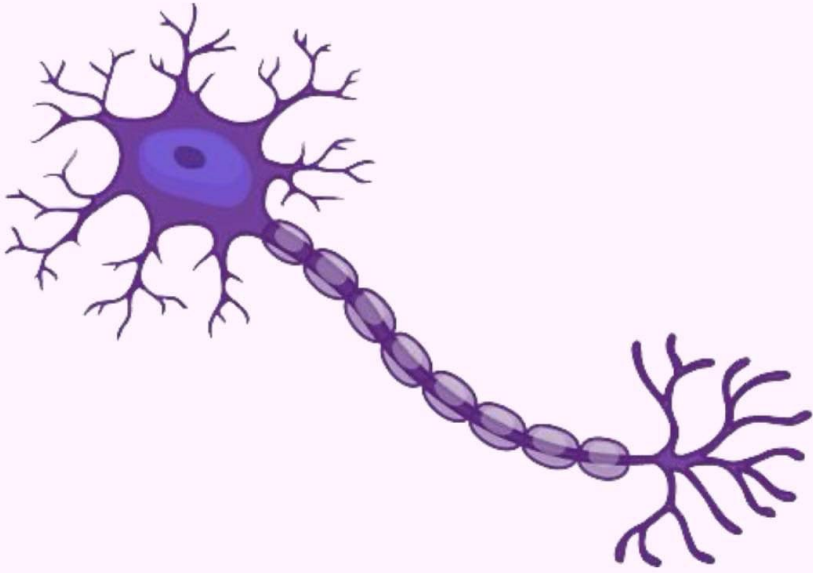




# PHYSIOLOGY



LEC NO. : 10

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وَقُلْ رَبِّ زِدْنِي عِلْمًا

# MEMBRANE POTENTIAL AND SYNAPSES

BY D GEHAN EL WAKEEL

## Action potential = nerve impulse

لانو صار عندي فكرة ادت لاني اعمل action

inside(-)  
outside(+)

**-Def:** action potential is the potential changes which occur in RMP of the nerve due to stimulation by effective stimulus, these changes propagate (self propagated) along the nerve, then reach the effector organ to produce action (hence the name action potential).

يعني بتتحرك من عصب لعصب ،  
نازلة من المخ لحد ما توصل للعضو  
المتأثر

RMF= polarization (استقطاب)

Action potential = depolarization

عشان يصير عندي الاكشن بوتينشل لازم يصير عندي  
مؤثر ، حطيت ايدي على اشني سخن او غزيت حالي  
بدبوس او قد يكون هاد المؤثر فكره تخليني امشي لقدام

## Ionic basis of action potential

Action potential is composed of 3 main processes:

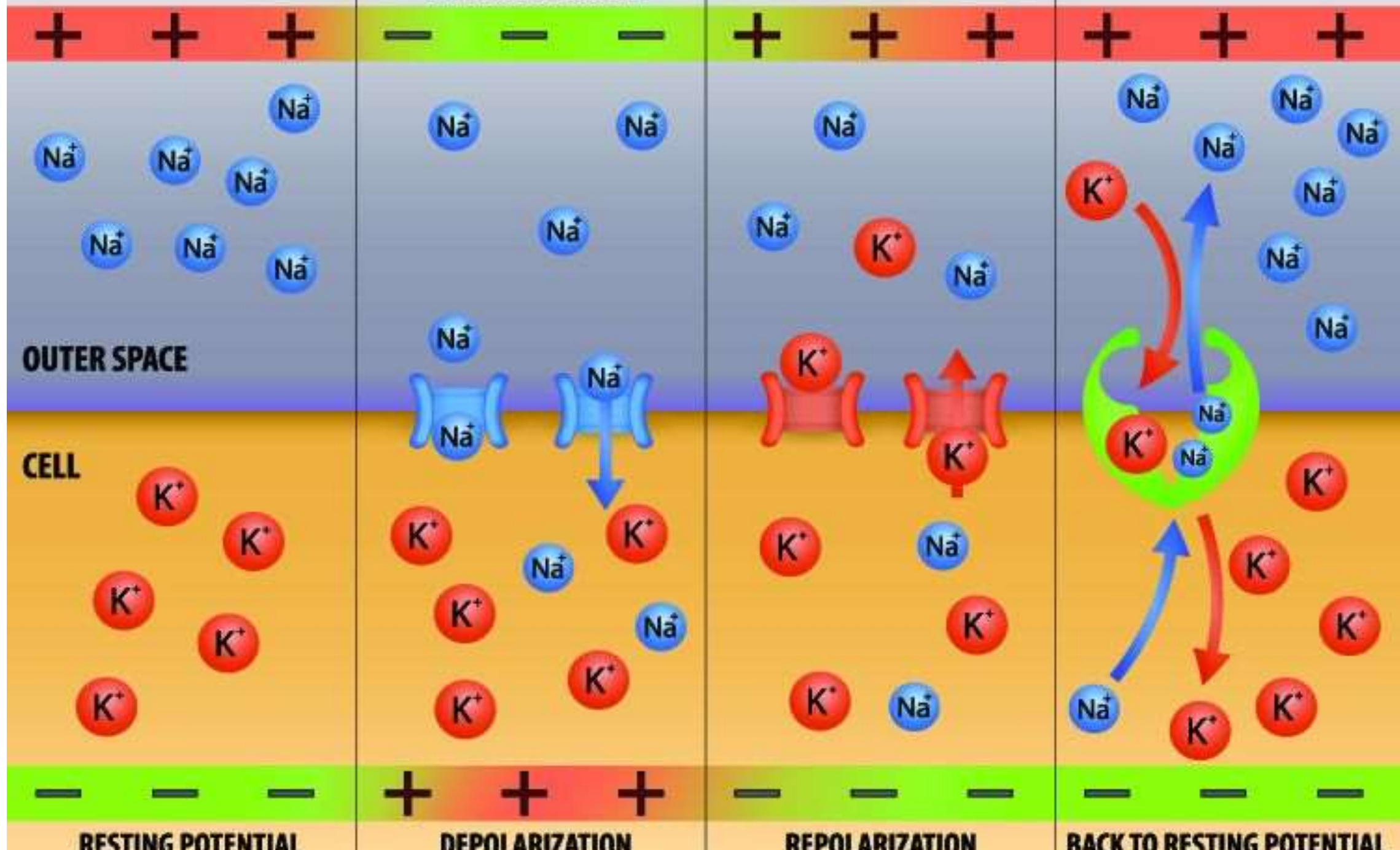
A- Depolarization.

