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L-31 **Electricity within the body**

The Nervous System and the Neuron.

The nervous system can be divided in two parts:
1-Central nervous system consists of the
a-brain b-spinal cord c-nerve fibers (neurons)
transmits sensory information to brain or spinal cord and from brain or spinal cord to appropriate muscles and glands.
2. Autonomic nervous system: Controls various internal organs such as the heart, intestines, and glands.

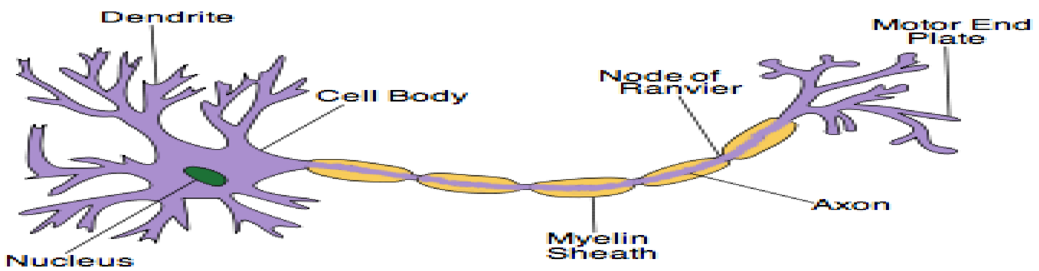
The basic structural unit of the nervous system is a neuron.
A nerve cell specialized for the

a. **Reception.**
b. **Interpretation.**
c. **Transmission of the electrical messages.**

A motor Neuron consists of a cell body that receives electrical messages from other neurons through contacts called synapses located on the dendrites.
The neuron transmits an electrical signal out word along axon Axons are ≈ 1 (m) long.
The axon carries the electrical signal to muscle, gland, or other neurons.
Axon terminals: Transmit electrical messages (information) from the neuron to muscles, glands or other neurons.

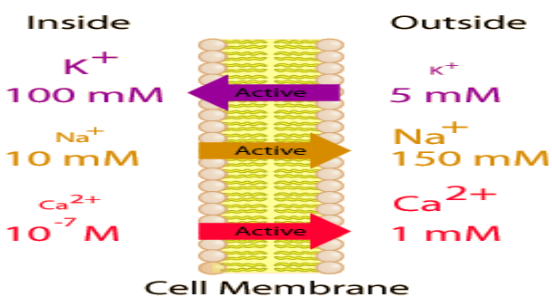
How does the human body generate electricity?

It is because chemical reactions between different atoms and molecules within the body.
The electricity generated inside the body severs for the control and operation of nerves, muscles, and organs.



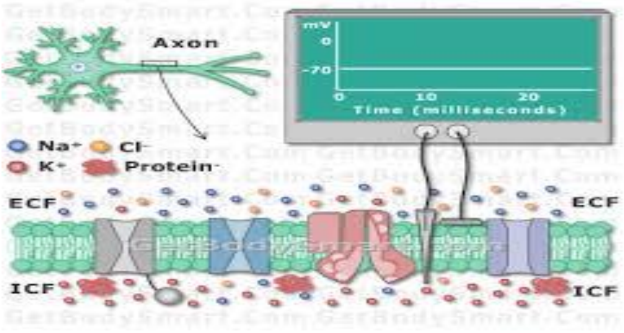
Electrical potentials of nerves

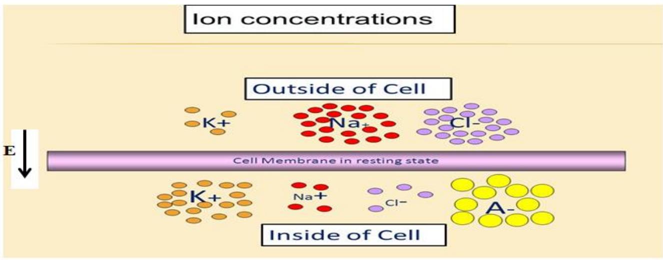
Across the surface or membrane of every neuron is an electrical potential difference (voltage).
This due to the presence of more negative ions on the inside of the membrane than the outside, the neuron said to be polarized.
The inside of the cell is typically 60-90 mv more negative than outside.



