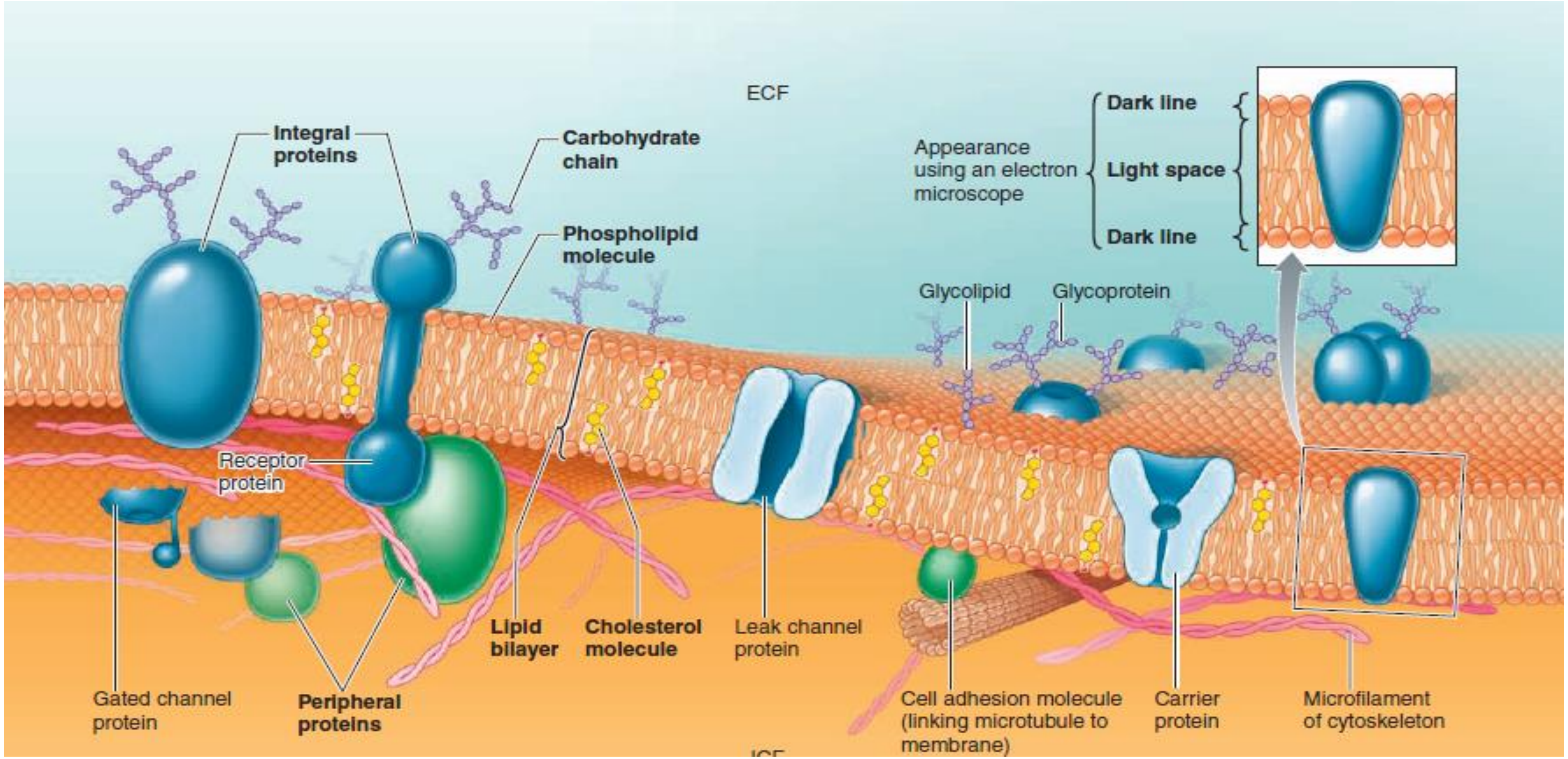

PHYSIOLOGY
النادي الطبي
Lec: 10 (للدكتور زهير)
Done by: leen Almulaifi

Lecture Objectives

- Describe the ionic concentration of major ions in the ECF and ICF (Review)
- Describe the ionic channels in the cell membrane (Review)
- Understand the function of the Na-K ATPase pup (Review)
- Understand and define the concept of diffusion potentials and equilibrium potential
- Understand the Nerst equation and its application to in calculating the equilibrium potentials of different ions and resting membrane potential
- Understand the GHK equation and its use in estimating the resting membrane potential

التفريغ بالنسبة لريكورد شعبة A

Cell membrane channels



Ion Channels In The Cell Membrane

لازم نكون عارفين إنه الـ membrane بكون selective ، يعني ما بدخل اي جزيء
حتى لو اختلفت التراكيز فهو بعطي رخصة الجزيئات حتى يدخلوا

دايمًا فاتحات

يسمح ←

- Leak ionic channels always permit the movements of selected ions across the cell membrane. Example K and Na channels → $[K^+] \uparrow$ ICF $[Na^+] \uparrow$ ECF

- Voltage-gated channels have gates that are controlled by changes in membrane potential. For example, the activation gate on the nerve Na+ channel is opened by depolarization of the nerve cell membrane; opening of this channel is responsible for the upstroke of the action potential.

