Faculty of Medicine 2012

Dr name : Eman Al-Khateeb

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Physiology

Sheet

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Price :

Done by :

Mohannad H. Sa'adeh

Physiology

Second lecture with Dr. Eman Al Khateeb

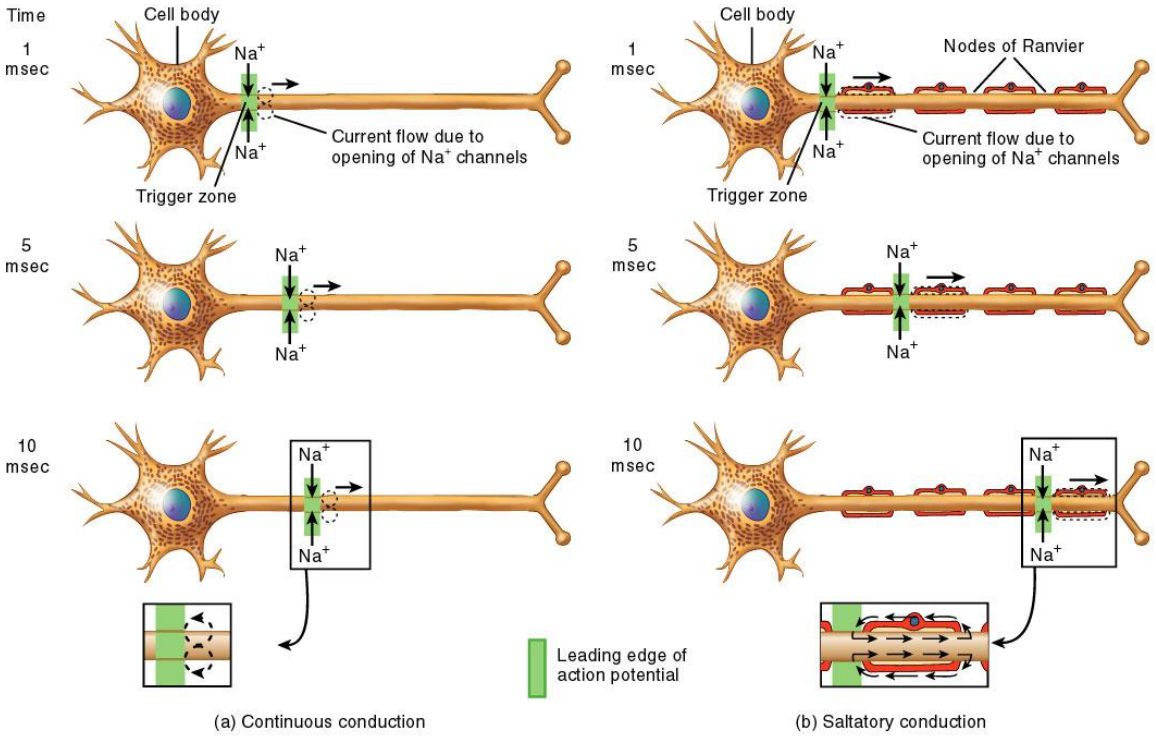
- **Saltatory conduction** :

  is a criteria of **<u>myelinated</u>** nerve fibers which is in the form of jumping .

** Comparison between the myelinated and the unmyelinated nerve fibers :

- Benefits of Saltatory condution (done by the myelinated nerve fibers) :
  1- Transmit information as fast as possible to the brain to alert it about dangerous stimulations (Balancing Equilibrium) .
  2- It's a form of energy conservation because we use less energy (less ATP and glucose usage, because we will use Na+/K+ pump less).
  3- less time needed to reach equilibrium .

- In the unmyelinated nerve fibers there is no jumping so it's going to be like walking (one step or one point is going to cause leakage of sodium inside the nerve fiber of the adjacent point where another depolarization condition occurs and another action potential) ,and if you can say it's just like walking step by step and this will make it much slower and much energy will be spent until we can reach the equilibrium.



