University of Al-Mustaqbal
College of Science
Department of Medical
Physics

Neurophysics

Fourth Stage

Transmission Lines

Second Licture

Prof.Dr.Nihad abdulameer Salih

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NERVE IMPLUSE PRODUCTION

The central nervous system (CNS) goes through a three-step process when it functions: sensory input, neural processing, and motor output. The sensory input stage is when the neurons (or excitable nerve cells) of the sensory organs are excited electrically. Neural impulses from sensory receptors are sent to the brain and spinal cord for processing. After the brain has processed the information, neural impulses are then conducted from the brain and spinal cord to muscles and glands, which is the resulting motor output.

How Can Generated Neuron Impulse :

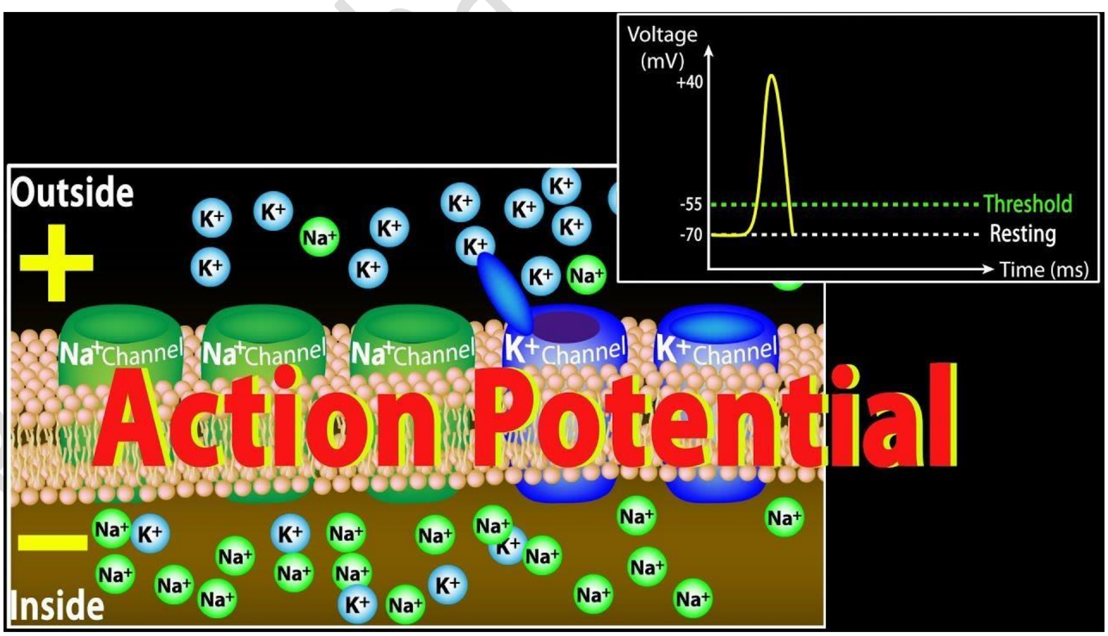
1. Receives signals

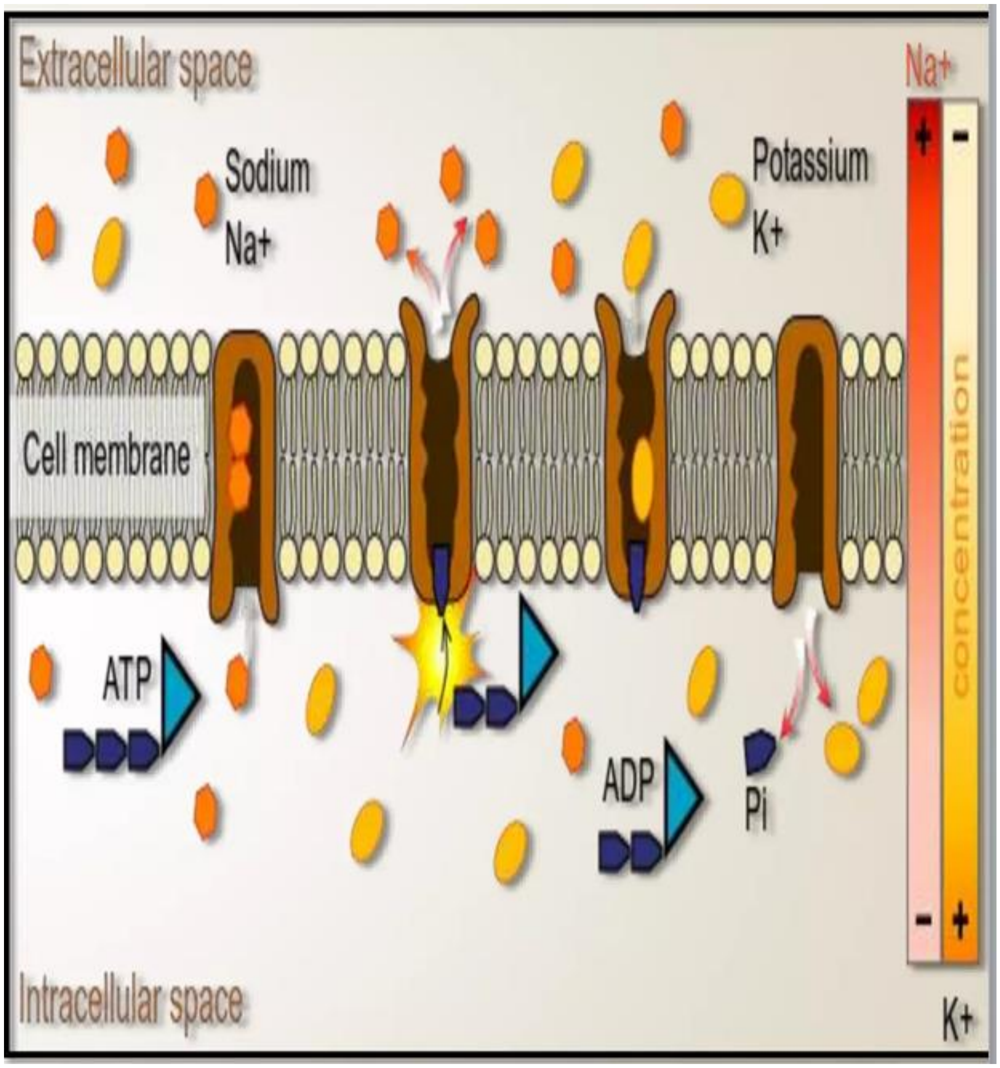
The process begins with dendrites, the small branches extending from the cell body of the neuron. Dendrites receive signals from other neurons or sensory receptors responding to stimuli like light, sound, or touch. This information is then passed on to the cell body.

When a neuron is not actively transmitting a nerve impulse, it is in a resting state, ready to transmit a nerve impulse. During the resting state, the sodium-potassium pump maintains a difference in charge across the cell membrane of the neuron. The sodium-potassium pump is a mechanism of active transport that moves sodium ions out of cells and potassium ions into cells. The sodium-potassium pump moves both ions from areas of lower to higher concentration, using energy in ATP and carrier proteins in the cell membrane.

The figure below shows in greater detail how the sodium-potassium pump works.

Sodium is the principal ion in the fluid outside of cells, and potassium is the principal ion in the fluid inside of cells. These differences in concentration create an electrical gradient across the cell membrane, called resting potential. Tightly controlling membrane resting potential is critical for the transmission of nerve impulses.