بصير بسبب توزيع الايونات الغير متساوي

عملية بتقلل السالبية داخل الخلية

- Ligand-gated channels have gates that are controlled by hormones and neurotransmitters like acetylcholine

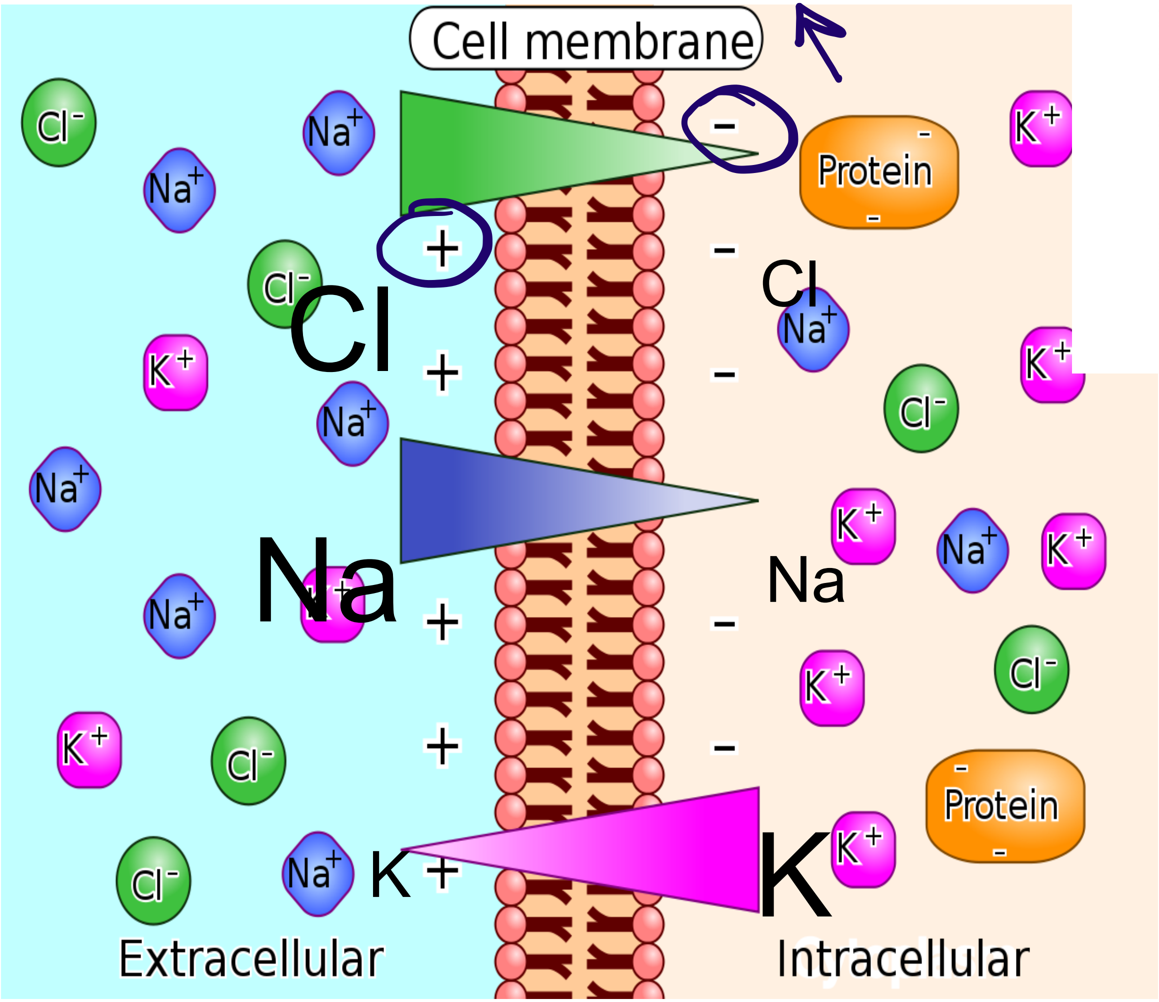
يعتمد على وجود نواقل عصبية

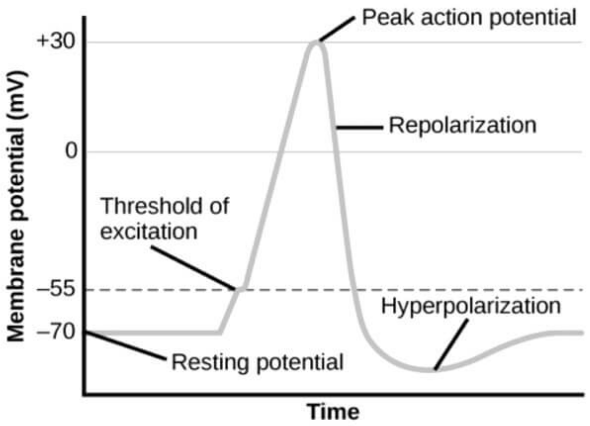
إذا صار depolarization
← الـ action potential برتفع فجأة

