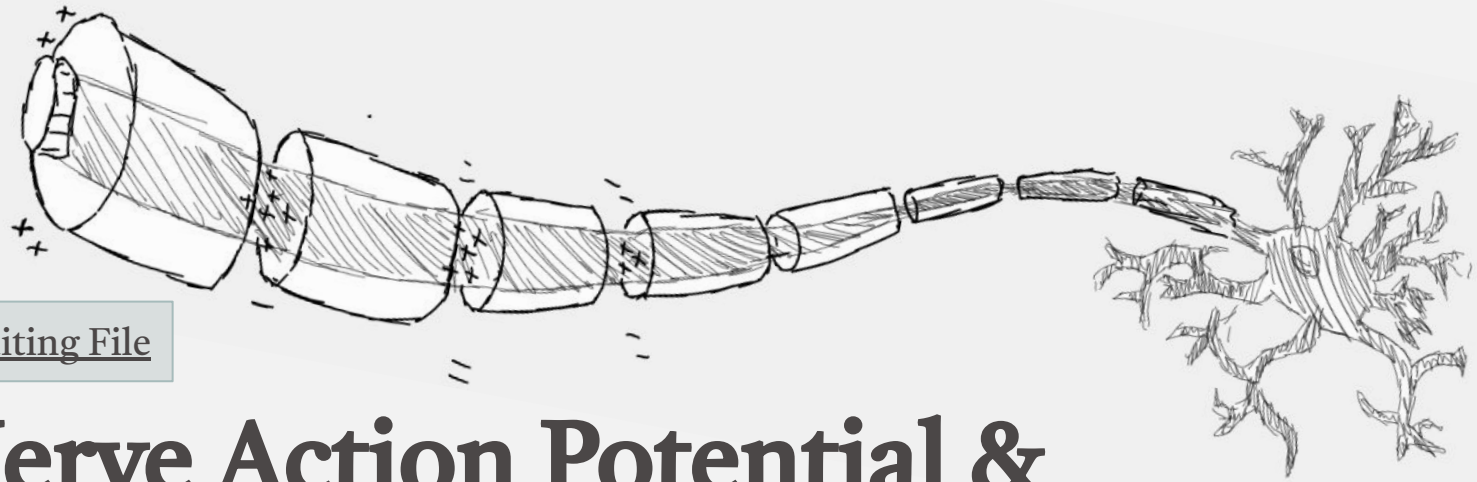


Editing File

Nerve Action Potential & Properties of Nerve Fibers

Color Index:
-Main Text -Important -Notes
-Boy Slides -Girl Slides -Extra

Ty to Hasan Alsugahyir for sketch (MED445 inshallah) <3

Objectives

01 Describe the mechanism of generation & propagation of AP.

02 Describe conduction along nerve fibers.

03 Describe the role of myelination & how nerve fibers are classified.

04 Know what happen to nerve impulses if myelin is lost.

This lecture is very important in medicine :3

The Action Potential

Video

- Nerve signals are transmitted by action potentials.
- Action potentials are rapid changes in the membrane potential that spread rapidly along the nerve fiber membrane to produce physiological effects.

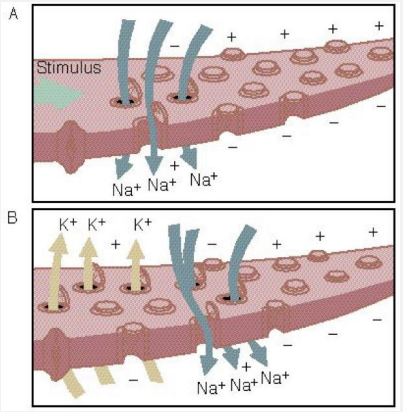
- **Examples of physiological effects:**

01 Transmission of impulse along nerve fibres

02 Release of neurotransmitters

03 Muscle contraction

04 Activation or inhibition of glandular secretion



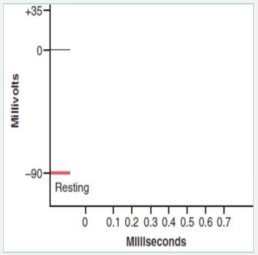
Each action potential:

- **Begins with:** sudden change from the normal resting negative membrane potential to a positive potential.
- **Ends with:** almost equally rapid change back to the negative potential.

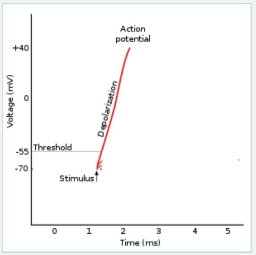
Stages of Action Potential

Video

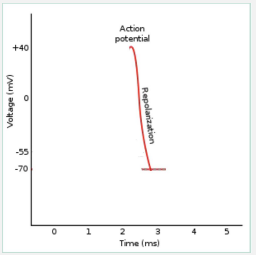
Resting/Polarized



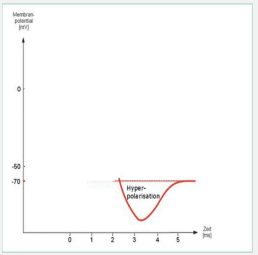
Depolarization



Repolarization



Hyperpolarization



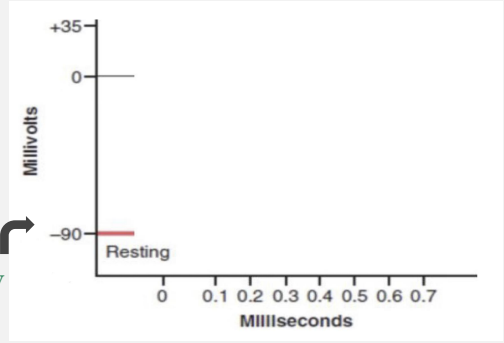
Stages of Action Potential:

Important Slide

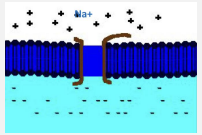
1. Resting /Polarized Stage

- The resting membrane potential before action potential begins is polarized.
- There is no Na+ action in this stage.
- K+ enter and exit through the leaking channels.
- No Energy required

Resting or polarized at -90mv



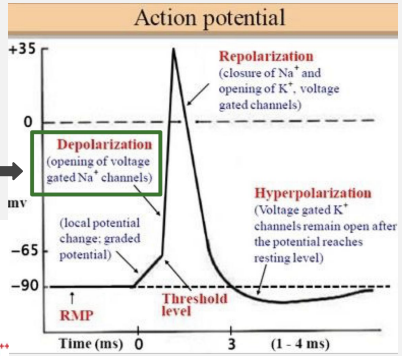
2. Depolarization Stage (Upstroke)



- The Membrane suddenly becomes permeable to Na+ ions → allowing tremendous numbers of +ve charged Na+ to diffuse to the interior of the axon (upstroke).
- Depolarization → decrease negativity inside by allowing Na+ to enter through the voltage gated Na+ channels.
- Na+ stops entering at +61mV but in reality it will stop at +35 mV, because there are counter channels (قناة مضادة) called “voltage gated K+ channels”.
- Voltage channels are sensitive to the change in the voltage.

Depolarization stage stops at +35 mV

Influx of Na+



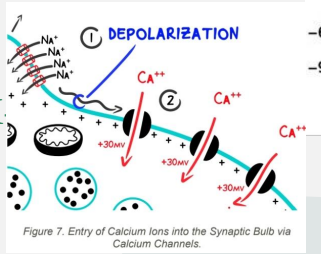


Figure 7. Entry of Calcium Ions into the Synaptic Bulb via Calcium Channels.

Stages of Action Potential:

Important Slide

Illustration from team 439:
هو فكرة الاسم أنه بالبداية يكون قطبيته سالبة (سالب 70 الى سالب 90) بعدين تبدا تزيد الشحنة الموجبة خلال جزء من الثانية وبتكمل تزيد وبتصير موجبة (50+ مثلا) وبعدين بترجع سالبة زي ماكانت قبل ونرجع نسميها Repolarization

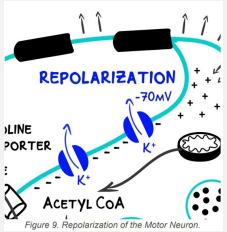
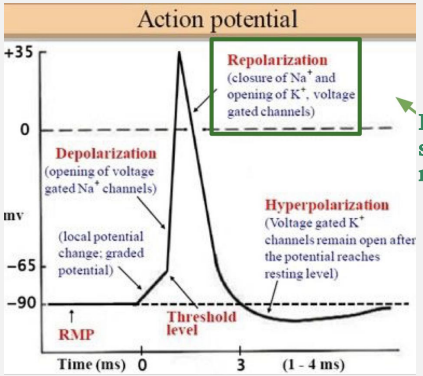


Figure 9. Repolarization of the Motor Neuron.

3. Repolarization Stage

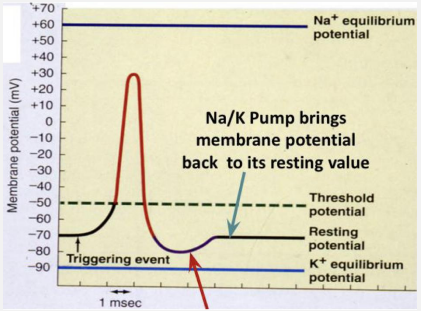
- The Na+ channels begin to close.
- K+ channels open.
- Rapid diffusion of K+ ions to the exterior → re-establishes normal -ve RMP (resting membrane potential).
- K+ exit through the voltage gated K+ channels.
- This stage increases the negativity inside the cell.
- K+ stops leaving the cell at -94mV but in reality it will stop at -90mV



Repolarization stage stops at -90 mV

4. Hyperpolarization Stage

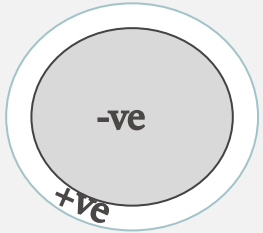
- For a brief period following repolarization, the K+ conductance is higher than at rest.
- Na+/K+ ATPase pump starts moving Na+ out and K+ in (against concentration gradient).
- Hyperpolarization is caused by high conductance of K+ channels.
- Team 442: Hyperpolarization may or may not happen.
- Extreme efflux of K+ (outside)



