Physiology 439

MED439
KING SAUD UNIVERSITY

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Resting membrane potential

Editing file

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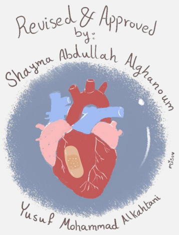
Red: Important
Black: In Male & Female slides
Blue: In male slides
Pink: In female slides
Gray: Notes & extra information



Objectives

01 Explain why some members are excitable

02 Describe the electrochemical basis of RMP

03 Describe the mechanism of generation and propagation of AP

04 Describe conduction along nerve fibers role of myelination and how nerve fibrs are classified

RMP is rest membrane potential.

mV: millivolt (unite)

Excitable tissues

Excitable tissues :

Tissues which are capable of generation and transmission of electrochemical impulses along the membrane.

Membrane potential :

A potential difference exists across all cell membranes
This is called Resting Membrane Potential (RMP).

Tissues

Non - Excitable

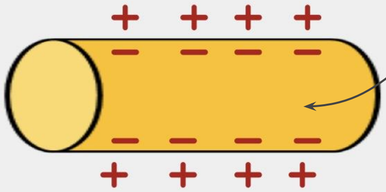
- RBC
- Intestinal cell
- Fibroblasts
- Adipocytes

Less negative RMP
-53 mv epithelial cells
-8.4 mv RBC
-20 to -30 mv fibroblasts
-58 mv adipocytes

Excitable

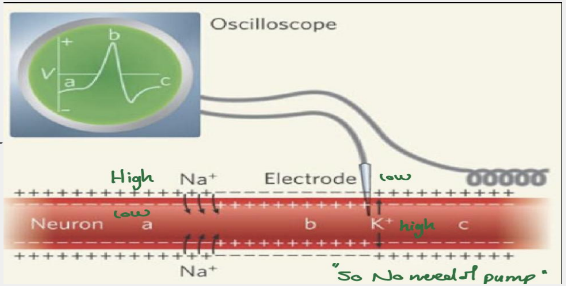
- Nerve
- Muscle :
skeletal - cardiac - smooth

Have more negative RMP
(-70mv , -90mv)



Inside is negative with respect to the outside.

This is measured using microelectrodes and oscilloscope (VOLTMETER)
This is about. -70 to -90 mV



Resting membrane potential

RMP depends on the following factors :

1. Ionic distribution across the membrane
2. Membrane permeability
3. Other factors
   - Na+/ K+ pump

Why the cell negative respect to the outside?

- k+ leak channel out flux تعد السبب الرئيسي للسالبية

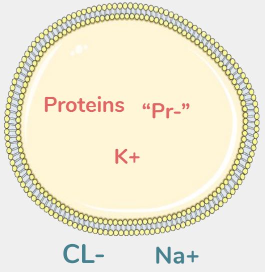
(cell membrane عنده نفاذية عالية جدًا للبوتاسيوم الموجب طبعًا يفتح في حالة الراحة وبيطلع البوتاسيوم بكميات كبيرة جدًا نسبةً للصوديوم الداخل فتكون السالبية أعلى داخل الخلية بالنسبة لخارجها)

- Large molecules (protein , RNA , DNA) كلها سالبة وموجودة داخل الخلية وماتطلع لأنها كبيرة
- Na+/k+ pump (it's just increases negativity by four mv) إذًا ما نعتبره من الأسباب الرئيسية تأثيره ضعيف يزيد السالبية حوالي 4-

*from high concentration to low concentration No need for any pump also we Consider it as passive so No need for energy .