Ionic composition and distribution across the cell membrane

leak ionic channels

بالوضع الطبيعي السالبية داخل الخلية أكبر





Na^+(outside): 142 mEq/L

Na^+(inside): 14 mEq/L

K^+(outside): 4 mEq/L

K^+(inside): 140 mEq/L

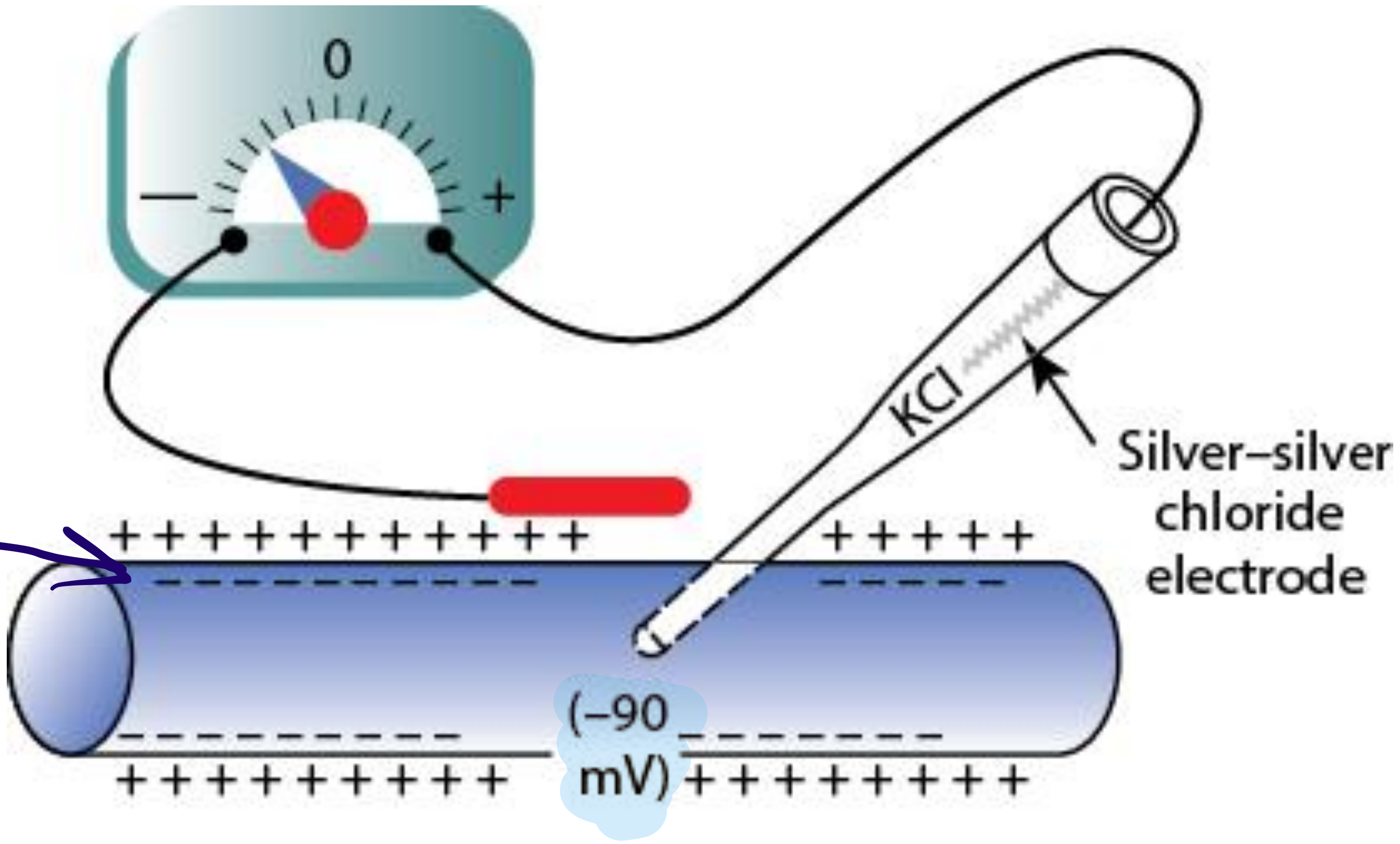
$$Na^+_{inside}/Na^+_{outside} = 0.1$$

$$K^+_{inside}/K^+_{outside} = 35.0$$

Measurement of resting membrane potential