B- Repolarization.

C- Redistribution of ions.

Q phases of the action potential)  
← 1/2/3.

# ACTION POTENTIAL



**Depolarization:** . تتغير الاشاره عن طريق بصير جوا الخليه موجب و خارج الخليه سالب  
المؤثر عمل على فتح قنوات الصوديوم ادى الى انو الصوديوم صار يدخل من بره لجوا  
Depolarization occurs due to the opening of the sodium channel .

**Repolarization :** انا عشان الاشاره تمر لازم يكون الجدار عندي بحالة الريست مشان هيك لازم ارجع  
عمل repolarization /RMP  
فعشان ارجعها لحاله الRMP بدي اخلي جوا الخليه موجب عن طريق خروج ايونات  
البوتاسيوم عن طريق ال ( efflux (passage the potassium outside )  
Repolarization occurs due to the open of potassium channels

**Backing to resting potential:** بدي ارجع للحاله الطبيعيه عشان صارت كمية  
البوتاسيوم بره اكثر من جوا الخليه  
بتيجي عندي sodium potassium pump

## A) Depolarization:

### Def:

- It is loss of normal polarized state of the membrane ( $\square$  potential difference between outer and inner surface of the membrane).
- the membrane potential changes from  $-70$  mv to  $+35$  mv.

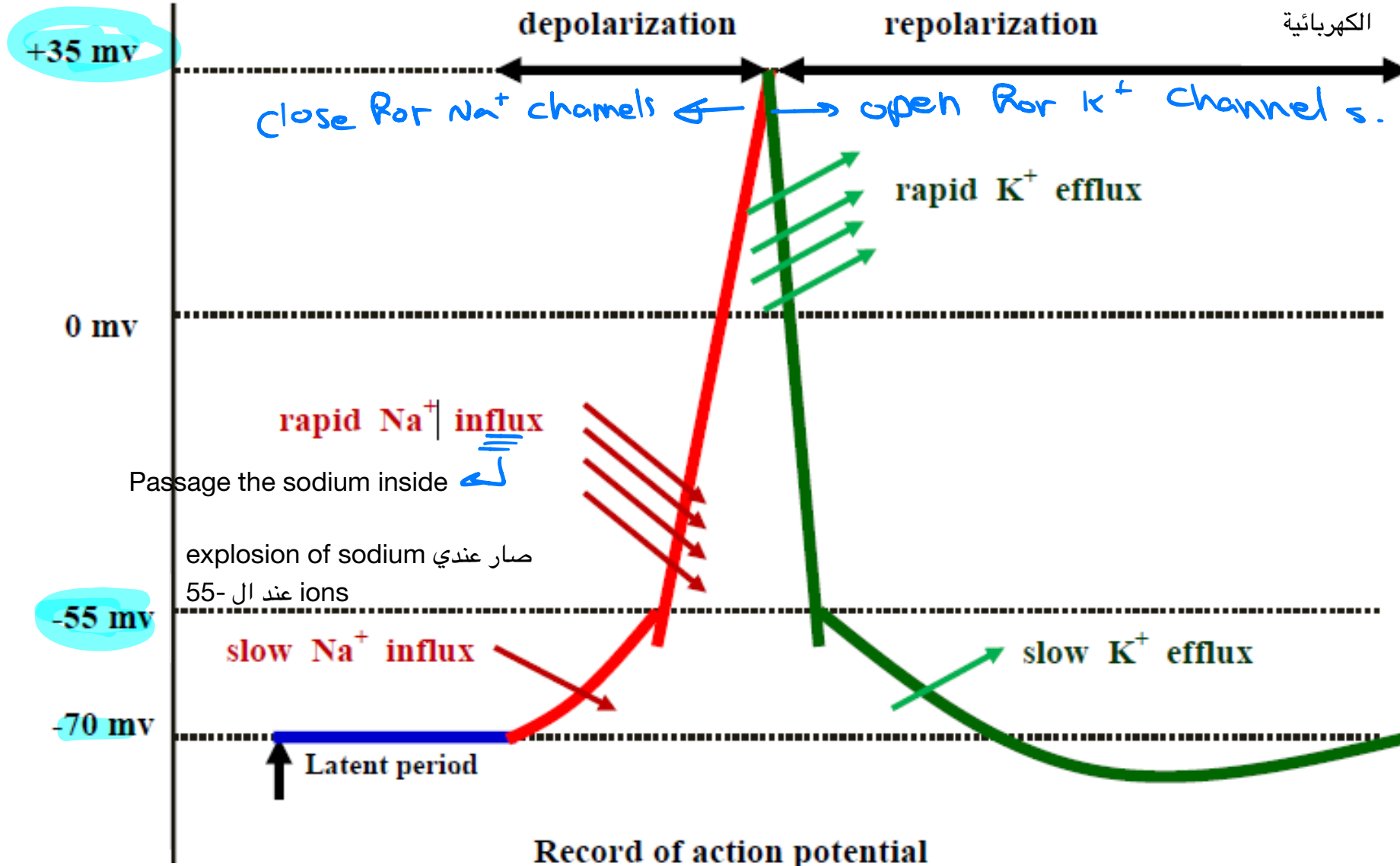
### Mechanism:

- The stimulus increases the permeability of the cell membrane to  $\text{Na}^+$  ions, which diffuse inside causing gradual change in the membrane potential from the resting potential ( $-70$  m.v) to isoelectric line (zero) and exceed it to  $+35$  mv (overshoot) by 2 steps separated by the firing level which equals  $-55$  mv.:

**1-Slow depolarization:** from  $-70$  mv to  $-55$  mv (firing level) due to opening of some  $\text{Na}^+$  channels

**2-Rapid depolarization:** from  $-55$  mv to  $+35$  mv (overshot), due to opening of all  $\text{Na}^+$  channels

Sodium gate يسميها voltage gate  
لانو هاي البوابات بتفتح عند تغير  
الكهربائية



Record of action potential

بتكون بطيئة لانو بالبداية بفتح عدد قنوات قليل فبكون slow influx  
بعدين بالتدريج بفتح عدد قنوات اكبر بصير عند rapid influx



## B) Repolarization:

### Def:

- It is restoration of membrane potential i.e return to normal polarity
- The membrane returns from +35 mv to -70 mv.

### Mechanism of repolarization:

- 1- stoppage of Na<sup>+</sup> influx. *↪ going inside*
- 2- beginning of K<sup>+</sup> efflux through opening of K<sup>+</sup> channels.  
*↪ going outside*

### c) Redistribution of ions inside and outside:

- Redistribution of Na<sup>+</sup> and K<sup>+</sup> ions to the normal resting condition is established by sodium potassium pump. *↪ الرجوع للحالة الطبيعية.*

## II-Conductivity

التوصيل ، قدرة العصب لتوصيل الاشاره  
من منطقه الى التانيه

Conductivity = propagation

- **After action potential is initiated, it propagates along the axon.**
- The action potential must be **propagated in order to transfer information from one place in the nervous system to the other.**
- **Conduction is possible because the action potential generated at one site on the axon, acts as a stimulus for the production of another action potential in the adjacent sites of the axon.**

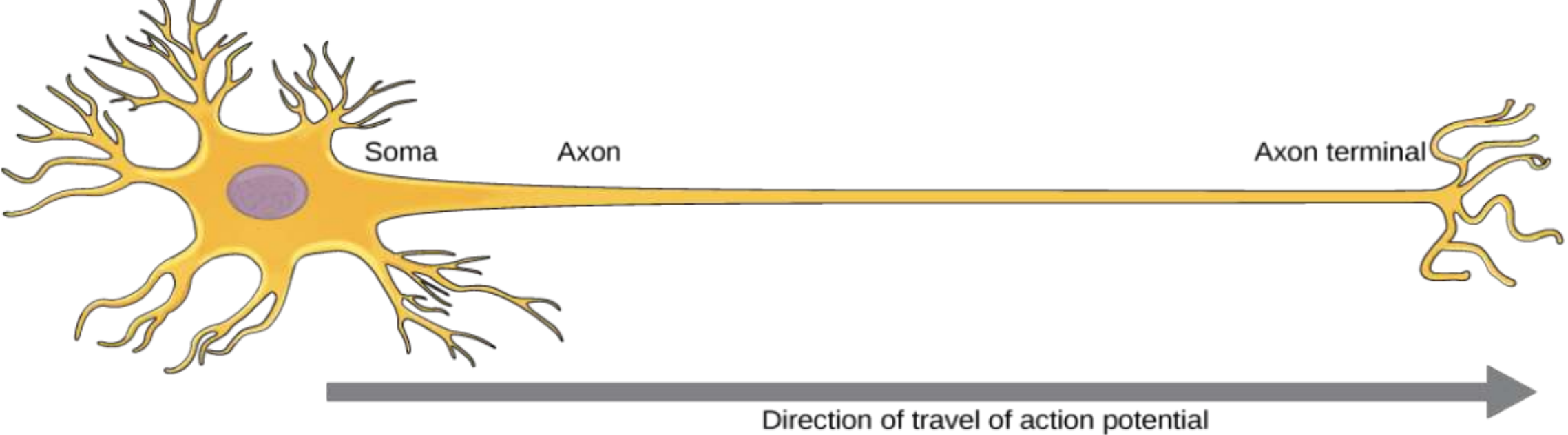
كيفية حدوث ال propagation :

الجزء الي بيحصله depolarization بحفز الجزء الي

جنبه عشان يصيرليه ديپولارايزيشن برضو ، اما الجزء

الي قبله بصيرله repolarization

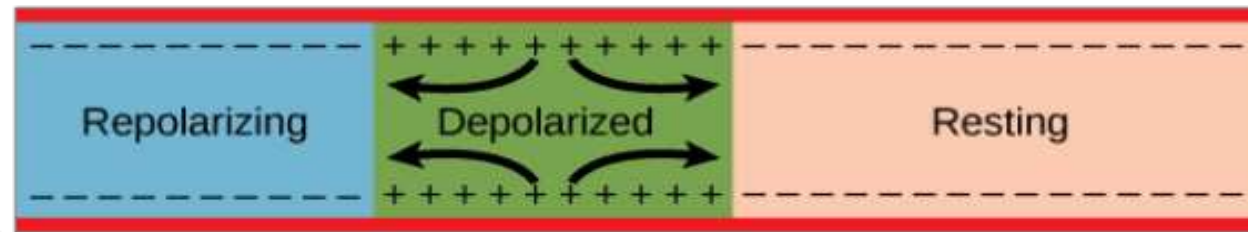
↓  
↓  
تدفع مع الصورة .



a. In response to a signal, the soma end of the axon becomes depolarized.



b. The depolarization spreads down the axon. Meanwhile, the first part of the membrane repolarizes. Because  $\text{Na}^+$  channels are inactivated and additional  $\text{K}^+$  channels have opened, the membrane cannot depolarize again.



c. The action potential continues to travel down the axon.



