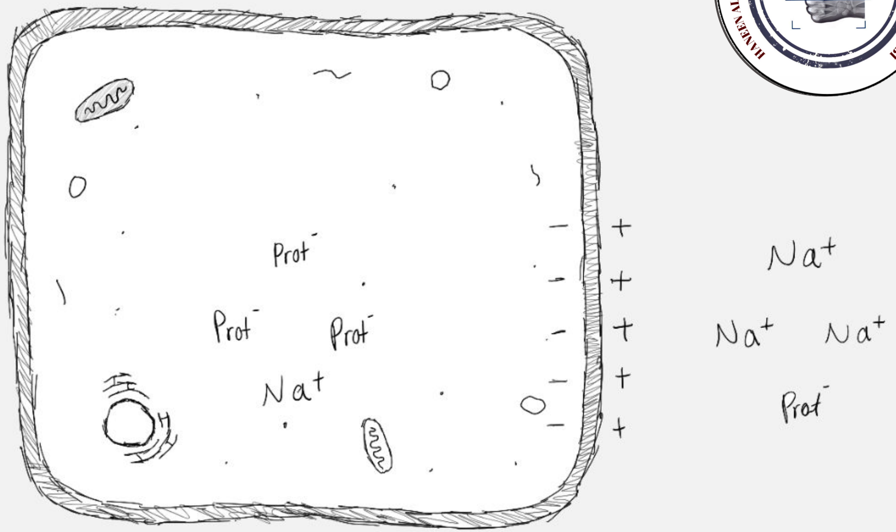


Editing File

Resting Membrane Potential

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

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

Objectives

01 Explain why some membranes are excitable.

02 Describe the electrochemical basis of RMP.

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

Excitable Tissue

tissues which are capable of generating and transmitting electrochemical impulses along the membrane. (give response)
Examples:

- Nerves
- Skeletal muscle
- Cardiac muscle
- Smooth muscle

Non-Excitable Tissue

tissues which are NOT capable of generating and transmitting electrochemical impulses along the membrane.

- RBCs
- Epithelial cells
- Adipocytes
- Fibroblasts
- Intestinal cells

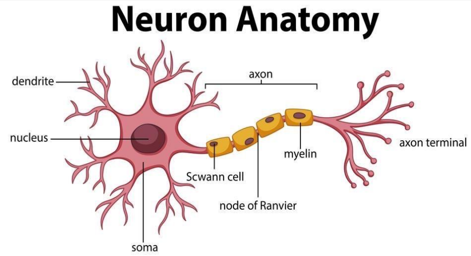
Anything that's not muscle or nerve cells

Neuron

Are the unit of function of CNS

Motor neuron parts & functions

- **Soma (cell body)**
- **Dendrites:** carry nerve impulses to the soma
- **Axon & axon terminal**
- **Axon hillock:** at which nerve impulses begin



Node of ranvier is unmyelinated between the myelinated region.

Myelin sheath

Is formed by schwann cell which deposits sphingomyelin.

Function:

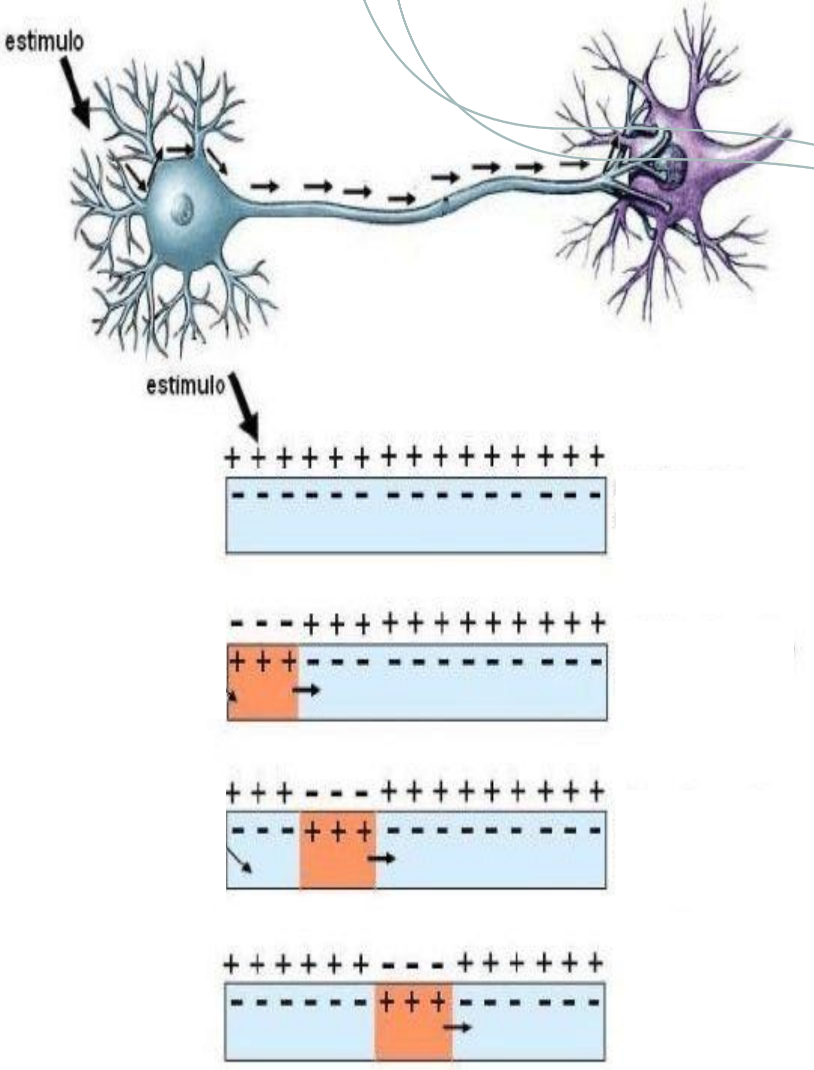
- Insulator
- Increase conduction velocity