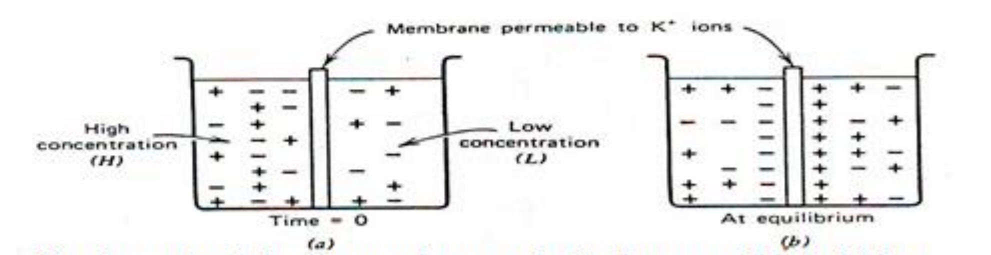
Resting Potential:

The inside of the cell is 60-90 mV more negative than the outside. This potential difference is called the *resting potential* of the neuron. The typical concentrations of various ions inside and outside the membrane of an axon.





Typical concentration in moles/liter of K^+, Na^+, Cl^-, and large protein ions (A^-) Inside and outside a cell. The inside of the cell is more negative than the outside by about 60 to 90 mV . E is electric felid.

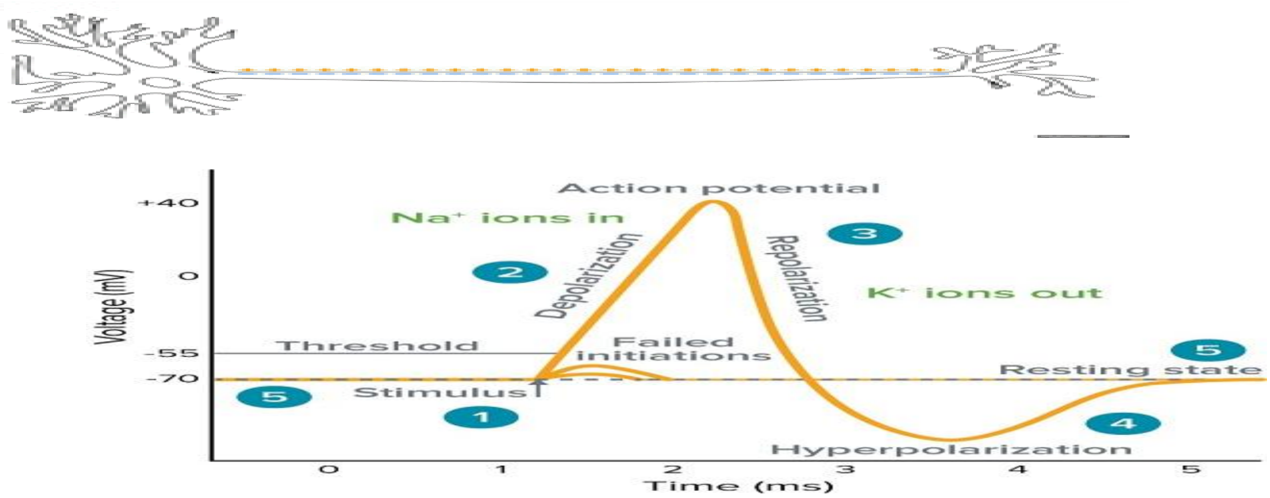


Resting potential a. A membrane selectively permeable to K^+ ions, b.The dipole layer provides an electrical force.

