PARASYMPATHETIC RESPONSES

- Parasympathetic responses support body functions that **conserve and restore body energy during times of rest and recovery.**
- **In the quiet intervals between periods of exercise**, parasympathetic impulses to the digestive glands and the smooth muscle of the gastrointestinal tract predominate over sympathetic impulses.
- This **allows energy-supplying food to be digested and absorbed**.

- في فترات الراحة بين التمارين يكون parasympathetic هو الأكثر نشاطا
وتكون nerve impulse الضامة فيه هي السائدة فتحفز الغدد على افراز الإنزيمات والعصارات الهاضمة
و تؤثر على smooth muscle في الجهاز الهضمي وتحفز حركة الأمعاء مما يسهل مرور الطعام وهضمه

REST-AND-DIGEST (SOME EXAMPLES)

- **Increasing SLUDD responses**, which include: salivation (S), lacrimation (L), urination (U), digestion (D), and defecation (D).

- "**Three decreases**", which include: decreased heart rate, decreased diameter of airways (bronchoconstriction), and decreased diameter (constriction) of the pupils.

REST-AND-DIGEST (SOME EXAMPLES)

- **Increasing SLUDD responses**, which include: salivation (S), lacrimation (L), urination (U), digestion (D), and defecation (D).

- "**Three decreases**", which include: decreased heart rate, decreased diameter of airways (bronchoconstriction), and decreased diameter (constriction) of the pupils.

Table 8–5 FUNCTIONS OF THE AUTONOMIC NERVOUS SYSTEM

Organ	Sympathetic Response	Parasympathetic Response
Heart (cardiac muscle)	• Increase rate	• Decrease rate (to normal)
Bronchioles (smooth muscle)	• Dilate	• Constrict (to normal)
Iris (smooth muscle) القزحية	• Pupil dilates	• Pupil constricts (to normal)
Salivary glands	• Decrease secretion	• Increase secretion (to normal)
Stomach and intestines (smooth muscle)	• Decrease peristalsis	• Increase peristalsis for normal digestion
Stomach and intestines (glands)	• Decrease secretion	• Increase secretion for normal digestion
Internal anal sphincter العضلة العاصرة الداخلية	• Contracts to prevent defecation	• Relaxes to permit defecation
Urinary bladder (smooth muscle) للمثانة	• Relaxes to prevent urination	• Contracts for normal urination
Internal urethral sphincter	• Contracts to prevent urination	• Relaxes to permit urination
Liver	• Changes glycogen to glucose	• None للسماح
Pancreas	• Secretes glucagon	• Secretes insulin and digestive enzymes
Sweat glands الأحشاء	• Increase secretion	• None
Blood vessels in skin and viscera (smooth muscle)	• Constrict تتضيق	• None
Blood vessels in skeletal muscle (smooth muscle)	• Dilate	• None
Adrenal glands	• Increase secretion of epinephrine and norepinephrine	• None

PHYSIOLOGY

FACULTY OF PHARMACEUTICAL SCIENCES
DR. AMJAAD ZUHIER ALROSAN

LECTURE 4, PART (2)- GENERATION AND CONDUCTION OF ACTION POTENTIAL.

Objectives

1. Discuss **myelination.**

2. Describe **electrical signals in neurons**.

(Pages 408-421 of the reference)

MYELINATION

- ***Axons surrounded by a multilayered lipid and protein covering, called the myelin sheath.***