Female Slides Only

Membrane potential:

Resting Membrane Potential (RMP): a potential difference that exists between the inside and the outside of the membrane during rest ,across all cell membranes.

- RMP is about -70 to -90 mV.

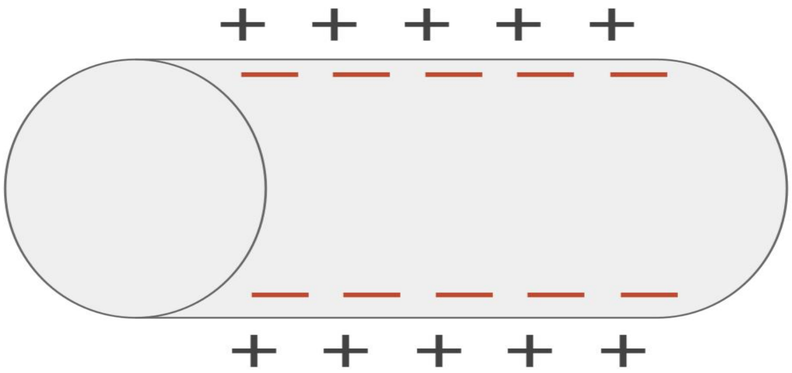


Membrane potential:

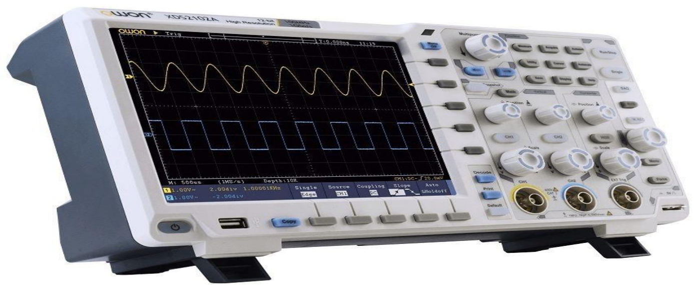
RMP is measured using microelectrodes and oscilloscope (voltmeter).

RMP differ based on the size and type of the cell.

💡 RMP is the default state of the cell. It corresponds to the sum of all diffusion potentials of extracellular and intracellular ions.



Inside is negative
with respect to the outside.



Oscilloscope voltmeter

RESTING MEMBRANE POTENTIAL

SAQ question

1. RMP depends on factors

- Ionic distribution (across cell membrane)
- Membrane permeability
- Na+/K+ ATPase pump

Efflux = Exits the cell, Influx = Enters the cell *Nernst potential = Equilibrium potential.

2. Factors contributing to negative RMP:

- One of the main factors is K+ efflux (K+ leak channel - Nernst potential: -94 mV).
- Contribution of Na+ influx is little (Nernst potential: +61 mV).
- Na+/K+ pump creates additional degree of negativity inside the membrane (-4 mV).
- Negatively charged protein ions remaining inside the membrane contributes to the negativity. Require ATP to diffuse outside the cell.

K+ leak channel: 100 potassium efflux while 1 sodium influx causing the positive charge to decrease while the negative charge increase due to the increasing of electrons inside and the decreasing of proteins outside the cell.

