BASIC CONCEPTS OF ELECTROTHERAPY

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lecture 1

Review of medical physiology

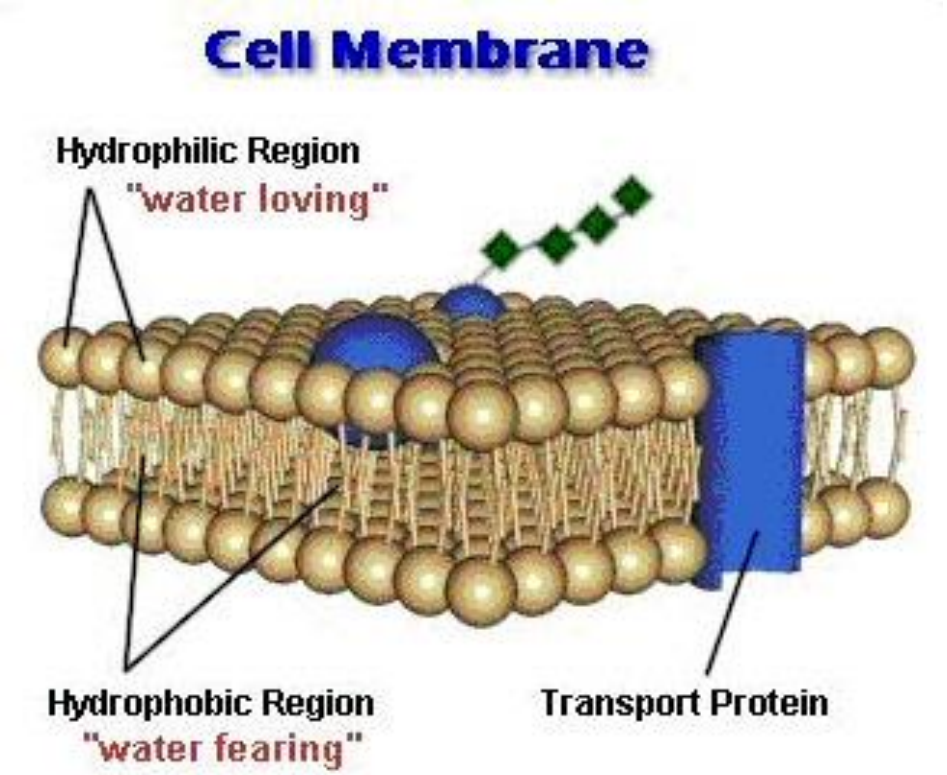
- The body is an organized system consisting of cells which are bathed in fluid. In the average young adult males,
- 18% of body weight is protein and related substances,
- 7% is material and
- 15% is fat.
- The remaining 60% is water, about a third of the total body water is extra cellular and two- thirds are intracellular fluid.

Review of medical physiology

- The electrical properties of the body tissues depends on the numerous ions (which are electric-diplode) dissolved in the water.

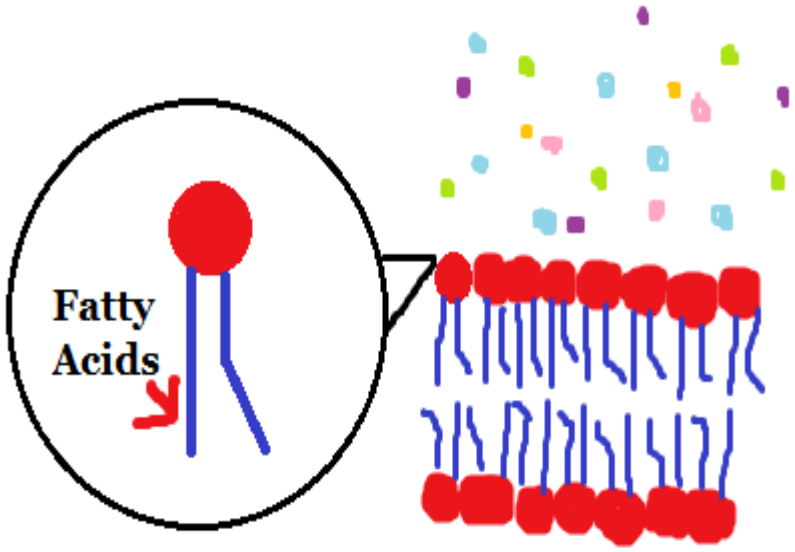
The Structure of The Cell Membrane

- The cell membrane is a very thin and elastic structure which envelopes the cell completely. The cell membrane is composed mainly of proteins (55%), lipids (phospholipids 25%, cholesterol 13%, and other lipids 4%) and carbohydrates (3%).



The Structure of The Cell Membrane

- The cell membrane consists of a double layer of lipids (phospholipids and cholesterol), they arranged so that the both layers of lipid molecules face inward and are thus not in contact with the intra and extra cellular fluid.