- The **myelin sheath:**

عزل

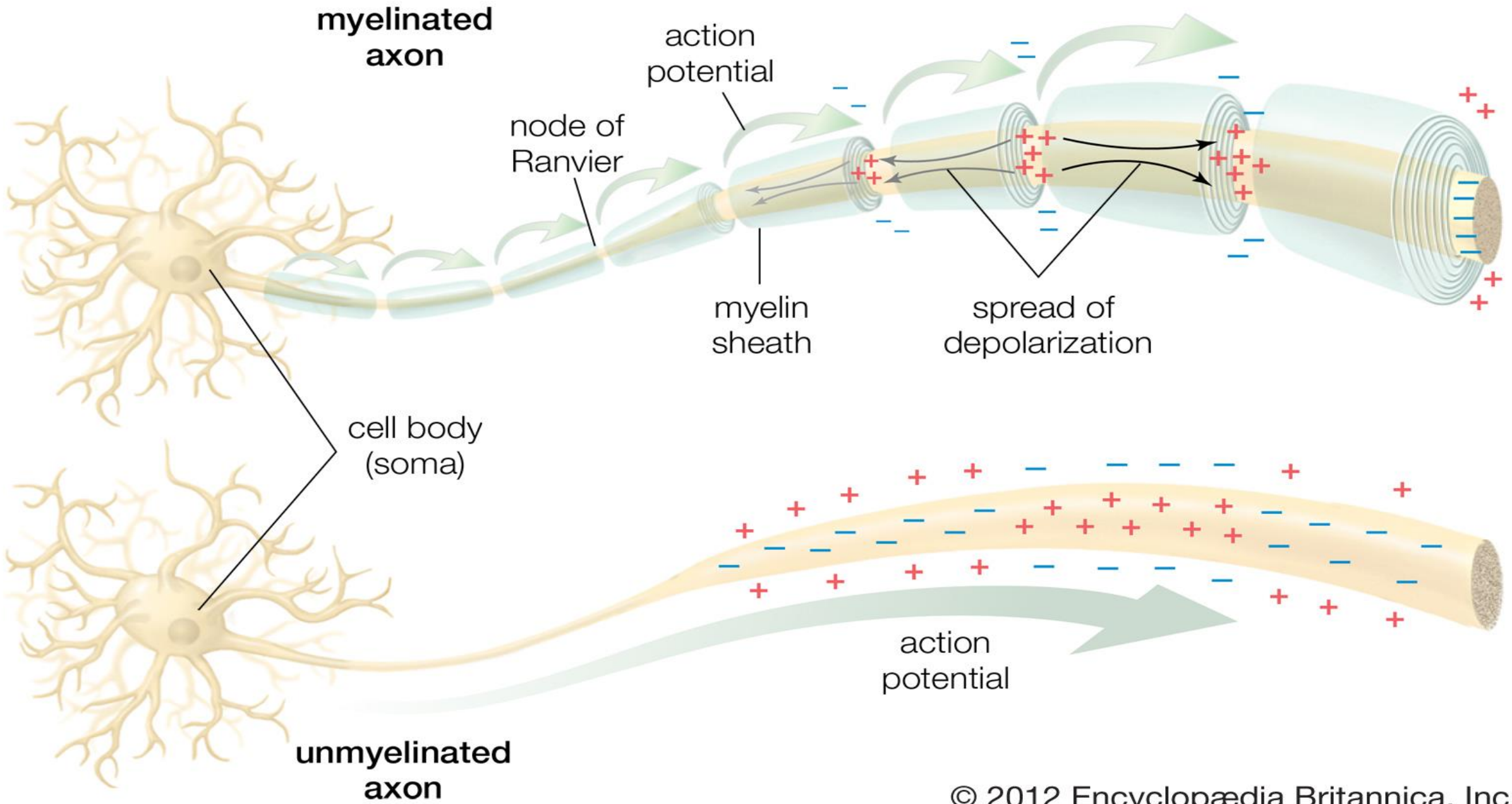
1. Insulates the axon of a neuron.

2. Increases the speed of nerve impulse conduction.

MYELINATION

- Two types of neuroglia produce myelin sheaths: Schwann cells (in the PNS) and oligodendrocytes (in the CNS).

postganglionic neuron من أكبر preganglionic neuron



ELECTRICAL SIGNALS IN NEURONS

- **Neurons communicate** with one another using two types of electrical signals:

1. **Graded potentials** (for short- distance communication only).
2. **Action potentials** (for communication over long distances within the body).

تنقل المعلومات الحسية

مثل السمع ، الرؤية ، اللمس

- **Graded potentials and nerve and muscle action potentials** are involved in the relay of sensory stimuli, integrative functions such as perception, and motor activities.

الوظائف التكاملية (معالجة المعلومات)
مثل الإدراك ، التفكير واتخاذ القرارات

إصدار أوامر حركية للعضلات (الأنشطة الحركية)

Example (for writing)

1. As you touch the pen, a graded potential develops in a sensory receptor in the skin of the fingers.
2. The graded potential triggers the axon of the sensory neuron to form a nerve action potential, which travels along the axon into the CNS and ultimately causes the release of neurotransmitter at a synapse with an interneuron.
3. The neurotransmitter stimulates the interneuron to form a graded potential in its dendrites and cell body.

4. In response to the graded potential, the axon of the interneuron forms a nerve action potential. The nerve action potential travels along the axon, which results in neurotransmitter release at the next synapse with another interneuron.

5. This process of neurotransmitter release at a synapse followed by the formation of a graded potential and then a nerve action potential occurs over and over as interneurons in higher parts of the brain (such as the thalamus and cerebral cortex) are activated. Once interneurons in the cerebral cortex, the outer part of the brain, are activated, perception occurs and you are able to feel the smooth surface of the pen touch your fingers.

إعياد

Note: Perception, the conscious awareness of a sensation, is primarily a function of the cerebral cortex.