3. Ionic distribution

- Extracellular Ions
  - Na+
  - Cl-
- Intracellular Ions
  - K+
  - Protein (negative charge)

	EXTRACELLULAR FLUID	INTRACELLULAR FLUID
Na^+	142 mEq/L	10 mEq/L
K^+	4 mEq/L	140 mEq/L
Ca^{++}	2.4 mEq/L	0.0001 mEq/L
Mg^{++}	1.2 mEq/L	58 mEq/L
Cl^-	103 mEq/L	4 mEq/L
HCO_3^-	28 mEq/L	10 mEq/L

No need to memorize the values, just know where each ion is higher Note that Na 142 in general But in boys' slides is 140 will be mentioned in slide 10

4. Causes of -ve charge of the cell

- K+ leak channel outflux (main reason)
- Large molecules Protein - RNA - DNA
- Na /k Pump

(Main reason)

- cell membrane has high permeability for k+ in resting membrane state the cell membrane will open and k+ outflux with high numbers compared to Na+ inside so cell negativity inside more than outside.
- Because it's from high concentration to low concentration there is no need for any pump (no energy needed.

Electrochemical Gradient

Electrochemical Equilibrium

An exact balance between 2 opposing forces.

- Chemical Driving Force
  - **Chemical driving force:** ratio of concentration on 2 sides of membrane (concentration gradient).
  - The concentration gradient that causes the ion to move from area of higher conc to area of lower conc.
- Electrical Driving Force
  - **Electrical driving force:** potential difference across membrane
  - Opposing electrical gradient that increasingly tends to stop the ion from moving across the membrane

Equilibrium: when electrical driving force is balanced by chemical driving force.

Male Slides Only

Chemical & Electrical Driving Forces of Potassium (K+)

1- K+ concentration intracellular is higher.

2- Membrane is freely permeable to K+ .

3- There is an efflux of K+ to ECF.

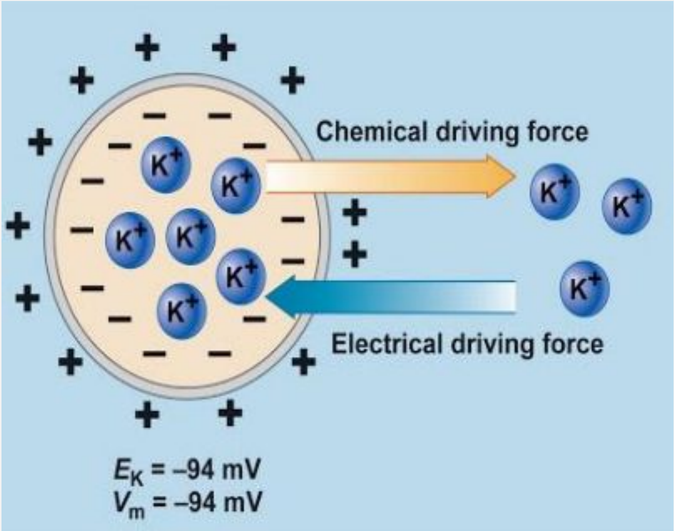
Chemical

4- Efflux of positive ions creates positivity outside & negativity inside.

5- Outside positivity resists efflux of K+ (since K+ is a positive ion).

6- At a certain voltage, equilibrium is reached and K+ efflux stops

Electrical



Male Slides Only

The Nernst Equation & Nernst/Equilibrium Potential

Nernst equation: Describes the balance of electrical and chemical forces across a cell membrane that will exactly prevent net diffusion of an ion.

- Named after Walther Hermann Nernst.

$$EMF\ (millivolts) = -\frac{61}{z} \times \log \frac{Concentration\ inside}{Concentration\ outside}$$

where *EMF* is electromotive force and *z* is the electrical charge of the ion (e.g., +1 for K^+).

ما يحتاج تحفظ القانون لكن أفضل لو تفهمه

- **Nernst potential (equilibrium potential)**: potential level across the membrane that will exactly prevent net diffusion of an ion.