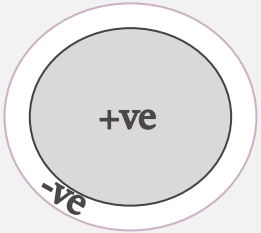
Hyperpolarization

Stages of Action Potential:

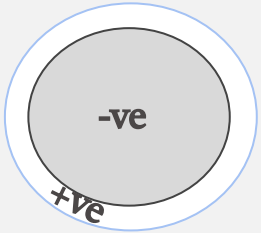
Extra slide



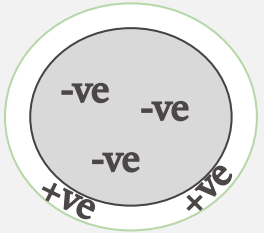
Resting (Polarized)



Depolarization

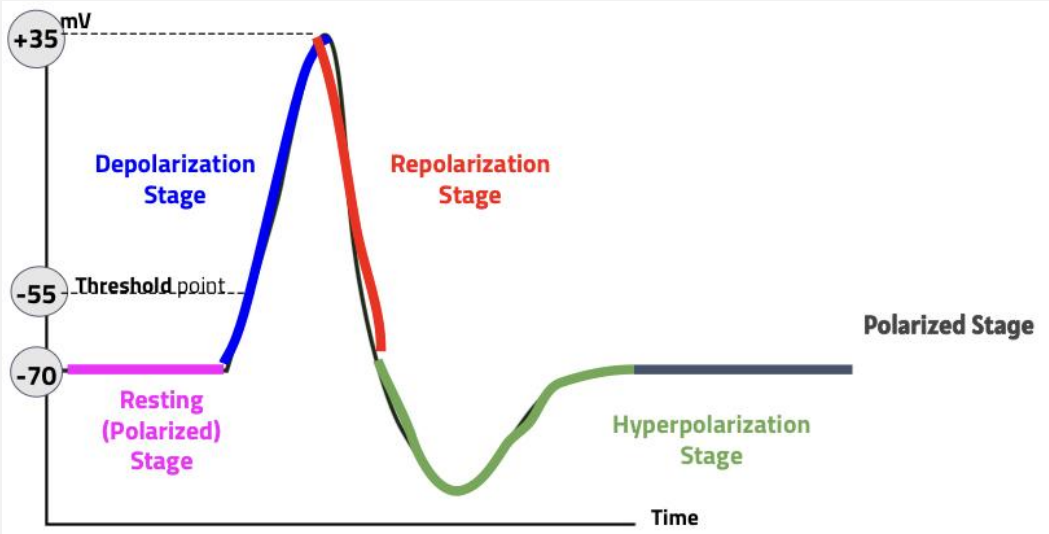


Repolarization



Hyperpolarization

