Animal Physiology
Prof. Mainak Das
Department of Biological Sciences & Bioengineering & Design Programme
Indian Institute of Technology, Kanpur

Lecture – 24
Signal Propagation in Neurons

Welcome back to the lecture series in Animal Physiology. So, we are into the fifth week and today, we will be starting the fourth class. So, in the previous class when we discussed about the action potential there are few points which I wish a philosophize very clearly because it is a very fundamental concept and this more of a kind of an understanding what needs to be you know in grilled in your basic framework. So, one of the things which I wish to highlight here. So, I have shown you the picture of a neuron or I have drawn a picture of neuron is a tapered one process called axon which is the longest process and you have multiple processes called dendrites and your muscle body.

So, first thing you have to understand that when an electrical event happened it could happen at different parts of the system. So, it is not that at one point the whole system is electrically active what does that mean is say for example, there are 5 rooms which are connected just imagine it for you see. So, if say an I number the room as A B C D E, now suppose room a got an electrical impulse that necessarily does not mean B C D E is going to get it, but there will be some impulse will travel here and there, but if a receives a threshold signal what we meant by threshold here is the fundamental the word what I used all or none if a receives a signal which is beyond a threshold which has telling you around in around minus 40.

So, if it receives the signal we change the membrane potential of that room A by say you know take it to minus 40 then there will be a process called all are none and which will immediately transmit huge way of to B. So, by the time it will go to B, A will regain its own original situation fine a originally was setting at a base level minus 80 right now it receives an impulse I had becomes say minus 40 and it generates a signal which moves to room B, there all connected. So, there is a corridor kind of thing right. So, let me just draw it for your there will kind of make more sense. So, today we are into write. So, week 5 or Roman 5 whatever lecture 4.

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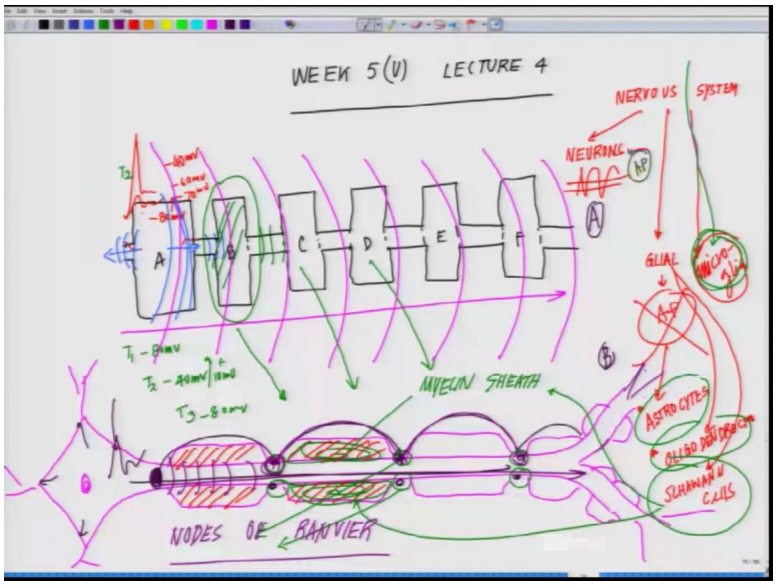

So, the analogy I am trying to give you is something like this imagine this. So, I name these rooms now say for example, I call it A; I call this room as B; call this room as you know a statutory realize it; what I am trying to tell you see I call this as D I call this as E I call this as F right. So, there are say six rooms for which are attached to each other now I say this one receive some signal some electrical impulse it receives, not good enough it just in a spread little bit here and they are that is it, it remain there, but say for example, this one receives a threshold something which say for example, this A is setting as minus 80 there are some shift it makes it say you know minus 70 or say minus 60 millivolt, it does not matter really those shifts local disturbance you know tuck that is it.

Nothing seriously happens, but if it receives something which could change the membrane although it is a minus 40, then this generates different level of wave and that wave pattern is starts to now propagate. It can propagate in both directions it can go like this also, but depending on which direction will be favored is depending on which direction the density of the sodium channels are higher remember this right we have talked about sodium channels potassium channels sodium potassium a t p s pump right. So, depending on the density in which direction will be higher it moves on that direction, its purely density gradient of sodium channel which dictates the term, but then it brings us to a question what makes nature to follow that kind of pattern is a very different question it is a evolutionary one of the most magical thing one nature is done.