Ion	Intracellular	Extracellular	Nernst Potential
Na+	14	140	+61
K+	140	4	-94
Cl+	4	103	-86
Ca2+	0.001	2.4	+127
HCO3-	10	28	-27

هذي القيمة اللي يرتاحون فيها , ما عاد
بيصير فيها دخول أو خروج

Male Slides Only

The Goldman Equation

- When the membrane is permeable to several ions, the equilibrium potential that develops depends on:

01 Polarity of each ion

02 Membrane permeability

03 Ionic concentration

- This is calculated using Goldman Equation:

EMF (millivolts)

$$= -61 \times \log \frac{C_{Na_i^+} P_{Na^+} + C_{K_i^+} P_{K^+} + C_{Cl_o^-} P_{Cl^-}}{C_{Na_o^+} P_{Na^+} + C_{K_o^+} P_{K^+} + C_{Cl_i^-} P_{Cl^-}}$$

ما يحتاج تحفظ القانون لكن أفضل لو تفهمه

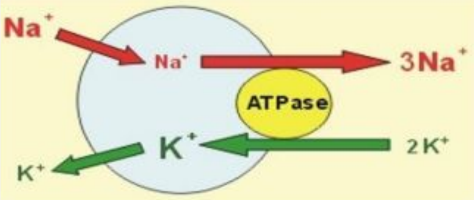
- Using this value in Goldman's equation gives a resting potential inside the membrane of -86 mV.

Boys' Doctor: K+ is the only ion that establishes the resting membrane potential in excitable tissues

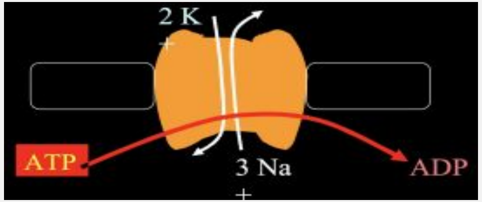
Male Slides Only

Na+ /K+ ATPase Pump

- Active transport system for Na+ /K+ exchange using energy.
- An electrogenic pump since 3 Na+ efflux are coupled with 2 K+ influx.
- Net effect of causing negative charge inside the membrane (-4 mV).



Na/K pump is the only way to get Na out

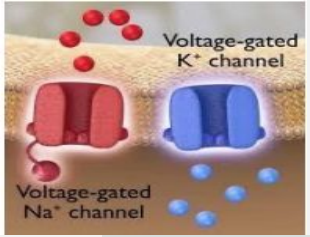


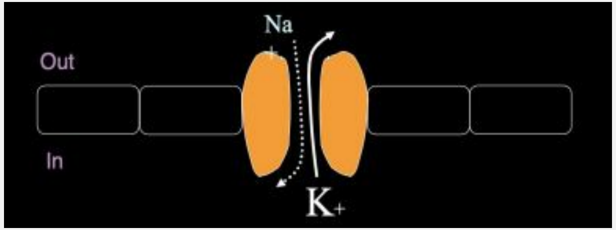
Anything with the word "pump" means it requires energy

Ionic Channels

- Leaky Channels (K+/Na+ leak channels)
  - More permeable to K+
  - Allow free flow of ions
  - Always open