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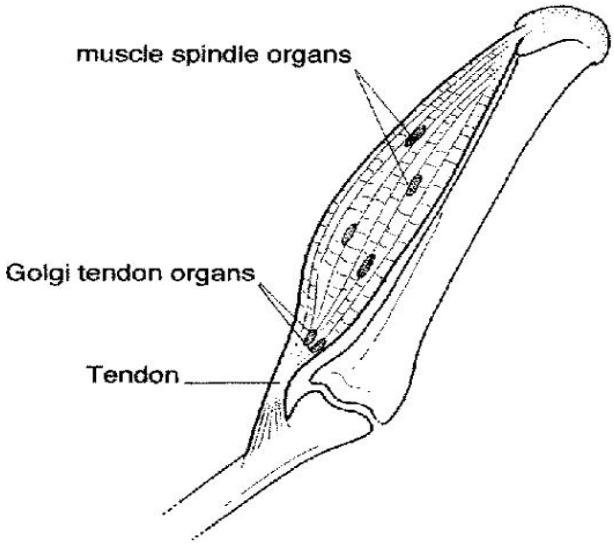
>> What makes saltatory conduction occurs??

It's the density of Na+ channels within the nodes of Ranvier that makes the jumping and the saltatory conduction. At the nodes of Ranvier, there is a huge amount of Na+ channels, this will cause the membrane reaching threshold very fast, while we come to the membrane of the axon of the nerve fiber underneath the myelin, the number of Na+ channels is much less, in order to let the membrane reaches the threshold difficultly "this lacking of the Na+ channels will not let the membrane reaches threshold" , while it's just by reaching to the next node of ranvier, which is no more than 1 or 2 mm away, immediately this membrane potential will reach the threshold and fire an action potential.

>>While at **unmyelinated** or (partially myelinated) nerve fibers there will be no difference in the density of Na+ channels all over the link of the nerve fibers so it has to be excited one step at a time .

- Two structures are responsible **for balance equilibrium and tension of the skeletal muscles** :



1) Muscle spindles

* Muscle spindles are the sensory receptors of skeletal muscles that determines the length of the muscle.

* Muscle spindles tell our brain whether the muscle is contracted or relaxed without even looking to it (it work subconsciously and transmit signals about the length of the muscle).

2) Golgi tendon (the receptors that are present within the tendon) they are receptors in the tendon, responsible for the tension of the muscle and tell the brain how much strength is required.

These two structures determine whether the muscle is contracted or relaxed and they are connected to the FASTEST nerve fibers because they are responsible for equilibrium of balance.

- **The visceral pain** (slow pain), usually is conducted by very small nerve fibers, because the pain does not matter to be very fast but It matters to be very persistent. For example, we do not want a person who has appendicitis to stay sleeping and then the appendix ruptures in his abdomen because this will be toxic and by the time he wakes up in the morning, he'll have got a septicemia! Therefore, we need the pain to keep alerting the brain so the patient wakes up and seeks help.

Remember: Pain never adapt.

**Resistance is a criteria of the diameter of the nerve fiber.*
**Myeline effects the capacitance of the membrane .*
** The most important information is the equilibrium of balance and this function is done by the fastest nerve fibers.*

- **In the excitable nervous tissues, we have :**

-- Action potential

-- Graded potential

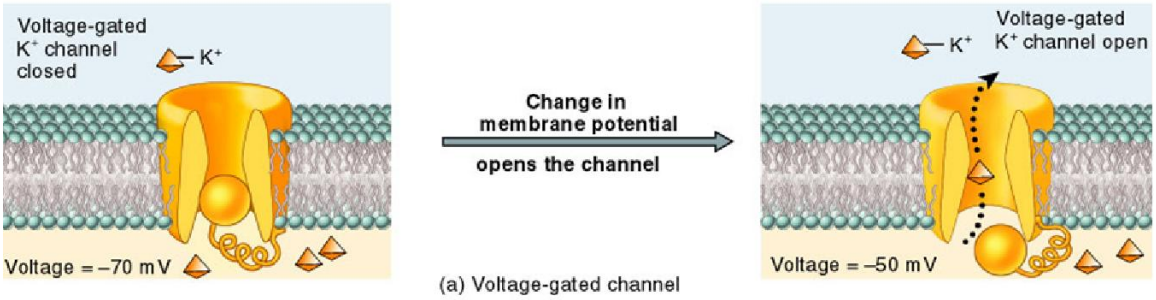
-- Resting membrane potential

Each one has a specific channels present in the excitable tissues as follows:

1) Action potential (depolarization and repolarization)

The responsible channels for it are the Voltage-Gated channels .

Upon changing of a voltage from -70mV to -50 or -55mV, these channels open and cause entrance of Na+.