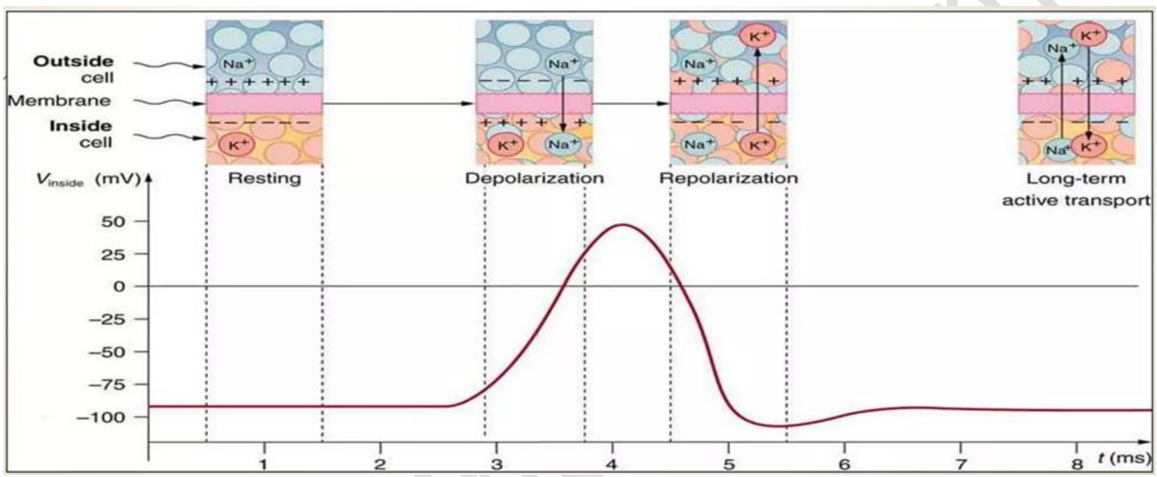


2. Triggers action potentials

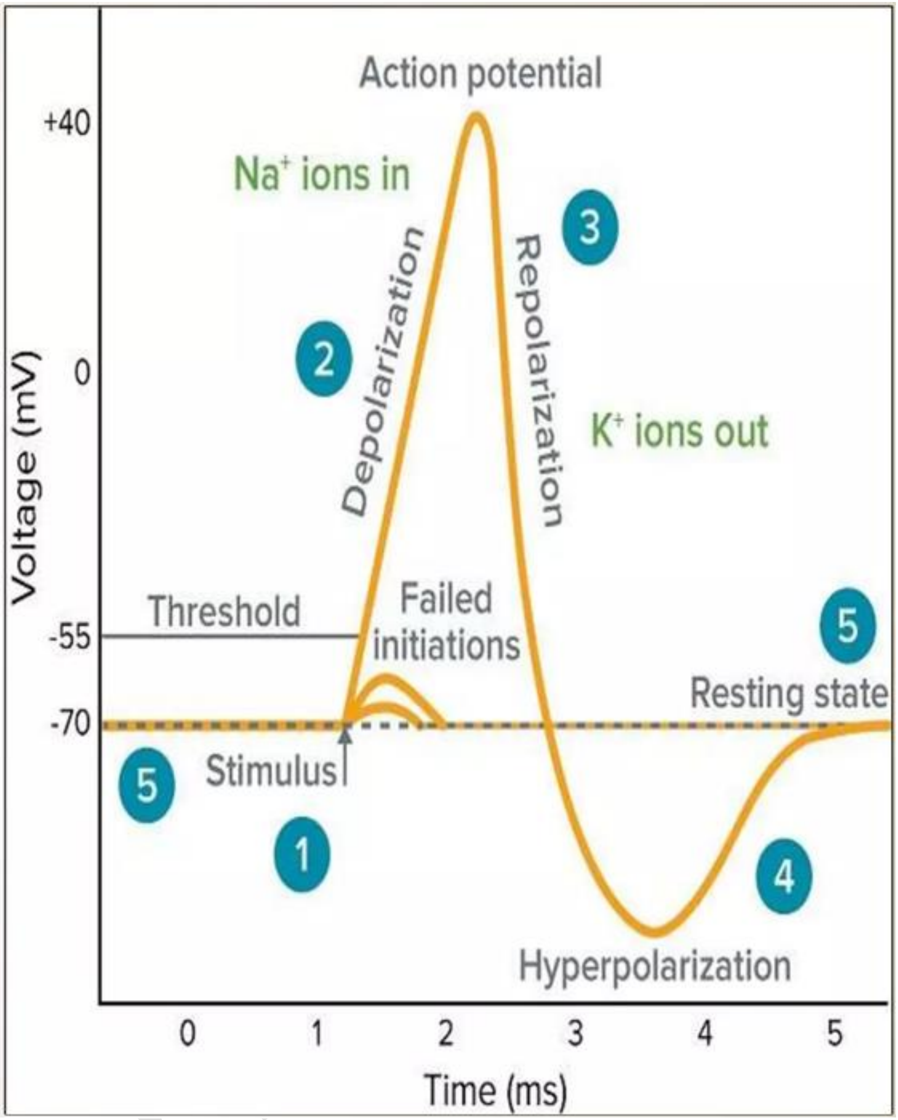
If the signal received is strong enough to pass a certain threshold, it triggers an action potential. An action potential is an electrical charge that starts in the cell body and then travels down the axon.