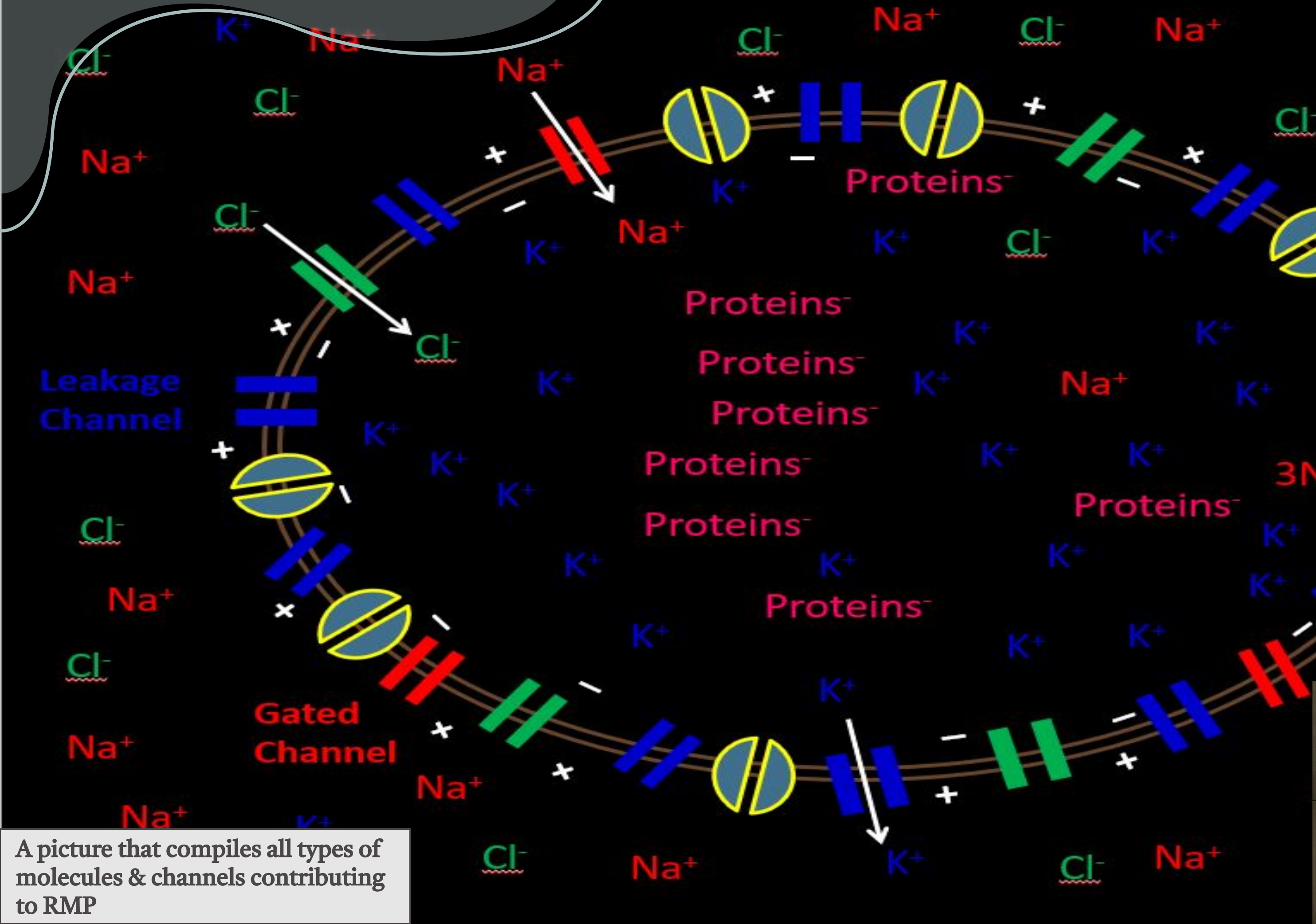
- In resting state:
  - K+ permeability 100 times greater than Na+





الصوديوم اللي يدخل منها مالها أي قيمة

The Na that enters from the leak channel "مالة قيمة"

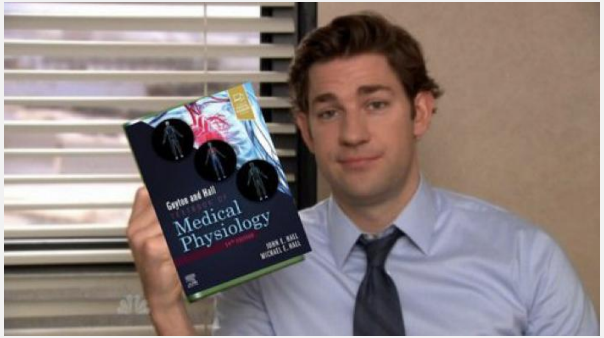


A picture that compiles all types of molecules & channels contributing to RMP

recommended video (from 0:37-17:03)

here

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

MCQs

Q1:The major ion in the resting membrane potential is?			
A- K+	B- Cl-	C- Na+	D- Ca+2
Q2:Concentration of Na+ ions in the extracellular fluid is........ mEq/L?			
A- 4	B- 10	C- 142	D- 85
Q3:The nernst potential of K+ ion is?			
A- -70	B- +127	C- +61	D- -94
Q4:The efflux of K+ to ECF happens because of ?			
A- Electrical force	B-Chemical force	C-Both	D-None

1/A 2/C 3/D 4/B

SAQs

Q1: Describe electrical driving force?

A: potential difference across membrane.

Q2: Describe electrochemical equilibrium?

A: An exact balance between 2 opposing forces.

Q3: What are the factors that affect resting membrane potential?

A: Ionic distribution across the membrane, Membrane permeability, Na^*/K^* ATPase pump.

Q4: What are the causes of -ve charge of the cell?

A: K+ leak channel outflux , Large negative protein RNA-DNA , Na/K pump.

Ahmad Addas

Nawaf Alshalan

Fawaz Almadi

Khalid Alkanhal

Abdulrahman Khaldi

Khalid Alghamdi

Talal Alrobaian

Abdullah Muhnna

Zyad Alshuhail

Ibrahim Al Bin Ali

Mays Ahmed

Alanoud Alnajawi

Joud Binkhamis

Shaden Alshammari

Lama Almoutairi

Leena Shagrani

Marwah Fal

Rahaf Mohammed

Huda Bassam

Aram Alzahrani

Noor Altalag

physiology.444ksu@gmail.com