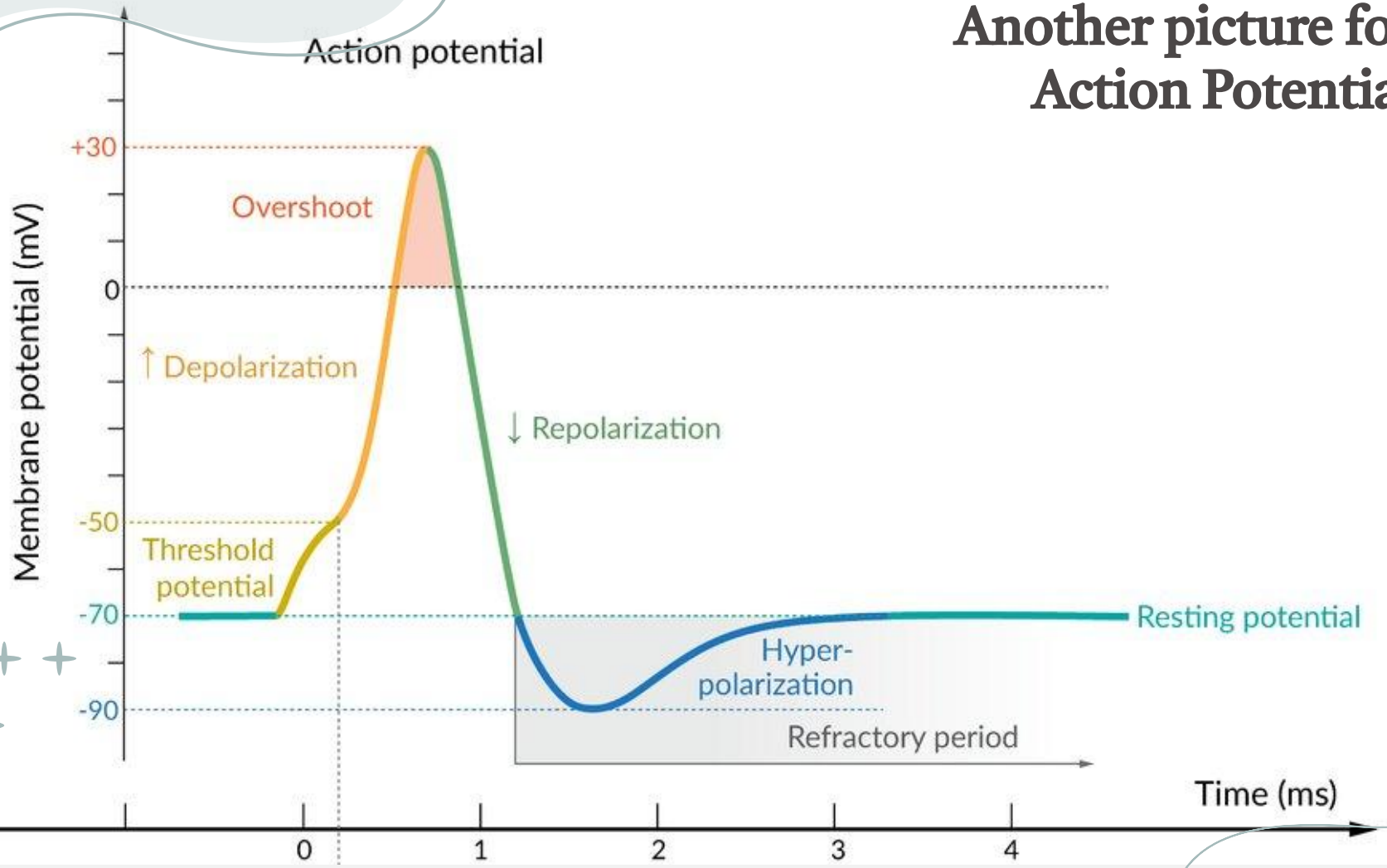
RMP ranges between -70 to -90 mV



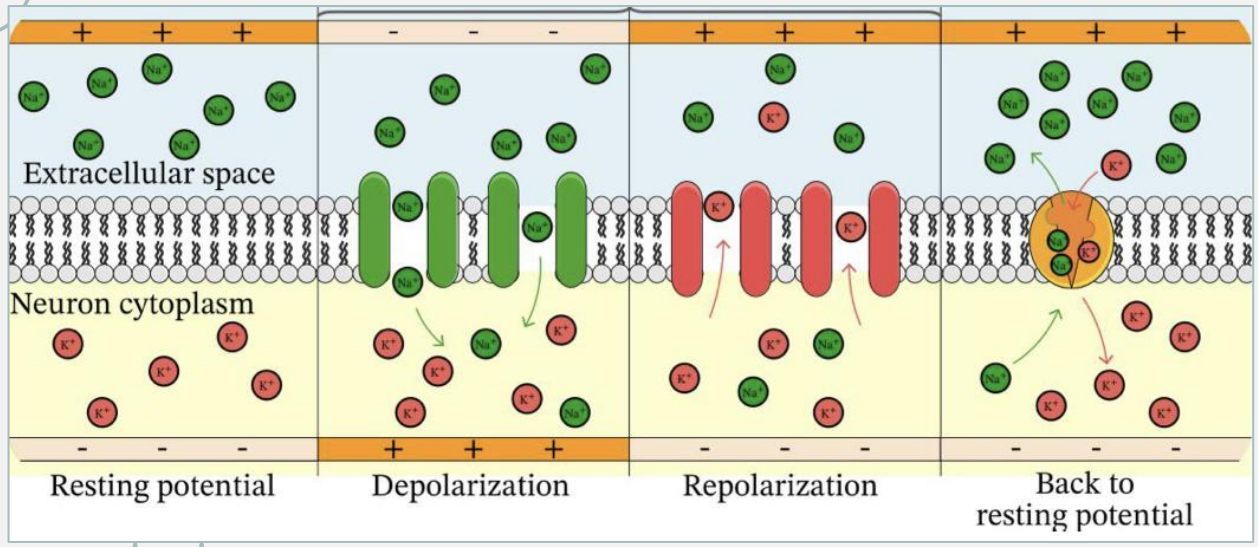
Dr.mannan's illustration 443 (1)

Notes (2)

Another picture for Action Potential



Action Potential



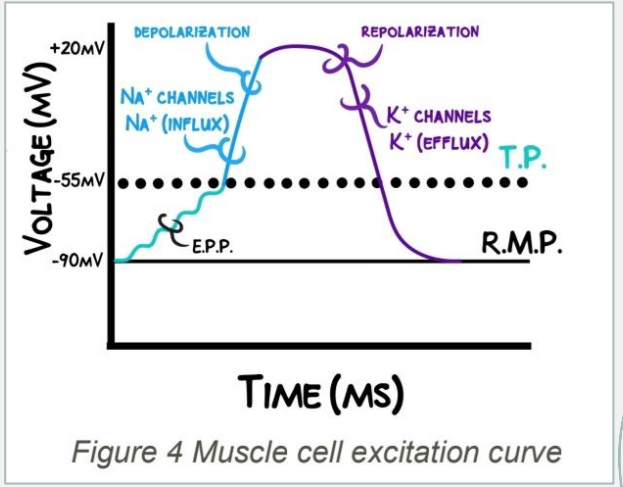


Figure 4 Muscle cell excitation curve

Extra Slide (Summary)

