Animal Physiology
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Lecture – 25
Neurotransmitter & Action Potential

Welcome back to the lecture series in Animal Physiology. We are in the fifth week. So, today we will be having our fifth lecture of the fifth series. So, if you recollect in the previous lecture, we talked about some series of neurotransmitters I name some of them like glycine glutamate, GABA, acetylcholine.

Today let us introduce another interesting parameters so that this list of neurotransmitters is fairly huge. So, do not get bogged down by the range and variations of neurotransmitter now what is the important for you to understand is a neurotransmitter as the name indicates it is kind of a messenger it binds to its receptor on the cell surface. And it results in a cascade of actions followed by that and for us most importantly in this case our concerned is the way they can be classified is either they will be called as excitatory or there will be called as inhibitory.

Inhibitory neurotransmitter excitatory how they got these 2 names, so, as we have already mentioned cells it is at by (Refer Time: 01:56) millivolt which is negatively polarized with respect to outside its formal positive. Now, say for example, neurotransmitter if we call this inhibitory neurotransmitter what this will do is it will bring down the membrane potential of the cell further negative it means if it is sitting at minus 80 millivolt it can make it to say minus 85 millivolt or even minus 90 millivolt how you can do that just put the logics and place that can only happen when inside the cell your increasing the negative ion concentrations where enough.

So, let us draw it that we will help you once again to kind of appreciate what I am trying to tell you.

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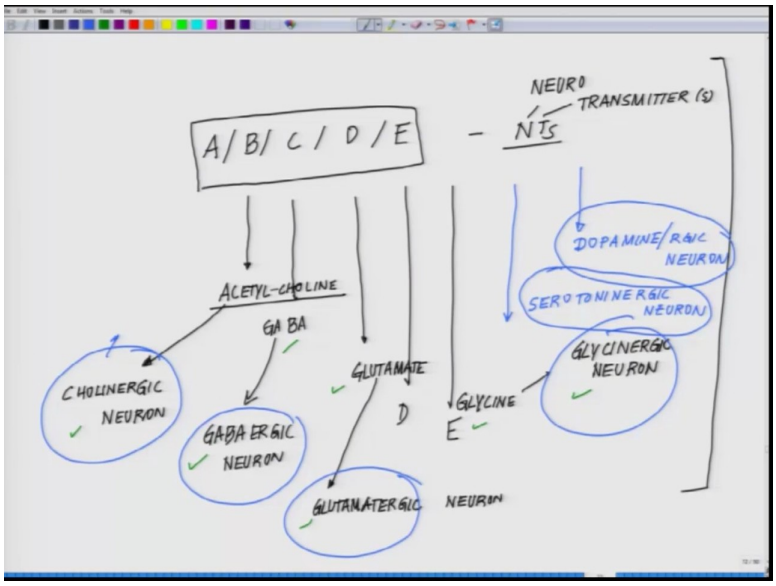

So, here where we were; so, you have this different kind of neurotransmitters glutamate glycine GABA.

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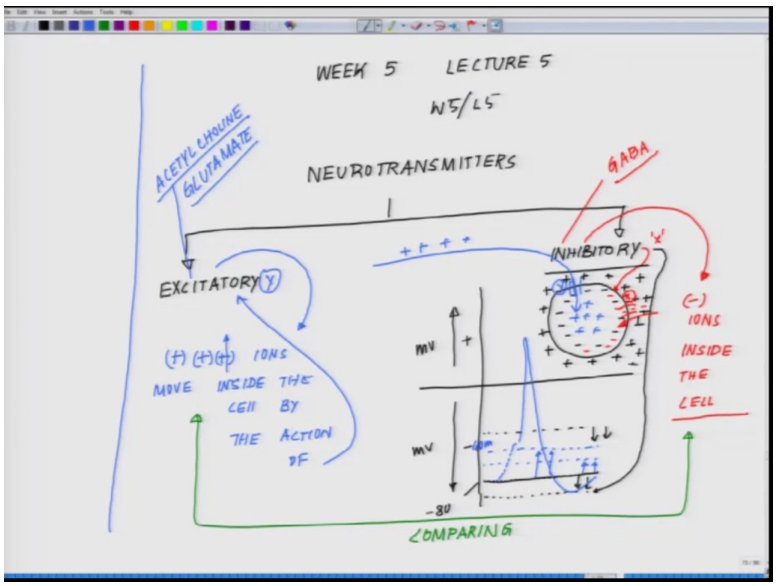

So, now today we are introducing one more concept. So, we are into week 5; lecture 5 so W5 L5. So, neurotransmitters classified into 2 categories excitatory. So, excitatory and inhibitory, now what I told you is that if it is a inhibitory neurotransmitter then if the cell is sitting. So, this is y axis is giving you the voltage in millivolt is in the positive side here and the negative side millivolt.