لـ في الغالب يكون سالب داخل الخلية وخارجها موجب

عملو تجربة لحتى يطلعوا القيمة



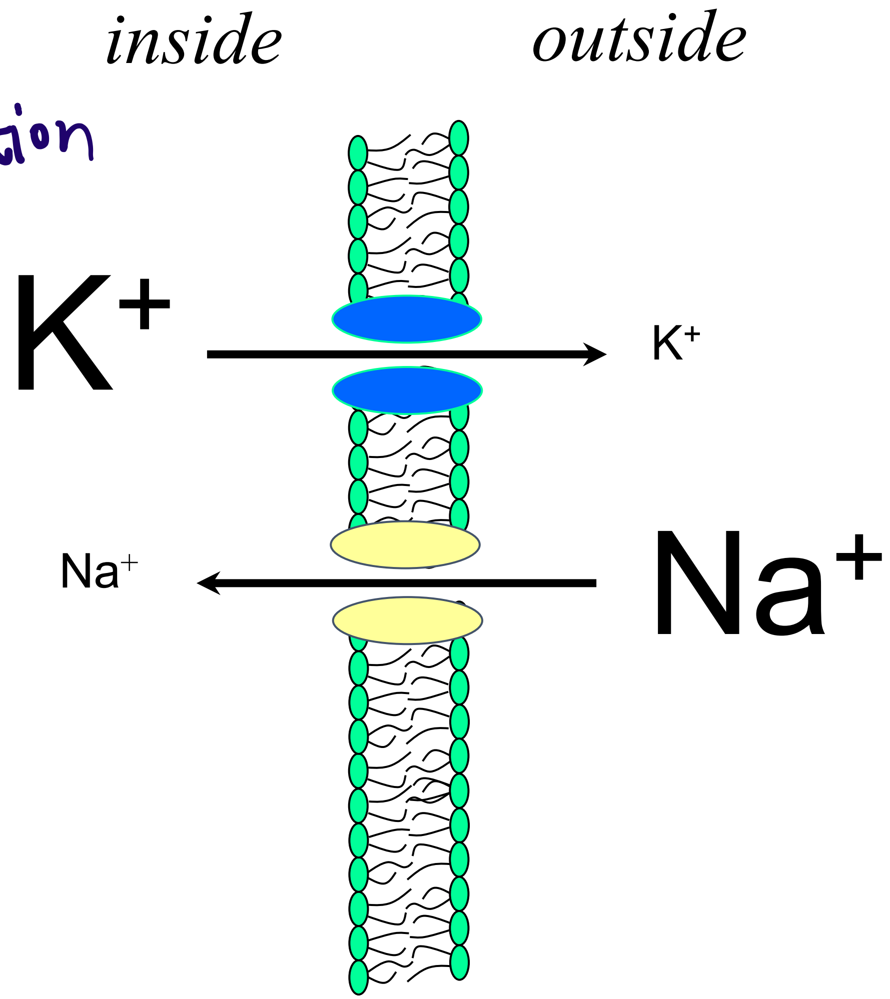
Simple Diffusion of Na^+ and K^+

through leak channels

no ATP

move due to its concentration gradient

من أعلى تركيز للأقل تركيز



Active Transport of Na^+ and K^+

uses ATP

ما بتشتغل غير لما يكونوا الا ثنين موجودين

(زي المخطوبين😭)