الإدراك

6. A stimulus in the brain causes a graded potential to form in the dendrites and cell body of an upper motor neuron, a type of motor neuron that synapses with a lower motor neuron farther down in the CNS in order to contract a skeletal muscle. The graded potential subsequently causes a nerve action potential to occur in the axon of the upper motor neuron, followed by neurotransmitter release.

7. The neurotransmitter generates a graded potential in a lower motor neuron, a type of motor neuron that directly supplies skeletal muscle fibers. The graded potential triggers the formation of a nerve action potential and then release of the neurotransmitter at neuromuscular junctions formed with skeletal muscle fibers that control movements of the fingers.

8. The neurotransmitter stimulates the muscle fibers that control finger movements to form muscle action potentials. The muscle action potentials cause these muscle fibers to contract, which allows you to write with the pen.

THE PRODUCTION OF POTENTIALS

The production of graded potentials and action potentials depends on two basic features of the plasma membrane of excitable cells:

1. The existence of a resting membrane potential.
2. The presence of specific types of ion channels.

RESTING MEMBRANE POTENTIAL

- The membrane potential, an electrical potential difference (voltage) across the membrane. This voltage is termed the resting membrane potential.

جهد الغشاء (Membrane Potential) هو الفرق في الشحنة الكهربائية (الجهد الكهربائي) عبر غشاء الخلية . بمعنى آخر ، هو الفارق بين الشحنات الموجودة داخل الخلية وخارجها على سطح الغشاء

جهد الغشاء في وضع الراحة يُعرف بـ جهد الراحة (Resting Membrane Potential) . هذا الجهد يحدث عندما تكون الخلية في حالة غير نشطة ولا تُرسل إشارات عصبية . في هذه الحالة ، يكون الجزء الداخلي من الخلية عادةً مشحوناً سلبياً مقارنةً بالجزء الخارجي

- This looks like voltage stored in a battery; you connect the positive and negative terminals of a battery with a piece of wire, electrons will flow along the wire. This flow of charged particles is called current.

The types of ion channels:

(اسماءها بتختلف حسب stimulus الذي يؤثر فيها)

1. Leak channels. دائما مفتوحة
2. Ligand-gated channel.
3. Mechanically-gated channel.
4. Voltage-gated channel.

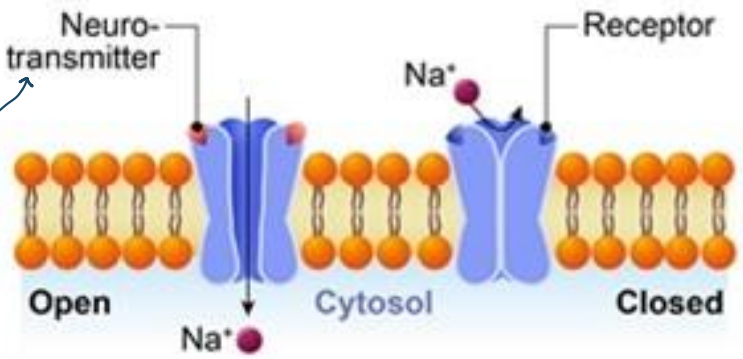
يحافظ sensory receptor او قريبة منه فلازم يصير activation للبروتين يفتح chanell cell