Stimuli & Potentials

01 Threshold Stimulus (Firing Level):

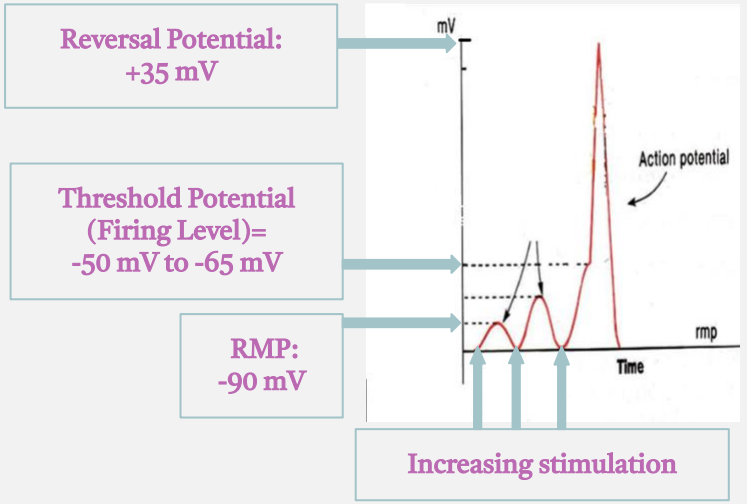
- The membrane potential at which
- Occurrence of the action potential is inevitable.
- Result: all Na+ channels will open
- نقطة اللاعودة

02 Acute Subthreshold Potential:

- Stimulus that results only in local depolarisation (acute local potentials) when stimulus is below the threshold.

03 All-or-Nothing Principle:

- Once threshold value for excitation is reached a full AP is produced.
- AP intensity can **NOT** be increased by increasing stimulus intensity.



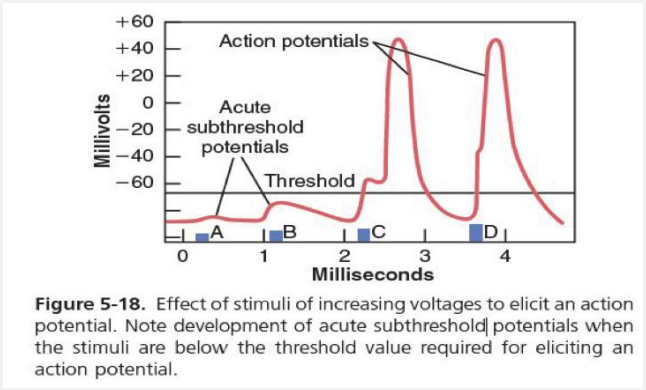


Figure 5-18. Effect of stimuli of increasing voltages to elicit an action potential. Note development of acute subthreshold potentials when the stimuli are below the threshold value required for eliciting an action potential.

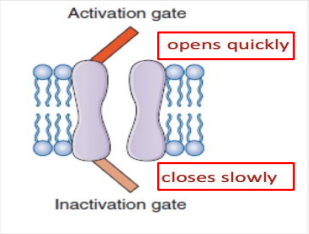
Q: What opens the voltage-gated channels?
A: Opened by a stimulus strong enough to depolarize them to threshold.

Types of Transport Channels Through the Nerve Membrane

01 Voltage gated channel Na+ channels

Important Slide ⭐

- The channel has **2 gates:**
  1. Activation gate → Facing ECF
  2. Inactivation → facing ICF



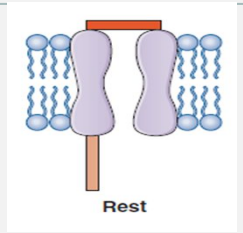
lidocaine (local anesthetic) مخدر موضعي **blocks this channel**

A. At Rest:
- Activation gate: closed
- Inactivation gate: open

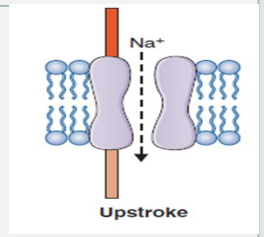
B. During upstroke of AP (depolarization):
- Activation gate: open
- Inactivation gate: open
- Na+ flows into the cell (down the electrochemical potential gradient → no energy).

C. During repolarization:
- Activation gate: open
- Inactivation gate: closed
- Can't elicit (Start) new AP.

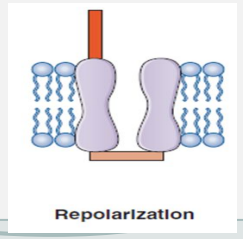
A



B



C



Types of Transport Channels Through the Nerve Membrane

02 Voltage gated channel K+ channels

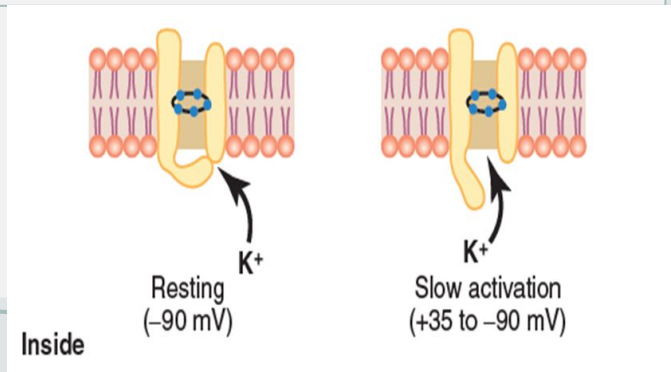
-The channel has only **1 gate**
- Open and closes **slowly**

Tetraethylammonium(**TEA**) **blocks this channel.**

At Rest:
The gate is **closed** preventing the potassium ions from passing through to the ECF