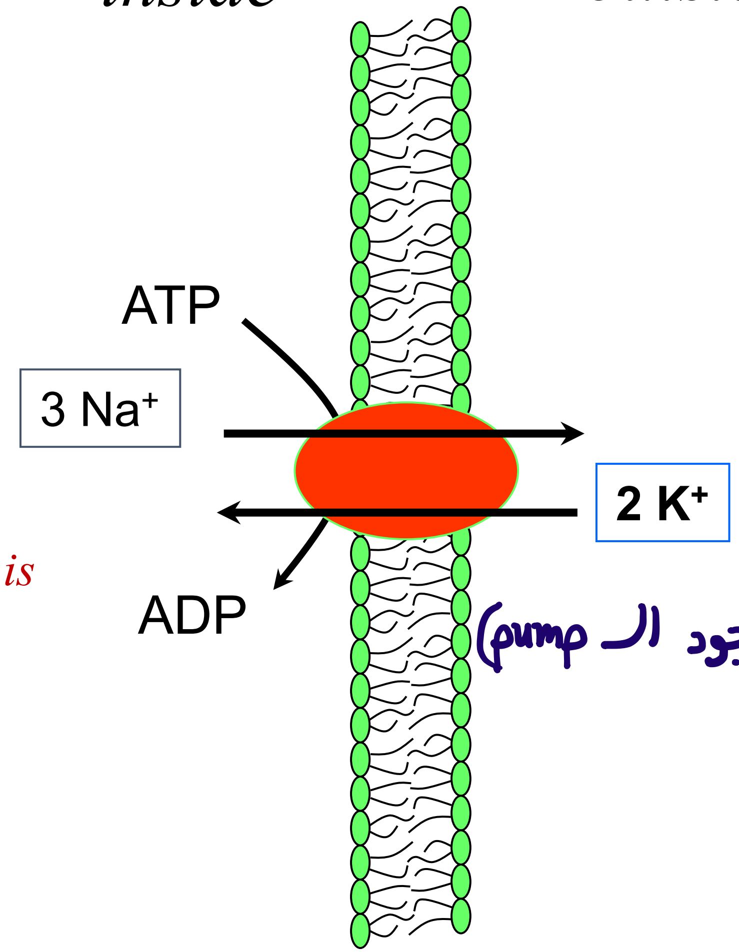
inside *outside*

K^+

Na+

Na^+

K+



no equilibraim

إذا تساوت التراكيز في حال عدم وجود الـ pump
رح يخرب عمل الخلايا

مهمة عشان ما يتحقق تساوي في الشحنات

Na K ATPase pump

Moves ions against concentration gradients

Sodium is pumped out of the cell, potassium is pumped in

The ATPase Na , K pump maintains concentration gradients

Coupling ratio is 3Na : 2K ⟸ مهم

what causes the resting membrane potential ←

Diffusion Potential

من الأعلى للأقل

- A diffusion potential is the potential difference generated across a membrane when a charged solute (an ion like K or Na) diffuses down its concentration gradient. (is caused by diffusion of ions)
- The magnitude of a diffusion potential, measured in millivolts (mV),and it depends on the magnitude of the concentration gradient, where the concentration gradient is the driving force.

1 electrical gradient

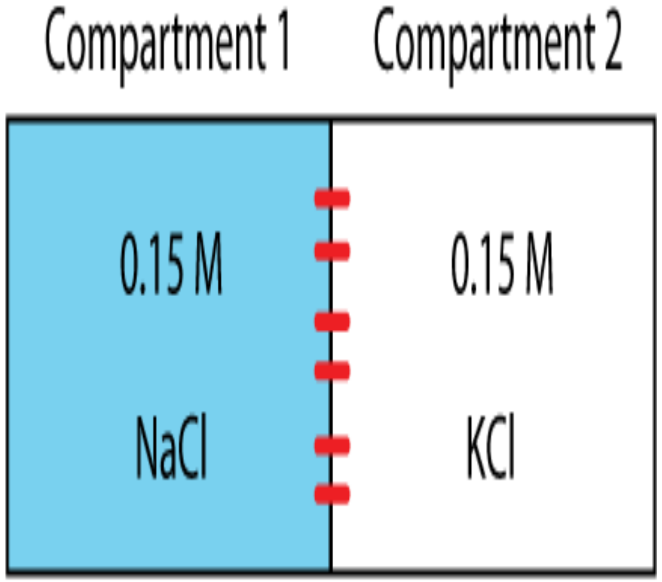
- The sign of the diffusion potential depends on the charge of the diffusing ion and the direction of movement

2 concentration gradient

- Finally, diffusion potentials are created by the movement of only a few ions, and they do not cause changes in the concentration of ions in bulk solution.

Diffusion potentials

- No channels
- So no diffusion across the membrane despite concentration gradients
- No separation of charge
- Membrane potential = 0



no channels = no diffusion

1- concentration gradient
2- permeable membrane

← شروط حدوث ال diffusion potential

Diffusion potential across cell membrane when the membrane is only permeable to K ions

