Al-Mustaqbal University

College of Science

Medical physics Department

Medical Physics II

Second Semester

3rd stage

Lesson 6

Electricity within the body

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The Nervous System

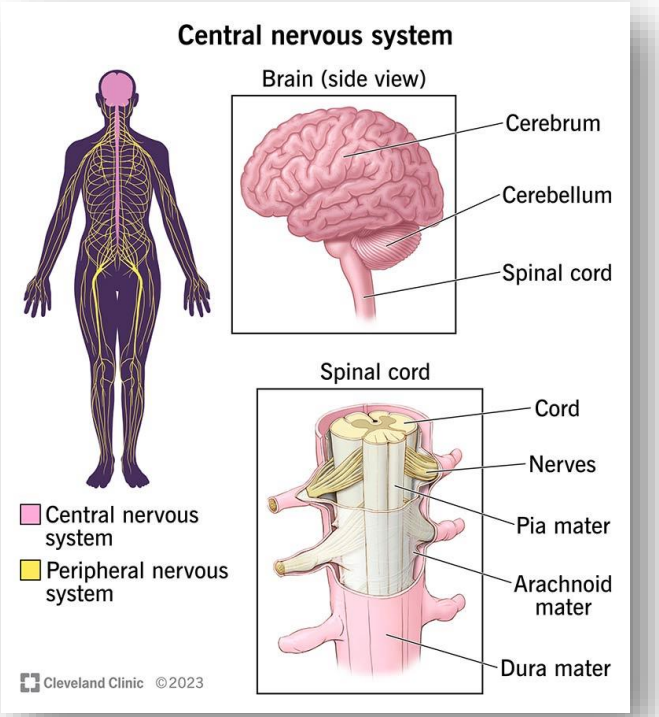
The **nervous system** can be divided into two parts: **The central nervous system** and **the peripheral nerves (neurons)**.

Central nervous system consists of; ***(1) The brain, (2) the spinal cord***

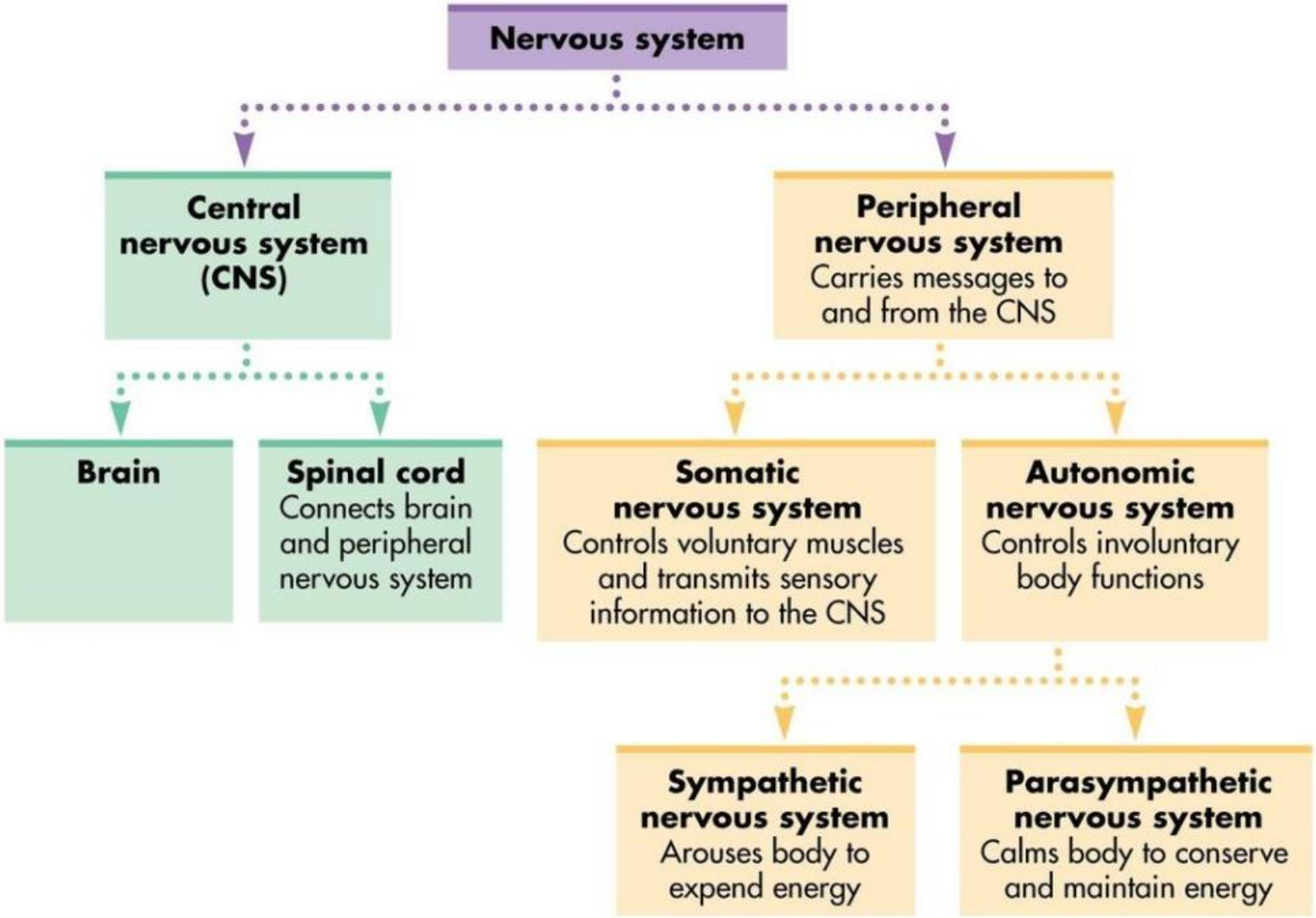
The peripheral nerves (Neurons) could be divided into; **Somatic system and Autonomic system.**