= stress

تفتح إذا تعرضت stress pressure ل مثل سماع صوت عالي أو التعرض لضربة

ION CHANNEL

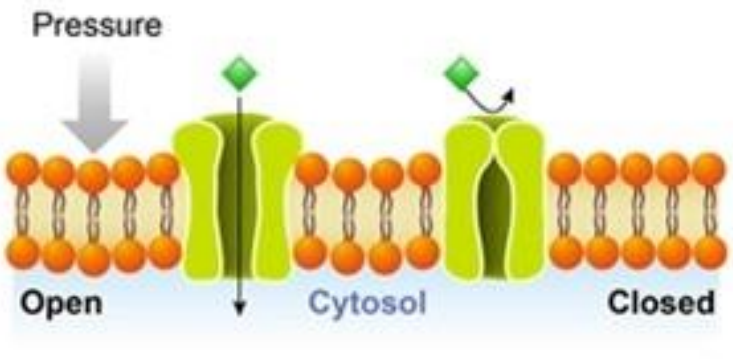
Ligand-gated



ligand ممكن يكون: agonist (مادة ترتبط باستقبل A) / antagonist

زي الهرمون نتيجة الارتباط بتفتح

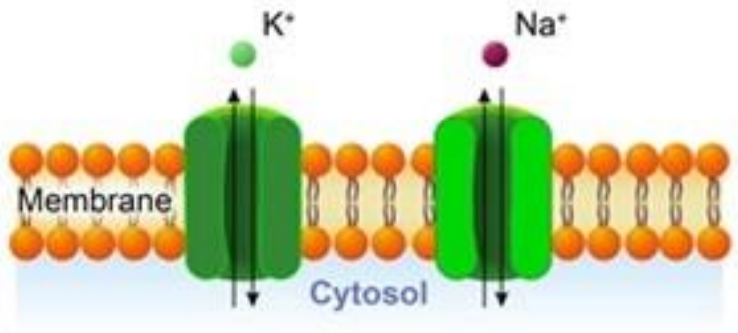
Mechanically-gated



في منهم بالأذن

leak channel

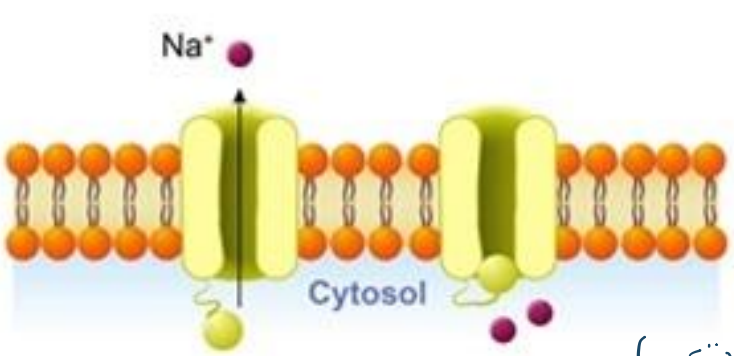
Always open



دائما فاتحة

اي imbalance بترجعه لـ balance (-70)

Voltage-gated



بتفتح نتيجة فرق الجهد بين داخل وخارج الخلية (حركة الأيونات)

Leak channels:

- Randomly alternate between open and closed positions.
- The plasma membranes have many more potassium ion leak channels than sodium ion leak channels.
- Leak channels are found in nearly all cells, including the dendrites, cell bodies, and axons of all types of neurons.

لها موجودة في جميع الخلايا ومعظم أجزاء الخلية العصبية

Ligand-gated channel:

- Opens and closes in response to the binding of a ligand (chemical) stimulus (a ligand can be including neurotransmitters (i.e. acetylcholine), hormones, and particular ions).

- Ligand-gated channels are located in the dendrites of some sensory neurons, such as pain receptors, and in dendrites and cell bodies of interneurons and motor neurons.

Mechanically-gated channel:

- It opens or closes in response to mechanical stimulation in the form of vibration (such as sound waves), touch, pressure, or tissue stretching.

اهتزاز

الأنسجة لمَدّ

- They are found in auditory receptors in the ears, in receptors that monitor stretching of internal organs, and in touch receptors and pressure receptors in the skin.

Voltage-gated channel:

- It opens in response to a change in membrane potential (voltage).

- They participate in the generation and conduction (توصيل) of action potentials in the axons of all types of neurons.