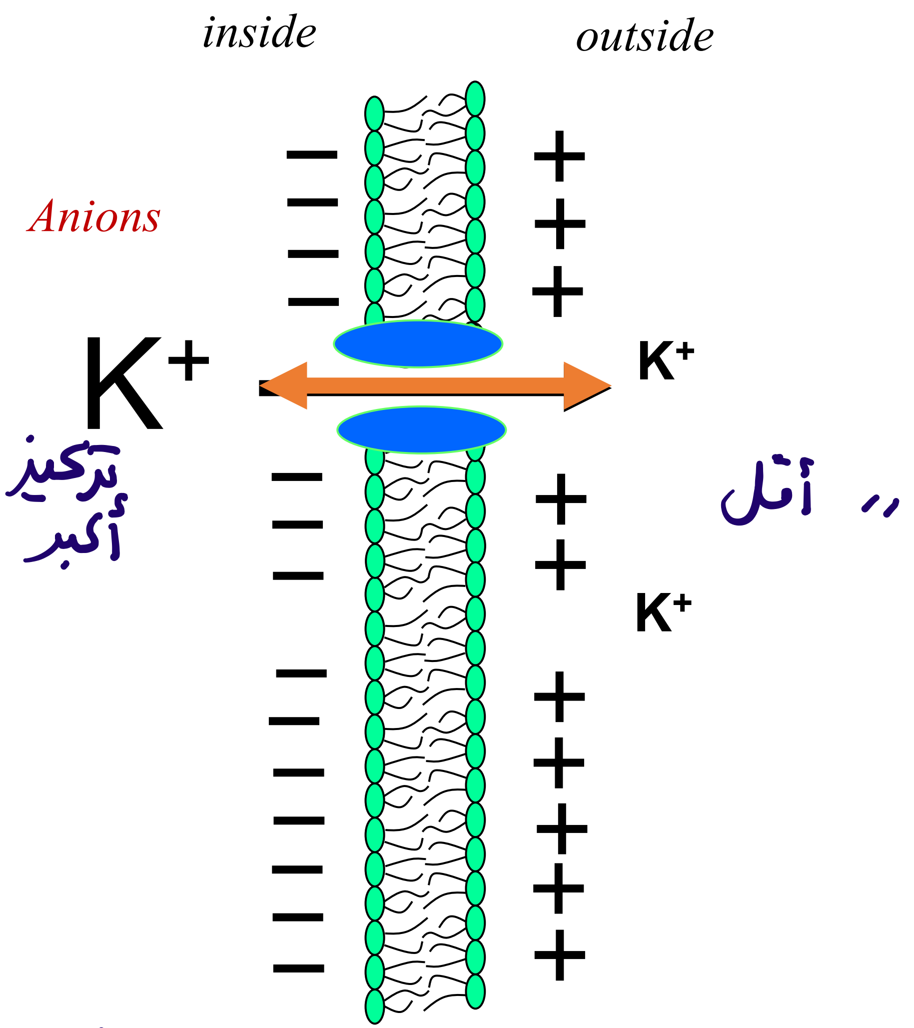
في حالة مرور
ال K+ فقط

If a membrane were permeable to only K^+ then…

K^+ would diffuse down its **concentration gradient** *creating positivity outside the membrane and electronegativity inside because of negative anions that remain behind and do not diffuse outward with the potassium* until the **electrical potential** across the membrane countered diffusion.
At equilibrium potential no net movement of K ions across cell membrane occurs

نفس القيمة عكس الاتجاه

The electrical potential that counters net diffusion of K^+ is called the K^+ equilibrium potential (E_K)/ K^+ Nernst Potential



equilibruim potential happens when electron force equals chemical force

+ (force of ions)

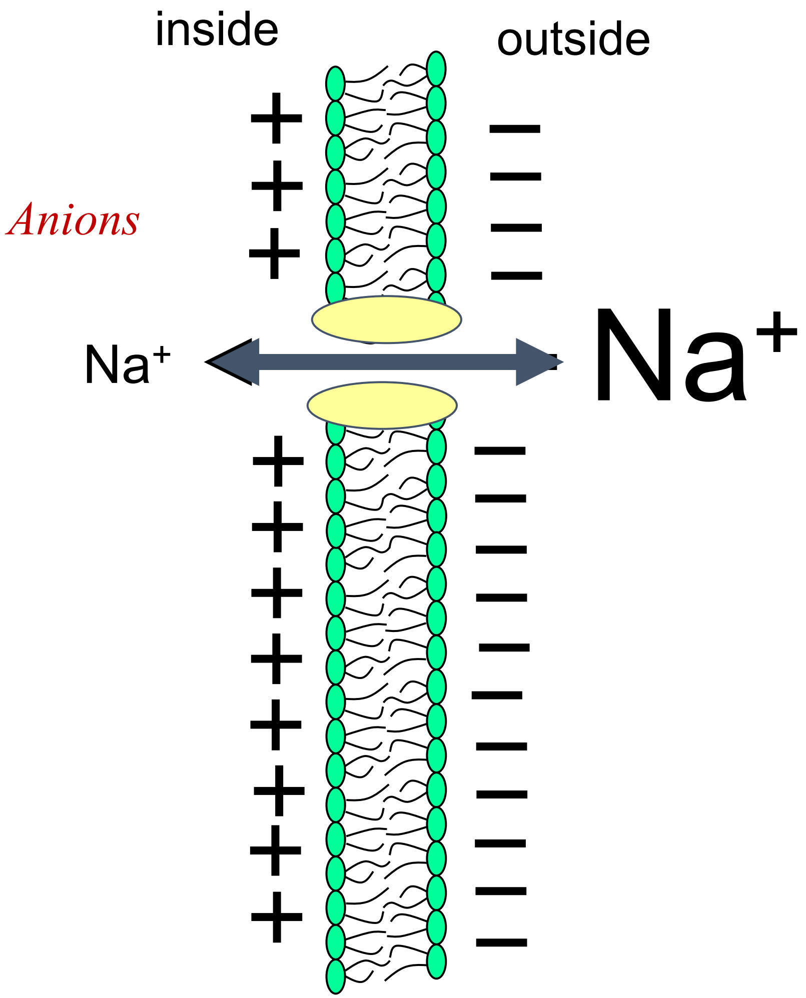
Diffusion potential when the membrane is permeable to Na ions

leak channels

If a membrane were permeable to only Na^+ then…

Na^+ would diffuse down its concentration gradient→negativity outside and positivity inside until potential across the membrane countered diffusion.

