Faculty of Medicine 2012

Dr name : Eman Al-Khateeb

Date : April - 17th - 2013

lecture no. : 6

Physiology

Sheet

Medical Committee
The University of Jordan

Price :

Done by :

Alaa Adamat

We will talk about:
- The difference between the synapses and junctions.
- Types of synapses.
- Synapses found in the brain.
- Study the chemical synapse by studying the neuromuscular junction because they have the same physiology.
- drugs and factors that affect the synaptic connections and NMJ.

The difference between junctions & synapses:

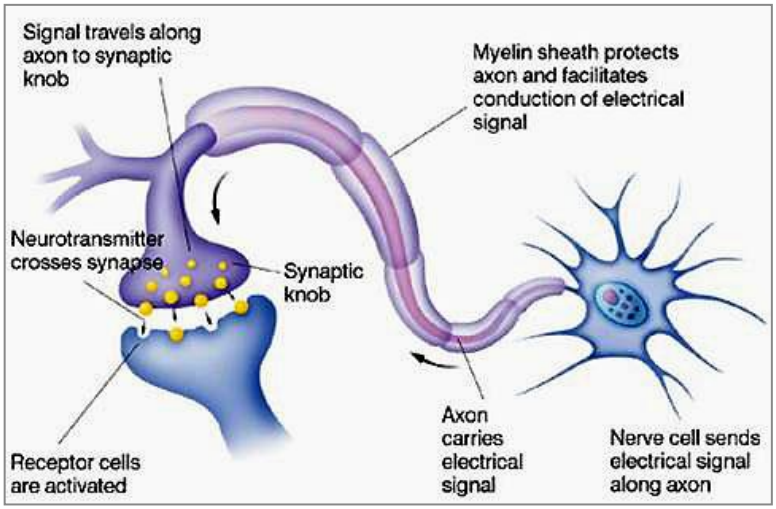
The junction happens to be between a neural tissue and a non neural tissue- another excitable cell- so it's a nerve supplying another tissue that could be; skeletal muscle, smooth muscle, cardiac muscle or a gland. For example: a nerve & a muscle it's a neuromuscular junction, or a nerve & a gland in order this gland to contract and release its secretion.

The synapse is a connection between two neural tissues or structures; it's the way the neurons talk to each other. For example: an axon with another neuron, an axon with a dendrite, a dendrite with other dendrite and so on.

****Here is a simple explanation to gather the information about Graded action potential, action potential & neurotransmitter release**:*

we have studied the electrical activity of the neural cells, the neural cell has all the right to think about the information or the input that is coming to it and then it decides whether to fire an action potential or not. This way of thinking is **G**raded action potential; gathers all the excitations and the inhibitions that take place at the level of the soma or the dendrite at this given second, if it reaches threshold it will fire an action potential that will propagate until the end of the axon.

The action potential will be transferred to another tissue whether it's a junction or a synapse here it's no more electrical, a chemical substance or signal is needed, it will be released and then it will be attached to the target tissue or cell; that has a highly specific receptors and will lead to opening or closing channels, so there will be a lot of changes within the target cell and the information will propagate from one place to another.



***There are two types of synapses*:**
Electrical synapse is found between 2 neighboring cells, there are tubular proteins like channels between them that allow the ions to pass freely from one cell to the other, its **bidirectional**.
Chemical synapse is a highly directional type of connection, there is always a pre & postsynaptic neuron and the information will always come from pre to post there is no return back , it's **unidirectional**.

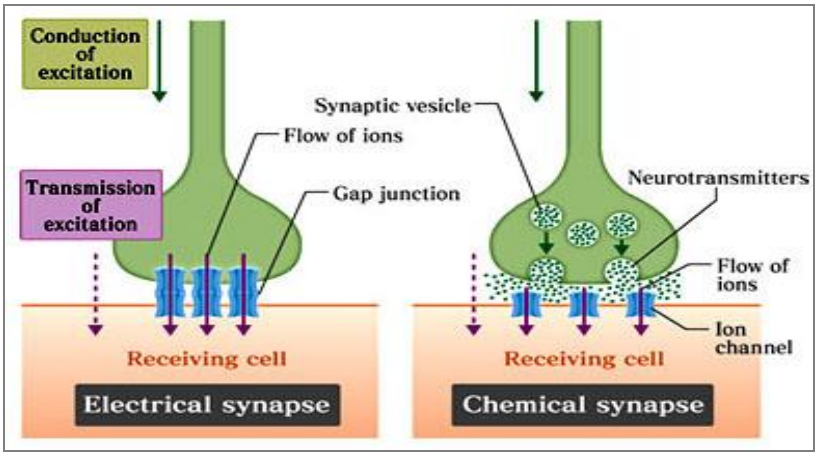
Types of synapses in our brain:
the most abundant type is **C**hemical synapses 99.9%, since we are highly sophisticated creatures and our brains do a lot of functions it must be highly directional; that's why the brain is hard to study.
We have a very small amount of **E**lectrical synapses like in the olfaction which is the smell sensation.

The Electrical synapses (gap junctions) are found in our body in:
the **h**eart and the **s**mall intestines, in the heart to cause excitation to all the myocardial muscle at the same second in order to eject blood, so we have gap junctions to move the ions in all directions to make sure that all ions are reaching the heart muscle at the same moment and the whole heart will contract , this is called syncytium of the heart (all together). Also it's found in the smooth muscles to digest and propel food or the end products of food so that the small and large intestines will work at the same time.