How it created its cord or directionality it has given coming back where I was. So, it generates that signal once it generates this signal, this signal will move to the next one and once it moves here to say it moves to B, what will happen by this time the one which A at say now let me start plotting at time T 1 this was at 80 millivolt when the impulse comes when the impulse that classic impulse came, this became minus 40 millivolt and may over shoot to say 10 millivolt positive then this will come back to its original position by T 3 it will come backs to it minus 80 millivolt, but by this time this B we will exactly follow the same pattern as you see here then this will transmitted to C this will transmitted to D and overall what you will see is a wave is getting propagated what will be looking to is something like this.

With respect to time these waves what I am drawing are with respect to time. So, there is a propagation which is taking place along these tube or along through these rooms. So, when you look at a axon if you have seen this picture let me or the real time axon into place, this is how. So, instead of the analogy of the room now I will give your technical analogy when you over you see this neurons they would show you a picture like this and let me introduce this part which I have an introduced purposefully waiting for the right opportunity to introduce this concept. So, whenever you will see classic picture you will see just now compare this picture A here with picture B exactly similar to room like analogy you see. So, these are the zones where you see in wherever now I am kind of you know these are those black spots what I am drawing are the zones which are rich in sodium channels very rich in sodium channel.

So, say for example, I electrical impulse or in signal comes here and if it is a threshold signal what is threshold I have already explain you what is threshold signal, it is the threshold signal we have some may back propagate like this I do not rule out trust my word I do not rule that out because there are a lot of computational models which are coming which those of you are interested in neuroscience or computational neuroscience they will see. So, please for god sake do not rule that out there is a possibility, but the major chunk if I go by the statistics and if I say the major chunk of the signal where that will move major chunk will move in this direction, just exactly what you saw in the analogy of the room and they will be. So, done what are these structures this is called the salutatory conduction, but what are these structures what I have drawn here now which I am shading as red room like a structure.

So, this is called so, a nervous system consists of broadly 2 basic type of cells (Refer Time: 09:50) site some cells which are of immune origin I am not talking about them at this stage they are. So, nervous system consist of 2 major cells one is the neurons which are electrically excitable. So, I am just putting something like this these are electrically excitable cells the other cell type is called Glial cells. Glial cells are not do not shoot they have certain electrical activity though, but do not shoot and action potential. So, these on shoots AP; action potential these one no AP, and yet within the glial cells there are three classifications what we see one is called Astrocytes we will come later about all these things Oligodendrocytes Dendrocytes and this is the third one called astrocytes oligodendrocytes and Schwann cells Schwann cells and there is one more cell type of the nervous system which I am putting it separately though it part of the name sounds with glia, but it is called microglia there are reason to put it separately how the years working in these areas.

Kind of realize that these cells where they we have very different (Refer Time: 11:35) feel see through the literature you see through their origin these cells are mostly have I immune function and their origin possibly is not really from the nervous the cells which the time to become nervous system their origin is not like that. It seems like it seems like a still I cannot tell with 100 percent confidence, it seems like some of the immune cells during development has kind of infiltrated into the nervous system mechanism and they said there because these microglia gets activated exclusively when there are neural inflammations when there are neural inflammations like spinal cord injury or you know some form of damage or some form of disease of the nervous system.

Otherwise they are quiescent or dominant cell setting there and their biology is not really the kind of familial properties what the neurons and the glial cells precise that is likely different that is why kind of you know kind of delineated from the main course. So, these are glial cells are astrocytes oligodendrocytes Schwann cells what are their functions they help. So, say for example, you know seen the electrical cords right there are so many electrical cords which are lying out here. So, one of them I just picked up say see this electrical cord as a covering this plastic or rubber covering. So, this is kind of an insulation there are neurons which does not have and yet most of them have it the one which does not have will come later we will once we will talk about some of the circuits

which purposefully nature may did the; they will have no covering. So, say for example, 2 axons are moving side by side like this right.

So, there is always a chance of just like 2 naked chords which are rolling there is always a chance of short circuit. So, in order to prevent the short circuit there are insulating materials and one of the insulating materials is called Schwann cells. So, that is what you see here the Schwann cells right and this kind of coating what you see is a Schwann cell coating how they are formed that would be another day we will be talking about this there is a whole geometry behind formation of the Schwann cells covering. So, and yet there are parts out here which I am circling now these parts are exposed parts rest of it is covered, but there are and this is called myelin sheath myelin sheath is formed by the Schwann cells and these small node like a structure where there is no myelin sheath presents that is called nodes of ranvier nodes of ranvier.

