosaic model, proposed by Singer and Nicholson in 1972, to explain the structure of biological membranes, where the fluid refers to the

movement of proteins and phospholipids by diffusion, and the mosaic is a pattern of scattered protein molecules. (6,7) Phospholipids produce a bilayer in which the lipid molecules' non-polar sections face the center of the bilayer and their polar head groups face outward, interacting with the aqueous phase on either side and flowing sideways in layers. (8) Proteins are incorporated in this bilayer, their hydrophobic regions in touch with the membrane lipids' fatty acyl chains. These proteins aid in the active transport of polar molecules and the diffusion of essential particles like as nutrients and hormones. (4,7) Glycerophospholipids, sphingolipids, and sterols are insoluble in water in the lipid bilayer. When they mix with water, they form minute lipid aggregates and cluster together, with hydrophobic moieties interacting with one other and hydrophilic heads engaging with the water. The aggregation lowers the overall hydrophobic surface area exposed to water and the number of molecules in the water shell at lipid-water contacts. (6,10)

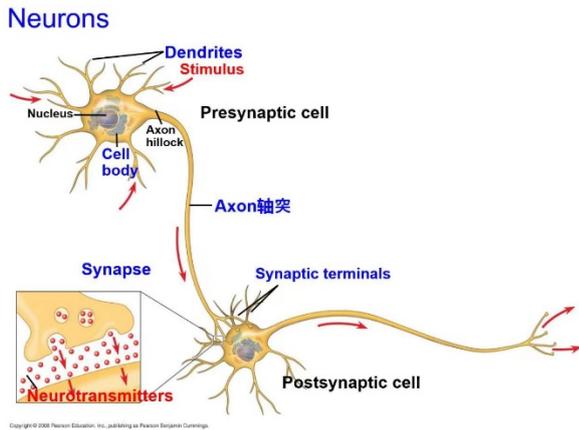


Fig.1 Neurons

Graded potentials and an action potential in a neuron

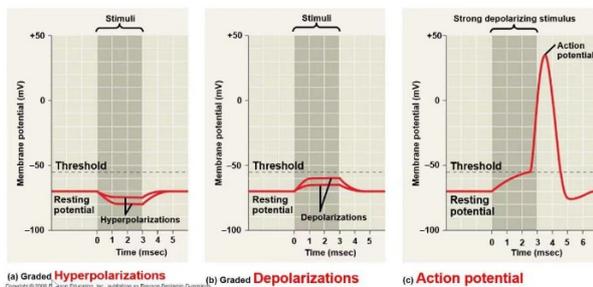


Fig.2 Graded potentials and an action potential in a neuron

3. Mechanisms of substance exchange

The partly permeable membrane permits certain substances to travel through it through some ways of transferring chemicals in and out of the membrane. Diffusion is a frequent mechanism that involves the net movement of substances from a higher concentration zone to a lower concentration region, resulting in the movement of molecules or ions down the concentration gradient. Diffusion aids in the creation of an equilibrium condition in which molecules and ions are uniformly distributed. (4)

Because some compounds or ions cannot diffuse across the phospholipid bilayer, utilizing channel proteins and carrier proteins facilitates their transport. Two kinds of protein are particularly specialized and can also be engaged in active transport. The channel proteins have a water-filled pore that controls ion exchange, whereas carrier proteins change shape when they attach to the carrier proteins, bringing the needed molecules or ions in. Another method, active transport, is comparable to assisted diffusion, but it requires energy, whereas facilitated diffusion is a passive mechanism.

Another common mechanism is osmosis, which means the net movement of water molecules from an area of higher water potential to an area of lower water potential. Water potential represents the tendency of water to move from one place to another, in the solution. When the

concentration of solute is low, the water potential of the solution is high, so the concentration of the solution is a key factor affecting the water potential.

The role of voltage-gated ion channels in the generation of an action potential

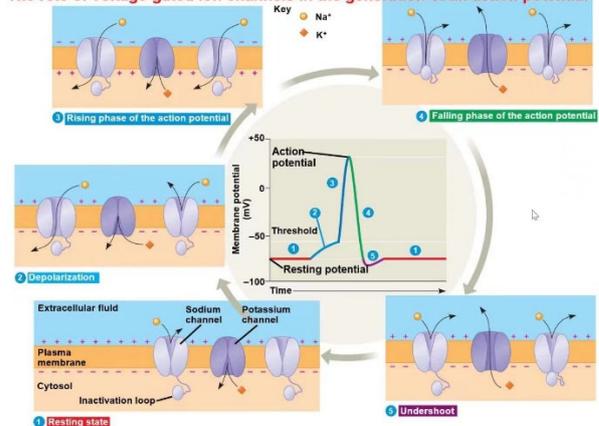


Fig.3 The role of voltage-gated ion channels in the generation of an action potential

