Organization of the nervous system, excitable tissues and membrane potentials

By

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Learning Objectives

1. Organization of the Nervous System

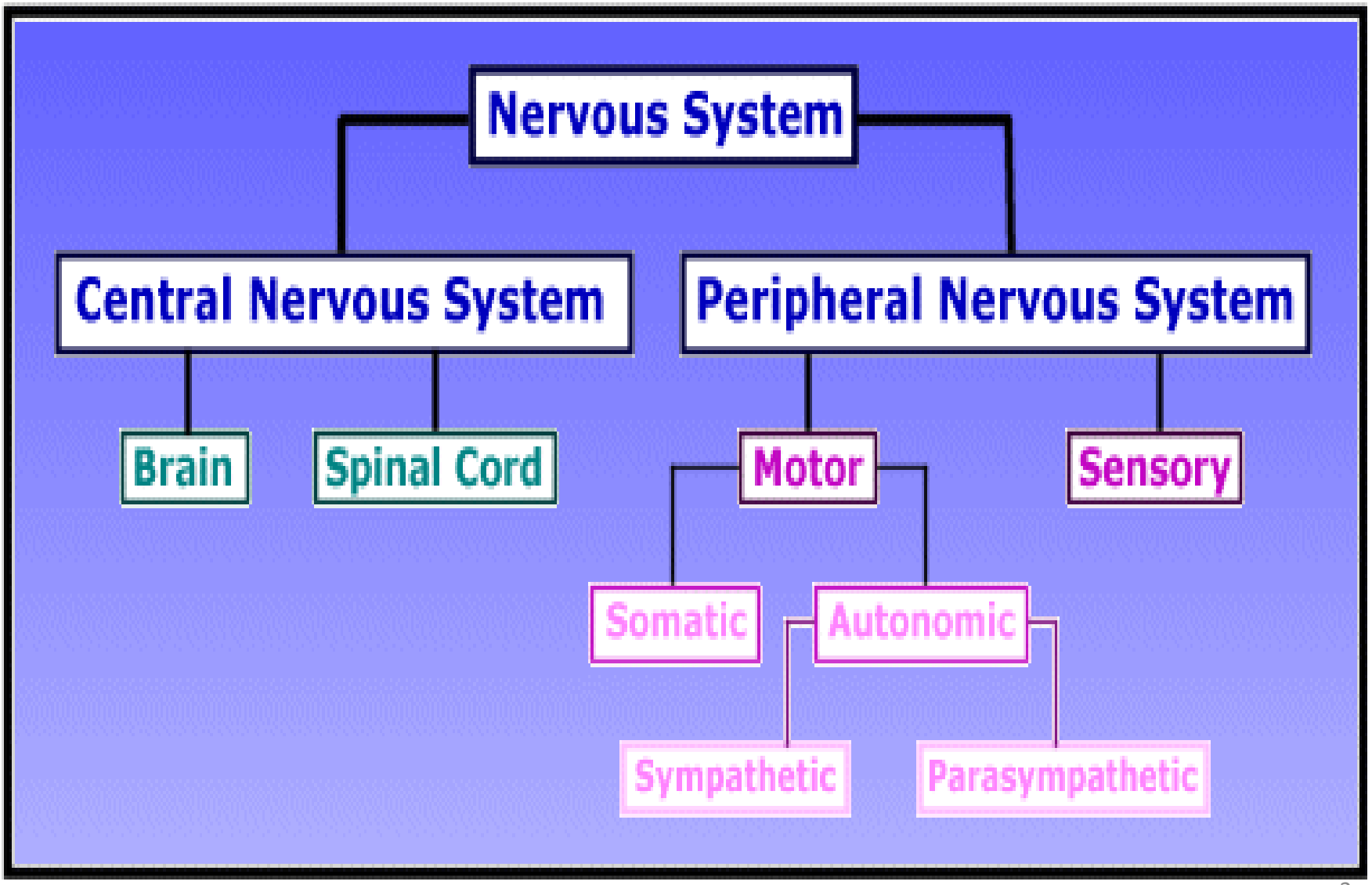
2. Excitable tissue (Nerve and Muscles)