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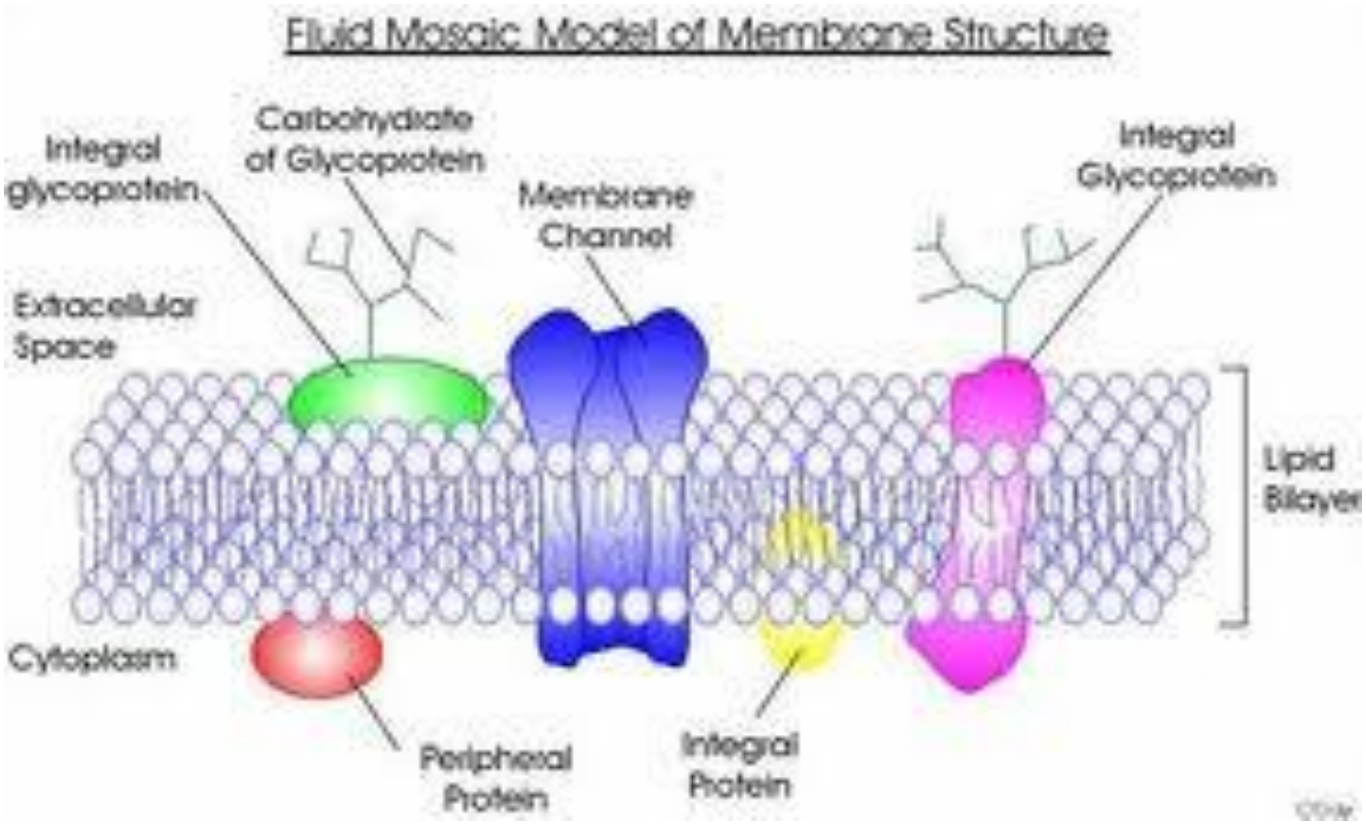
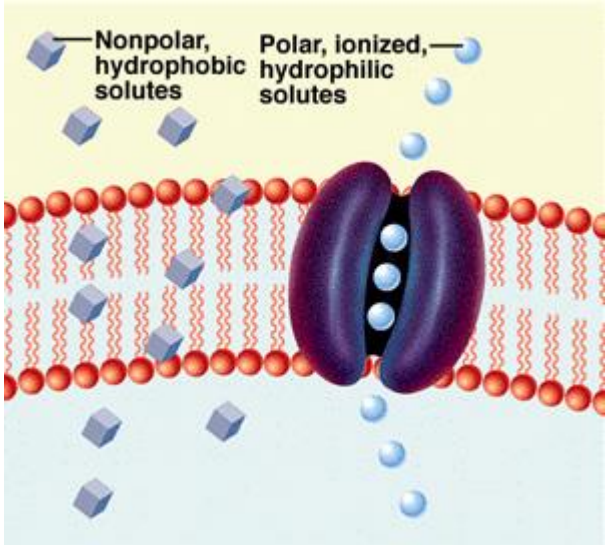
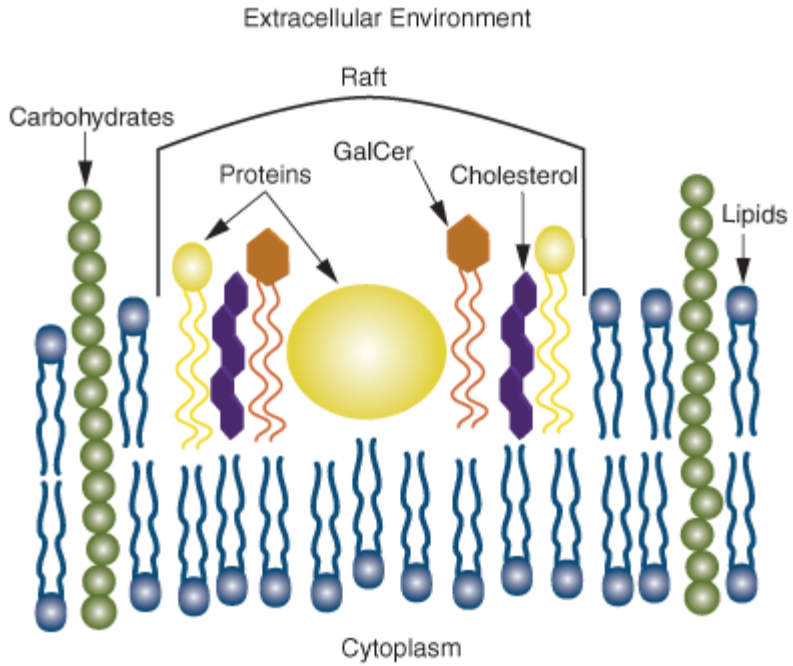


The structure of the cell membrane

- Some of the globular proteins are arranged to allow water molecules and some solutes to pass passively through the membrane either by diffusion or by carrier-mediated. Other solutes may be moved across the membrane by active transport using energy (ATP) to move the substances against their concentration gradient.