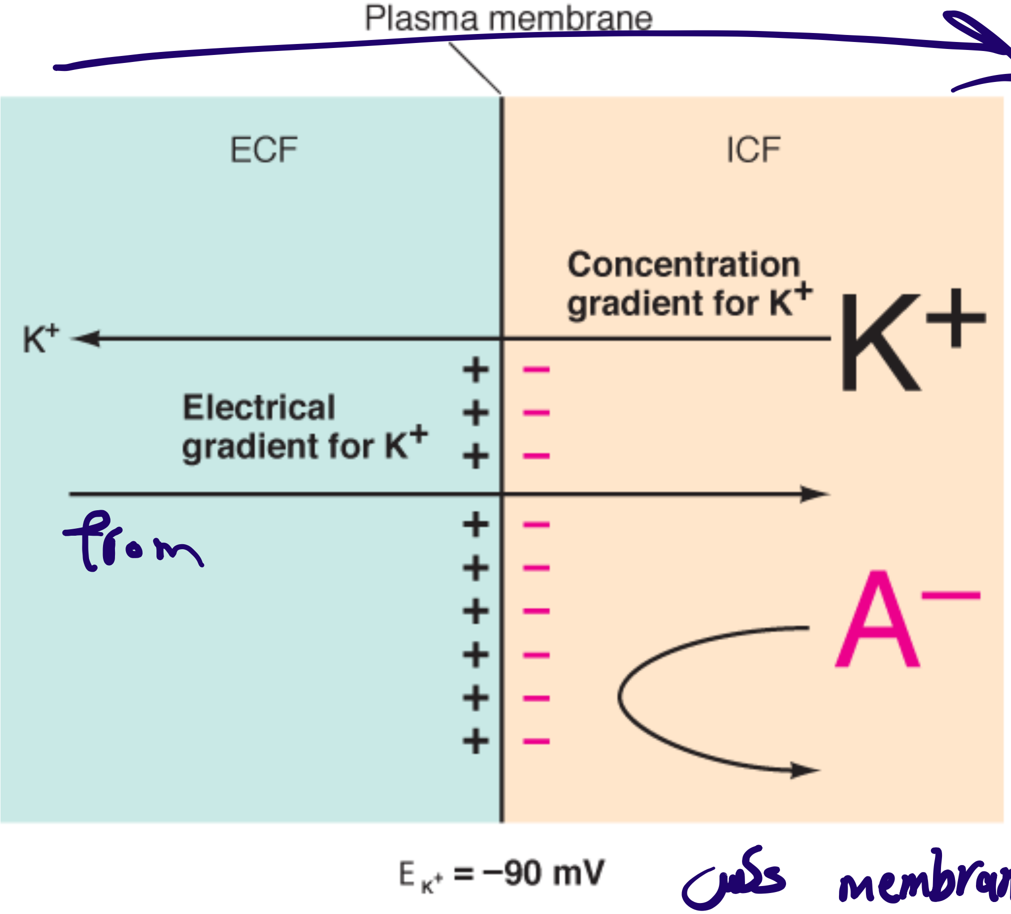
The electrical potential that counters net diffusion of Na^+ is called the Na^+ equilibrium potential (E_{Na}).



Diffusion potential and equilibrium potential for K ions (—)

ال equilibrium بكون لحظي فقط، موجود بالجسم
هو ال Homeostasis (steady state)