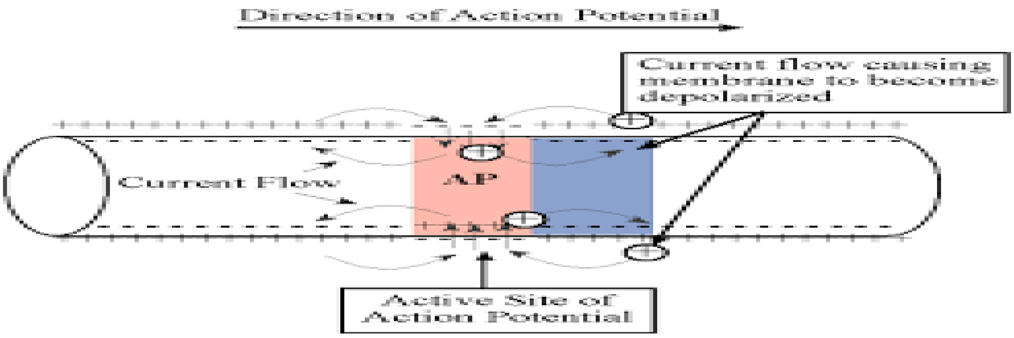
The resting membrane potential of a neuron is about -70 mV (mV=millivolt) - this means that the inside of the neuron is 70 mV less than the outside. At rest, there are relatively more sodium ions outside the neuron and more potassium ions inside that neuron.

Action Potential: **When the neuron is stimulated, a large momentary change in the resting potential occurs at the point of stimulation. This potential change, is called the *action potential.* Propagates along the axon.**

An action potential is a rapid rise and subsequent fall in voltage or membrane potential across a cellular membrane with a characteristic pattern.



An *action potential* is caused by positive ions moving in and then out of the neuron at a certain spot on the neuron membrane.
An action potential is initiated by a stimulus above a certain intensity or *threshold*. Not all stimuli initiate an action potential.
Sufficient current is required to initiate a voltage response in a cell membrane; if the current is insufficient to depolarize the membrane to the threshold level, an action potential will not fire. Examples of cells that signal via action potentials are neurons and muscle cells.
The action potential is the major method of transmission of signals within the body. The stimulation may be caused by various physical and chemical stimuli such as heat, light, sound, and others.



Depolarization

Certain external stimuli reduce the charge across the plasma membrane by facilitated diffusion of sodium into the cell reduces the resting potential at that spot on the cell .
If the potential is reduced to the threshold voltage (about -50 mv in mammalian neurons), an action potential is generated in the cell.
A stimulus causes a gate in the *Na+ Channel* to open. Since there is a high concentration of Na+ outside, Na+ diffuses into the neuron until the electrical potential changes to ~ +30 mV.
Repolarization
Depolarization causes the *K+ Channel* gate to immediately open. K+ diffuses out of the neuron. This reestablishes the initial electrical potential of ~-70 mV.
Refractory Period
During this time (~ 1 msec), the Na+ and K+ Channels cannot be opened by a stimulus.
The *Na+/K+ Pump* actively pumps Na+ out of the neuron and K+ into the neuron. This reestablishes the initial ion distribution of the resting neuron.
This single action potential acts as a stimulus to neighboring proteins and initiates an action potential in another part of the neuron. The wave of action potentials travel from the dendrites all the way to the axon terminals. At the axon terminal, the electrical impulse is converted to a chemical signal.

The factors affect the speed of propagation of action potential

The decrease in either will increase the propagation velocity

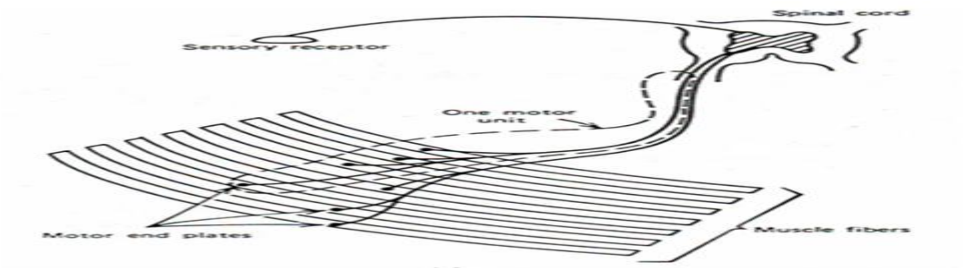
1. **The resistance within the core of the membrane. The internal resistance of an axon decreases as the diameter increases (large diameter → higher velocity).**
2. **The capacitance across the membrane (charge stored), the greater the stored charge on a membrane → the longer it takes to depolarize it , and thus the slower the propagation speed**