So, the cell is sitting at some around this if I construct this as minus 80. Now I said by the action of a neurotransmitter if it is a neuroinhibitory, neurotransmitter it will further shifted to the negative direction it will make it say minus 85 or something or minus 90 or wherever it is sitting it may sit here it may it may be sitting here and it will become further negative and what is the remark I used to justified. I told you that if this is that cell it has negative ion negatively charged ions which are in higher number as compared to outside then such further negative polarization can only happen when I am increasing the negatively charge ions inside and that is promoted by inhibitory neurotransmitter.

So, how it does; so, when I inhibitory neurotransmitter say x comes and binds on this surface of the cell something like this it is binding it opens up channels which will allow the influx of the an ions or negatively charged ions. So, this opens up a gate which allows the negatively charged ions to get inside the cell and talked about these gates and the channels they are very specific at times they are very specific at times their non specific. So, for the time being for your basic fundamental understanding if it is a inhibitory neurotransmitter then on all likelihood this is going to permit the inflow of negatively charged ions inside the cell this basic fundamental should be clear in your mind by the same token if it is an excitatory neurotransmitter out here.

Then this does the reverse thing what it does in the case of excitatory if this is the baseline, where I have shown the baseline minus eighteen excitatory one will do the reverse it will make it more positive inside will be more positive from its base line again from its baseline if the baseline is sitting at say minus 40 to becomes a minus 30, it is all relative. So, do not like get confused we very clear it is always a very relative parameter from this baseline it will make it more positive and how that is possible that is possible when similar to this if I compare this 2 situation comparing.

So, in this situation once again positively charged ions move inside the cell by the action of excitatory neurotransmitter say it is a y. So, it y minds here then this allows the passage of something like this. So, in the light of this if you remember where we digressed while we started talking about the synapse I told you I will have to explain you about neurotransmitters. So, in the light of this if you remember I told you all or none if I could change the membrane potential say from minus 80 to say you know minus 40 millivolts. Say for example: somewhere other like this then there is no stopping this

wave shoots up and comes back you remembered that. So, the binding of the neurotransmitter can lead to the generation of action potentials.

So, these are those external things now let us come back after giving you this brief you as examples of inhibitory neurotransmitters GABA is one such inhibitory neurotransmitters excitatory neurotransmitters are many like acetyl choline glutamate which is a very prominent and based on that I have already mentioned there are neurons which are named as gabaergic. Remember gabaergic neurons glutamatergic neurons cholinergic neurons. So, cholinergic is a non-specific a time channel opener glycinergic neuron. So, similarly you have serotoninergic neuron which secretes serotonine dopaminerrigic neuron which secrets dopamine neuron.

So, what I will request you please do this simple exercise pick up any book check all the different kind of neurotransmitters and classify them is it an excitatory or is it in inhibitory what it is you know which family it belongs to it, it will help you to kind of figure out based on the basic knowledge what have offered you.

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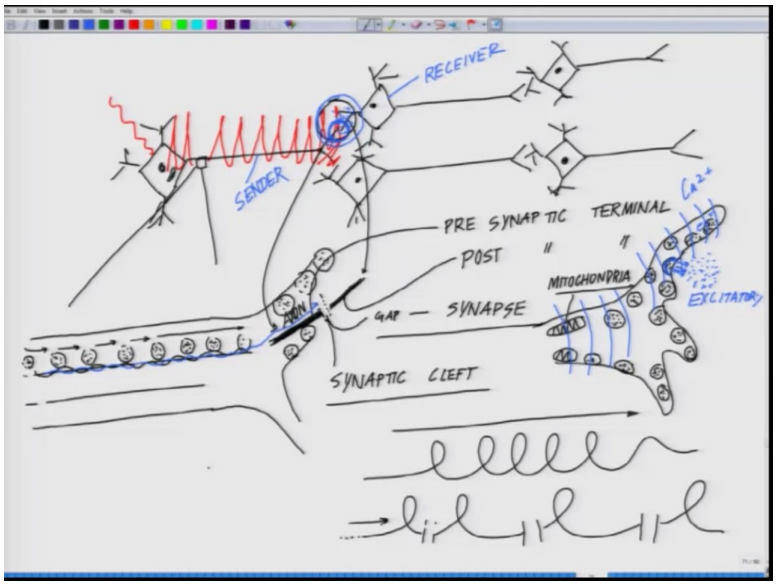

