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BIOLOGY 12
NERVE IMPULSE

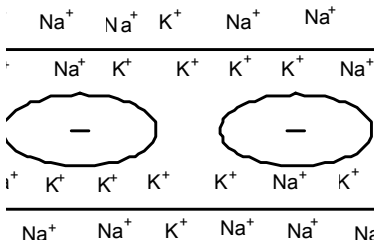
A **nerve impulse** **IS A WAY A NEURON TRANSMITS INFORMATION USING ELECTROCHEMICAL CHANGES** that moves in one direction along the length of a nerve fiber. It is electrochemical because it involves changes in **VOLTAGE** as well as in the **CONCENTRATIONS** of certain **IONS**. Since it is electric we can use an **oscilloscope** (a type of voltmeter that shows a graph of voltage changes) to measure potential differences (voltages). **Voltage**, often measured in millivolts (mV), is a measure of the electrical potential between two points which are on the inside and outside of an axon.

There are three distinct phases in the generation of a nerve impulse along an axon: **RESTING**, **ACTION** and **RECOVERY** phases.

RESTING PHASE:
The **RESTING POTENTIAL** difference across the membrane of the axon when it is NOT conducting an impulse is **-60mV**.

There are three types of ions that are significant:

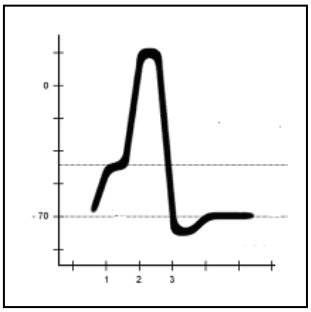
ION	CHARGE	MORE CONCENTRATED
Na	+	outside of axon
K	+	inside of axon
large organic	-	inside of axon



At rest, the membrane of the nerve cell is **NOT** permeable to these ions. The outside of the neuron is slightly more **POSITIVE** than the inside because of the distribution of ions. The **LARGE ORGANIC NEGATIVE** ions cancel the effect of the **POSITIVE POTASSIUM** ions. The uneven distribution of ions is maintained by **ACTIVE** transport across the **Na/K** pump which operates **WHEN EVER THE NEURON IS NOT CONDUCTING AN IMPULSE**.

ACTION PHASE:
if the nerve is stimulated beyond a **THRESHOLD** level by an electric shock, pH change, mechanical simulation then a nerve impulse is generated. A change in potential is seen on the oscilloscope – this nerve impulse is called the **ACTION POTENTIAL**.

Phase	DEPOLARIZATION	REPOLARIZATION
Voltage	-60 TO 40	40 TO -60
Membrane Ion Permeability	Na+	K+
Movement through Axon	OUTSIDE TO INSIDE	INSIDE TO OUTSIDE
Axon Polarity	POSITIVE	NEGATIVE



*-during the **upswing** (-60mV to +40mV) the membrane becomes permeable to Na+ ions*

-Na+ ions move from outside to inside of axon –depolarization occurs (the inside of the axon becomes positive)

*-in the **downswing** (+40mV to -60mV) membrane becomes permeable to K+*

-K+ moves from outside to inside of axon –repolarization (since the inside of the axon becomes negative again)

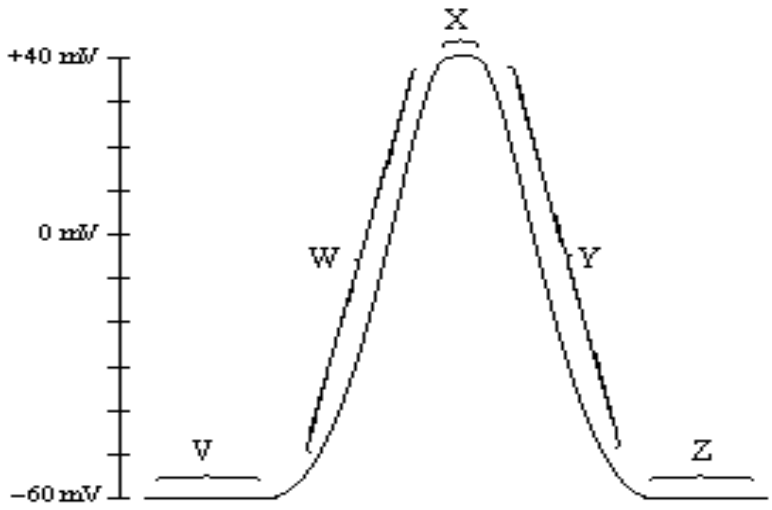
The magnitude of these changes is always the same – this means that as long as the threshold stimulus has been reached, there will be an impulse, and each impulse is equal to each other impulse. This feature is termed "**all-or-none**" (either there will be an impulse that will be like all other impulses, or there will be none). A strong stimulus does not mean a bigger impulse; rather it means a greater number of impulses (more nerves involved or a single nerve conducting a series of impulses).

RECOVERY PHASE:

Between nerve impulse transmissions, **K+** ions are returned to the **INSIDE** of the axon, **Na+** to the **OUTSIDE** by **ACTIVE** transport through the **Na/K** pump in the recovery period. The recovery period is essential to re-establish the resting condition so the neuron can conduct another impulse

SOME THINGS TO NOTE:

The speed of nerve impulses is quite rapid –due to the structure of the nerves. The myelin sheath (formed by tightly packed spirals of the cell membrane of Schwann cells) of most nerve fibers and the nodes of Ranvier help with the speed of the transmission of the nerve (200 m/s) in myelinated fibers – only 0.5 m/s in non-myelinated fibers. The reason is that the nerve impulse "jumps" from node to node in myelinated fibers. In non-myelinated fiber, the nerve impulses must depolarize and repolarize each point along the nerve fiber.



On the above graph, label the **RESTING PHASE** and **RECOVERY PHASE**. Then label where Na+ moves into the axon (**DEPOLARIZATION**). Label the place where Na+ gates close and the K+ gates open. Then label where K+ moves out of the axon (**REPOLARIZATION**). Indicate the place where the [Na+] and [K+] are returned to their original concentrations.

V = resting phase
Z = recovery phase
W=depolarization
Y=repolarization