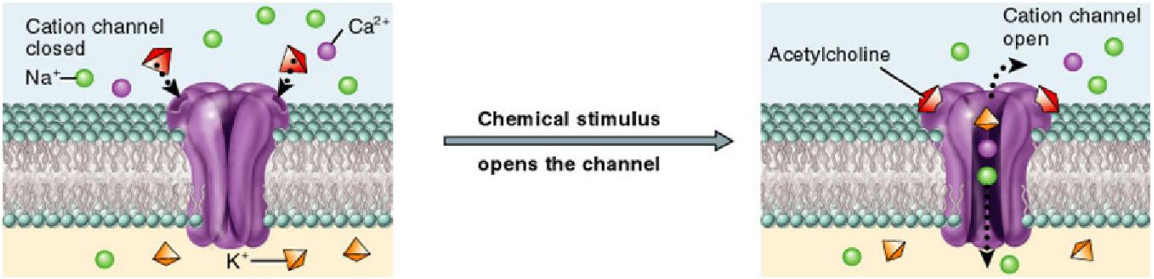


(a) Voltage-gated channel

2) Graded potential (the criteria of formation of the graded potential) :

- Ligand gated channels :

When there is a site on the channels" just like the key and the key hole" where the chemical substance sits in this receptors "channels" then the channel will open and ions will enter (we will study it in full details in the synapses , neuromuscular junctions and graded potential) .



(b) Ligand-gated channel

- Mechanically gated channels :

They work and open when you press stretch or distort the membrane.

Dr. Eman once said: "Our job as a teachers is not to graduate you as an excellent student, our job is to teach you how not to kill people !!"

The refractory period:

- **Absolute refractory period :**

"When the membrane is resistant to any further stimulation and no other action potential can be generated **no matter** how strong the stimulation is."

* We can find it in the action potential. And it's a major difference between it and the graded potential.

Q. Why does it occur?

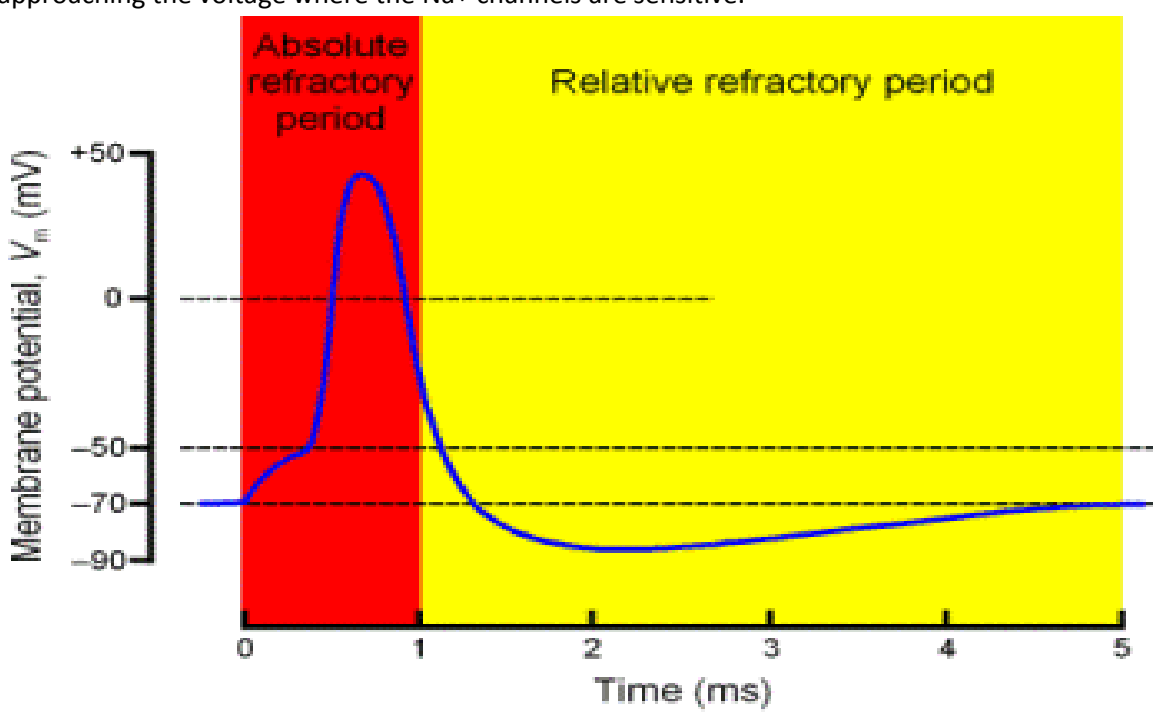
1) Na+ voltage-gated channels are very sensitive to -55 - -60 mV (the time of channels' opening) so when the membrane potential is +35 mV or +20 mV it is not an ideal time for these channels to open.