There is **no myelin sheath**

There is myelin sheath  
و هوه بسرع ال conduction كثير كثير

### Continous conduction

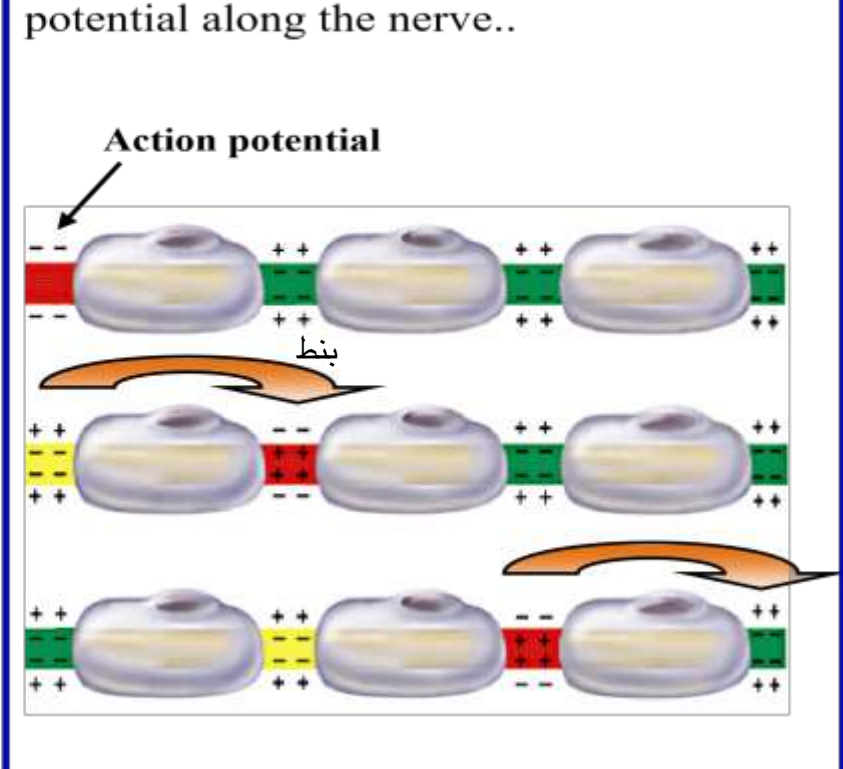
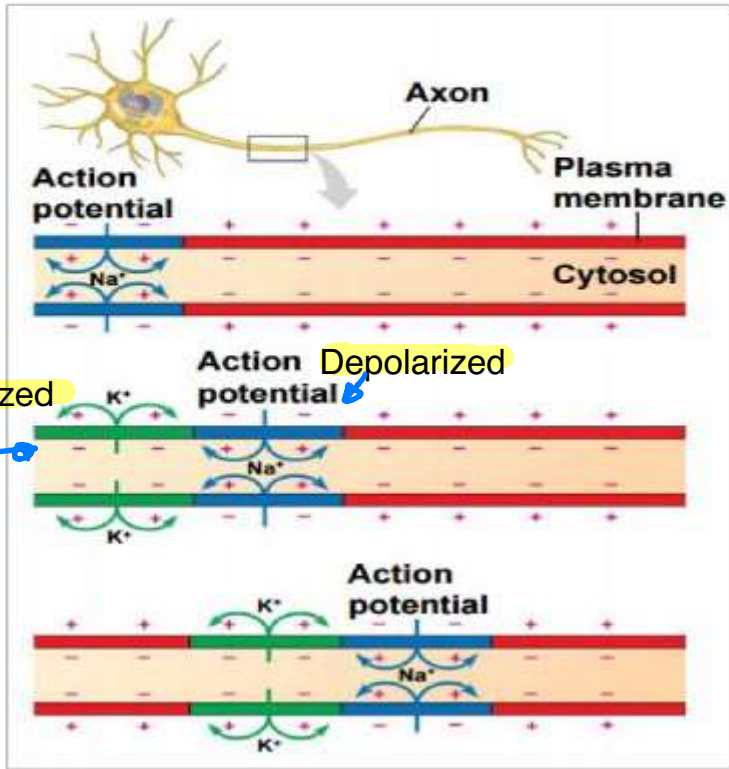
### Saltatory conduction

- It is propagation in **unmyelinated** nerve fibers.

- It is propagation in **myelinated** nerve fibers.

- action potential is **conducted from one point to another** by local electric circuit.

- charges **jump from one node to another** along the nerve causing spread of action potential along the nerve..



Repolarized

This process is **very slow**  
لانو يتمشي شوي شوي  
شوي شوي

**Velocity of conduction:**  
**Slow (0.5-2.0 meter/sec)**

**Velocity of conduction:**  
**Fast (may reach up to 120 met/sec).**

This process is **very fast**  
لانو بنط من عقده لعقده

# TYPES OF SYNAPSES

منطقة تشابك الاعصاب

Functional connection between neuron and neuron is called synapse

The human brain contains at **least 100 billion neurons**, each with the

ability to influence many other cells.