Now, let us go back to the synapse I told you something about this part right remember. So, I told you that there are these vesicles which travel out here and I have already told you that you know cells could be glutamatergic garbargic whatever. So, what happens at this synapse at this synapse once an action potential wave reaches this synapses there are

couple of reactions which takes place, but I will tell you the results first of all you up to appreciate the result then we will talk about the role of calcium and all other things.

At this point I will stop it I will leave it there and I will tell you what the end result happens. So, once the action potential reaches out at the step what this neuron what happens is certain unique flux of cautions takes place and how it takes place will come later into it which are mostly calcium and this is all happening inside this leads to these vesicles what you are saying these vesicles get opened up here outside like this and once they open up transiently. So, these neurotransmitters are secreted by this particular neurons say for example, if this is the send a neuron and for our study we are talking about the receiver neuron.

So, at this location the neurotransmitters are you know given out these neurotransmitters if they are excitatory then they will bind to this receiver neurons dendritic terminals right. So, let me draw it again for you make more sense.

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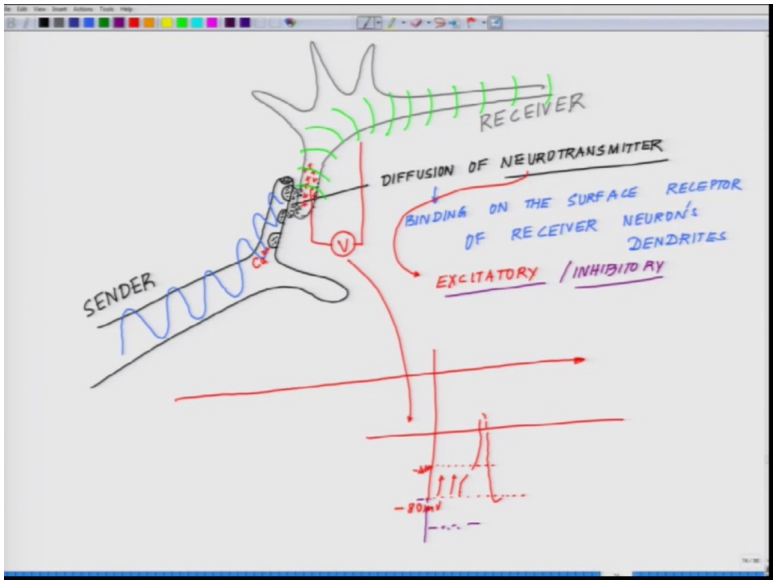

So, say for example, this is the sender neurons axon and terminal just for your simplicity I am keeping it very very simple and this is the dendritic terminal of the receiving neuron. So, this is the sender which is in dark black and this one is the receiver and signal propagation is taking place in this direction. So, electrical wave traveled all the way in the form of action potential out here. So, you have a series of neurotransmitters laden vesicles which are present here these are all filled with neurotransmitter this black

dots are showing the neurotransmitter led in vesicles at this location there is a flux of calcium ion we will come later into that.

But that leads to the opening of these vesicles outside and the neurotransmitters are secreted in this small cleft like this there is a diffusion of neurotransmitter taken place here diffusion of neurotransmitter. Now these neurotransmitter, now binds to the membrane of the dendrite of the receiver neuron binding on the surface receptor of receiver neuron dendrites binding on the surface receptor of the receiver neurons dendrites now if this neurotransmitter is. Say for example, if this neurotransmitter is excitatory then what will happen this cell which otherwise is sitting. So, if I keep a voltmeter with respect to the cell what will happen this cell is originally sitting at the reading wish schedule minus 80 millivolt or minus 70 millivolt wherever.