The way the conduction happens is these are those excited is zone. So, it is moving like this and you really see it almost looks like the conduction is hoping. So, it moves in this direction, but then what happens once it reaches the fag end.

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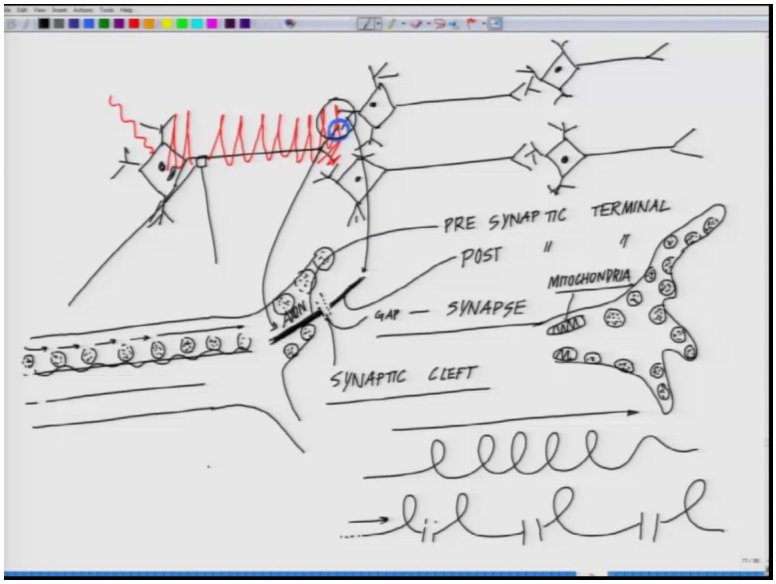

So, now let us make the circuit little bit more complex here is one neuron see this here is the second neuron here we have a third neuron likewise and the network goes on as complex as you wanted to make and this has its dendritic tree like this; this is the dendritic tree fine now when signal is travelling from here. So, I said that suppose some

stimulus scheme and it results in a threshold. So, this threshold the action potential is traveling the single action potential now I am making multiple action potentials like.

It reaches here of course, part of it will reach here 2 add this zone what is happening now let us blow up the zone out here this is small part where there is you could see a part of the dendrite which is this one and part of the axon which is this one there is a small narrow gap I am highlighting the gap by this part there is a gap this small gap is called synapse or this cleft area is called synaptic cleft this is possibly one of the landmark discoveries of last century synapse and a lot or maybe most of the truths about are very existence lies in those synapses what are those synopses and what they do now you realize one thing unlike cable like this which is continuous here we are in a situation where something like this.

Now, here you can explain the transmission of information lets continuous cables you know anything can move from one into another end right, but; however, going to justify this because there is a gap there is a gap there is a gap. So, this is the zone where something very interesting happen chemistry takes over what chemistry does neurons have the other property of synthesizing a series of communicating chemicals called neurotransmitters these neurotransmitters are synthesized in the body of the neurons and they are ferried like you have seen the cargo trains they are ferried at the site of synapse lets draw it that will make more sense lets blow up this image. So, if you blow up this image it will be something like this I am just blowing it up.

So, this is cell body were all the syntheses taking place and these neurotransmitters are put in vesicles these vesicles just like the I told you that like a cargo train and there are almost real like structure out here of different proteins these cargos started to travel like this slowly the travel and these cargos are filled with neurotransmitters is dots what I am drawing are then neurotransmitters filled in though vesicles which I am constraining them as the cargoes they are moving towards the synaptic region. So, there are kind of you know hopping on those reals like this slowly slowly moving there and if I blow up this zone the synaptic zone there are 2 right one is the axonal end the other one is the dendritic end the axonal end is called pre synaptic terminal and the dendritic end is called postsynaptic terminal right.

So, let us put the nomenclature in place. So, this one which is this part now let me just you know go it up little bit more this is the axonal end I am just putting this is your pre synaptic terminal and this part which is the dendritic end is your post synaptic terminal now at the fag end of the pre synaptic terminal the axonal terminal what you see is say for example, of a stretched this diagram you will see a lot of vesicles which are setting there like this. So, under the microscope specially this was figured out by very good quality electron microscopy people who are the earlier people like Sherrington all those people when they saw it another microscope what they observe was very interesting they saw electron dense regions at pre synaptic terminals. So, most of the old pictures if you look at them there will be something like you know I have drawn it very like you know something like this.