2) Na+ voltage-gated channel has two gates (activation gate and inactivation gate) , so when the inactivation gate is closed it is difficult to open the channel again.

In other words, we do reach the equilibrium potential of Na+ where there is no further transport of Na+ in or out and the net movement is almost zero.

- **Relative refractory period :**

"If the stimulus is **strong enough**, an action potential might occur because here, we are approaching the voltage where the Na+ channels are sensitive."



***** The refractory period of a large nerve doesn't take more than 1/2500 sec. For example, the nerve with a refractory period equals 1/2500 sec. there is 2500 AP can be generated per 1 sec. So we get that whenever the refractory period increases the number of action potentials per second (**Frequency of AP**) decreases.

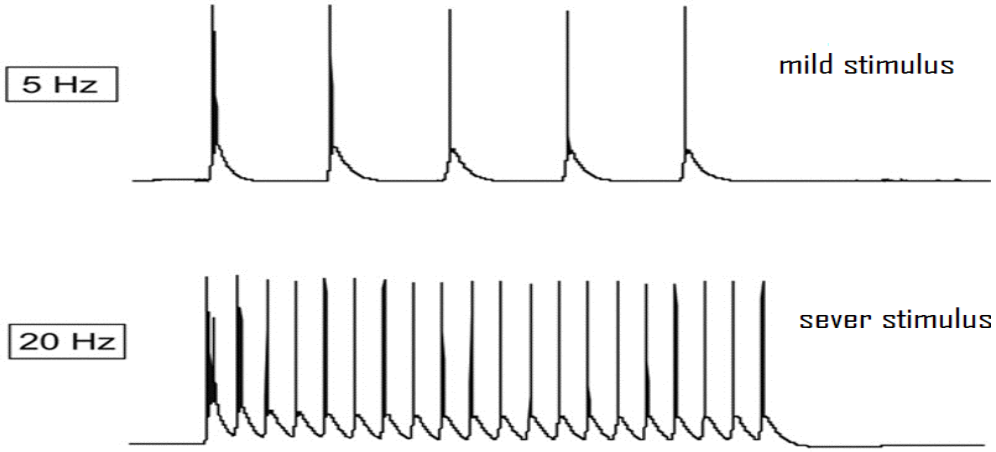
* Refractory period plays a role in the frequency of the action potential as we said , and the frequency is the best way to tell our brain that the stimulation is severe, moderate or mild. But how does that happen?!! There are two things responsible for determining whether the stimulation is sever, moderate or mild:

1) The number of action potentials reaching the brain.

Suppose that there is a housewife working in a kitchen, she burnt the tip of her finger or she had a massive burn! The brain decides "via frequency" that the first incident is simple and mild while the other is very severe. (More action potentials >>> more severe is the stimulus)

2) The number of the nerve fiber stimulated. (The area of the damaged (stimulated) tissue).

When there is a burn in the tip of the finger, the number of nerve fibers stimulated is less than the nerve fibers stimulated when the burn is in the whole hand for example! (The nerve fibers stimulated will be more) .



<u>Some notes Dr. Eman said :</u>

- The artificial stimulus is different from the normal physiological one. If we put and electrode on the arm and stimulate it, the stimulation will be bidirectional (to the central and to the peripheral). On the other hand, if you touch a table, the stimulus will go from the peripheral to the CNS (central nervous system) and when the CNS want to order any muscle, the stimulus go from it to the muscle and so on.
- The excitable tissues are able to be exited in many ways but they do a specific function and have specific criteria. BUT we are talking about the **peripheral nerve fibers** unless Dr. Eman says something else.

Features and major functions of Action potential:

- Regenerative
- Threshold
- Move along axon
- Voltage gated channels
- Propagates
- All or None
- Amplitude above 100 mV (from -70mV to +35mV)
- Short duration
- Depolarizing then repolarizing
- Refractory period
- No summation.
- **Function:** carries information **faithfully unchanged** from one end of neuron to other, without decrement and with a pulse code.

Ionic Disturbance

"one of the most dangerous conditions where there is a change in the excitability of the CNS"

"Convulsion"

These words have the same meaning whenever you read it "in this level of studying":

Convulsion / Fit / Seizure / Epilepsy … their meaning is: Hyper excitability of the CNS

- Ionic disturbance might cause an Convulsion and we will talk about it today **BUT** convulsion might happen because of many things such as :
  - When children have fever, this might cause a convulsion.
  - When someone drinks a toxic substance, he might go into seizure.
  - When someone has a stroke in his brain, he might go into convulsion.
  - When someone, who is already capable to going into epilepsy, watches TV too much, he might go into epilepsy due to high lighting.