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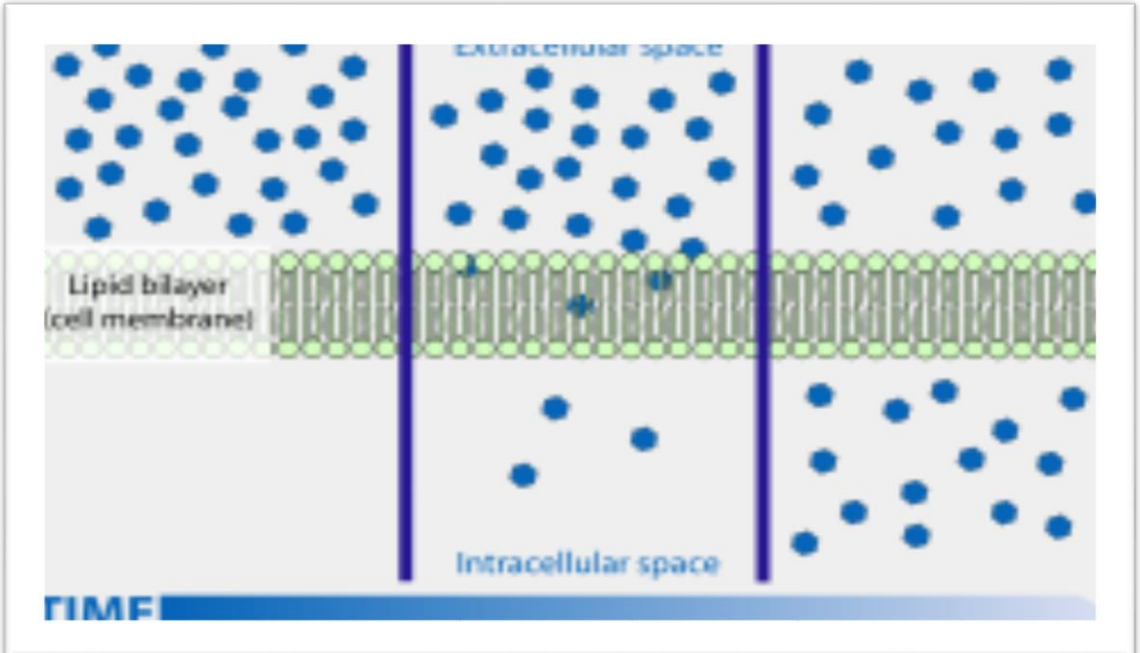
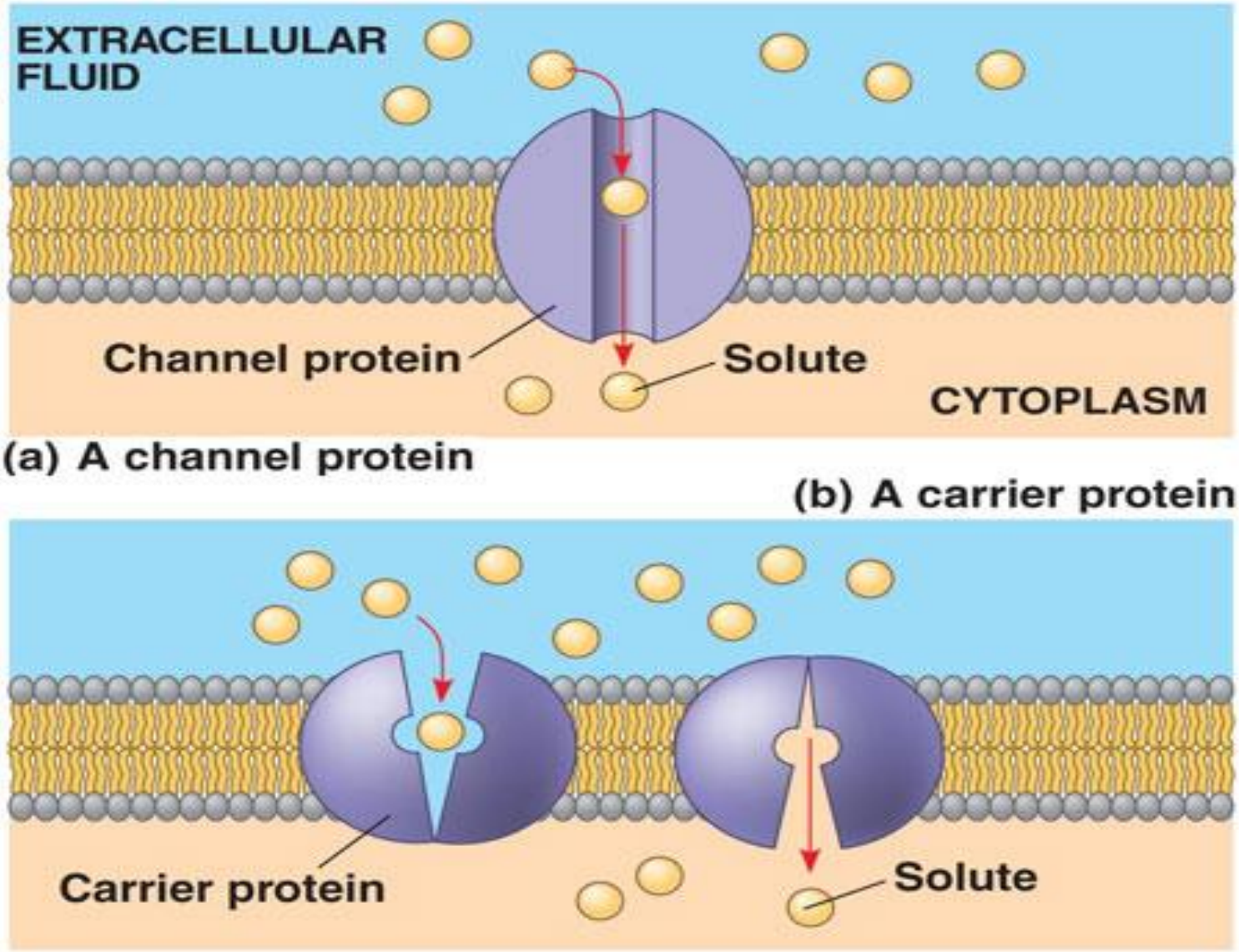
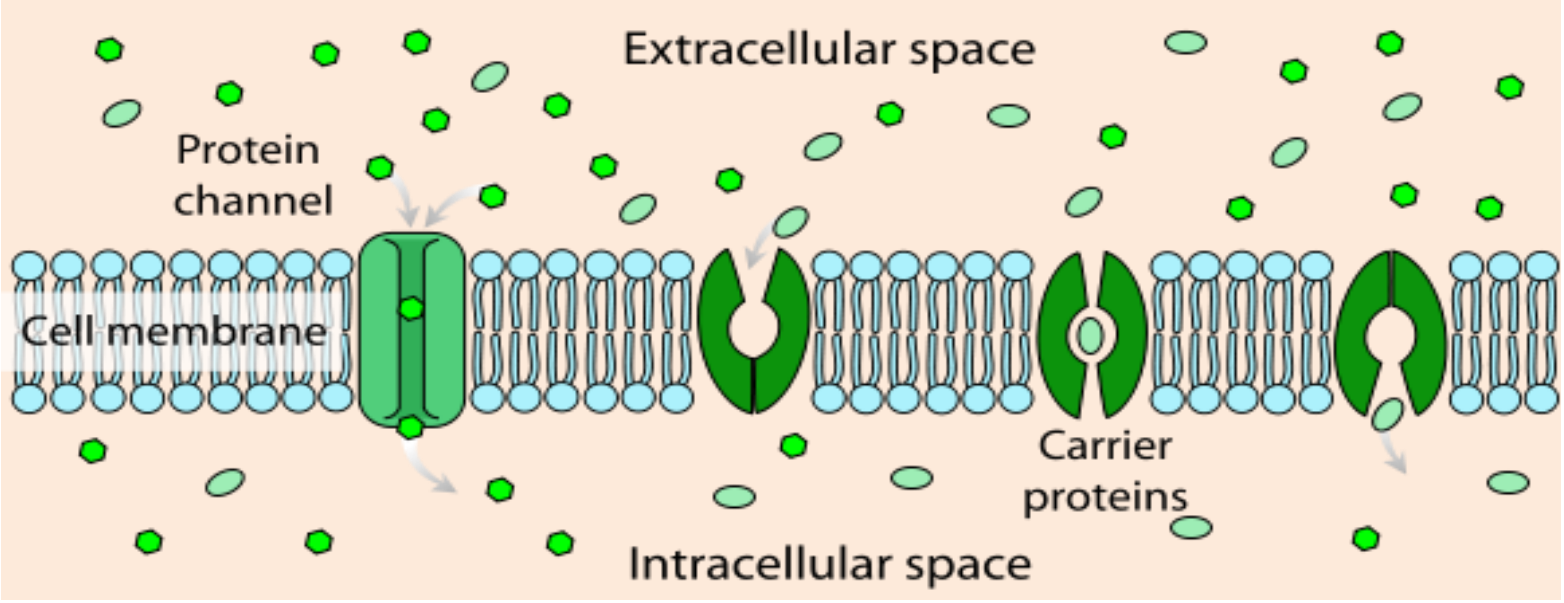
Simple Diffusion is the net movement of material from an area of high concentration to an area with lower concentration. The difference of concentration between the two areas is often termed as the *concentration gradient*, and diffusion will continue until this gradient has been eliminated



. Since diffusion moves materials from an area of higher concentration to the lower, it is described as moving solutes "down the concentration gradient" (compared with active transport, which often moves material from area of low concentration to area of higher concentration, and therefore referred to as moving the material "against the concentration gradient").


EXTRACELLULAR FLUID
Channel protein
Solute
CYTOPLASM
(a) A channel protein
(b) A carrier protein
Carrier protein
Solute

- separates the extracellular fluid which lies outside the cell and the intracellular fluid inside the cell. The extracellular fluid contains large quantities of sodium Na+ but only small amount of potassium K+. The intracellular fluid contains large quantities of K+ but only small amount of sodium Na+.