Major intracellular ions

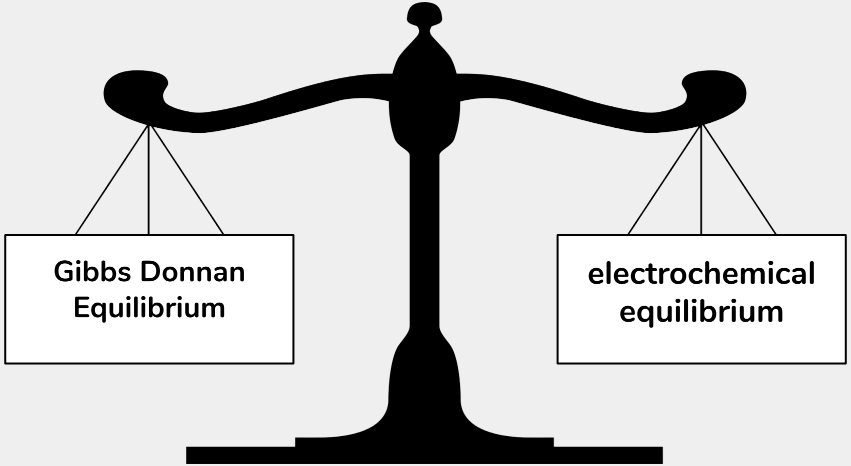
Major Extracellular ions



Gibbs Donnan Equilibrium

- When two solutions containing ions are separated by membrane that is permeable to some of the ions and not to others an **electrochemical equilibrium** is established.

- Electrical and chemical energies on either side of the membrane are equal and opposite to each other you will see in the next slides more details.



Gibbs is the scientist who discovered this

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Electrochemical gradients

At electrochemical equilibrium, there is an exact balance between two opposing forces:

1- Electrical driving force = potential difference across membrane
- opposing electrical gradient that increasingly tends to stop K+ from moving across the membrane

2- Chemical driving force = ratio of concentrations on 2 sides of membrane (concentration gradient).
- The concentration gradient that causes K+ to move from inside to outside taking along positive charge and

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

This slide was found only in male slides

Chemical & Electrical driving forces of Potassium(K+)

Chemical

- K+concentration intracellular is higher
- Membrane is freely permeable to K+
- There is an efflux of K+ to extracellular fluid

Electrical

- Efflux of positive ions creates positivity outside and negativity inside
- Outside positivity resists efflux of K+ (since K+ is a positive ion)
- At a certain voltage, equilibrium is reached and K+ efflux stops

Nernst equation & goldman

know that the nernst equation describes the ***balance of electrical and chemical forces that will prevent diffusion of ion***.

-goldman equation later and is more accurate.

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

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

EMF (millivolts)

$$= -61 \times \log \frac{C_{Na^+_i} P_{Na^+} + C_{K^+_i} P_{K^+} + C_{Cl^-_o} P_{Cl^-}}{C_{Na^+_o} P_{Na^+} + C_{K^+_o} P_{K^+} + C_{Cl^-_i} P_{Cl^-}}$$

This slide was found only in male slides

Nernst potential and Goldman Equation

Nernst potential : or equilibrium potential is the potential level that will prevent net diffusion of specific ion. make sure you memorise Na+ and K+ values.

the equilibrium potential inside the membrane depends on :

- polarity of each ion
- membrane permeability
- ionic concentration
- Goldman equation gives a resting potential inside the membrane of -86 mV

It's important to Memorise K & Na Nernst potential values. + to be on the safe side know the chief ions :)

Ions	Intracellular	Extracellular	Nernst potential
Na+	14	142	+61
K+	140	4	-94
Cl-	4	103	-86
Ca2+	0.0001	2.4	+134
Hco3-	10	28	-27

Na+/K+pump and ionic channel

Na+/K+ pump: (it's just increases negativity by four mv)

-Active transport system for Na+/K+ exchange using energy therefore it requires energy in the form of ATP.

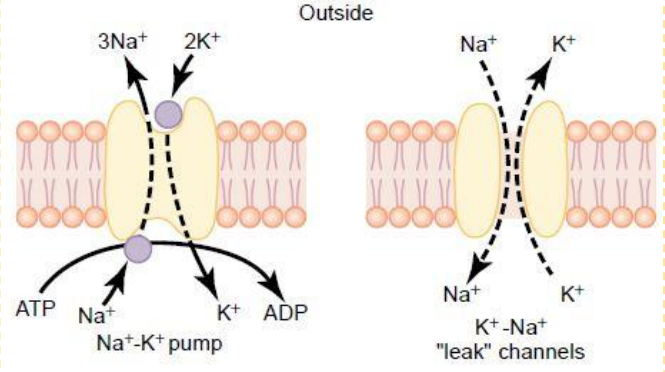
- It is an electrogenic pump since 3 Na+ efflux coupled with 2 K+influx

-Net effect of causing negative charge inside the membrane

Ionic channels:

Leaky channels example (K+/Na+ leak channels) are more permeable to K and allow free flow of ions.