3. Resting Membrane Potential (R.M.P)

4. Action Potential/ Ionic Basis of Excitation and Conduction

5. Propagation of Action Potentials

Organization of nervous system



Excitable tissues

1. Nerve cell

2. Muscle cells

i. Skeletal muscle cell

ii. Smooth muscle cell

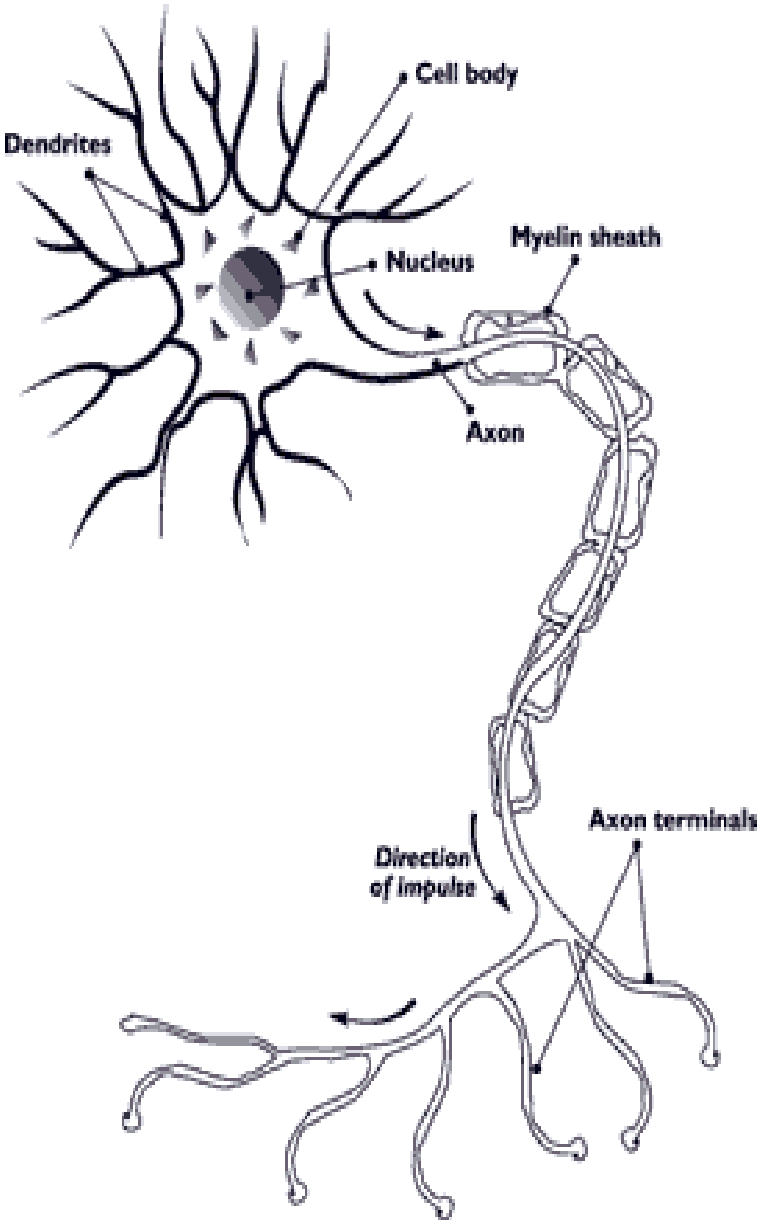
iii. Cardiac muscle cell

Nerve cells

- The neurons are the basic building blocks of the nervous system, their axons may or may not myelinated.

- The myelin sheath is produced by the Schwann cells. It envelops the axon except at the ends & **the nodes of Ranvier**

- The impulse is conducted faster in myelinated than unmyelinated nerves.



Clinical correlate (Multiple Sclerosis)

- ✓ Multiple sclerosis (MS) is a famous autoimmune disease attacking the central nervous system that cause nerve sheath demyelination followed by axon damage and paralysis.

- ✓ Affected Pathways: Pyramidal and cerebellar pathways, medial longitudinal fasciculus pathway (bilateral Conjugate gaze), optic nerve and posterior column

- ✓ Clinical features: sensory deficit, fatique, muscle weakness spaticity, leg stiffness, monoocular vision loss, nystagmus, Internuclear opthalmoplegia, diplopia, ataxia, intention tremor, loss of bowel and bladder, constipation, neuropathic pain, hyperalgesia, anxiety, depression, memory loss.

A patient with Multiple Sclerosis

Resting membrane potential

Definition: It is the potential difference recorded across the cell membrane at rest.