- The cell membrane allows the passage of both ions to some extent but has an active transport mechanism that brings K+ into the cell and expels Na+. This sodium-potassium (Na+-K+) pumps uses adenosine triphosphate **(ATP)** to move these ions against their passive gradients. There is continuous pumping of three sodium ions (Na+) to the outside for each two potassium ions (K+) pumped to the inside of the membrane causing loss of positive charges from the inside of the membrane

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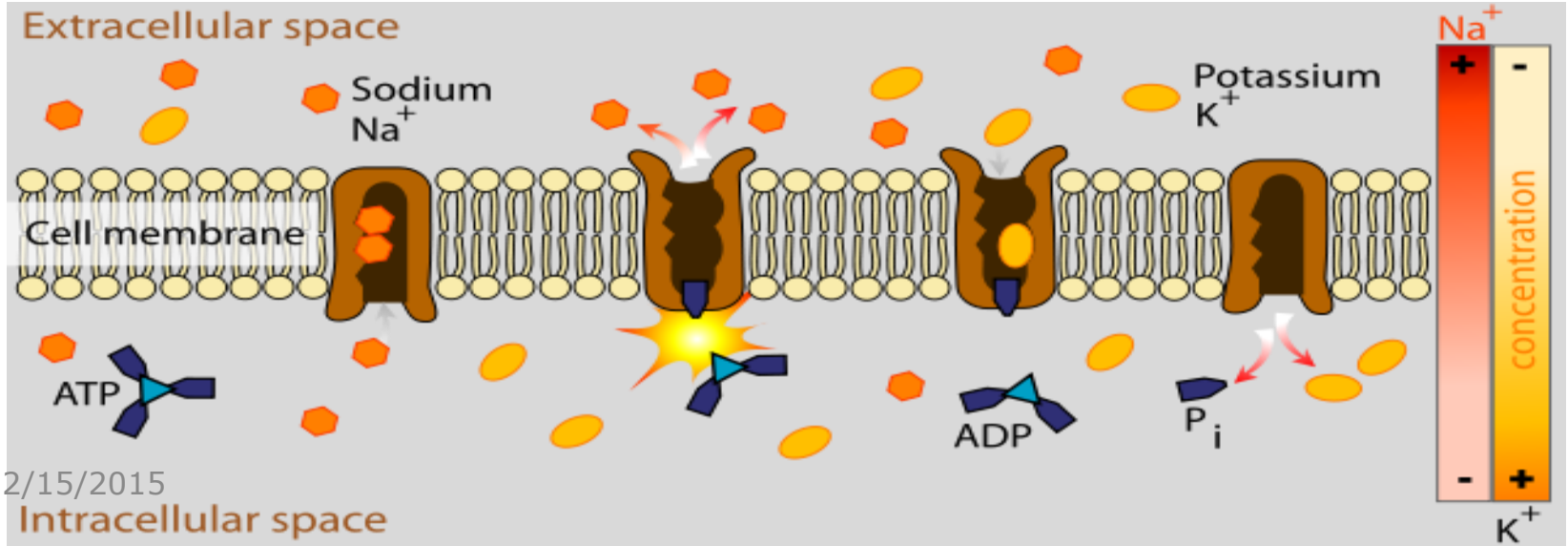
Resting membrane potential

- Resting membrane potential **(RMP)** is the difference of potential across a normal cell membrane at rest in which the inside of the cell is relatively negative to the outside. Due to the selective membrane permeability and the mechanism Na+-K+ pumping action, the distribution of the charged particles across the membrane is not uniform.



Resting membrane potential

- The resting membrane potential varies in the cells of different tissues **(between -60 to -90mV).** In the nerve and smooth muscle fibers it is usually **-70mV**, for skeletal muscle fibers **-80mV** and for glial cells -**90mV**

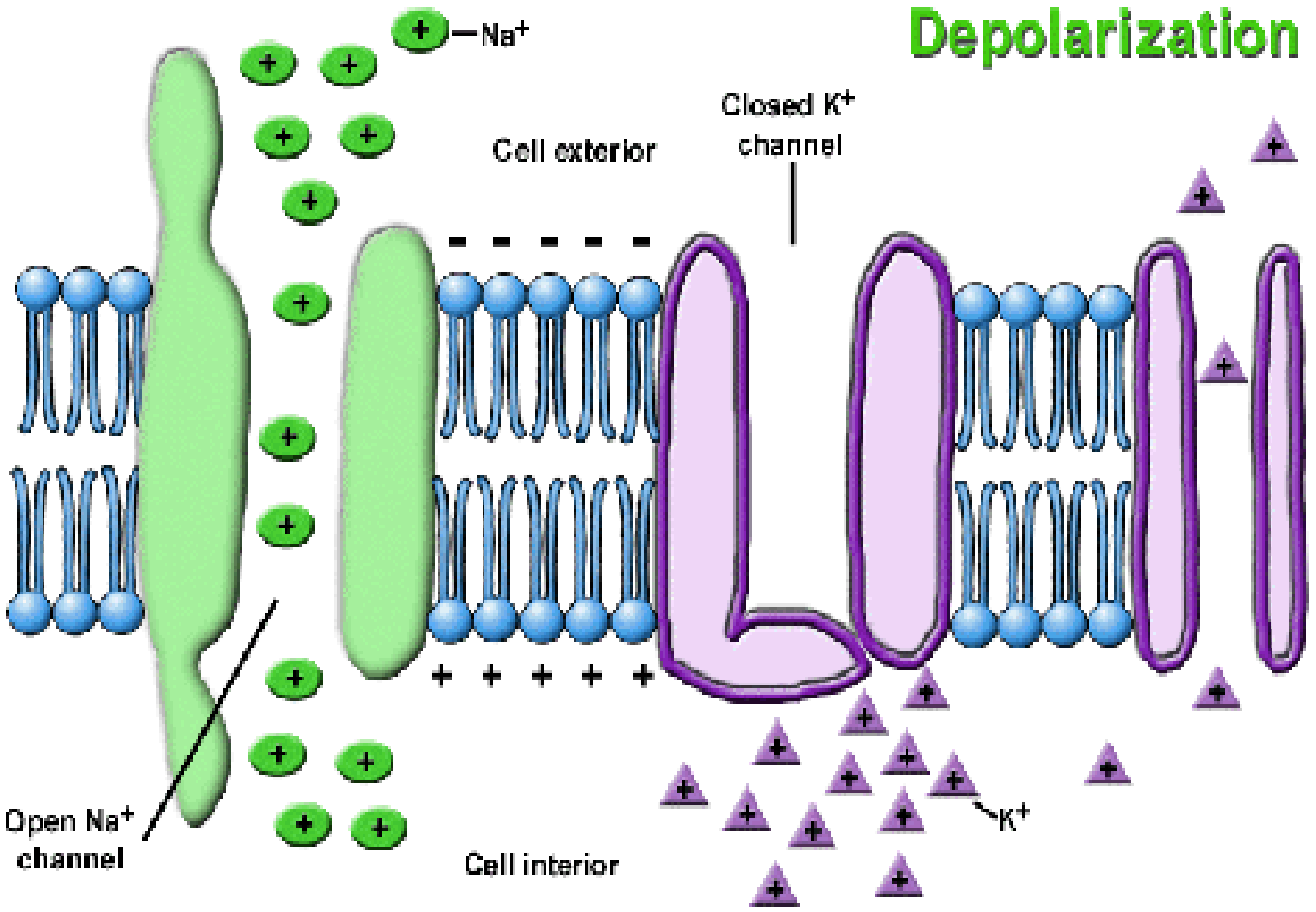
The nerve action potential (nerve impulse)

- The nerve action potential or nerve impulse is a very brief wave of electrochemical activity taking about **1ms** which passes along the nerve fiber using energy already stored as a part of the membrane potential.