Shortly after depolarization:

- When the sodium channel **begins to be inactivated** (reach +35 mV)
- The potassium **channel opens**, **resulting in K+ efflux** (return -90 mV)



Refractory Periods

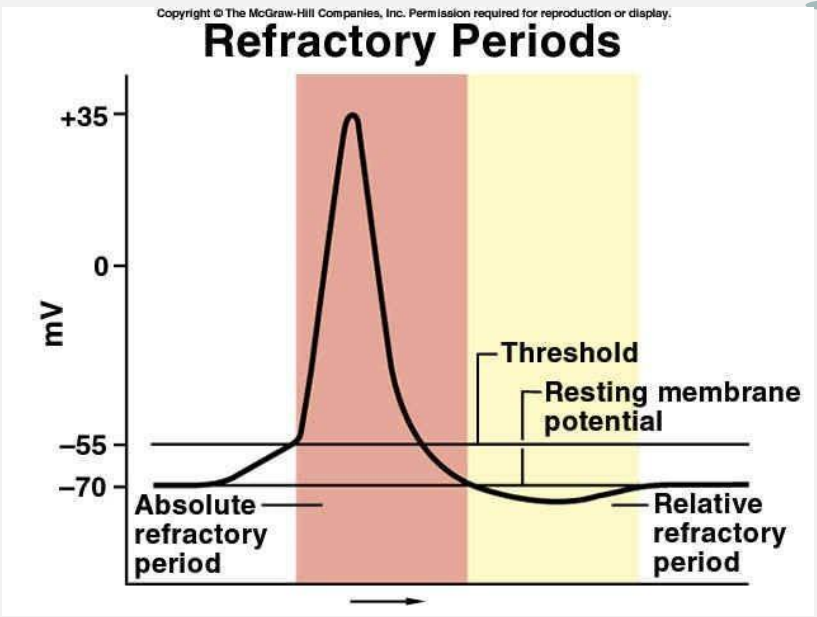
Two Stages:

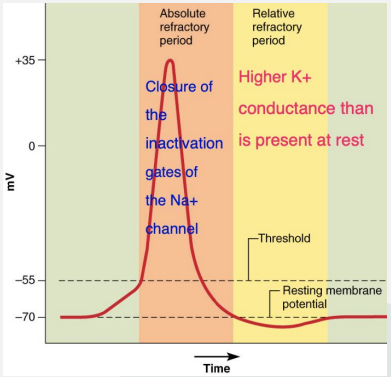
01 Absolute refractory period

- The period during which a second action potential **cannot be elicited**, even with a strong stimulus.
- It will not open at all, needs to go back in RMP to start another AP.

02 Relative Refractory Period:

- Can trigger **new action potential** if stimulus is **very strong.**
- When the potential difference reach RMP it will be able to be stimulated.
- Needs a strong (suprathreshold) stimulus to cross the threshold.





Propagation of Action Potential

Important Slide

It is the spread of depolarization down nerve fiber by local currents.

A

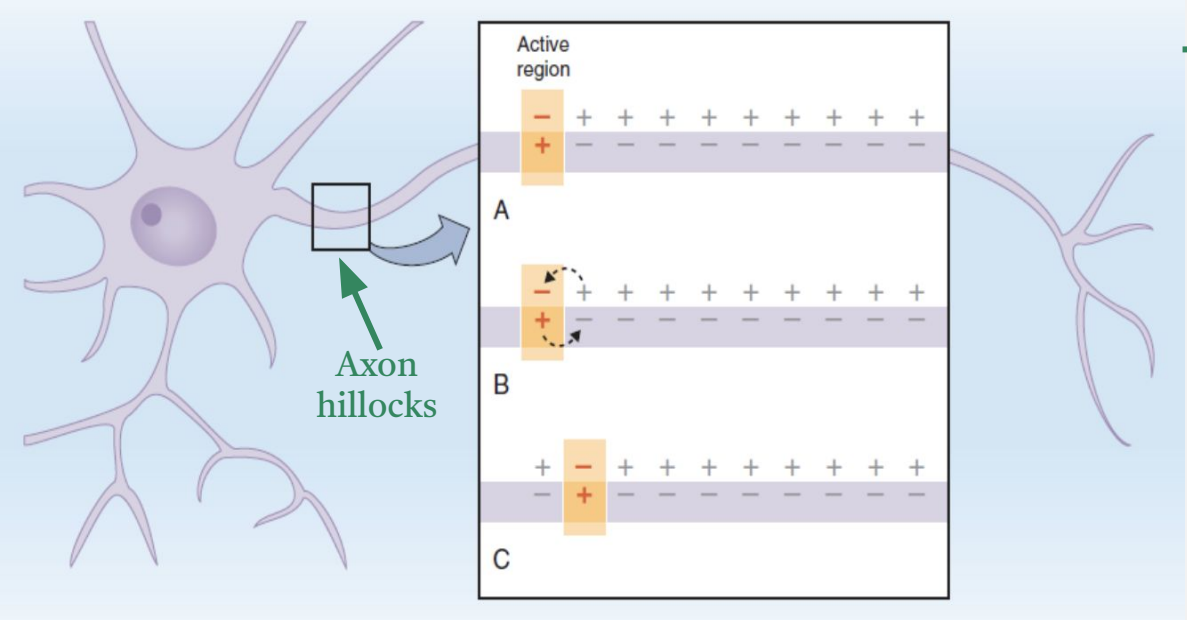
The initial segment of the **axon fires an AP.**
Potential difference will be reversed (inside → +ve & outside→ -ve due to depolarization).
The adjacent area (neighbouring segment) is **inactive (at -ve RMP).**