ال ١٠٠ بليون هدول بتشابكه مع اشياء تانيه ، منطقة تشابكها مع عصب تاني بالايدي بالاجر و غيره هاي المنطقة بسميها synapse

Such **communication is made possible by synapses**, the functional

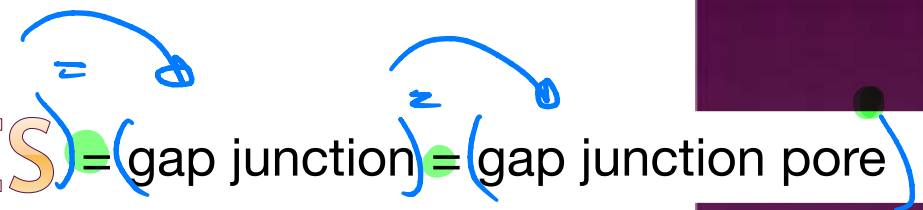
**contacts between neurons**.  
مش ضروري يكون between neurons ممكن  
النيورون يتصل مع عضلة او مع غدة و غيره

**Although there are many kinds of synapses within** the brain, they can be

divided into two general classes: **electrical synapses** and **chemical**

**synapses**.

# SITES OF ELECTRICAL SYNAPSES = (gap junction) = (gap junction pore)



1- **Electrical synapses** are the neurophysiological product of  $\odot$

gap junctional pores between neurons that **allow**

positive charge  
or  
negative charge

**bidirectional flow of current** between neurons. They are

**expressed throughout the mammalian nervous system,**

including **cortex**, **hippocampus**, **thalamus**, **retina**,

القشرة المخية

مسؤول عن الذاكرة

مسؤول عن الحركة

شبكة تبتع العين

**cerebellum**, and **inferior olive**.

أجزاء من ال  
nervous  
system  
(فقاً)

المخيخ مسؤول عن التوازن

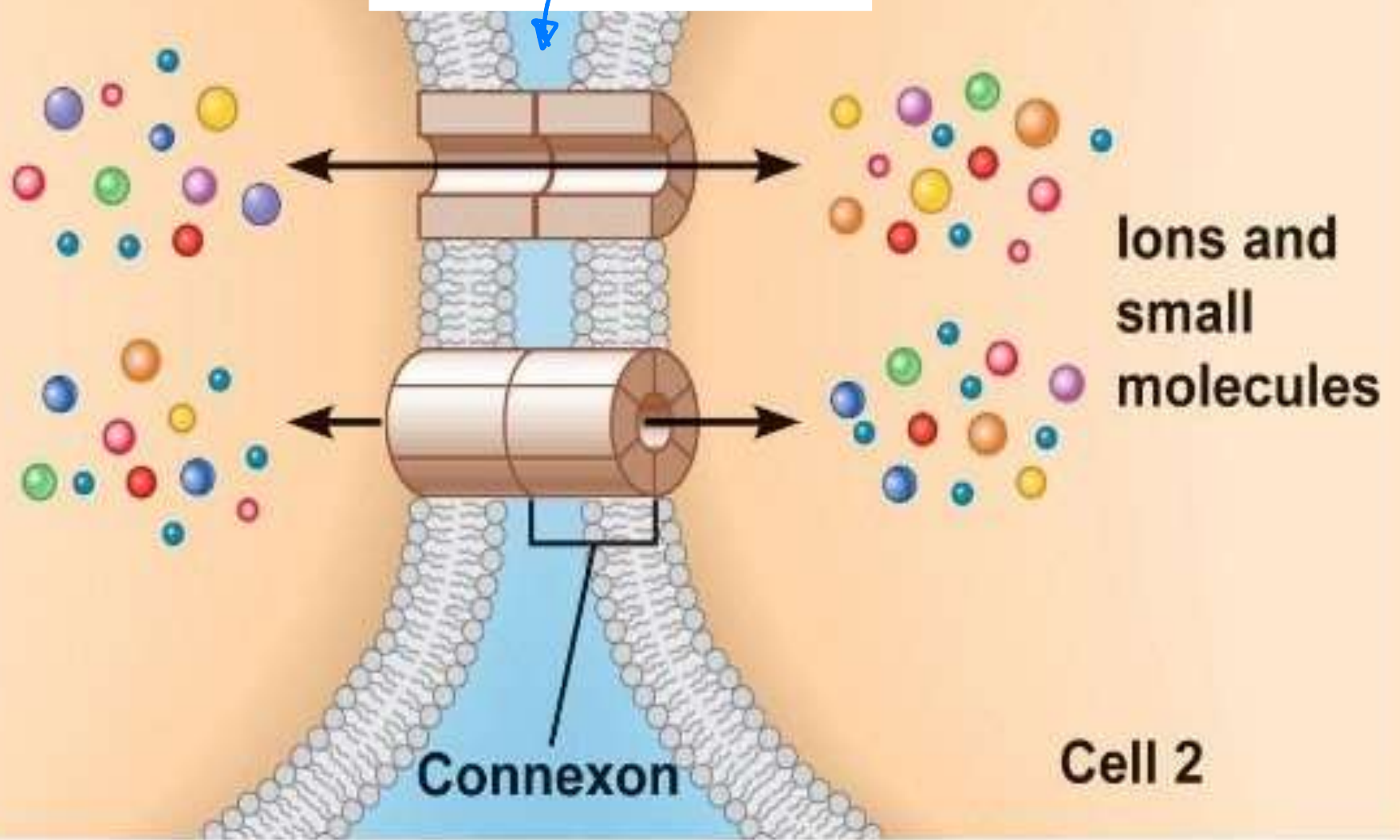
مسؤولة عن الحركة

2- In cardiac muscle  $\odot$

3- in smooth muscles  $\odot$

تسمى الرابطة الكهربائية  
بجوجون

بتكون عندي pore in electrical synapse  
يعني ال connections between cells  
طريق pore (فتحة)  
هاي الفتحة بتسمح بمرور الايونات direct  
بالاتجاهين وبتكون مفتوحة بكل الاوقات