The nerve action potential (nerve impulse)

- The action potential is the reversal of the membrane potential from -70mV to +30mV.
- Before the action potential occurs the membrane is said to be "polarized" because of the very large negative membrane potential. When an impulse (mechanical, electrical, etc) with enough strength is initiated, the membrane suddenly becomes very permeable to sodium ions, allowing tremendous of sodium ions to flow to the interior of the membrane. This is called depolarization

The nerve action potential



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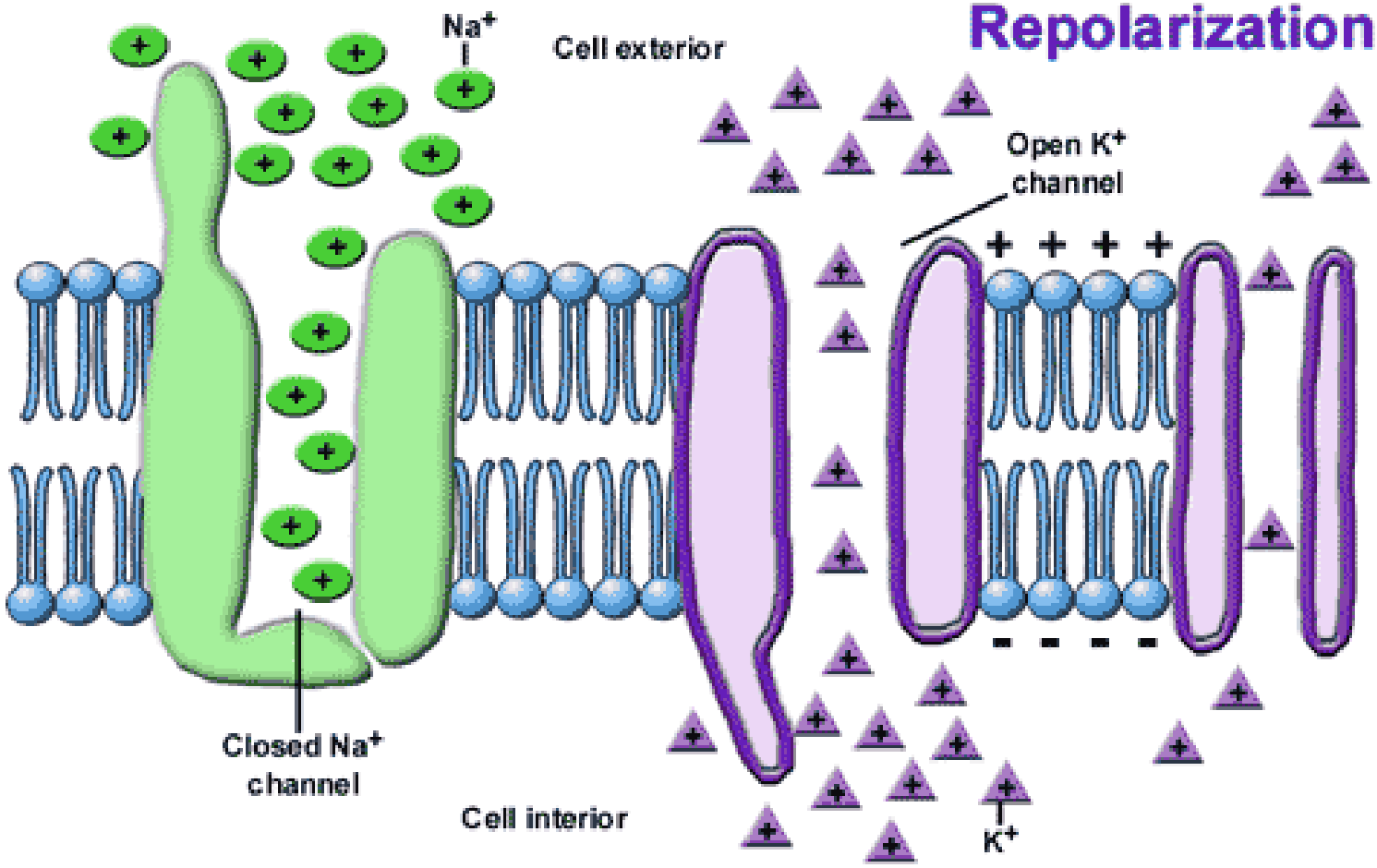