B

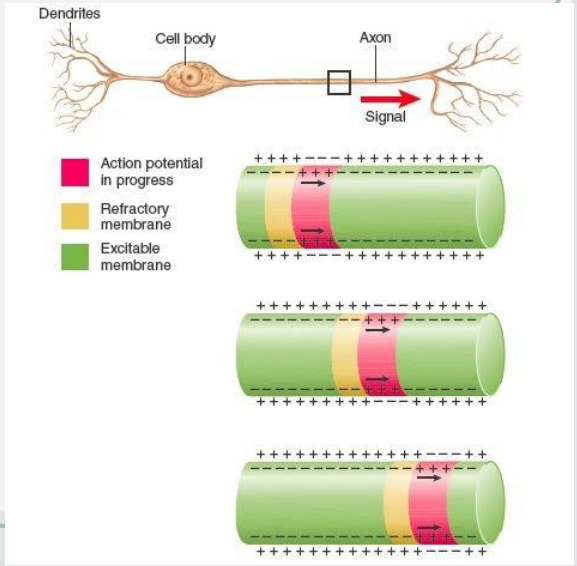
The **+ve charge** inside the nerve **flows to** the adjacent **inactive area**, the local flow causes the **adjacent area to be depolarized** to threshold **firing an AP**, while the original **active** region **repolarized** back to the **RMP**

C

The local flow causes the **adjacent area to be depolarized** to threshold **firing an AP**, while the original **active** region **repolarized** back to the **RMP**



This process takes place in all organs except the skeletal muscles.



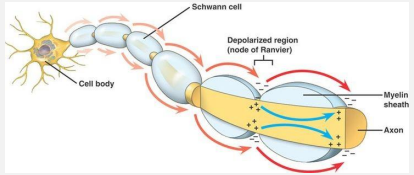
Conduction velocity

speed at which action potentials are **conducted** (propagated) **along a nerve** or muscle fiber.
Mechanisms that increase conduction velocity along a nerve:

Nerve diameter	• **Larger** diameter → **faster** transmission. • **Because**: large fibre offers **less internal resistance** (Ri) to local current flow → more ions will flow. • **Internal resistance is inversely proportional to cross sectional area.**
Myelination	Myelin is a **lipid insulator** that makes it more difficult for charges to **flow** (decreasing it) **between ICF and ECF**, increases membrane resistance; Rm, which forces currents to flow along the path of least resistance of the axon interior. The layers of Schwann cell membrane contain the lipid substance **sphingomyelin** which is excellent electrical insulator Node of Ranvier: small **uninsulated area** where ions can flow with ease.

Saltatory Conduction

It is the jumping of action potentials from one node of ranvier to next as they propagate along myelinated fiber.

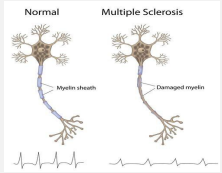


Values

- **Increase conduction velocity**
- **Conserves energy for axon because only nodes depolarize**

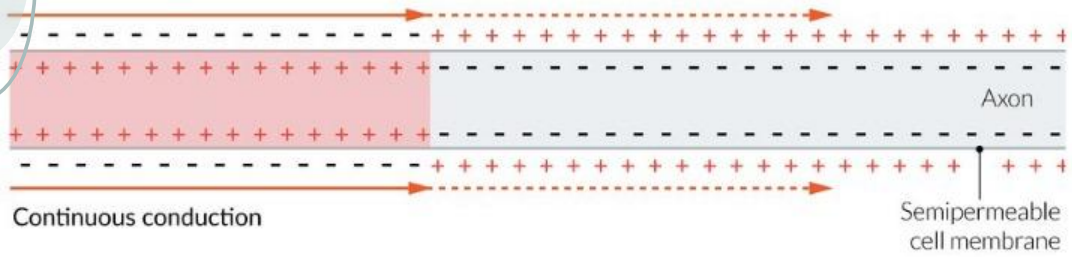
Lost Myelination

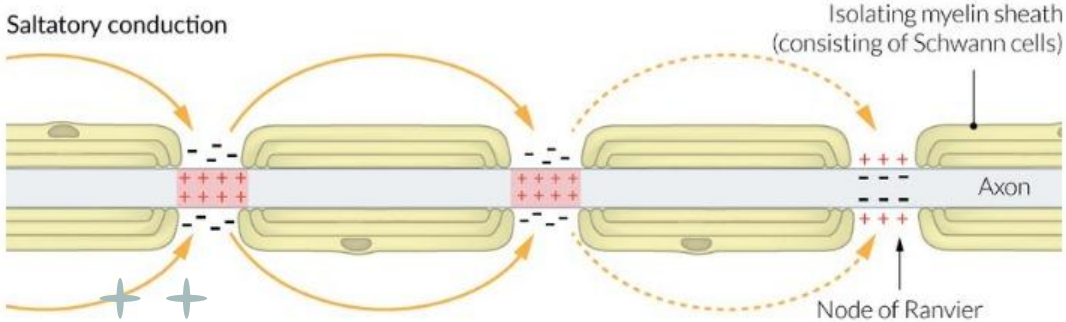
Loss of myelin sheaths around nerve causes a **decrease** in membrane **resistance** → current (impulse) can leak out across the membrane during conduction of local currents.