Neurons that transmit sensory information to the brain or spinal cord is the *afferent nerves*, while neurons that transmit information from brain or spinal cord to muscles and glands is the *efferent nerves*.

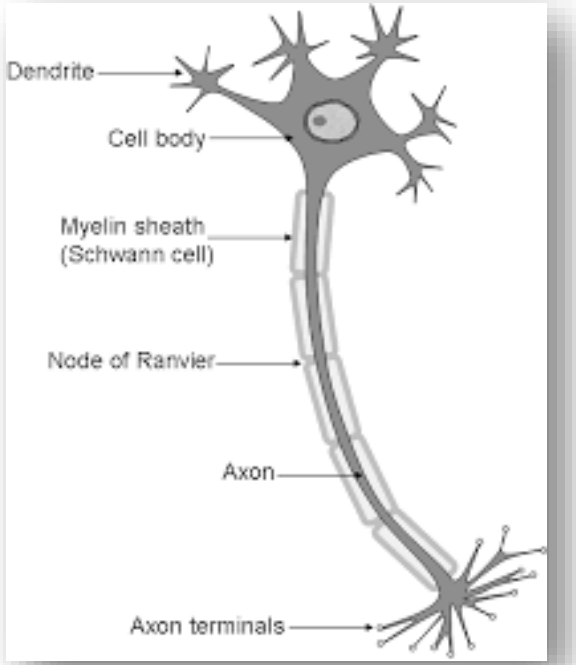
Autonomic nerves system controls various internal organs such as the heart, intestines, and glands.



The brain is complicated, it's the body's most important organ and is given special protection. It is surrounded by three membranes within the protective skull. The brain floats in a shock absorbing fluid called cerebrospinal fluid (CSF). The actual weight of brain is ~ 1500 g and because it's floating in the CSF fluid, its effective weight is ~ 50 g. The brain is connected to the spinal cord, which is also surrounded by CSF and is protected by the bone of the spinal column.


Nervous system
Central nervous system (CNS)
Peripheral nervous system
Carries messages to and from the CNS
Brain
Spinal cord
Connects brain and peripheral nervous system
Somatic nervous system
Controls voluntary muscles and transmits sensory information to the CNS
Autonomic nervous system
Controls involuntary body functions
Sympathetic nervous system
Arouses body to expend energy
Parasympathetic nervous system
Calms body to conserve and maintain energy

Neuron



The basic structure unit of nervous system. Neurons are responsible for receiving and transmitting information as electrical signals. Each part of the neuron plays a role in communicating information throughout the body. It is specialized for the reception, interpretation, and transmission of electrical messages.

A neuron consists of;