The chemical synapses are highly directional & complicated;
In our brain, instead of having one type of neurotransmitter, each neuron has 2 or 3 types of neurotransmitters that affect the postsynaptic cells differently. For example: if it releases neurotransmitter #1 the cell might get excited, #2 the cell might get inhibited, #3 or it's called neuromodulator the cell might be stimulated for months, which is highly different from what is happening at the neuromuscular junction we can contract or relax the muscle in one second.

When we talk about the synapses in the brain we are talking about the background of all psychological illnesses that the human beings are suffering due to chemical disturbances in the brain, and the neurological disorders like Parkinson, Alzheimer and Huntington disease.

In order to study the chemical synapses we should study the neuromuscular junctions because it has the same physiology but in a simpler form and its simpler to reach rather than the chemical synapse that is harder to reach.



In the terminals of the neurons there are Mitochondria that indicate it's a highly active area for example thousands of action potential and millions of Graded action potential are formed just by sitting and listening (the presynaptic area are full of mitochondria). Also there are vesicles containing neurotransmitters in order to be released; first the arrival of action potential, second the opening of voltage gated calcium channels that will lead to the influx of Ca+2 to the inside and adhere to the protein calmodulin that will cause the vesicle to fuse with the membrane and rapture.

Certain factors that affect the synaptic connections and transmitters:

- Some ionic disturbances like Ca+2, if it's not found there will be no influx no release of NT, no connection.
- Also the PH which is the hydrogen ion concentration, the normal range of PH in our body is highly specific and between 7.35 -7.45 any change will cause disturbances of many enzymatic reactions and synaptic connection which is much more important. For example: **Acidosis** that depresses and inhibits the synaptic connection if the PH decreases like for 7 and the patient will go into comma (deep sleep), it's found in the diabetic patients that didn't take insulin because there is too much glucose but it can't enter the cells & give energy so the body will breakdown the amino acids and fatty acids, the end products of the breakdown of fatty acids will cause ketoacidosis. The patient will go into comma, to treat this give the patient glucose, insulin and bicarbonate.

Alkalosis increases the excitation of the synaptic connection and the NT secretion causing hyper activity that will result in epilepsy, for example hysterical hyperventilation, it's found commonly in teenagers that go under certain issues like heart breaking and so on, they start hyperventilation (fast breathing) by doing this they start washing the CO2 in their body, will result in alkalosis causing tetany. To treat this we use a paper bag so that the patient will re breathe her own Co2 or you might hit her strongly but this is not recommended: P

if we don't treat this in 6 hours the patient might go under epilepsy or even status epileptical; many attacks one after the other that will affect the breathing and the brain.

Both acidosis and alkalosis are dangerous on the synaptic connection.

-Hypoxia: there is no enough oxygen that causes the depression of the synaptic connection that result in heart attack.

- Also Caffeine found in coffee, theophylline in tea & theobromine in cocoa excites the synaptic connection and stimulates it so we can focus more when we study.

Now we will explain the physiology of the neuromuscular junction which we said before is similar to the chemical synapse found in the brain and the spinal cord and usually any drug that affects the NMJ affect the chemical synapse also, in NMJ after the arrival of the action potential to the nerve terminal which is **m**otor because it's supplying a muscle (the sensory will go to the brain) >> open voltage gated Ca channels >> Ca+2 influx which is found at a high concentration outside >> release the **acetylcholine** which is found here because it's a NMJ >> # of vesicles is 125 each one containing 10000 Ach molecule. Therefore no way any second we try to contract a muscle or relax it and we were unable because in each Action potential we release a huge amount of Ach.
Remember there is no attachment between the prejunctional nerve fiber and the postjuctional muscle, there is a space called a **cleft** here it's a neuromuscular cleft, the cleft is also found in the synapse.
>> Then **2** Ach will bind to a single highly specific Ach receptor are found in a specific place on the muscle called the **motor end plate** >> will let the most available positively ions to enter which is **Na**+ >> causing depolarization if it has reached the threshold then it will causes mechanical change by actin & myosin over lap. This is an Example of **Graded** Action Potential.

If the Ach remains for too long it will lead to muscle spasm so it has to be destroyed and broken down instantly by an enzyme called **acetylcholinesterases** found at the **postjunctional membrane** (the muscle).
Also Ach is synthesized by **Acetylcholine Transferase** which is found at the **nerve terminal**.

Drugs that work on NMJ or neurons; drugs could be chemical or natural from plants called herbs

- giving chemical substances similar to Ach like nicotine that causes potentiation of the junction.

- competitive inhibitors or antagonists on Ach receptors; that compete with Ach to bind on the receptor and causes inhibition, like Tubocurarine it's a toxin coming from a plant that was used in hunting and these days it's used in surgeries to relax the muscles.

- prevent Ach release at NMJ like (Botulinum toxin from ***Clostridium botulinum*** bacteria) that synthesize Botox which was used for the first time of the history of medicine, if someone has wrinkles it's given to him to relax the muscle and paralyze it, so the surgeon must be careful cause it may lead to eye drop or breathing issues that's why it must be given in small doses.
Also it's found in canned food that leads to bacteria Botulinum growth, it will secrete a toxin that will leads to gastroenteritis like vomiting and diarrhea also toxicity because it inhibits the Ach release from the nerve fibers.

- Blocking Ca+2 voltage gated channels that can inhibit the transmission (antiepileptic drugs) & anything that can **potentiate** calcium can increase the transmission, the epilepsy drugs are working on this.

Good Luck XD
too deep to have any quotations for you