Resting Membrane Potential

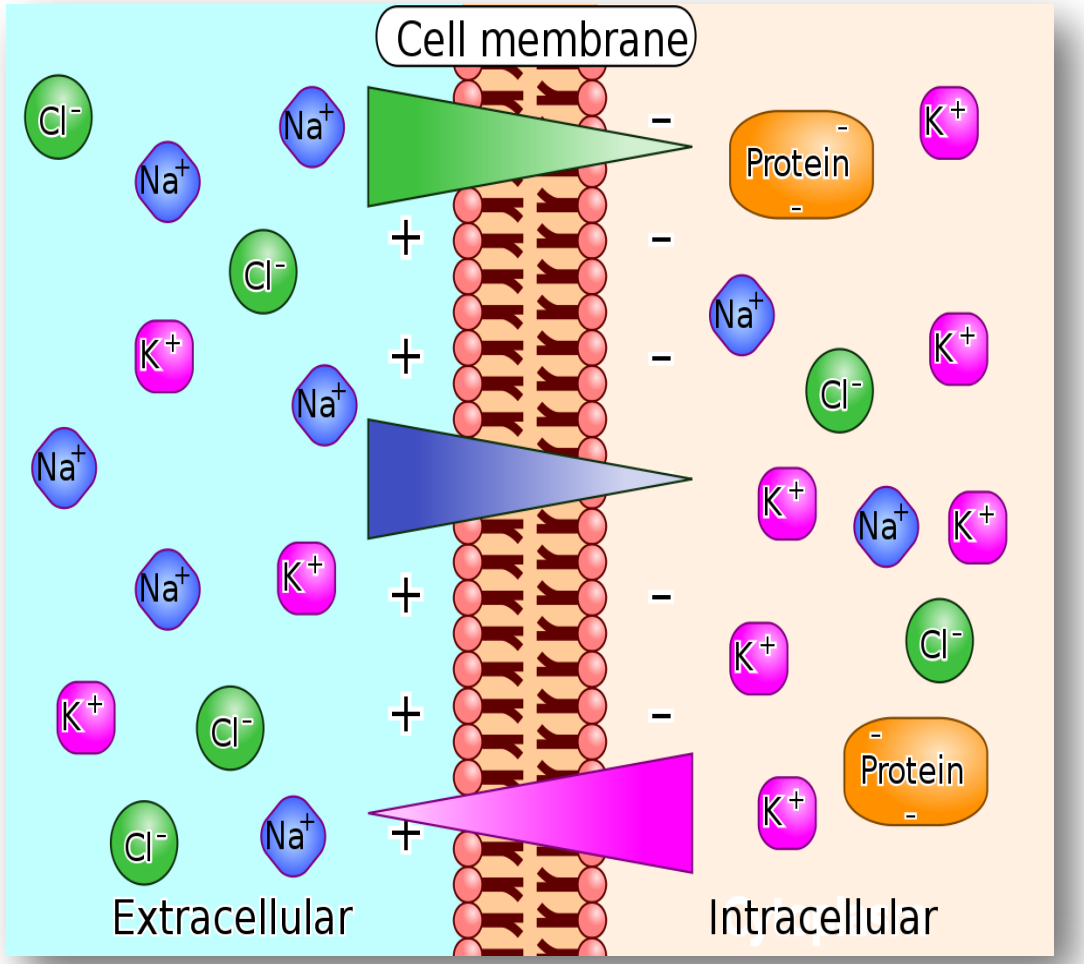
حالة من الإستقطاب

- A cell that exhibits a membrane potential is said to be polarized.

- **Three factors that contribute to the resting membrane potential:**

1. **<u>Unequal distribution of ions in the ECF and cytosol:</u>** as more and more positive potassium ions exit, the inside of the membrane becomes increasingly negative, and the outside of the membrane becomes increasingly positive.

الداخل أكثر سالبية من الخارج



Resting Membrane Potential

2. **<u>Inability of most anions to leave the cell:</u>** They cannot follow the potassium cations out of the cell because they are attached to nondiffusible molecules such as ATP and large proteins.

يوجد مركبات (anions) زي البروتينات أعدادها كبيرة و يصعب
خروجها من الخلية لكبر حجمها أو ارتباطها بمركبات كبيرة الحجم زى ATP

تسرب أيونات K للخارج

وجود مضخات Na , K

Na-K ATPase يتم تعويضها من

3. **Electrogenic nature of the Na–K ions ATPases**: The small inward Na ions leak, and outward K ions leak are offset by the Na–K ions ATPases (sodium–potassium pumps). However, they expel three Na ions each two K ions imported electrogenic, which means they contribute to the negativity of the resting membrane potential (it is very small: only -3 mV of the total -70 mV resting membrane potential in a typical neuron).