It's an all-or-nothing event, which means it will always travel the entire length of the axon, regardless of the strength of the signal, as long as the signal surpasses the necessary threshold.

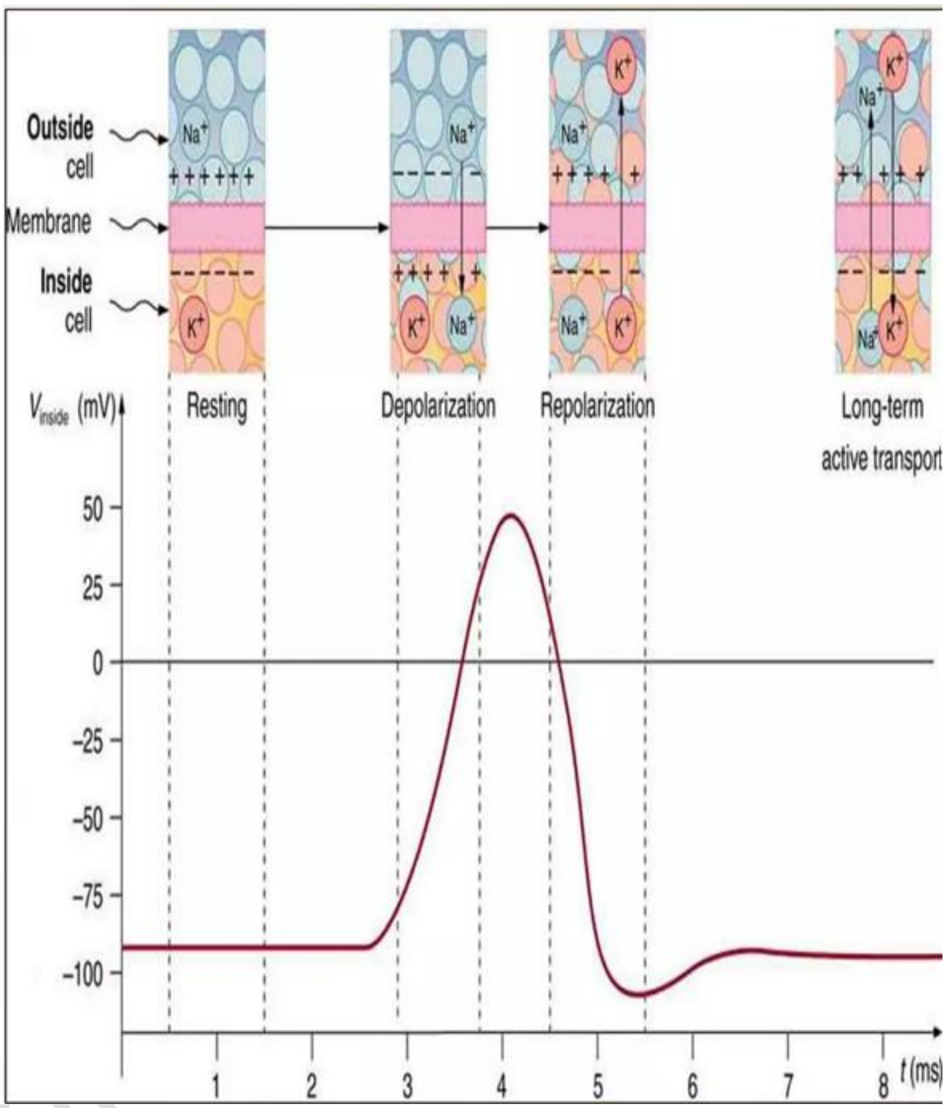
An action potential, also called a nerve impulse, is an electrical charge that travels along the membrane of a neuron. It can be generated when a neuron's membrane potential is changed by chemical signals from a nearby cell.In an action potential, the cell membrane potential changes quickly from negative to positive as sodium ions flow into the cell through ion channels, while potassium ions flow out of the cell.