Cell 1


Cell 2

Connexon

Ions and  
small  
molecules

# TYPES OF SYNAPSES

عملية ال contact في ال chemical synapse تتم عن طريق ناقل كيميائي (neuro transmitter) هاد النيورو ترانزيميتر موجود بحويصلات و هاي الحويصلات موجوده في نهايات العصب

In contrast, chemical synapses **enable cell-to-cell communication** via the 

secretion of neurotransmitters

; **the chemical agents released by the presynaptic** neurons produce secondary

current flow in **postsynaptic neurons by activating**

**specific receptor** molecules

. The secretion of neurotransmitters is triggered by the **influx of**

**Ca<sup>2+</sup> through voltage-gated** channels, **which gives rise to a transient increase**

**in Ca<sup>2+</sup> concentration within the**

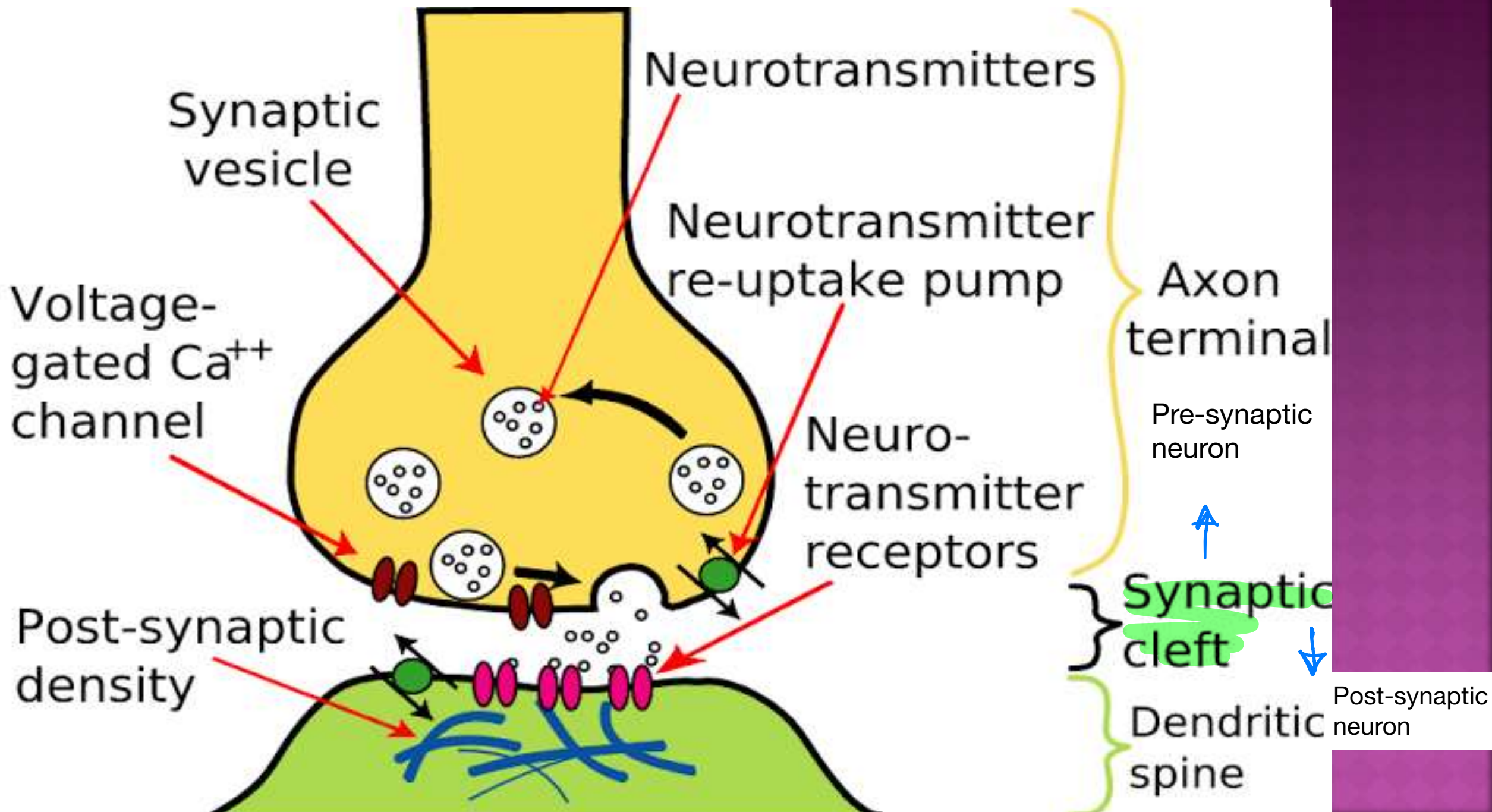
**presynaptic terminal.**

الاتحاد مع العصب الي تحتيه بسمح لحدوث تغيرات في العصب

عند مرور الاشارات العصبية تفتح قنوات الكالسيوم و هاي القنوات عبارة عن voltage gated بتفتح بالاشاره الكهربائية ، الكالسيوم لسبب ما بخلي بروتين معين موجود بالحويصله يتحد مع بروتين في الجدار و يفرقع و بطلع ال neuro transmitter

هاد النيورو ترانزيميتر بتحد مع مستقبلات بالعصب الي تحتيه





# THE MECHANISM OF CHEMICAL SYNAPTIC TRANSMISSION

-The rise in  $\text{Ca}^{2+}$  concentration causes synaptic vesicles—the presynaptic organelles that store neurotransmitters—to fuse with the presynaptic plasma membrane and release their contents into the space between the pre- and postsynaptic cells.