Now, if these excitatory neurotransmitters binds to this receiver neuron what will happen its membrane potential is going to if it is an excitatory, because of the influx of the positive ions here because of the binding this place becomes positive and it may even reaches a minus 40 millivolt and at this stage this cell will shoot and action potential and this action potential wave. Now from here we will start to travel like this again the same thing will be repeated at its end. This is the most simplistic way you can understand it vice versa if instead of this being excitatory this is inhibitory. Then what will happen this minus 80 from minus 80 it will go further down it will become negatively hyperpolarized it is already in a polarizer state of minus 80 this will become negatively hyperpolarized.

So, for this cell to shoot and action potential will be much more difficult the second one. Now with this very simplistic view point let us try to explode this picture in a giant network that is where the whole world is going.

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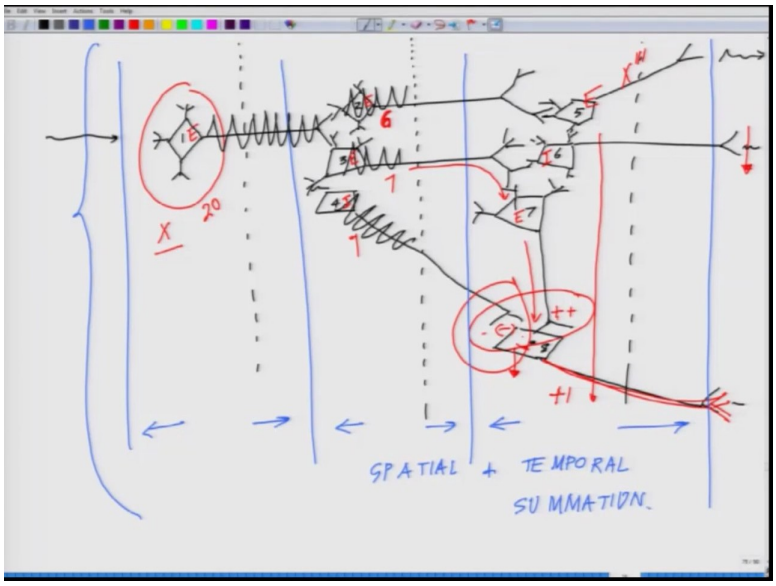

So, let me draw the giant network that will help you to appreciate what I am trying to tell you. So, I am get me few minutes or it done with this let me number then 1 2 3 4 5 6 7 8. So, you can see that at different level I have drawn them and anyway this goes on an similarly this is (Refer Time: 20:56). Now on this situation say for example, this one shoots and action potential and this is excitatory then this excitatory neurotransmitter will provoke to shoot action potential out here.

Second another action potential shootout here it does excitatory another action potential you shoot here, but say for example, this neurons secrets and inhibitory neurotransmitter what will happen out here this action potential is going to one we shoot further this will make this one secret to go further negative where as if this one is excitatory if this neuron 3 4 3 and 4 is three is e this is I and this is e. Now this excitatory will further secret another excitatory and is suppose this is I this one; one kind of you know dam down the signal out here. Similarly the one which is out here, if it is excitatory its make it is further excitatory. So, you see now here you got a chunk of certain x signal x signal we have split up, but now here you there is a dampening of the signal and only part of the x prime is moving further.

So, imagine of vast network. So, what you are seeing there is a competition taking place of signal at different level based on whether the signal is inhibitory or excitatory. So, if I say this is say 20 and then these signals is split up to say you know 5 7 7 5 7 7 14 say 6

my; I am just giving a random number now what will happen this seven here it will be say minus one because it is not no more transmitting it out here it quite is or say plus one, some more other say for example, if this one is say excitatory some more other this one the signal comes like this. So, this will have a positive excitatory signal as well as the negative signal and based on the quantity of the negative versus positive. It will decide what signal is going to go further if the positives are more if the excitatory factor is more as compared to the inhibitory factors.

Than the excitatory factor will travel partly what is over it can afford if the inhibitory part is more as compared to the excitatory part then automatically the signal will get dampen. So, this is on a most simplistic network what I can tell you how these signals are being transmitted. Now, in the light of this, I wish you people to stretch your imagination to think how a complex vast network is going to function.

So, with this I will leave you here to ponder upon the role of these different excitatory and inhibitory neurotransmitters and how at the synapse the signal gets transmitted and in the next class we will come back about these roles of calcium. And we will talk little bit more about special and temporal summation of signals.

Thank you, thanks for your patience listening.