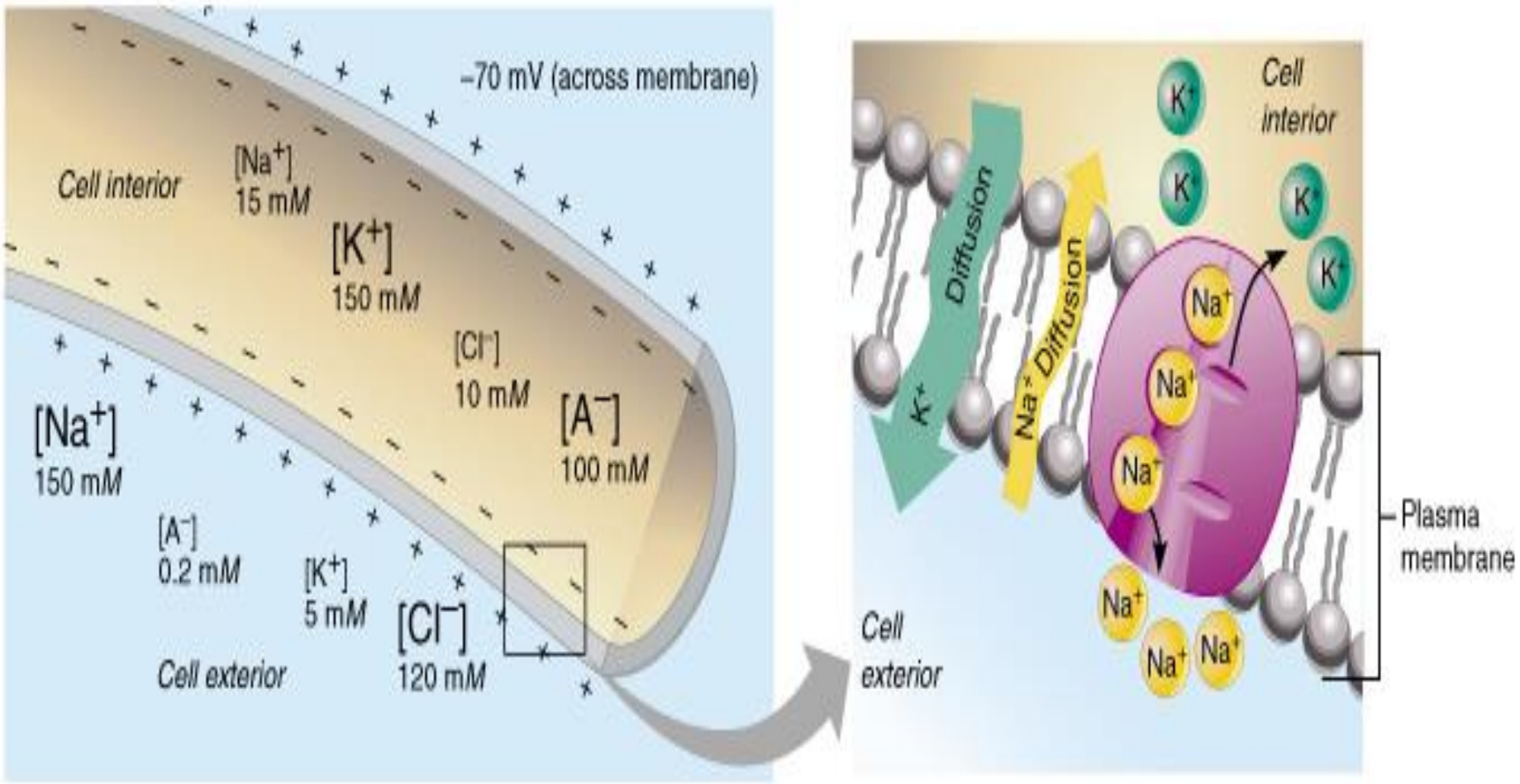
Factors that establish a resting membrane potential

1. Concentration of ions in and out of the cell.

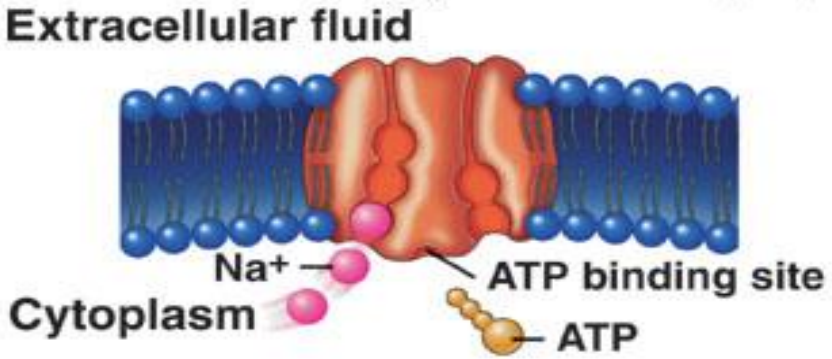
2. Selective permeability of the cell membrane. The K+ diffuses out the cell & Na+ diffuses inside the cell according to concentration gradient. The K+ permeability is 50-75 folds more than Na+

3. Na+-K+ ATPase pump: an active process that needs energy taken from ATP. This is very important to maintain the concentration gradient across the cell membrane