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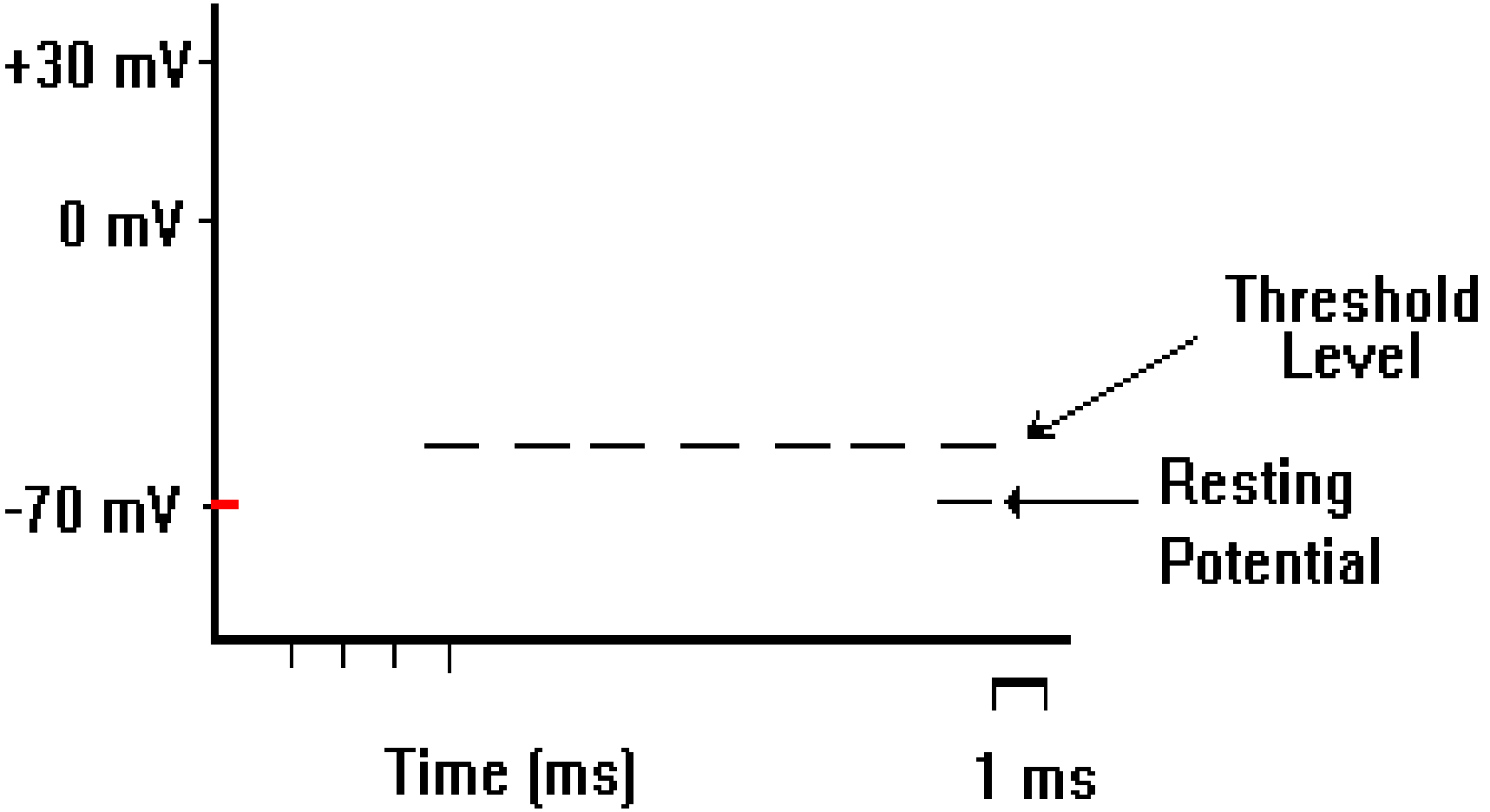
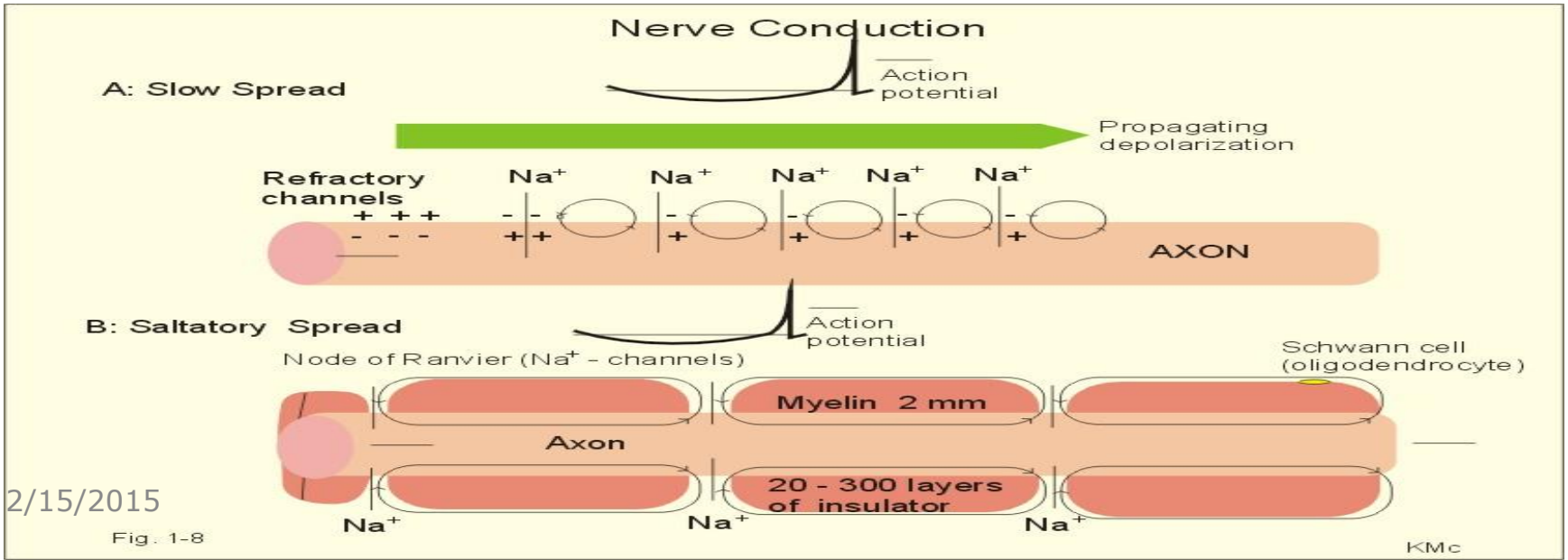


Propagation of action potential

- The speed of propagation of action potential (nerve impulse) along the nerve fiber varies in different nerves and depends on the diameter of nerve fiber (the larger the diameter, the higher the speed of propagation due to its lower electrical resistance).

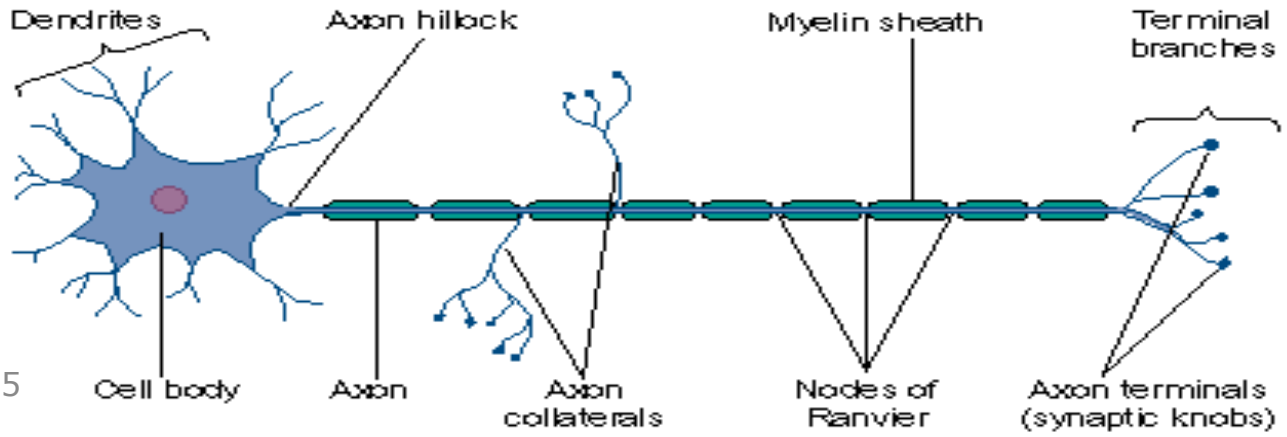
Propagation of action potential

- Also the myelinated nerve fiber is faster than non myelinated nerve due to presence of nodes of Ranvier which allow the action potential to skipping from node to node with less energy used



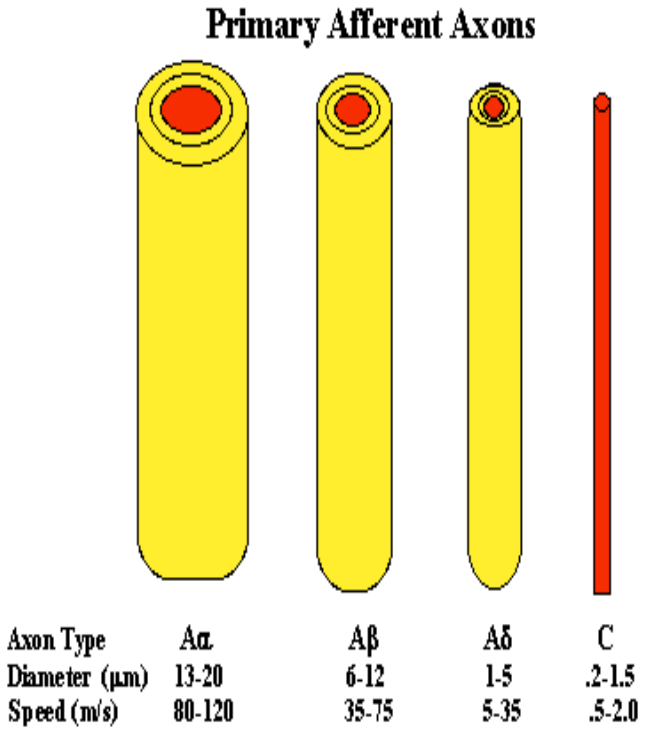
Types of nerve fibers

- Peripheral nerves are composed of many fibers-nerve cell processes- both sensory (afferent) and motor (efferent). The motor fibers start from the cell in the anterior horn of the spinal cord (called anterior horn cell). The cell bodies of the sensory nerves are found in the dorsal root ganglia.