-Although it is not yet understood exactly how  $\text{Ca}^{2+}$  triggers exocytosis, specific proteins on the surface of the synaptic vesicle and elsewhere in the presynaptic terminal evidently mediate this process.

كله عم حركه ضري  
حدايد 15

# SITES OF CHEMICAL SYNAPSES

-**Chemical synapses** are biological junctions through which neurons' signals ○

can be sent to each other and to non-neuronal cells such as those

neuron → neuron  
neuron → muscle  
neuron → gland

in muscles or glands.

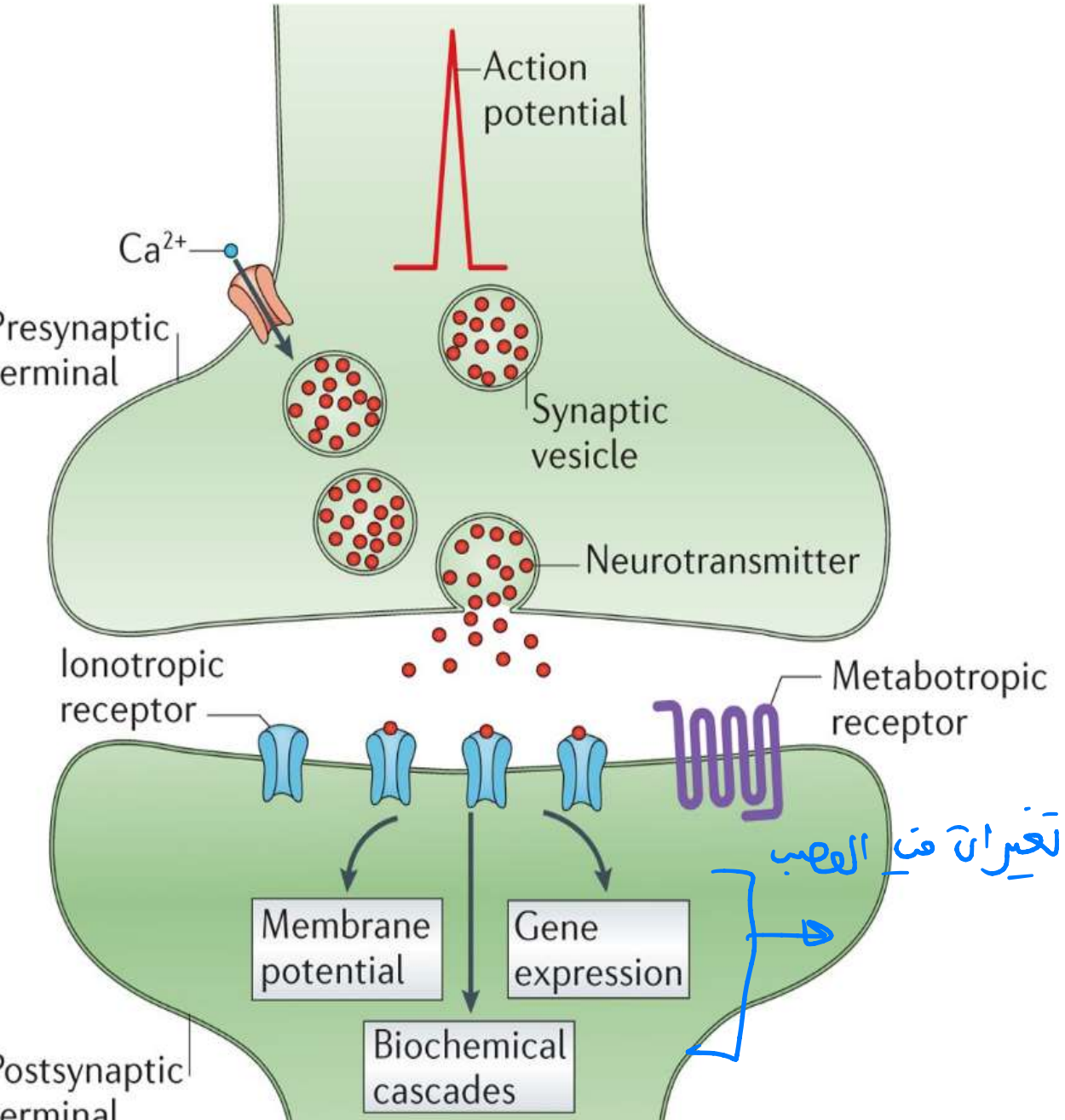
**Chemical synapses allow neurons to form** circuits within the central nervous