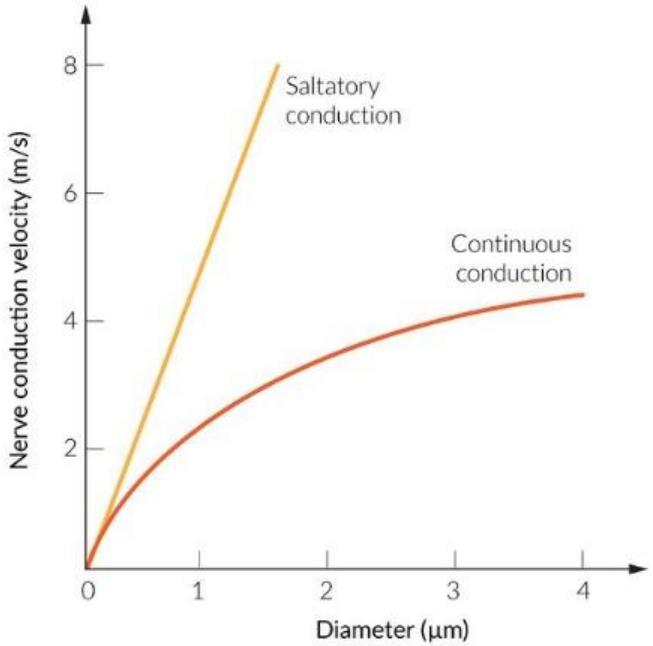


Multiple Sclerosis

- Autoimmune disease (Immune system attacks: myelin sheaths around axons + axons themselves).
- Usually young adult are affected.
- Blindness & problems controlling muscles (ultimately paralysis).
- Scar tissue (sclerosis) replace some damaged cells.







Difference between saltatory & continuous conduction

Conduction Velocity (summary):

The **slowest** due to small nerve diameter (small fiber offer large resistance to local current flow) .

Faster than number 1 due to the large nerve diameter (The larger the diameter the fastest the transmission).

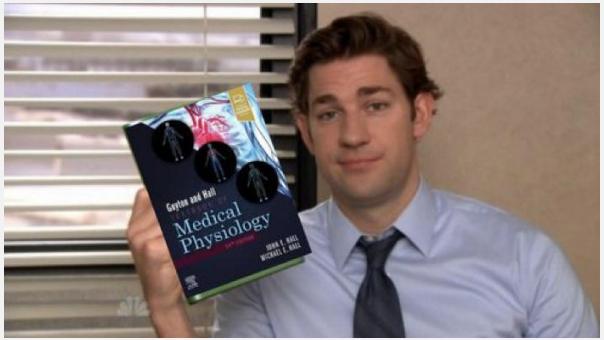
The **fastest** due to the myelinated region.

here

recommended video
(from 17:04-till the end of the vid)

You can find the pages related to this lecture from (Guyton) here

Note: Guyton has extra information that might not be with us, but if you want to learn more about the topic make sure to check it out :3



Thanks to team 443 <3

Answers: 1.B 2.B 3.C 4.B

MCQs

Q1: Which of the following will re-establish resting membrane potential?			
A- Na+/K pump	B- K+ efflux	C- Proteins	D- Na+ influx
Q2:Which phase of the action potential is caused by the closure of the inactivation gate of Na+ channels in the nerve axon?			
A- Hyperpolarization	B-Absolute refractory period	C-relative refractory period	D-Depolarization
Q3: Which of the following events occur during the repolarization phase of action potential?			
A-K+ influx	B-Closure of voltage gated K+ channels	C-Activation gate of Na+ channel opens	D-Increased membrane permeability to Na+
Q4:the Na+ activation gate is closed during which of the following?			
A-Upstroke	B-Rest	C-Repolarization	D-Depolarization

SAQs

A 21-year-patient came to the hospital complains of muscle weakness, inability to work (other related symptoms) and it was found that he was suffering from Multiple sclerosis;

Q1: What is the affected part of the nerve in this case and the cause?
A: The Immune system attacks the myelin sheaths surrounding axons as well as the axons themselves.

Q2: What are the myelin functions and why does it play a major role in nerve conduction?
A: Myelin is an insulator that makes it more difficult for charges to flow between intracellular and extracellular fluids.

Q3: It is the jumping of action potentials from one node of ranvier to the next as they propagate, what is this conduction called?
A: Saltatory Conduction.

Ahmad Addas

Nawaf Alshalan

Fawaz Almadi

Khalid Alkanhal

Abdulrahman Khaldi

Khalid Alghamdi

Talal Alrobaian

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Lama Almoutairi

Leena Shagrani

Marwah Fal

Rahaf Mohammed

Huda Bassam

Aram Alzahrani

Noor Altalag