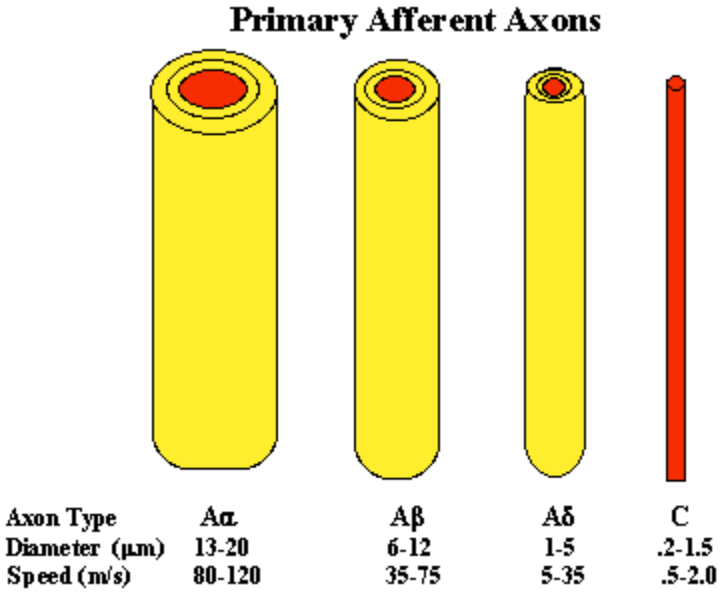
Types of nerve fibers

- There are three groups of nerve fibers:
- 1. Group A nerve fibers; they are thick myelinated nerve, somatic nerves which have diameter of 2 to 20 μ and subdivided into ∂, ß, y,δ type. This group has high conduction velocity from about 10 to 100 meter/sec.



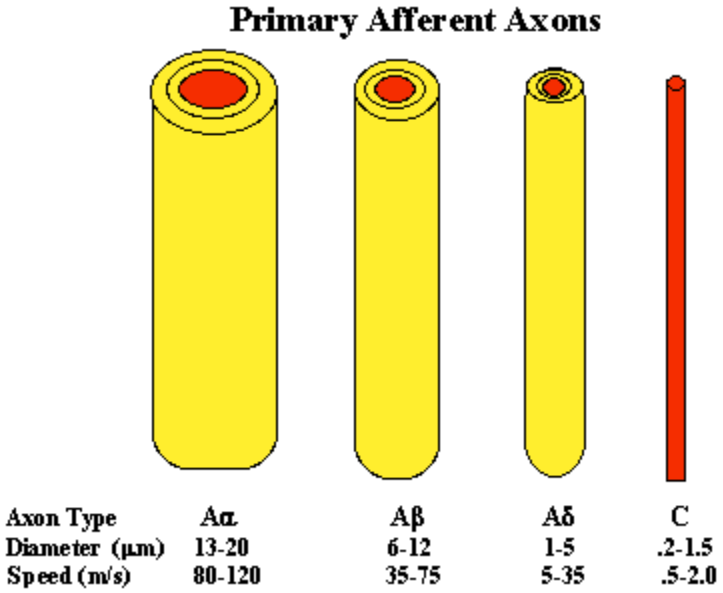
Types of nerve fibers

- 2. Group B nerve fiber; they are thin myelinated nerve fiber (pre-ganglionic nerve fiber). They have a diameter of 1-5 μ and moderate conduction velocity from 5-15 meter/sec.



Types of nerve fibers

- 3. Group C nerve fiber; they are un-myelinated nerve fibers (post ganglionic fibers) have a diameter less than 1 μ and characterized by slow conduction from 0.5 to 2 meters

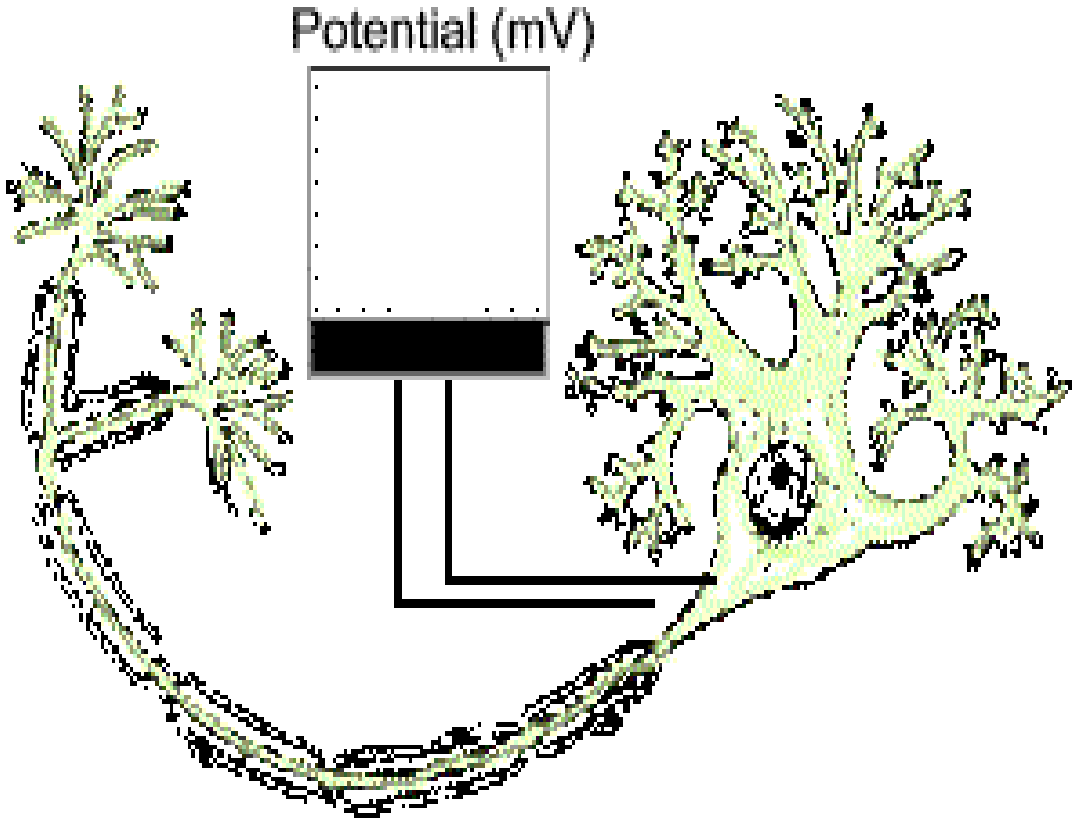


Effect of electrical stimulation on nerve fibers

- The application of electrical stimulation through two external electrodes can modify the behavior of an excitable membrane. Under the negative electrode (cathode) the membrane will be in depolarization and under positive electrode (anode) the membrane will be hyperpolarization.

Effect of electrical stimulation on nerve fibers

- If the stimulus reached to the threshold (effective) it will produce nerve impulse (action potential). The strength (amplitude) of stimulus to produce nerve impulse varies according to the membrane type (myelinated or un-myelinated) because of the high resistance of such fibers to current flow.