system. They are crucial to the biological computations that

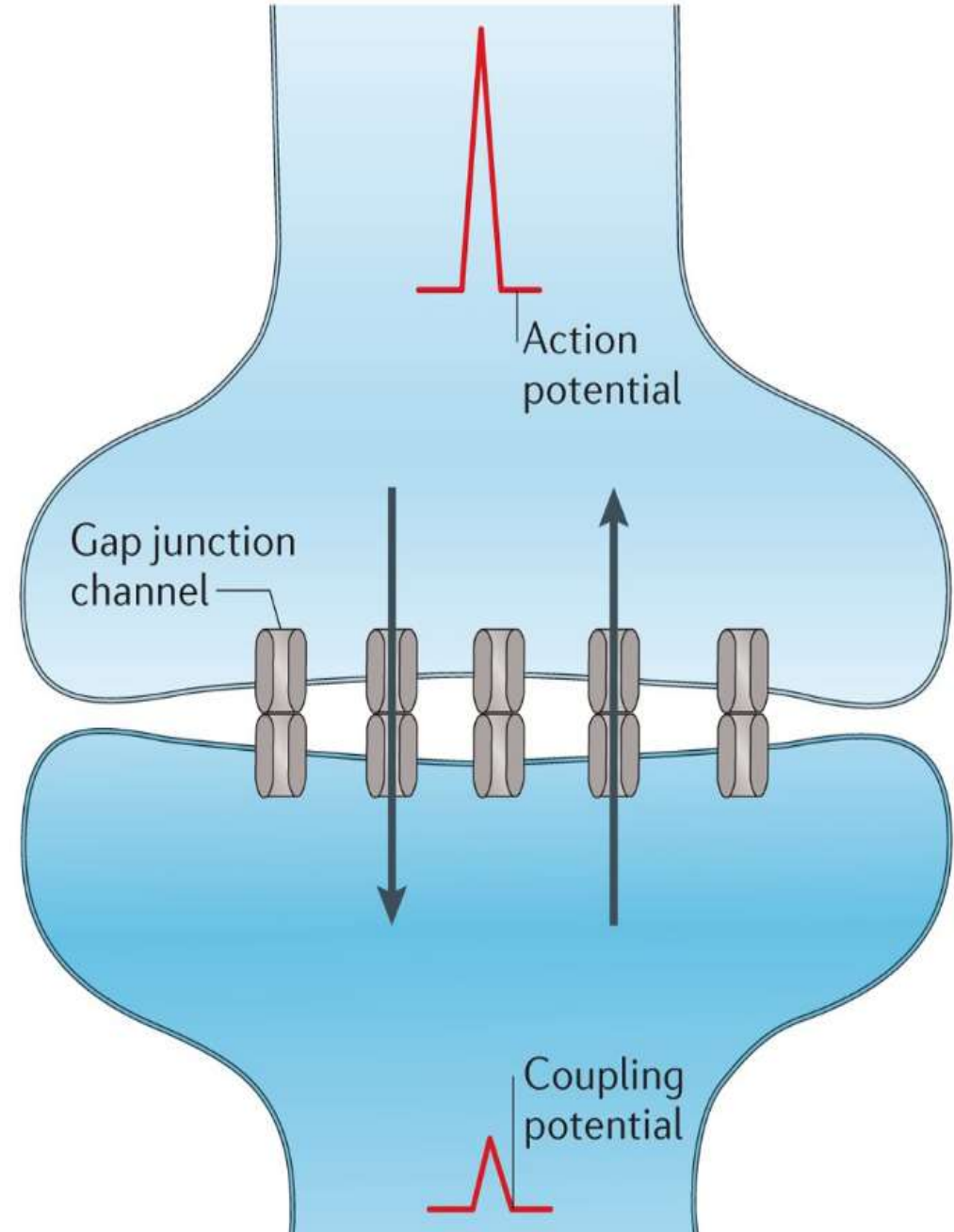
underlie perception and thought. They allow the nervous system to connect to

and control other systems of the body.

## Chemical synapse



## b Electrical synapse



# QUESTIONS

1- which is the main cause of resting membrane potential?

Na diffusion through passive channels (a)

Na diffusion through voltage gated channels (b)

K diffusion through passive channels (c)

Ca diffusion through voltage gated ca channels (d)

Protein diffusion through the cell membrane (e)

## 2- WHICH IS THE MAIN CAUSE OF DEPOLARIZATION PHASE OF NERVE ACTION POTENTIAL?

Movement of k outside the nerve cell (a)

Na K pump (b)

Chloride influx (c)

**Increased permeability of the cell to Na** (d)

Movement of K inside the nerve cell (e)

### 3-DURING THE SLOW PHASE OF DEPOLARIZATION :THE FIRING LEVEL OCCURS AT WHICH OF THESE VALUES?

- 55mv (a)
- +35mv (b)
- 70mv (c)
- 0mv (d)
- 65mv (e)

4- IN RAPID DEPOLARIZATION THE OVERSHOOT OCCURS  
AT WHICH OF THESE VALUES?

-90mv (a)

0mv (b)

+35mv (c)

-55mv (d)

+70mv (e)



## 5- WHICH IS THE MAIN CAUSE OF REPOLARIZATION IN NERVE ACTION POTENTIAL

Na influx (a)

Na k pump (b)

Ca pump (c)

Cl influx (d)

Beginning of k efflux (e)

## 6- WHICH IS THE CAUSE OF REDISTRIBUTION OF IONS INSIDE AND OUTSIDE THE NERVE CELL AT THE END OF ACTION POTENTIAL?

K efflux (a)

Na influx (b)

Na k pump (c)

Ca pump (d)

Cl influx (e)

7-  
WHICH IS THE VELOCITY OF CONDUCTION OF NERVE IMPULSE BY  
SALTATORY CONDUCTION?

- 10 meter per second (a)
- 120 meter per second (b)
- 2 meter per second (c)
- 50 meter per second (d)
- 70 meter per second (e)

## 8-WHICH IS THE TRIGGER OF RELEASE OF THE CONTENTS OF PRESYNAPTIC VESICLES IN CHEMICAL SYNAPSES?

- Ca influx inside the nerve terminal (a)
- Na influx inside the nerve terminal (b)
- Rise of K level inside nerve terminal (c)
- Chloride exit outside the nerve terminal (d)
- Na efflux outside the nerve terminal (e)



# SHORT ESSAY QUESTIONS

- 1-Define RMP ,mention its value and describe its causes ○
- 2-Mention the three basic types of ion channels
- 3-Define action potential and describe its phases ○
- 4-Compare between chemical and electrical synapses as ○  
regard the
  - Define sites of expression and mechanism of transmission ○