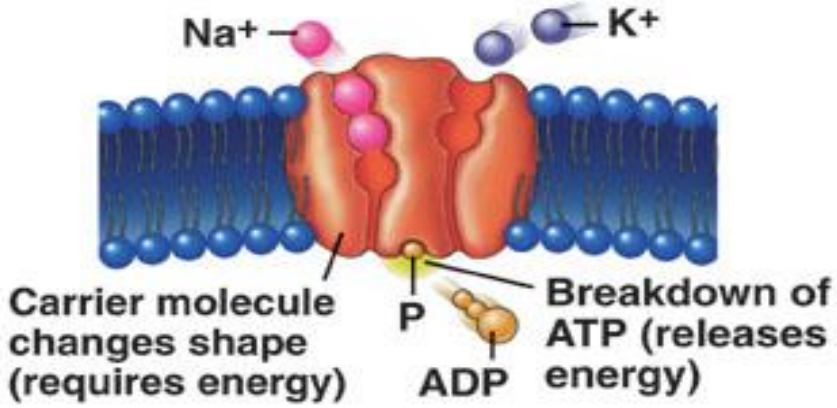
Resting Membrane Potential



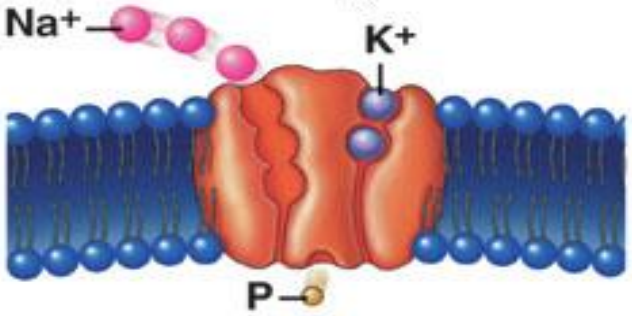
Sodium-Potassium ATPase Pump



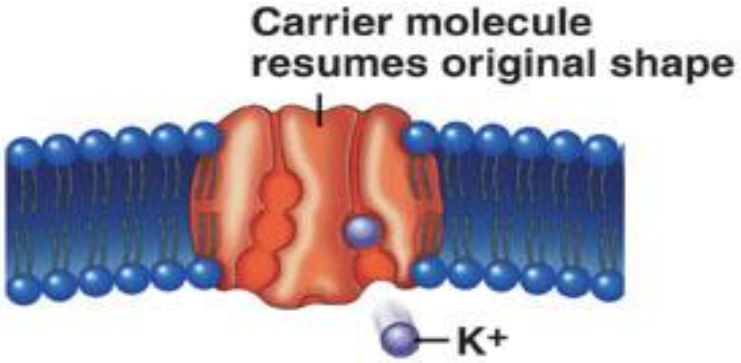
1. Three Na^+ and ATP bind to the carrier molecule.



2. The ATP breaks down to ADP and phosphate and releases energy. The carrier molecule changes shape, and Na^+ are transported across the membrane.