Effect of electrical stimulation on nerve fibers

- In addition if the nerve fiber is stimulated continuously by the cathode electrode, a state of continuous depolarization will be produce unless the stimulus strength (amplitude) is increased (known as accommodation or depolarization block). If the strength (amplitude) of the electric current is very weak (subthreshold), the action potential will not take place.

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Effect of electrical stimulation on nerve fibers

- There is a direct relationship between the amount of time the current applied to the membrane and the capacitance and resistance of the membrane. The time will be longer for excitable membrane of large capacitance such as skeletal muscle fibers (about 35msec), and much shorter for nerve cell membrane of small capacitance (1msec).

The action potential of muscle cells

- The muscle fibers like the nerve, when they stimulate produce an electrical disturbance and then contract. Skeletal muscle give action potential when they contract and this action potential can be picked up, amplified by an electromyography. The action potential recorded from one motor unit or more.

Refractory periods

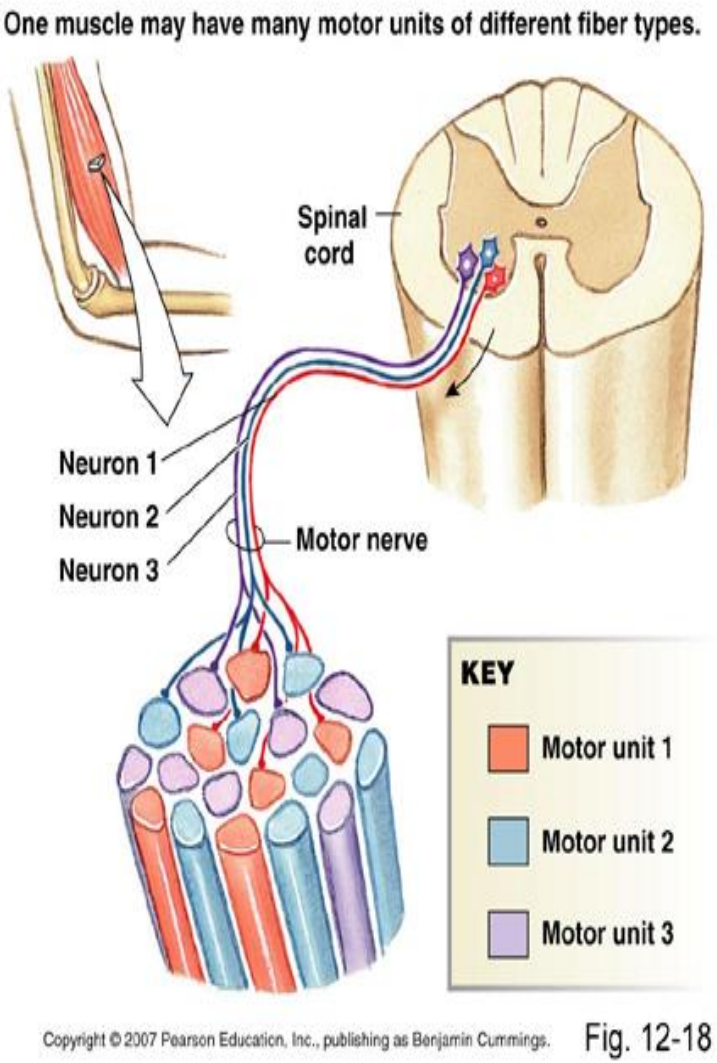
- Once the nerve impulse has occurred, changing the membrane potential to +30 mV, it returns to its resting value in about 1msec. during this time which is called absolute refractory period, no stimulus however its amplitude can cause another nerve impulse.

Refractory periods

- The next **10-15msec** is called relative refractory period at which the nerve impulse can be triggered again but with larger stimulus than is normally needed. After this, the nerve is regained to its normal resting state .

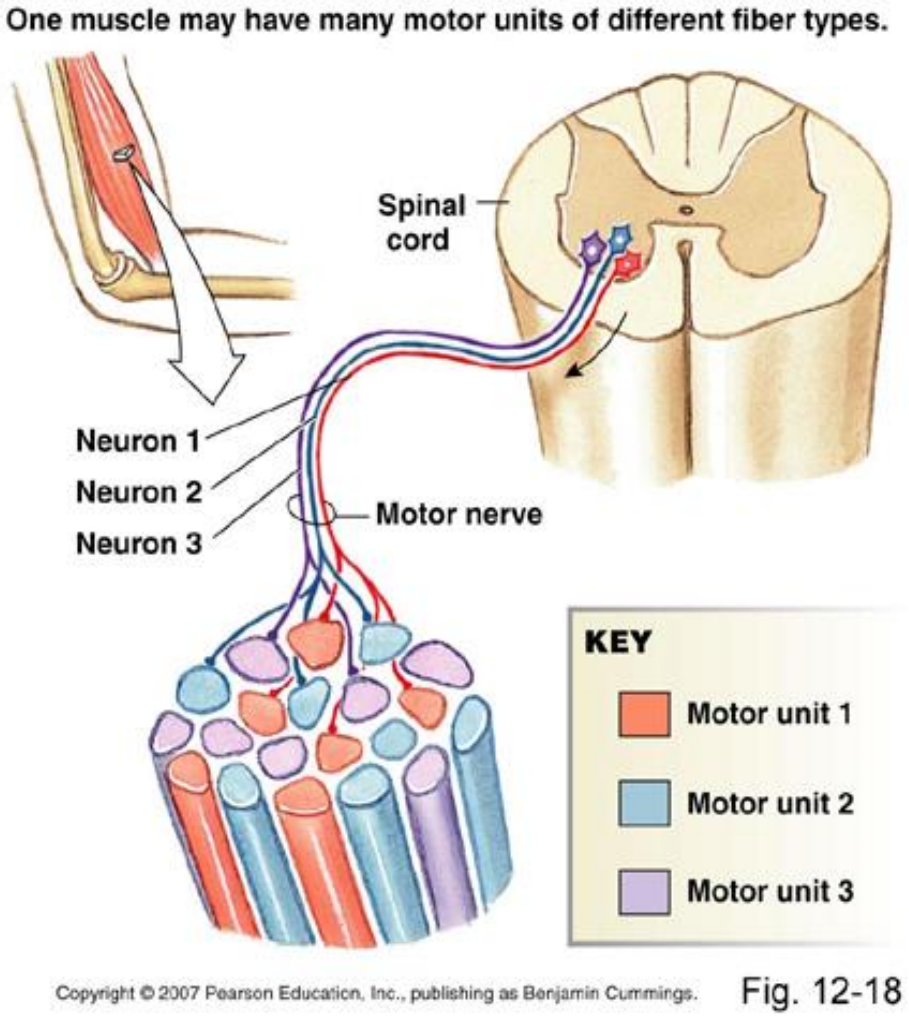
Motor Unit

- The smallest unit of movement that the central nervous system can control is the motor unit. Motor unit consists of a single motor nerve (alpha motor neuron from each anterior horn cell) attached with muscle fibers it supplies.



Motor Unit

- In order to electrically stimulate a normally innervated muscle effectively and painlessly, the active electrode is applied to the motor point.



Motor Point

- Motor point is a point on the skin surface at which the motor nerve trunk enters the muscle. It is a point with low resistance so it stimulate electrically with less current intensity. The motor point can be estimated at the junction of the proximal third with the distal two third of the muscle belly.

Questions?????????