Editing file

Resting membrane potential

- Red : important
- Black : in male / female slides
- Pink : in female slides only
- Blue : in male slides only
- Green : notes
- Gray : extra
- Guyton

Objectives

- Explain why some membranes are excitable.
- Describe the electrochemical basis of Resting Membrane Potential (RMP).
- Describe the mechanism of generation and propagation of Action Potential (AP).
- Describe conduction along nerve fibers, role of myelination and how nerve fibers are classified.

Excitable Tissue and Membrane Potential

- Excitable tissues: Tissues that can produce or transmit an electrochemical impulse when stimulated.

- Excitable Tissues: Tissues which are capable of generation and transmission of electrochemical impulses along the membrane

- All other body tissues are not excitable. (for example RBCs, Intestinal cell, Adipocytes and Fibroblasts)
- Example of excitable tissues: nerve tissues and muscle (Skeletal, Cardiac and Smooth)

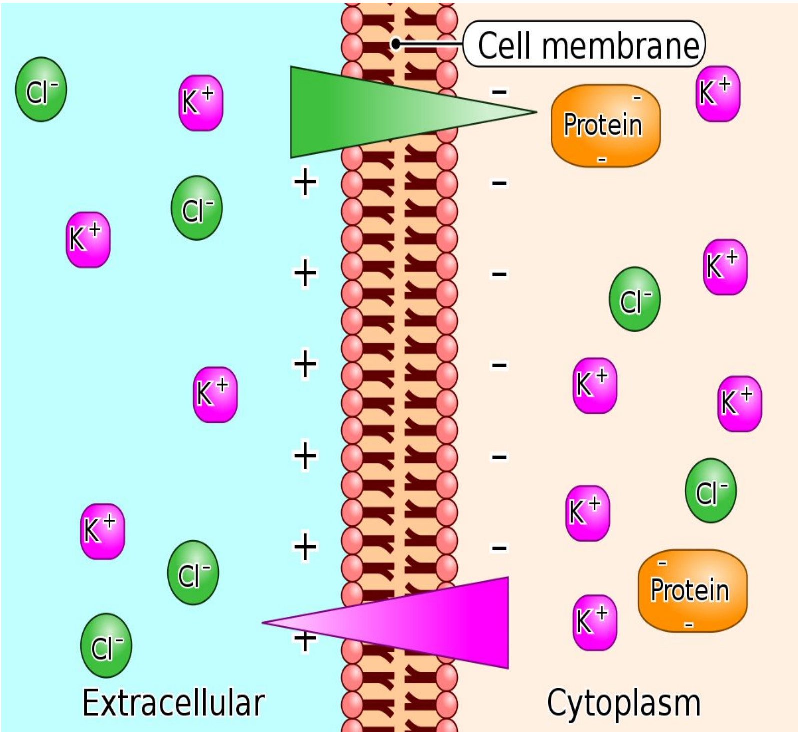
- Resting Membrane Potential (RMP): is the potential difference across the cell membrane caused by ions inside and outside the cell when there is no stimulus.

- It is more negative inside the cell, this is in part because intracellular proteins (-ve charge) can't permeate the membrane, thus staying inside the cell.

Excitable Tissue and Membrane Potential

- Other ions (mainly K+, Na+, and Cl-) have varying membrane permeability, and move based on chemical force (concentration gradients) or electrical force (charges).
- RMP is measured by a voltmeter to be -70 to -90 mV.

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.

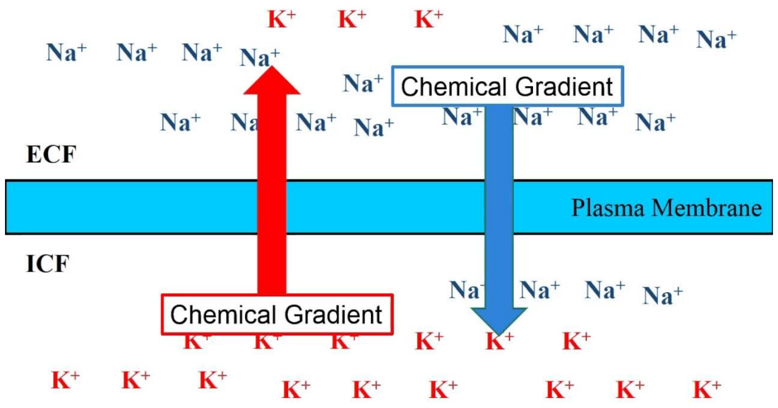


non excitable tissue:
Non-excitable tissues have less negative RMP
-53 mV epithelial cells
-8.4 mV RBC
-20 to -30 mV fibroblasts
-58 mV adipocytes

excitable:
Excitable tissues have more negative RMP (- 70 mV to - 90 mV)