3. Na^+ diffuse away from the carrier molecule, two K^+ bind to the carrier molecule, and the phosphate is released.

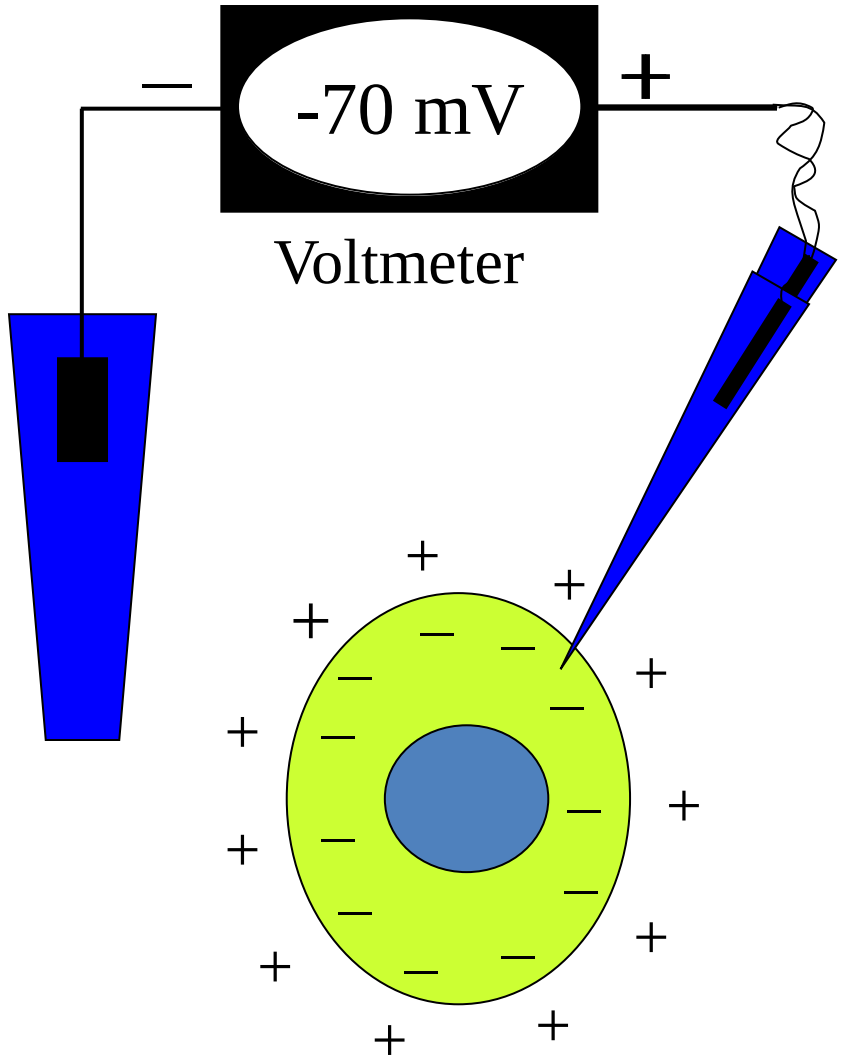


4. The carrier molecule resumes original shape, transporting K^+ across the membrane, and K^+ diffuse away from the carrier molecule. The carrier molecule can again bind to Na^+ and ATP.

Recording electrical events in living tissues

- It is recorded by cathode ray oscilloscope

it is negative in polarized (*<u>resting, the membrane can be excited</u>*) state with the potential difference inside the cell membrane is negative relative to the outside.



Excitation & conduction:

Nerve cells have low threshold for excitation.
The stimulus may be electrical, chemical or mechanical.

Two types of potentials may be produced

- Local (Non-propagated action potential) named after its location **synaptic, generator or electrotonic** potential
- PROPAGATED ACTION POTENTIAL (nerve impulse).

Both are due to changes in the conduction of ions across the cell membrane that are produced by alternations in the ion channels

All or none law:

- Application of a threshold stimulus either produces a full response or not at all.

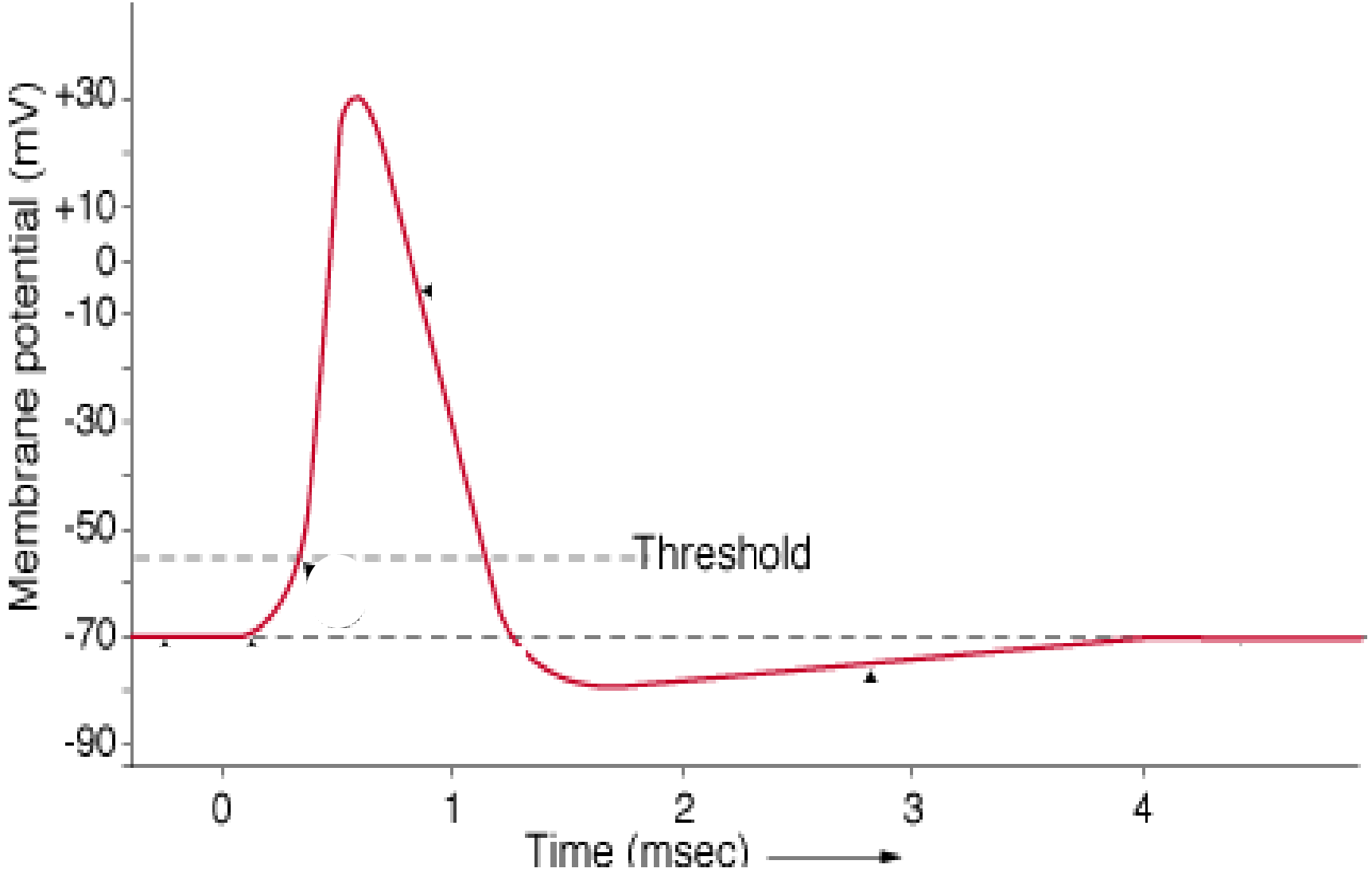
- Further increase in the intensity of a stimulus produces no increment or other changes in action potential.