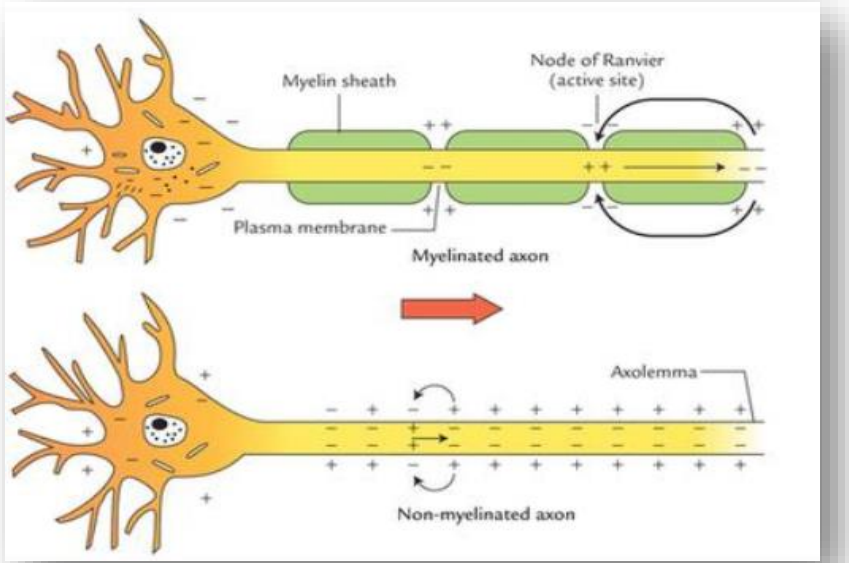
The cell body that receives electrical messages from other neurons through contacts called ***synapses*** located on the ***dendrites*** or on the cell body.

The dendrites are the parts of neuron specialized for receiving information from ***stimuli*** or from other cells. If the ***stimulus*** is strong enough, the neuron transmits an electrical signal outward along a fiber called an ***axon***.

The axon or nerve fiber, which may be as long as 1 m, carries the electrical signal to muscles, glands, or other neurons.

Axon

Examination of the axons of various neurons with an electron microscope indicates that there are two different types of nerve fibers:



- **Myelinated nerves:** The membranes of some axons are covered with a fatty insulating layer called myelin that has small uninsulated gaps called *Nodes of Ranvier* every few millimeters.
- **Unmyelinated nerves:** The axons of other nerves have no myelin sleeve (sheath).

The myelin sleeve is a very good insulator, the action potential decreases in amplitude as it travels through the myelinated segment just as an electrical signal is attenuated when it passes through a length of cable. The reduced signal then acts like a stimulus at the next node of Ranvier (gap) to restore the action potential to its original size and shape. This process repeats along the axon; the action potential seems to jump from one node to the next, that is, it travels by saltatory conduction.

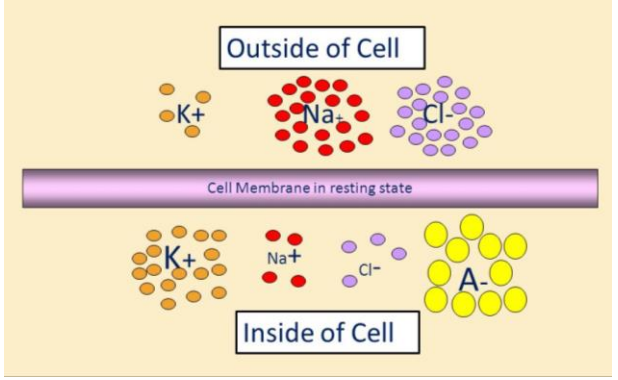
Electrical Potential of Nerves

When the neuron is stimulated, a large momentary change in the resting potential occurs at the point of stimulation. This potential change, called the action potential, propagates along the axon. 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, cold, light, sound, and odors.

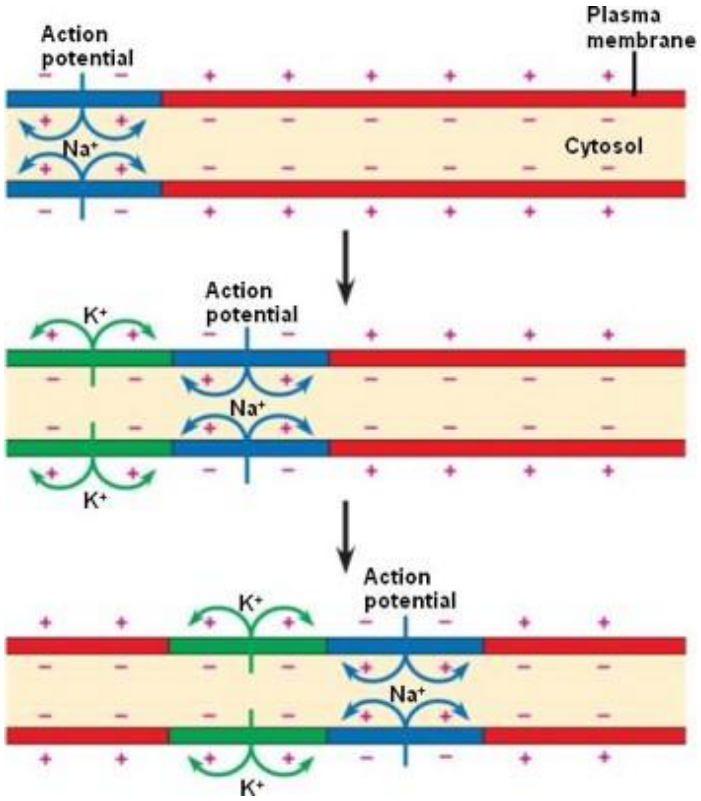
A single nerve consists of a cylindrical semi-permeable membrane (axon). The origin of almost every electrical potential which arises within the body is a semi-permeable membrane. A cross the surface or membrane of each neuron is an electrical potential (voltage) difference due to the presence of more "negative ions" on the inside of the membrane than the outside, the neuron said to be polarized (resting potential). The membrane potential difference is about 70 mV, with the outside being regarded as being at 0 and the inside being at - 70 mV.