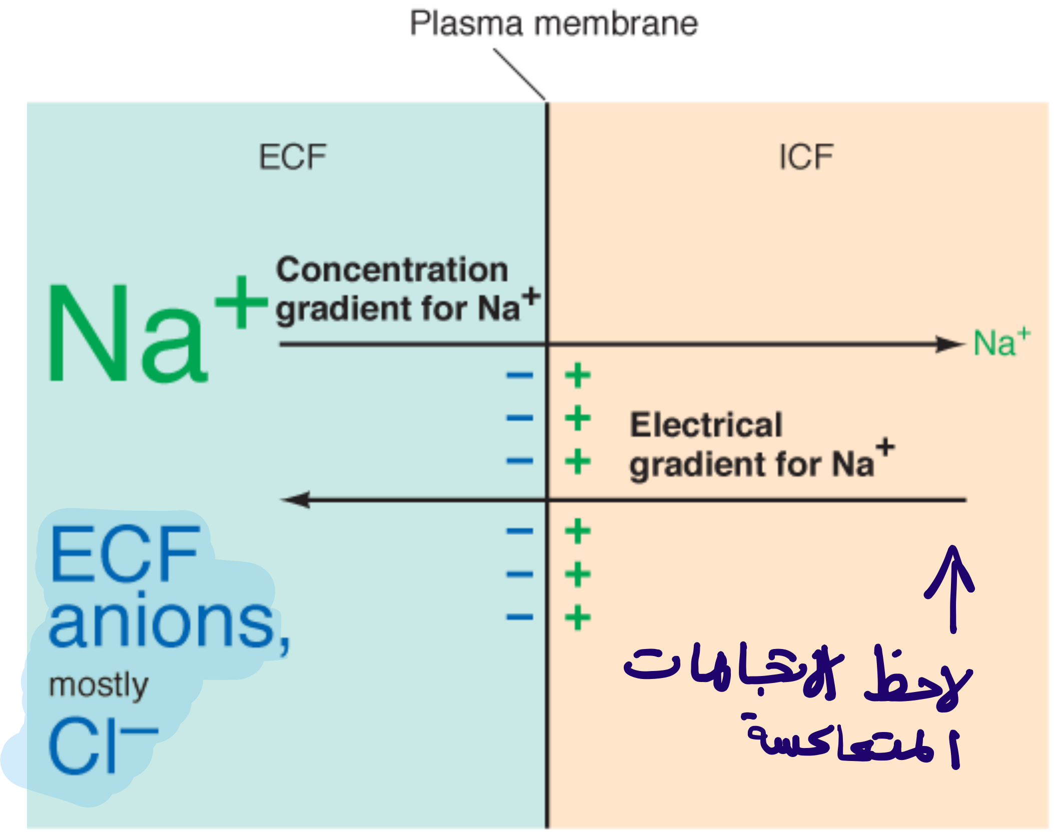
النقاط بتتدرس



1. The concentration gradient for K^+ tends to push this ion out of the cell.
2. The outside of the cell becomes more + as the positively charged K^+ ions move to the outside down their concentration gradient.
3. The membrane is impermeable to the large intracellular protein anion (A^-). The inside of the cell becomes more – as the positively charged K^+ ions move out, leaving behind the negatively charged A^-.
4. The resulting electrical gradient tends to move K^+ into the cell.
5. No further net movement of K^+ occurs when the inward electrical gradient exactly counterbalances the outward concentration gradient. The membrane potential at this equilibrium point is the equilibrium potential for K^+ (E_{K^+}) at –90mV.

بكون ال membrane potential عكس
إشارة ال potential ل K+ (موجب)

Diffusion potential and equilibrium potential for Na ions (+)



E_{Na^+} = +60 mV

1. The concentration gradient for Na^+ tends to push this ion into the cell.
2. The inside of the cell becomes more + as the positively charged Na^+ ions move to the inside down their concentration gradient.
3. The outside becomes more – as the positively charged Na^+ ions move in, leaving behind in the ECF unbalanced negatively charged ions, mostly Cl^-. → ما بقدر يخترق الـmembrane فنخلق شحنة سالبة
4. The resulting electrical gradient tends to move Na^+ out of the cell.
5. No further net movement of Na^+ occurs when the outward electrical gradient exactly counterbalances the inward concentration gradient. The membrane potential at this equilibrium point is the equilibrium potential for Na^+ (E_{Na^+}) at +60 mV.

لاحظ الإشارة

Equilibrium potential (Nerst potential)

اللي بخططه حكا عنه الدكتور بالمحاضرة

- The concept of is simply an extension of the concept of diffusion potential. If there is a concentration difference for an ion across a membrane and the membrane is permeable to that ion, a potential difference (the diffusion potential) is created. Eventually, net diffusion of the ion slows and then stops because of that potential difference
- **Equilibrium potential** is the diffusion potential that exactly balances (*opposes*) the tendency for diffusion caused by a concentration difference. At electrochemical equilibrium, the chemical and electrical driving forces that act on an ion are equal and opposite; therefore, no net diffusion of the ions occur.

نفس الشي

- **Nerst Potential** The potential across the cell membrane that exactly opposes net diffusion of a particular ion through the membrane= the membrane potential at which there is no net (overall) flow of that particular ion from one side of the membrane to the other) → تعريف الـ diffusion
- At electrochemical equilibrium (Equilibrium Potential) , the chemical and electrical driving forces acting on an ion are equal and opposite, and no further net diffusion occurs
- Nernst Equation is used to calculate the equilibrium potential for an ion at a given concentration difference across a membrane, assuming that the membrane is permeable to that ion

بحسب منه الـ equilibruim potential ← لأيون معين بشرط إنه يخترق الـ membrane

Nernst equation and calculations of the equilibrium potential (Nerst potential)

- Electromotive force (mv)

= (RT/ZF) log (C_o /C_i)

. **EMF (mV)** = ±61 x log $\frac{\text{Ion conc. Inside}}{\text{Ion conc. outside}}$

- C is concentration of the ion [X^+]
- ***C_o = [X+] outside cell***
- ***C_i = [X+] inside cell***

- R = gas constant
- T = Temp. ° Kelvin
- Z = charge on ion
  - -1 for Cl^-, +2 for Ca^{2+}
- F = Faraday's number
  - charge per mol of ion
- ln means log to base e

يعطيكم العافية
حاولو ما تصيرو هيكل
عظمي🥰