- The action potential failed to occur if the stimulus is sub-threshold, it produces only local changes with no propagation.

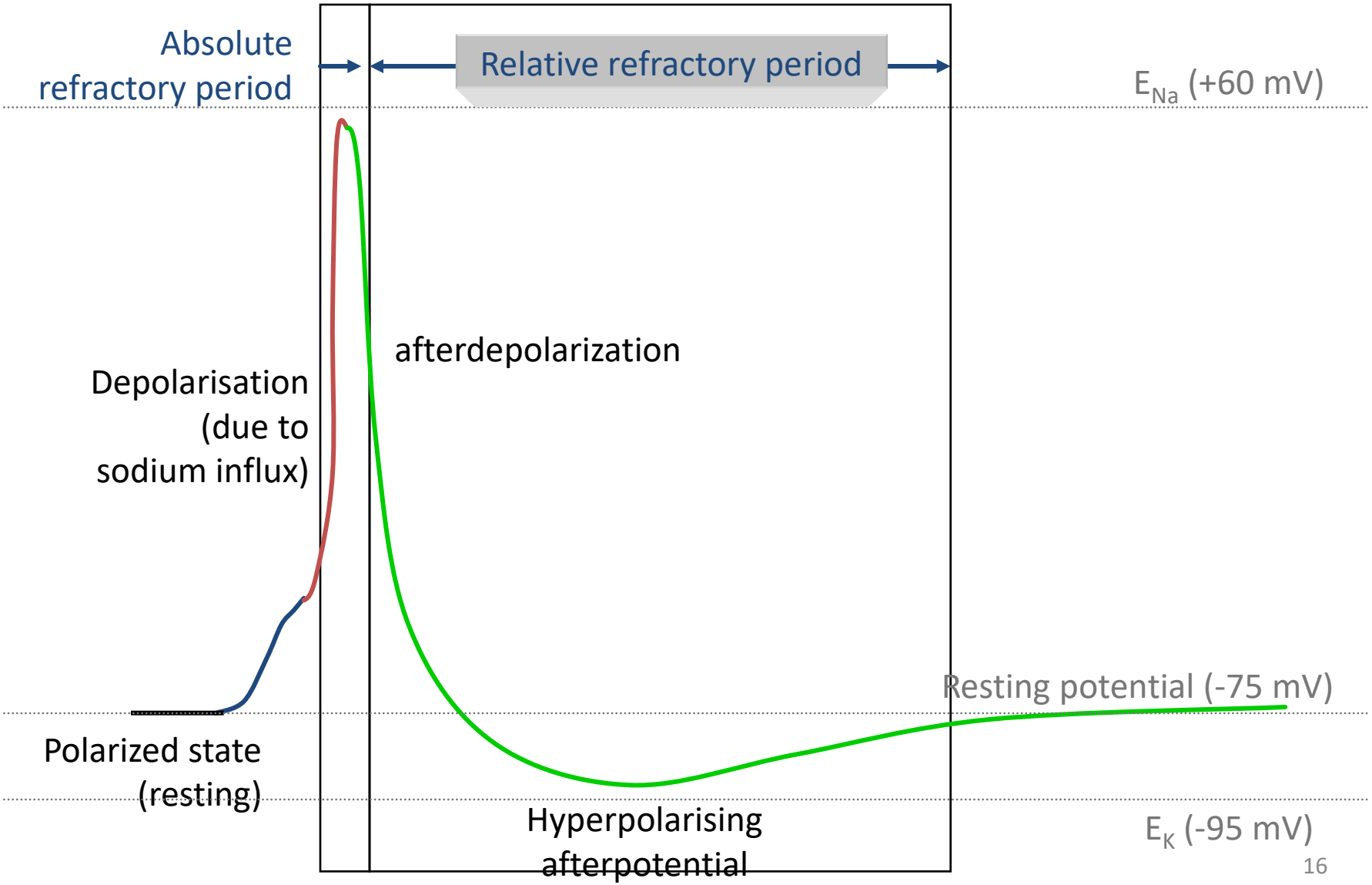
The Action Potential (AP)