-In **resting state** K+ permeability is 100 times more than Na+.



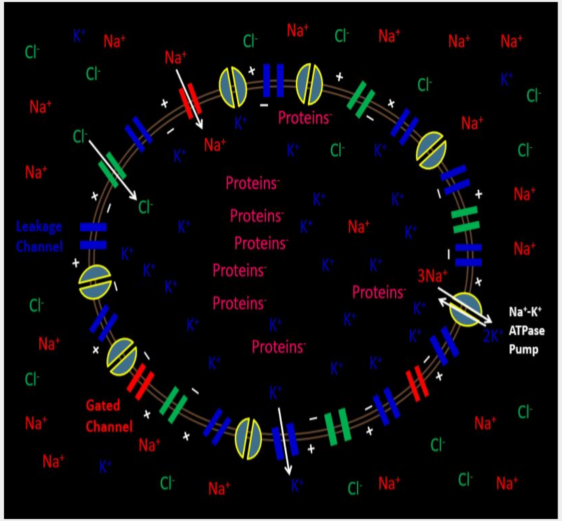
نجمع معلوماتنا باختصار تخيلوا معي الخلية دائمًا مثل هذا الكيس المليااااان بوتاسيوم داخلها بيكون أكثر وبحالة الراحة السيل ممبرين بيطلع البوتاسيوم بشكل سلس بدون طاقة ولا شيء لأنه من عالي لقليل وبنفس الأسلوب بالمقابل بيدخل صوديوم بدون طاقة كذلك ، لكن ليييييش ما قلنا أنه بيتعادل وماراح يصير عندي فرق بالشحنة بما أنه بيطلع بوتاسيوم موجب وبيدخل صوديوم موجب بعد ؟ السبب مثل ما ذكرنا أنه نفاااااذية السيل ممبرين للبوتاسيوم أعلى ب١٠٠ ضعف من نفاذيته للصوديوم باختصار مقابل كل ١٠٠ بوتاسيوم يطلع بيدخل لي ١ صوديوم إذًا السالبية داخل الخلية بتكون أعلى من خارجها

Efflux = **Ex**it the cell
Influx = **En**ters the cell

Factors contributing to RMP

- The main and important factor is K+ efflux (Nernst Potential:-94mV).
- Contribution of Na+ influx is little (Nernst Potential:+61mV) .
- Na+/K+ pump creates additional degree of negativity inside the membrane (-4mV).
- also the proteins are negatively charged so they will contribute.

overall net result is -70 to-90 mV inside the cell.



QUIZ!

MCQs

Q1: all of the following non excitable tissue except :			
A) Fibroblast cells	B) Adipocytes	C) epithelial cells	D) Cardiac muscle
Q2: we consider Na / K pump as :			
A) Active transport with energy	B) active transport without energy	C) passive transport with energy	D) passive transport without energy
Q3 :which one is true about the factors contributing to RMP :			
A) K+ efflux nernst potential : -94 mv	B) Na+ efflux by leaky channel is high	C) negatively charged proteins freely crossing out.	D) Na/k pump create <u>high</u> additional negativity
Q4 :which of the following is the most important factor in contributing to RMP?			
A) Na/K Pump	B) K+ EFFLUX	C) Fibroblast cells	D) Protein
Q5 :overall net result inside the cell in mV			
A) 35-40 mV	B) 70-90 mV	C) -70-90 mV	D) 100mV

SAQ

Q1: RMP depends on 3 factors mention them:

Q2: Define Excitable tissue :

MCQs key answer :
1) D
2) A
3) A
4) B
5) C

SAQ answer key :
1) ionic distribution across the membrane - membrane permeability- Na/K pump
2) slide 3

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THANK YOU

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Question bank