Why this potential difference exists?

The resting potential of a nerve exists because the membrane is impermeable to large protein A^- ion and permeable for K^+, Na^+ and Cl^- ions.

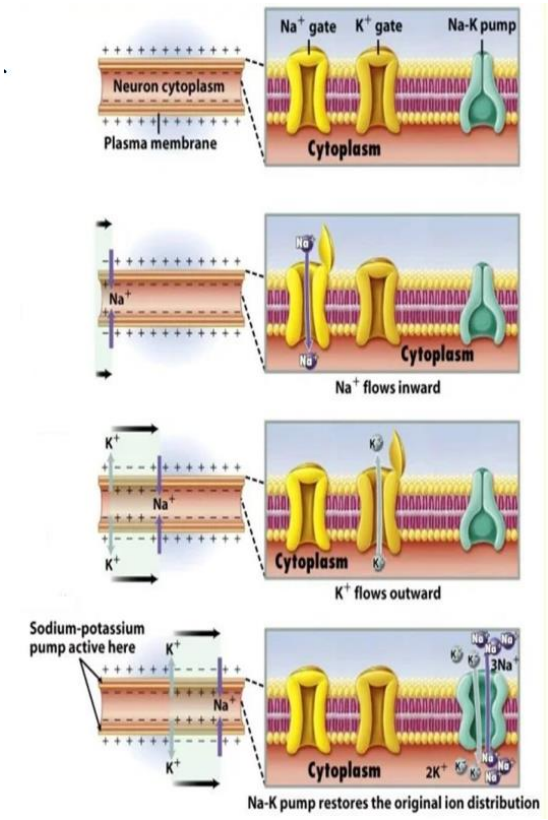


If the left end of the axon is stimulated, the membrane walls become porous to Na ions and these ions pass through the membrane, causing it to *depolarize*. The inside goes positive. The reversed potential in the stimulated region causes ion movement which in turn *depolarizes* the region to the right. Meanwhile the point of original stimulation has recovered (*repolarized*) because K ions have moved out to restore the resting potential.



Stages of Action Potential

1. **Resting:** cell at rest, resting potential equal to (-70 mV). Lots of Na^+ outside, lots of K^+ inside.
2. **Depolarization:** Na^+ channels open, positive Na^+ rushes inside, membrane potential increases. Lots of Na^+ inside, lots of K^+ inside membrane, potential = +30 mV.
3. **Repolarization:** K^+ channels open, Na^+ channels close, positive K^+ rushes outside, membrane potential drops back down. Lots of Na^+ inside, lots of K^+ outside (opposite of the resting state).
4. **Polarization (Resting):** return to the resting potential.



Factors Affecting the Propagation Speed of Action Potential

Two primary factors affect the speed of propagation of the action potential: ***The resistance*** within the core of the membrane. The internal resistance of an axon decreases as the diameter increases, so an axon with a large diameter will have a higher velocity of propagation than an axon with a small diameter. ***The capacitance*** (or the charge stored) across the membrane. The greater the stored charge (the capacitance) the longer it takes to depolarize it and thus the slower the propagation speed.

Exercises

1 Nervous system consists of ; brain, spinal cord, and ----------

(a) Myelin (b) Dendrites (c) Neurons (d) Action Potential (e) None of them

2 The actual weight of brain is ~ 1500 g and the effective weight is ~ 50 g. This is because the existence of ----------

(a) Cerebrospinal fluid (b) Skull (c) Nerves system (d) Axon (e) None of them

3 The cell body receives electrical messages from other neurons through contacts called ---------located on the dendrites.

(a) Neurons (b) Synapses (c) Stereo Celia (d) Cochlea (e) Brain

4 The resting potential of a nerve exists because the membrane is impermeable to -------- ion and permeable for other ions

(a) K^+ (b) Na^+ (c) Cl^- (d) A^- (e) None of them

5 Two primary factors affect the speed of propagation of the action potential:

(a) Resistance and Capacitance (b) Action potential and Stimuli (c) Temperature and Pressure

(d) Brain and Neuron (e) Ions and signals