Chemical synapse

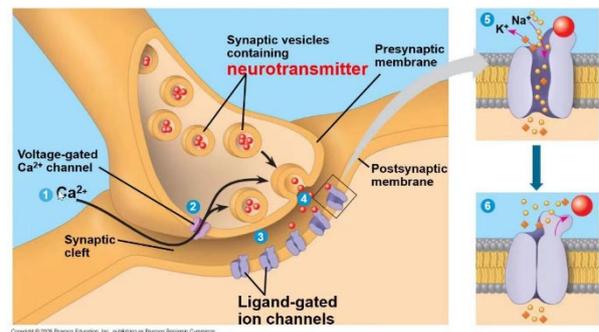


Fig.4 Chemical synapse

4. Cell signaling

Cell signaling is essentially a chemical system through which cells recognize and respond to certain stimuli, such as cell communication. Electrical or chemical signaling pathways can include a number of compounds such as neurotransmitters and hormones. Cell signaling progresses via numerous phases. A stimulation causes cells to release a specific chemical known as a ligand in the first portion. The ligand is subsequently delivered to target cells, where it binds to receptors. Those receptors on the cell surface have a particular shape to identify the ligand and change shape when the ligand is bound. The receptors cross the membrane, carrying messages within the cell. Because receptors change form, the next component of this route is able to connect with the receptor, which delivers signals. This is known as transduction, since the signal is turned into the message. The following component in the signaling pathway is frequently a 'G-protein,' which controls the release of a 'second messenger,' which is a small molecule that diffuses through the cell and transmits messages. When one receptor is stimulated, multiple second messengers

respond, resulting in an amplification of the initial signal. The second messenger activates a specific enzyme, which in turn activates other enzymes, amplifying the impact of amplification. As a result, a massive quantity of enzymes is created to affect the desired alteration in cell metabolism. (9)

5. Nerve cells

In the nervous system, there are three kinds of neurons: sensory neurons, intermediate neurons and motor neurons. Sensory neurons, just as its name implies, are used for detect the stimulus and transmit impulses from the receptor to the central nervous system. The cell body of sensory neurons is on the middle part of its axon, with dendrites in the front. (3)

Intermediate neurons, also relay neurons, is an intermediate between sensory neurons and motor neurons, as they transmit the impulse from sensory neurons to motor neurons. (4)

Motor neurons transmit nerve impulse from central nervous system to those which respond to the impulse, called effectors. The motor neurons have a cell body at the top of the cell, with many dendrites and a nucleus. (5) They have one long axon, like a tail, with some Schwann cells and node of Ranvier on it. At the bottom, there are synapses releasing chemicals called neurotransmitter.

Although the axon is very long, which seems like the transmission of nerve impulse takes long time, some special components on the axon facilitate the transmission of the impulse. Myelin, made by specific cells called Schwann cells, is an insulating material surrounding the axons. The myelin has abundant phospholipids which are impermeable to water and ions in the tissue fluid. The myelin helps with the faster transmission of electrical signals, as they are insulators, resulting in a shorter distance for transmitting impulse, so the impulse only passes the node of Ranvier, a very tiny gap between Schwann cells. (2)

6. How neurons work together

Neurons can transmit electrical impulses rapidly along the cell surface membrane from one end of the cell to another. The electrical signals are not transmitted as an electron flow, but as a slight change in the distribution of charged ions across the cell surface membrane, which is action potential. This potential difference is archived by the Na/K pump, which controls the movement of sodium and potassium ions across the axon membrane between the tissue fluid and cytoplasm. Normally, three sodium ions are pumped out of the membrane and two potassium ions are pumped in by ATP, leading to an electrochemical gradient and potential difference. When the electric current stimulates the axon to open the voltage-gated channels, resulting in sodium ions pass through the membrane. (1) As the concentration of sodium ions is larger outside than inside, the sodium ions enter the cell membrane through the open channels, which is a process called depolarization.

There is a threshold potential of about -60 and -70mV , which means that the action potential only occurs when the potential difference reaches this value. After the stimulus has passed, the potential difference returns to -70mV by repolarisation. (1) During this time, the sodium ion voltage-gated channels close and diffusion of potassium ions occurs. The potassium ions move outward to remove the positive charge inside the axon and return the potential difference to -70mV . (4)

If the action potential has just occurred, the new action potential cannot be generated behind, because the region behind recovering to the rest and the sodium pumps are still closed. This is a refractory period, so the action potential does not appear again, preventing the merge of action potentials.

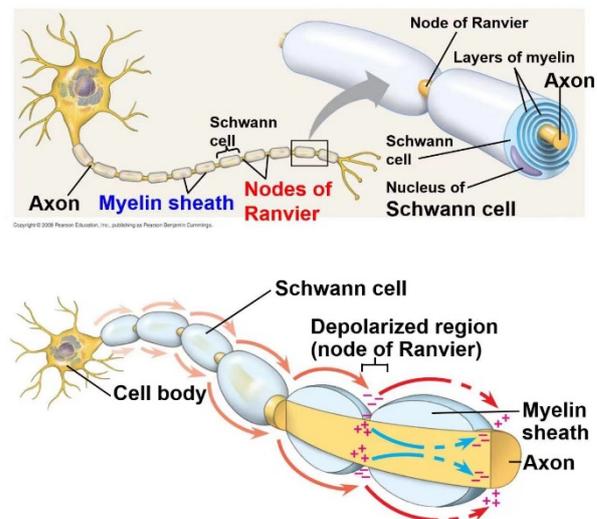


FIG.5 Membrane Surface

7. Prospects

As the knowledge about cell membranes and the mechanism of the nerve cell is cutting-edge, it is much easier to do some deeper exploration to cure some severe nerve diseases. With the technology of stem cell, there could be some trials to test if stem cells can help with the cure of injury in the central nervous system.

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