تسرب أيونات Na

تخرج 3 أيونات Na إلى الخارج
تدخل 2 أيونات K إلى الداخل

توصف هذه العملية بأنها electrogenic لأنها تساهم في توليد فرق في الشحنة

Comparison of Graded Potentials and Action Potentials

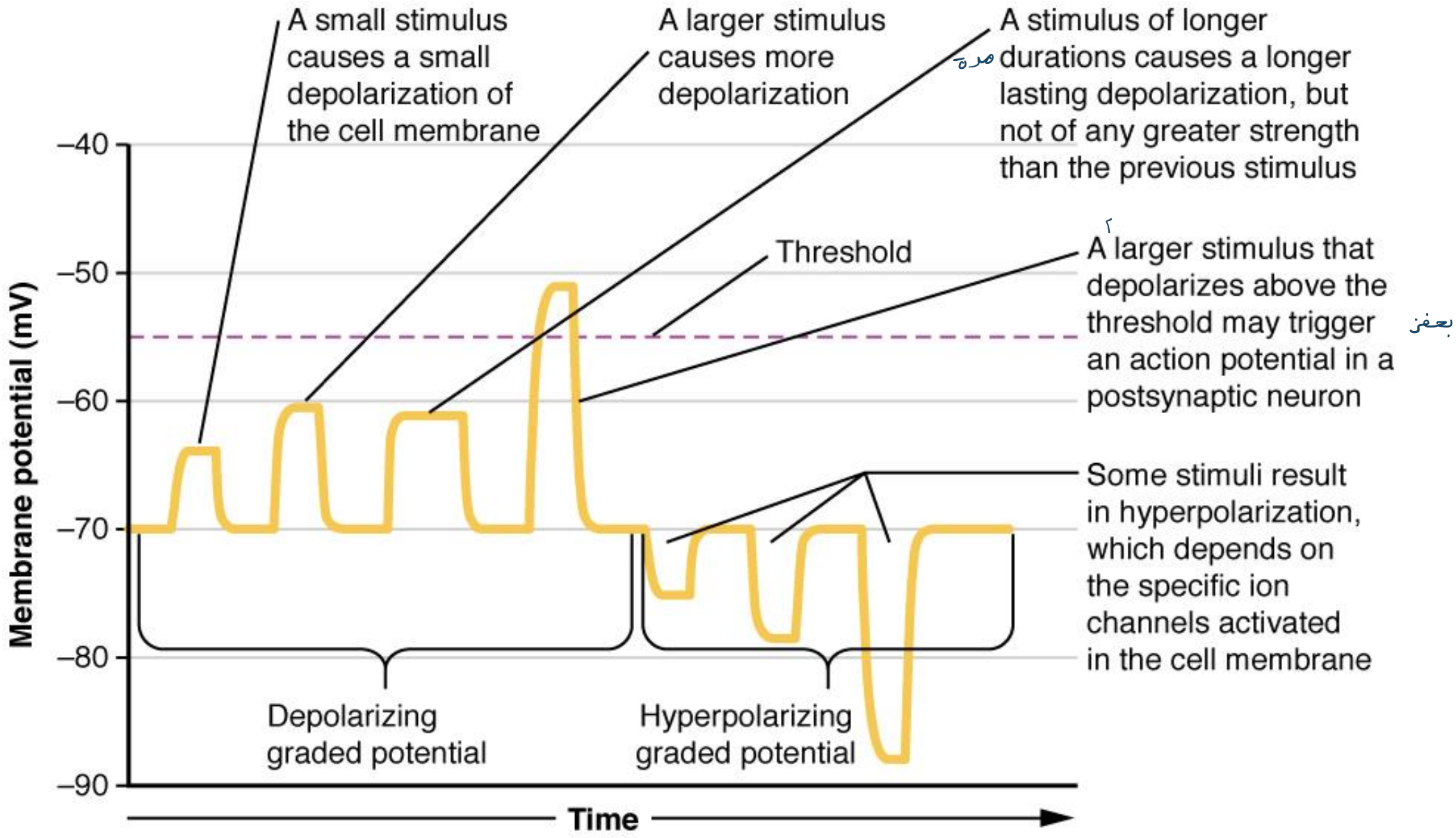
Graded Potential

1. Stimulus does not reach threshold level.
2. Stimulus causes local change in membrane potential e.g. -70 to -60mv
3. It dies down over short distance. يموت بعد مسافة قصيرة
4. Can be summated.
5. Does not obey all or none law.

يقل مع الوقت

Action Potential

1. Stimulus reaches threshold level therefore causes AP. → action potential
2. Stimulus causes depolarization to threshold level.
3. It is propagated.
4. Can not be summated.
5. Obeys all or none law.


A small stimulus causes a small depolarization of the cell membrane
A larger stimulus causes more depolarization
A stimulus of longer durations causes a longer lasting depolarization, but not of any greater strength than the previous stimulus
Threshold
A larger stimulus that depolarizes above the threshold may trigger an action potential in a postsynaptic neuron
Some stimuli result in hyperpolarization, which depends on the specific ion channels activated in the cell membrane
Depolarizing graded potential
Hyperpolarizing graded potential
Membrane potential (mV)
–40
–50
–60
–70
–80
–90
Time

GRADED POTENTIALS

- **The graded potential** is a small deviation from the resting membrane potential that makes the membrane either more polarized (hyperpolarizing graded potential, inside more negative) or less polarized (depolarizing graded potential, inside less negative).

- The graded potential occurs when a stimulus causes mechanically- gated or ligand-gated channels to open or close in an excitable cell's plasma membrane.

خلايا تستطيع
إنتاج وتوصيل السيالات العصبية

لو انضربت ضربة مش قوية
graded potential بصل ← -70 — -60 ← إذا فرد العجم
إذا كانوا أكثر من ضربة متتالية بحيث العتبة بصير AP
إذا وصل العتبة (-55) بصير AP

GRADED POTENTIALS

- The graded potentials are useful for short-distance communication only (localized and dies after this distance). However, it can become stronger and last longer by summating with other graded potentials (summation is the process by which graded potentials add together).