If this is the pre synaptic terminal the pictures will be like this lot of vesicles sitting there in and around area and is one more organelle which is very prominent out here this is how the electron micrograph images were they are at the time and this is all I am talking about 1940s 30s when these things where slowly getting unraveled. So, these are the electron dense zones which could be seen very close to the synaptic cleft now out here there is another organelle which is very prominently observe that is the mitochondria where the huge number of mitochondria which are present there. So, whenever mitochondria is present at a place one has to one get this feel that they are must be some kind of a energy transaction or there is a need for huge amount of energy in that this unity.

Talking about the neurotransmitters the nervous system synthesize the whole range of neurotransmitters starting from glutamate to gaba acetylcholine interestingly what is slowly emerging is that during the nervous system formation all the neurons has the potential to form all the neurotransmitters possible or at least a family of neurotransmitters, but as we develop different neurons takes up or decided to stick to one kind of neurotransmitters say for example, what I meant by that.

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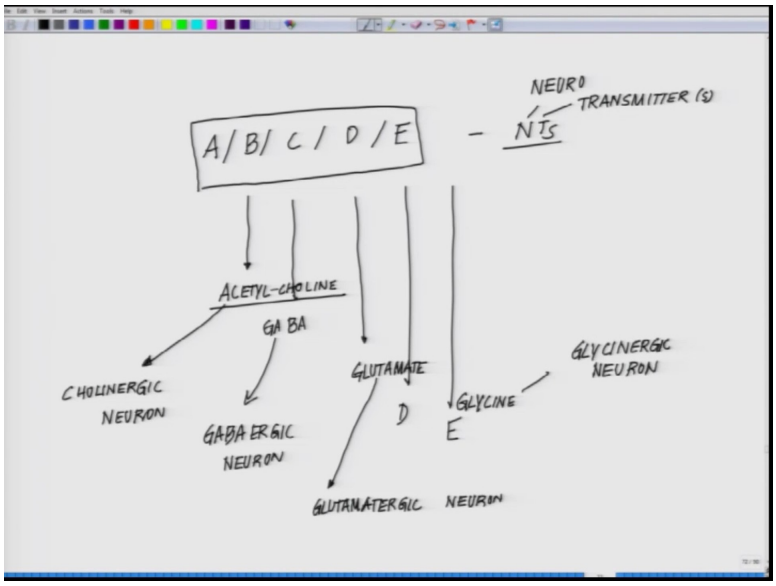

Say for example, I say a neuron can produced say A B C D and E and A B C D E are the NTs or neurotransmitters; neuro transmitters. Now at birth possibly of a neuron and neuron possibly will be able to produce all these 5 in its your (Refer Time: 25:09), but as the neurons position itself at different anatomical location with different kind of functionality they eventually will have a dominant production of say either A or B or C or D or E or you know whatever so, based on that there is another nomenclature because if you remember the slight before when I talked about I only talked about this classification I did not go into the classification of the neurons right. So, let us put the classification in place little bit before; before I gain I get back to the synaptic zone based on that neurons can be classified which neurotransmitter they are producing.

Say for example, neuron produces the neurotransmitter say acetylcholine. So, then say if say a is stands for acetylcholine; acetylcholine, if it is producing acetylcholine then this neuron will be termed as cholinergic neuron cholinergic neuron. So, it means the major neurotransmitter which is produced by this neuron is acetylcholine with the word of thought for you people that does not rule out that this neuron cannot produce other neurotransmitters maybe produces we do not know in a very trace amounts because originally all these neurons have the potential produce any neurotransmitters.

So, say for example, a neuron is producing a neurotransmitter say gaba G amino beta (Refer Time: 27:12) acid. So, it will be called as gabaergic neuron, similarly say for

example, a neuron produces glutamate then this is called glutamatergic neuron suppose neuron produces glycine then this is called glycinergic neuron. Now likewise this list can go on and on, but there is a catch how we can classify because that classification we will help us to understand the synapse slightly better.

So, I will close in here in the next class we will talk about the classification from here and we will talk about what happens at the synapse.

Thanks a lot for your attention.