ELECTROMYOGRAM (EMG)

Electrical Signals From Muscles –Electromyography (EMG)

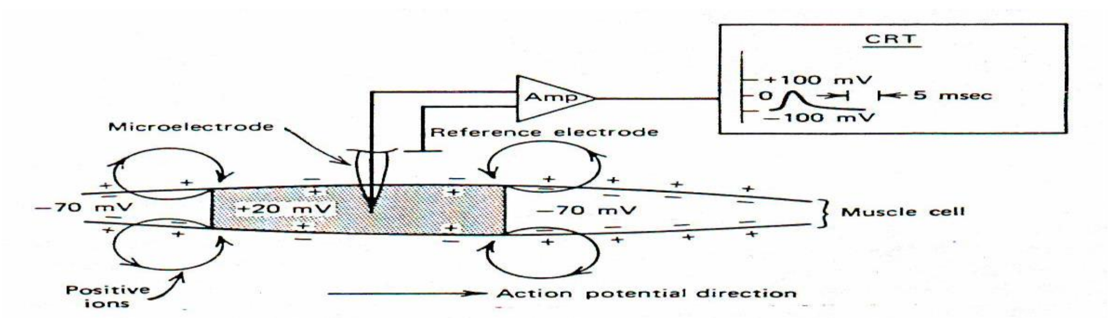
Is an electro diagnostic medicine technique for evaluating and recording the electrical activity produced by skeletal muscles
EMG is performed using an instrument called an electromyography, to produce a record called an electromyogram
An electromyography detects the electrical potential generated by muscle cells when these cells are electrically or neurologically activated.
The signals can be analyzed to detect medical abnormalities, activation level, or recruitment order, or to analyze the biomechanics of human or animal movement.

A muscle is made up of many motor units .A motor units consist of a single branching neuron from the brain stem or spinal cord and the 25 to 2000 muscle fibers (cells) it connects to via motor end plates.

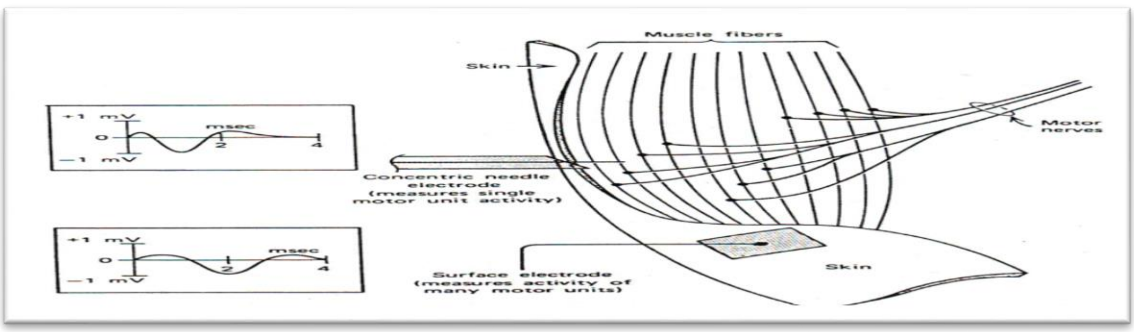


Schematic of a neuron originating at the spinal cord and terminating of several muscle cells. The neuron and connecting muscle cells make up a motor unit(dashed line)

Muscle action is initiated by an action potential that travels along an axon and is transmitted across the motor end plates into the muscle fibers, causing them to contract.



EMG electrodes usually record the electrical activity from several fibers. Either a surface electrode or a concentric needle electrode inserted under the skin is used .