The action potential is a rapid change in polarity that moves along the nerve fiber from neuron to neuron. In order for a neuron to move from resting potential to action potential-the neuron must be stimulated by pressure, electricity, chemicals, or another form of stimuli. The level of stimulation that a neuron must receive to reach action potential is known as the threshold of excitation, and until it reaches that threshold, that threshold, nothing will happen. Different neurons are sensitive to different stimuli, although most can register pain.



The change in membrane potential results in the cell becoming depolarized. An action potential works on an all-or-nothing basis. That is, the membrane potential has to reach a certain level of depolarization, called the threshold, otherwise, an action potential will not start. but is This threshold potential varies but generally about 15 millivolts (mV) more positive than the cell's resting membrane potential. If a membrane depolarization does not reach the threshold level, an action potential will not happen. You can see in Figure above that two depolarizations did not reach the threshold level of -55mV.



The first channels to open are the sodium ion channels, which allow sodium ions to enter the cell. The resulting increase in positive charge inside the cell (up to about +40 mV) starts the action potential. This is called the depolarization of the membrane. Potassium ion channels then open, allowing potassium ions to flow out of the cell, which ends the action potential. The inside of the membrane becomes negative again. This is called repolarization of the membrane. Both of the ion channels then close, and the sodium-potassium pump restores the resting potential of -70 mV.- The action potential will move down the axon toward the synapse like a wave would move along the surface of the water.