- An action potential is: A regenerating depolarization of membrane potential that ***propagates*** along an ***excitable*** membrane.
- Propagates : Conducted without decrement (an 'active' membrane event)
- Excitable : Capable of generating action potentials
- **Properties of Action potentials**
  - are all-or-none events
    - need to reach threshold
  - have constant amplitude
    - do not summate
  - are initiated by depolarization
  - involve changes in permeability
  - rely on voltage-gated ion channels

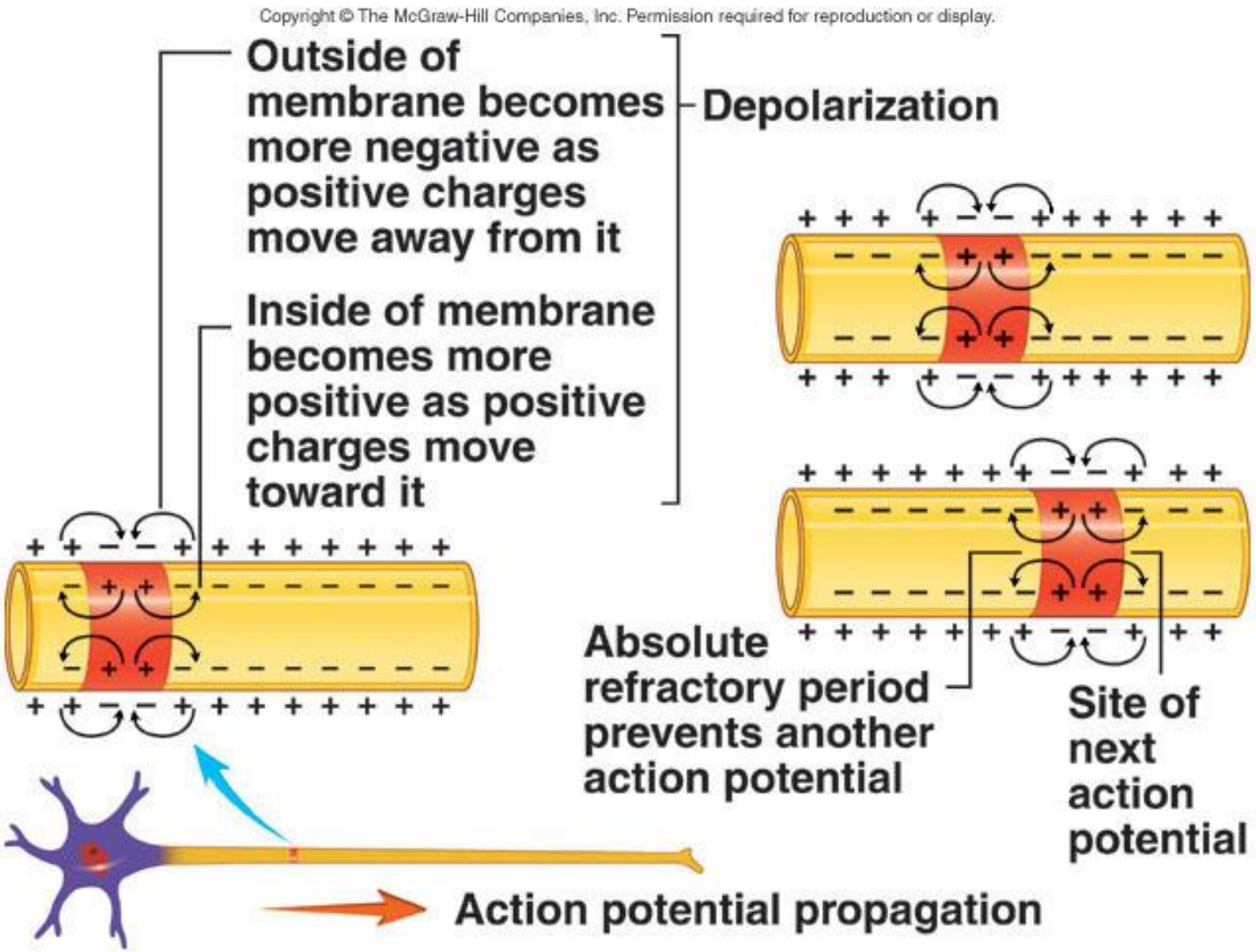
Action Potential (AP) in a nerve cell



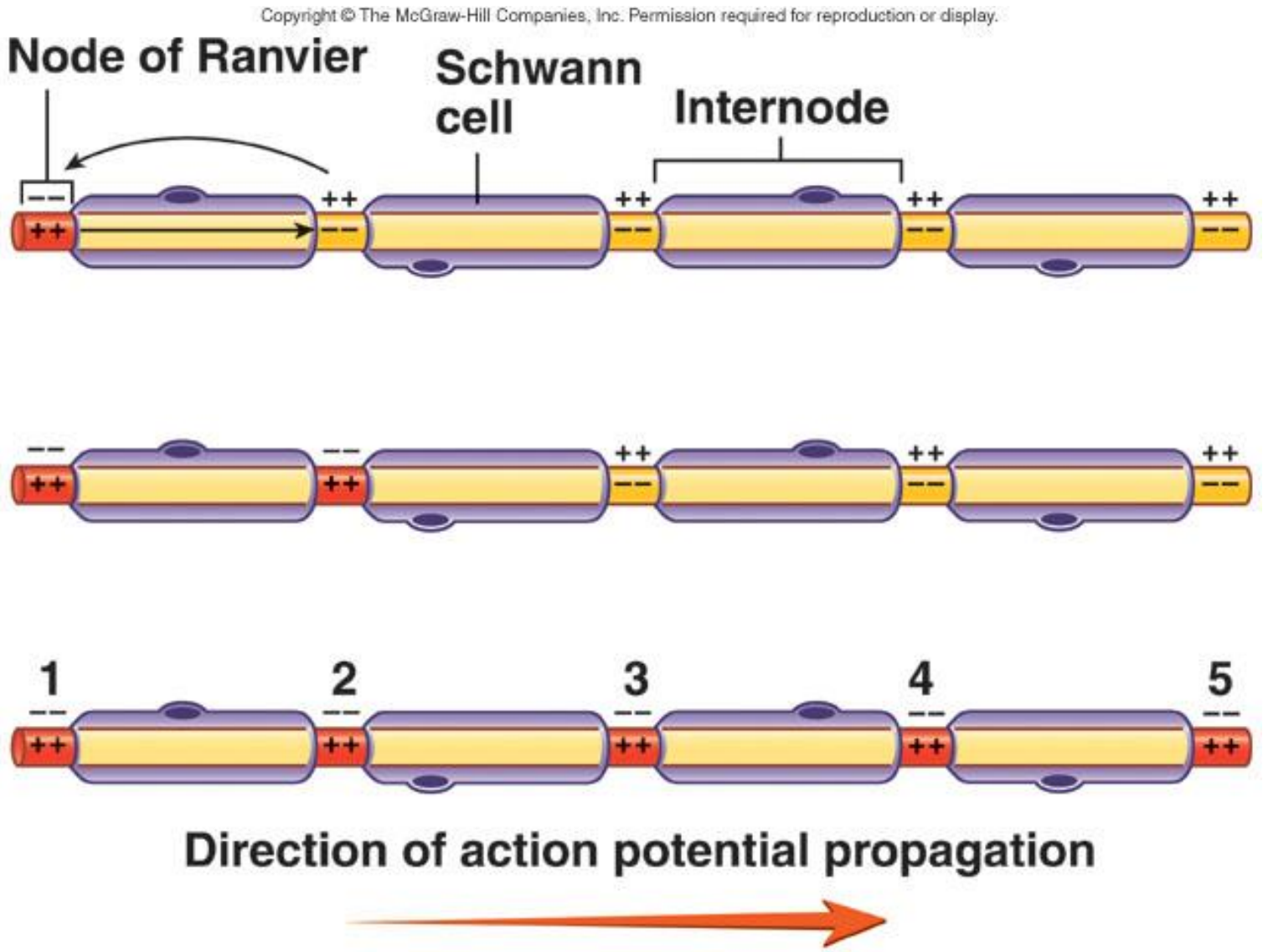
Refractory Periods



Action Potential Propagation



Saltatory Conduction: Action Potential Propagation in a Myelinated Axon



Thank you