As we said, we will talk about the convulsion caused by the ionic disturbance. It is life threatening and very dangerous.

* **Convulsion happens because of** something we call **Hypocalcaemia** which stands for the lack of Ca++ extracellularly (condition of convulsion). Most of convulsion patients have some problems in the **parathyroid glands** (which are responsible for the regulation of Ca++ in the body).

**Some children are born with sensitive area in the brain excites the brain more than usual (stronger than usual) causing convulsion.*

**There is hypercalcemia and there is hypokalemia, but these cause paralysis.*

**Parathyroid glands : 4 small glands located behind the thyroid gland.*

- When a surgeon want to remove the thyroid gland he must do his best not to damage the parathyroid, but because of their small size and the same blood supply with thyroid gland, they usually die. Thyroid patient might go into epilepsy after you remove his thyroid gland due to the damage of the parathyroid glands, and if you did not care about that very well and that will be a life threatening and he might die because of his ionic disturbance rather than the surgery it self !
- **Symptoms mark hypocalcaemia :**

  { hyperexcitability begins}

  - Numbness in the fingers' tips and face.
  - Trembling muscles.

  *If you do not give the patient Ca++ he will go into convulsion.

- **Why does hyperexcitability (convulsion) occur when Ca2+ ions decrease extracellularly ?!**

  The membrane has got Na+ voltage-gated channels which are lined by negative charge to transport positive charge into the membrane. Both Na+ and Ca++ are attracted by the negativity of the Na+ voltage-gated channel, but this channel is small and only can transport Na+ ions not Ca++ ions due to the large size of Ca++ ions. We can see that both Na+ and Ca++ do compete with each other to enter the channel but only Na+ enters it. So when Ca++ ions decrease outside, Na++ ions stay there alone and there is no ions to compete with (nothing will resist its entrance), so Na+ ions will pass faster to the inside, making the action potential faster and it increases the excitability of the membrane leading to convulsion.

- **Convulsion has two phases :**

  1- **Tonic phase**:

  in this phase, the muscles will go into full contraction without any relaxation due to thousands and thousands of action potentials generated by the excited CNS so the person will go into full tetanus "arching".

If this stays for long period it will cause death because of the full and persistent contraction of the respiratory muscles and there is no breathing, but luckily, the neurotransmitter chemicals get exhausted in the brain so this phase does not remain more than one minute then the body goes into Clonic phase.

*"CNS" stands for Central Nervous System (the brain and the spinal cord).

2- Clonic phase

- In this phase, there is contraction and relaxation.
- The patient might bite his tongue.
- The patient might urinate or defecate on himself because of the strong contraction of the abdominal muscles.

The patient will be miserable in this phase, but the breathing will be back !!

>> **After two minutes**, the patient will go into a static condition (but he will not be very well oriented because there is a lot of electric charge in his brain) and he **gets conscious** as the following:

- He opens his eyes.
- He is in a level of conscious (below the normal).
- He goes to sleep for 1 or 2 hours.
- Recovers with headache for 2 or 3 hours.
- Conscious

- **<u>How can you help a patient in an epileptic incident ??</u>**
  > **During the tonic phase and the clonic phase**, we do not touch the patient wherever he was even if he was at the hospital. The only way to help him is to use a tongue depressor "metal type"and put it in his mouth then invert it to open his mouth and fix his tongue so he will not bite it. If you try to touch him, he might hit you or injure himself so just <u>LEAVE HIM ALONE</u> for these two minutes.
  > **When these two phases finish** you should:
  - Turn him on one side to ensure breathing.
  - Clean his mouth and try to remove all the froth and the saliva.
  - Ask nurses to clean him and give him sedation.

- Sometimes, epilepsy patients feel that they are going into a fit so they lay or sit, not to fall down when the fit starts. On the other hand, there is unexpected fits, because of ionic disturbance or fever. These patients do not know when they will go into epilepsy.

  *** in this lecture we studied the hypocalcaemia in the CNS only not for any other tissues, this is different in different types of tissues.

**Saliva: The watery mixture of secretions from the salivary gland.*
**Froth: Salivary foam released as a result of disease or exhaustion.*
**Sedation: a medication that commonly induces the nervous system to calm*