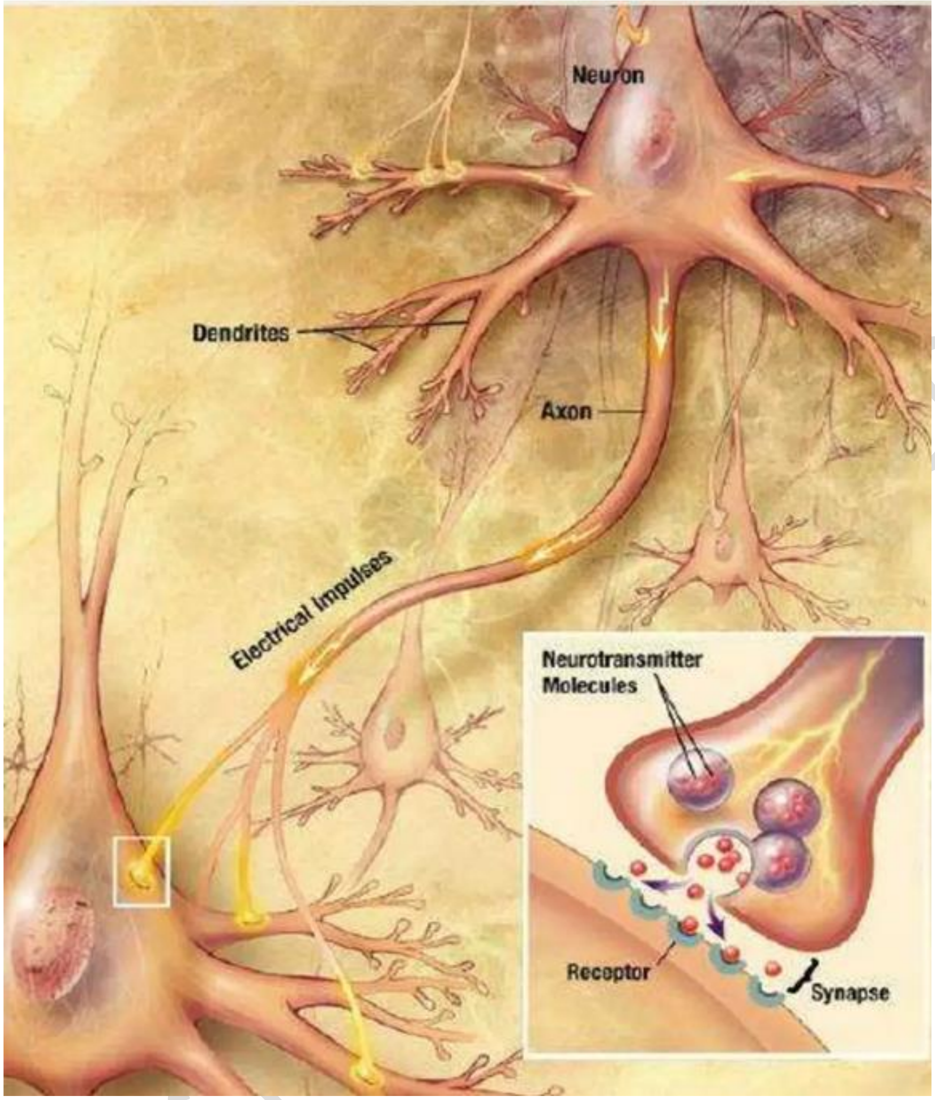
In myelinated neurons, ion flows occur only at the nodes of Ranvier. As a result, the action potential signal "jumps" along the axon membrane from node to node rather than spreading smoothly along the membrane, as they do in axons that do not have a myelin sheath.This is due to a clustering of Na^+ and K^+ ion channels at the Nodes of Ranvier.Unmyelinated axons do not have nodes of Ranvier, and ion channels in these axons are spread over the entire membrane surface.

3. Transmits signals

The action potential travels along the axon toward the axon terminals near other neurons or muscle cells. At the axon terminals, the electrical signal triggers the release of neurotransmitters, chemical compounds that carry the signal across the synaptic gap to the next cell.

TRANSMITTING NERVE IMPULSES

The place where an axon terminal meets another cell is called a synapse. This is where the transmission of a nerve impulse to another cell occurs. The cell that sends the nerve impulse is called the presynaptic cell, and the cell that receives the nerve impulse is called the postsynaptic cell. Some synapses are purely electrical and make direct electrical connections between neurons. However, most synapses are chemical synapses. Transmission of nerve impulses across chemical synapses is more complex. At a chemical synapse, both the presynaptic and postsynaptic areas of the cells are full of the molecular machinery that is involved in the transmission of nerve impulses. As shown in the diagram below, the presynaptic area contains many tiny spherical vessels called synaptic vesicles that are packed with chemicals called neurotransmitters. When an action potential reaches the axon terminal of the presynaptic cell, it opens channels that allow calcium to enter the terminal.



Calcium causes synaptic vesicles to fuse with the membrane, releasing their contents into the narrow space between the presynaptic and postsynaptic membranes. This area is called the synaptic cleft. The neurotransmitter molecules travel across the synaptic cleft and bind to receptors, which are proteins that are embedded in the membrane of the postsynaptic cell.

In 1948, Hodgkin [8] reported that some of the neuronal cells fired repetitively in response to a sustained stimulus current when its strength is above a threshold dependent on the cell. They were classified into two, Class I and II (Hodgkin's classification), according to the frequency of their repetitive firing (see Figure 2).

Table 1. Ionic concentration in the intracellular and extracellular fluids(mM kgH_2O^{-1}).

	Squid Axon		**Mammalina muscular cell**	
ion	**Intracellular**	**Extracellular**	**Intracellular**	**Extracellular**
K^{+}	400	20	155	4
Na^{+}	50	440	12	145
Cl^{-}	40 ~ 150	560	4	120
A^{-}†	385		155	