تستمر لفترة أطول

- The graded potential occurs in the dendrites or cell body of a neuron in response to a neurotransmitter, it is called a postsynaptic potential.

sensory receptor التي تحدث في graded potential

sensory neuron التي تحدث في graded potential

- The graded potentials that occur in sensory receptors and sensory neurons are termed receptor potentials and generator potentials.

GENERATION OF ACTION POTENTIALS

- An action potential (AP) or impulse is a sequence of rapidly occurring events that decrease and reverse the membrane potential.

- An action potential has two main phases: a depolarizing phase and a repolarizing phase.

- During the depolarizing phase, the negative membrane potential becomes less negative, reaches zero, and then becomes positive. During the repolarizing phase, the membrane potential is restored to the resting state of -70 mV. Following the repolarizing phase there may be an after-hyperpolarizing phase, during which the membrane potential temporarily becomes more negative than the resting level.

ACTION POTENTIALS

- An action potential occurs in the membrane of the axon of a neuron when depolarization reaches a certain level termed the **threshold**.

- An action potential will not occur in response to **a subthreshold stimulus**. However, an action potential will occur in response to a threshold stimulus, a stimulus that is just strong enough to depolarize the membrane to threshold. In other words, an action potential either occurs completely or it does not occur at all. This characteristic of an action potential is known as the **all-or-none principle**.

ACTION POTENTIALS

- Several action potentials will form in response to a **suprathreshold stimulus.** Each of the action potentials caused by a suprathreshold stimulus has the same amplitude (size) as an action potential caused by a threshold stimulus.

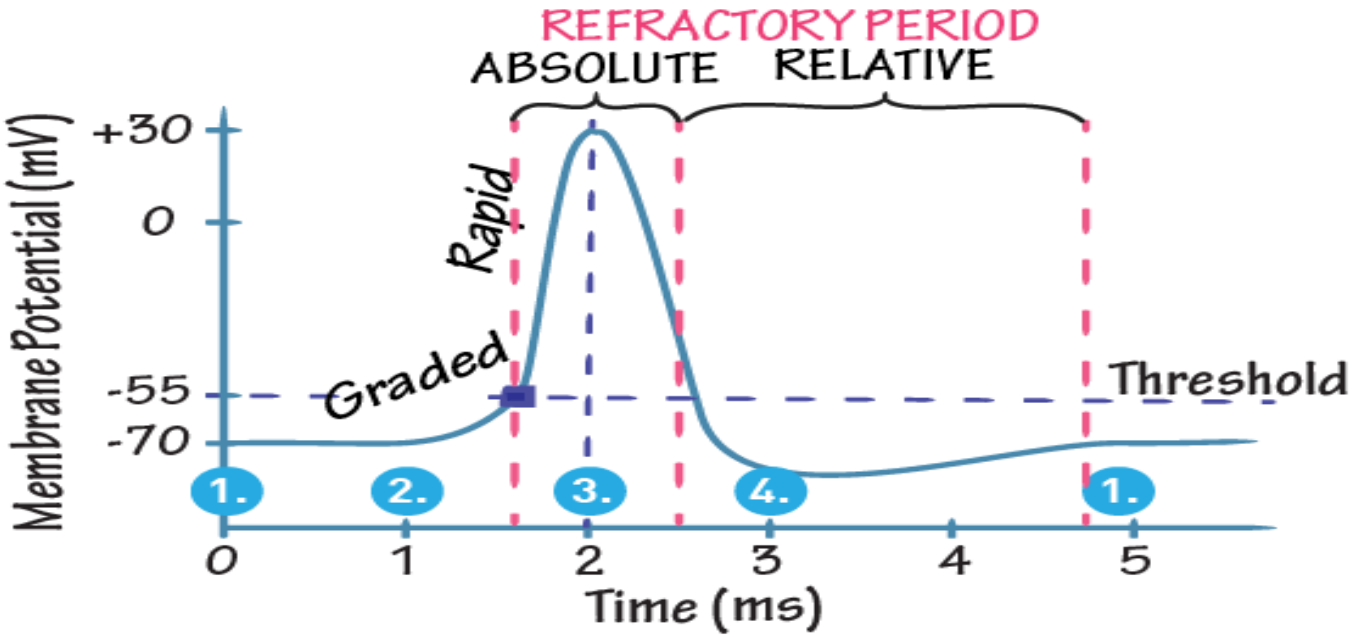
اكبر من العتبة

مقدار التغير في فرق الجهد يبقى ثابت حتى وإن كان السيال العصبي ناتج من suprathreshold stimulus

- إذا وصل لـ subthreshold (تحت العتبة) لن يتكون action potential

- إذا كان suprathreshold (فوق العتبة) ح ينتج action potential

Action Potentials



1. Resting state - All gated ion channels closed
2. Depolarization - Na+ channels open, K+ channels closed
3. Repolarization - Na+ channels inactivated, K+ channels open
4. Hyperpolarization - Na+ channels reset and closed, K+ channels still open

DEPOLARIZING PHASE

حركة الداخل

- Inward movement of Na ions, the depolarizing phase of the action potential.