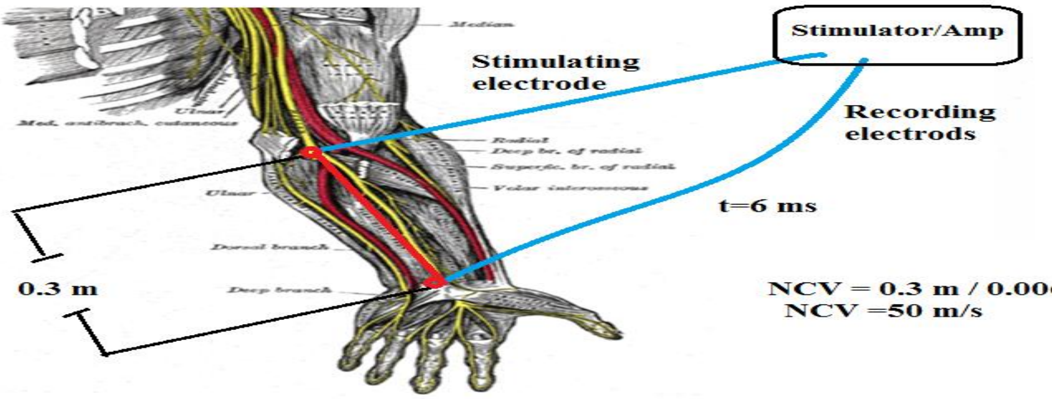
Nerve Conduction Velocity Calculation

It is the speed at which an electrochemical impulse propagates down a neural pathway. Conduction velocities are affected by a wide array of factors, including: age, sex, and various medical conditions.

Nerve conduction studies are performed as follows:

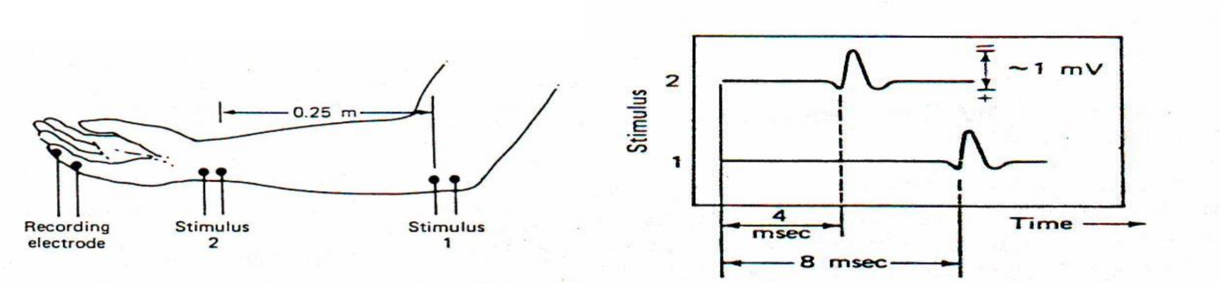
1. **Two electrodes are attached to the subject's skin over the nerve being tested.**

2. **Electrical impulses are sent through one electrode to stimulate the nerve.**
3. **The second electrode records the impulse sent through the nerve as a result of stimulation.**
4. **The time difference between stimulation from the first electrode and pick-up by the downstream electrode is known as the latency. Nerve conduction latencies are typically on the order of milliseconds.**



Method of measuring the motor nerve conduction velocity

- **The latency period for the response to stimulus 1 is 4 msec longer than that for the response to stimulus 2 :** $\Delta t = 4 \times 10^{-3}\ sec$
- **The difference in distance Δx is 0.25 m**
- **The nerve conduction velocity V = $\Delta x / \Delta t$ =0.25m / $4 \times 10^{-3}\ sec$ =62.5 m/sec**



The sensory nerve conduction velocity can be determined by stimulating at one location and recording the responses with electrodes placed at known distances.
The response traveled the 0.25 m from 1 to 2 in 4.3 msec :
The conduction velocity is 0.25/4.3 $\times 10^{-3}$ sec = 58 m/sec
The conduction velocity from 2 to 3 is 0.20 m/4 $\times 10^{-3}$sec =50 m/sec