Factors of Resting Membrane Potential

K+ efflux (male slides only)	Na+ influx (male slides only)	Na+/K+ pump
• K+ ions move outside the cell (down its concentration gradient) through K+ leaky channels. • Since the outside is more positive, an electrical force slightly resists this efflux. • At a certain voltage an equilibrium is reached and K+ efflux stops, this is called the ion's Nernst Potential. • K+ is the main factor of RMP.	• Na+ ions move into the cell (down its concentration gradient) through Na+ leaky channels. • Na+ permeability is 100 times less than that of K+. • Using Goldman's Equation, the membrane potential equals -86 mV. • the value is much closer to K+ potential due to its permeability.	• An electrogenic pump (producing a change in the cell's electrical potential). • It uses ATP (Active transport system) to pump 3 Na+ out of the cell and 2 K+ into the cell (against their concentration gradients). • Creates additional negativity inside the cell (-4 mV). (the reason for that is the net loss of +ve ions from inside the cell).



البنات صح مو موجودة عندنا لكن الدكتورة شرحتها

Ion	ICF	ECF	Nernst potential
K+	14	142	-92 mV
Na+	140	4	+61 mV
Cl-	4	103	-86 mV

Resting Membrane Potential cont

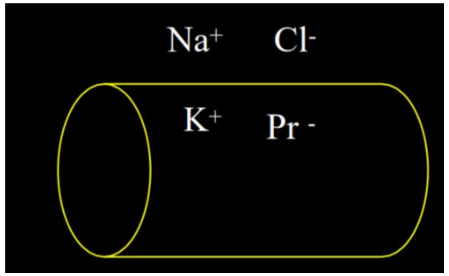
Ionic channels

- Leaky channels (K+/Na+ leak channels)
  - More permeable to K
  - Allows free flow of ions

Ionic distribution

- Major ions
  - Intracellular ions
    Ex. K+ , Proteins
  - Extracellular ions
    Ex. Na+ , Cl-

In the resting state K+ permeability is 100 times more than that of Na+



Resting Membrane Potential cont

drs note : تذكرو الخلية كيس بوتاسيوم كبير !

Resting Membrane Potential factors:
- Ionic distribution across the membrane
- Membrane permeability
- other factors:

- One of the main factors 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).
- Negatively charged protein ions remaining inside the membrane contributes to the negativity.
- Net result: -70 to -90 mV inside.

Nernst Potential and Goldberg Equation

- **Nernst potential:** the potential level that will prevent net diffusion of a specific ion.
- In other words, it when the ion efflux and influx are equal in rate.
- It is calculated using the following formula, where Z is the charge of the ion.

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

- The **Goldberg equation** is similar to the Nernst equation, but it takes into effect several ions instead of one. This gives you a potential of -86 mV inside the membrane.

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

- (Goldberg equation) + (Na/K pump) = (-86 mV) + (-4 mV) = -90 mV.

This table shows the Nernst potentials of the major cell ions

Ion	Nernst potential
K+	-92 mV
Na+	+61 mV
Cl-	-86 mV
Ca2+	+134 mV
HCO3-	-27 mV

Example Calculations

From Guyton
(Not included in the slides only for your information)

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

K+	Na+	Ca2+
$EMF = -\frac{61}{z} \times \log \frac{Conc.In}{Conc\ Out}$	$EMF = -\frac{61}{z} \times \log \frac{Conc.In}{Conc\ Out}$	$EMF = -\frac{61}{z} \times \log \frac{Conc.In}{Conc\ Out}$
$EMF = -\frac{61}{+1} \times \log \frac{140}{4}$	$EMF = -\frac{61}{+1} \times \log \frac{14}{142}$	$EMF = -\frac{61}{+2} \times \log \frac{0.0001}{2.4}$
$94 = -\frac{61}{+1} \times 1.54$	$61 = -\frac{61}{+1} \times -1.006$	$134 = -\frac{61}{+2} \times -4.38$

Quiz

SAQ

Q1- mention 3 affecting RMB factors?
Q2-give 2 examples of an excitable tissues?

Answers
SAQ1-
k efflux
Na influx
NaLK Pump
SAQ2- nerve, muscles

1)	Which one of the choices is not an excitable tissue?	2)	which one is not a factor of RMP?
A.	muscles.	A.	NA\K Pump.
B.	myofibrils.	B.	NA influx
C.	neurons	C.	k influx
D.	RBCs	D.	Ionic distribution.

3)	Which of these statements is not true about RMP?	4)	Which one of these ions IS NOT major extracellularly?
A.	it is a potential different.	A.	Na
B.	works on excitable tissues only	B.	Mg
C.	voltage gated channels is an affecting factor.	C.	Cl
D.	cell membrane is 100 times more permeable to K than Na	D.	

Answers key: 1d) 2c) 3c) 4b)

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Thank you

@physiology438

Editing file

Summary file for your revision