- This changes the membrane potential from -55 mV to +30 mV.

- Each voltage-gated Na ions channel has two separate gates, an activation gate and an inactivation gate.

DEPOLARIZING PHASE

- In the resting state of a voltage-gated Na ions channel, the inactivation gate is open, but the activation gate is closed (Na ions cannot move into the cell through these channels).

- At threshold, voltage-gated Na ions channels are activated, both the activation and inactivation gates in the channel are open and Na ions inflow begins (more channels open, Na ions inflow increases, the membrane depolarizes further).

to the inside

e

- However, the concentration of Na ions hardly changes because of the millions of Na ions present in the extracellular fluid.

REPOLARIZING PHASE

- At threshold level, depolarization also opens voltage-gated K ions channels.

- Slower opening of voltage-gated K ions channels and closing of previously open voltage-gated Na ions channels produce the repolarizing phase of the action potential (Na ions inflow تتدفق ببطء للداخل slows and accelerating K ions تتدفق للخارج بتسارع outflow, the membrane potential to change from +30 mV to -70 mV, inactivated Na ions channels to revert to the resting state).

AFTER-HYPERPOLARIZING PHASE

- During this phase, the voltage-gated K ions channels remain open and the membrane potential becomes even more negative (about -90 mV).

- As the voltage-gated K ions channels close, the membrane potential returns to the resting level of -70 mV.

REFRACTORY PERIOD

- The period of time after an action potential begins during which an excitable cell cannot generate another action potential in response to a normal threshold stimulus is called the refractory period.

في هذه الفترة تكون الخلية العصبية غير قادرة على إنتاج action potential آخر

تكون قادرة على إنتاج graded potential

- In contrast to [واحد] action potentials, graded potentials do not exhibit a refractory period.

مثال: واحد بكتب لطول فترة كتابته AP بضل بتشتغل فترة راحة

لعمل propagation بس تتعب skeletal muscle

للأعصاب المسؤولة عن الكتابة وخلال هاي الفترة لا تنتج AP

PROPAGATION OF ACTION POTENTIALS

إنتشار

- In contrast to the graded potential, an action potential is not decremental (it does not die out, action potentials function in communication over long distances.). Instead, an action potential keeps its strength as it spreads along the membrane. This mode of conduction is called propagation.

- The action potential regenerates over and over at adjacent regions of membrane from the trigger zone to the axon terminals. However, it cannot propagate back toward the cell body because any region of membrane that has just undergone an action potential is temporarily in the refractory period.

THANK YOU

AMJADZ@HU.EDU.JO

$-70mV \longrightarrow +30\ mV \Rightarrow$ depolarization = activation

لأني ببعد عن state (-70)

$+30mV \longrightarrow -70\ mV \Rightarrow$ repolarization

$-70\ mV \longrightarrow -90\ mV \Rightarrow$ hyper polarization = inhipition

ممكن تتفير هاي الأرقام خاصة في القلب

كيف يتكون AP ؟

resting membrane potential (-70 mV)

بتدخل Na داخل الخلية ← | → بتطلع K خارج الخلية

leak Na^+ & leak K^+ channels بكون بشتغال و Na/K ATPase عشان يحافظ على الجهد عند -70mV

بطلع 3Na خارج الخلية

بدخل 2K داخل الخلية

↑

stimulus ← ex: neurotransmeter بأثر على الخلية

ligand-Na^+ gated channle بفتح ← بتدخل Na^+ إلى داخل الخلية حتى يوصل فرق الجهد إلى -55mv (threshold) ← action potential بصير graded potential

بس يوصل لـ threshold بفتح Voltage-gated Na^+ channels بتدخل Na إلى داخل الخلية وبتعمل depolarization بوصل فرق الجهد إلى +30mv وبعدين بتسكر

↓

بتفتح Voltage K^+ gated channel وبتطلع K^+ خارج الخلية و بوصل فرق الجهد إلى -70mv = (repolarization) hyperpolarization

ممكن تضلها مفتوحه ويوصل فرق الجهد إلى -90mv (after-hyperpolarization) بعدين برجع -70mv (resting membrane potential) بعد ما تسكر قنوات K

← بتدخل الخلية (refractory period) ما بتتنتج خلالها سيال عصبي جديد