Bioelectricity
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Lecture - 16

Welcome back to the lecture series on Bioelectricity in NP-TEL. So, today we will be initiating the sixteenth lecture and this whole series of forty two lecture or forty lecture. So, in the last lecture, we talked about pretty much the tail piece of the stretch reflex arc I told you that like the signal from the sensory neuron gets carried from the muscles spindle to the sensory neuron. In the sensory neuron, it is split up into two the inter neuron; and within a inter neuron actually gets split into two the gamma motor neuron and alpha motor neuron. The gamma motor neuron are the one which tell the spindle to come back to its original shape, and alpha motor neuron are the once which tells the extrafusal or the the other bit junk of muscle to come back to its original shape.

So, in the last lecture, where I ended was this, there are some central problems which kind of frustrated the scientists fairly early during say nineteen forty's fifties with the action potential which are being known. The logic was very straight forward logic is something is muscle is a three-dimensional structure. So, think of a structure, let me let me draw it.

So, let us formerly welcoming on the lecture sixteenth and. So, say for example, your imagine this is a muscle these are the muscle layers which consists of lot mile tubes and all those things mile fibers and all now the neuron which are coming through they are coming like this. So, these are the motor terminals or the neuromuscular junctions and these are the (( )) and everything. So, this is the zone where basically the acidly colleen will be secreted out. So, now, what was the fundamental question which was being asked is. So, at this stage action potential travels down (( )) like this action potential travelling down travelling down here out here there is this acetyl cooling coming out and then it generates another series of action potential in the muscles. So, these are the skeletal i am just putting s k for muscle a p action potential and this one is the m n for the mouton neuron action potential and out here what you see is essentially the a chemical synapse now the question which was raised is.

How from the surface the electrical signal travels all the way down into the muscle and how this brings about a contraction in the muscle as of now we talked about electrical signal followed by a chemical signal followed by another electrical signal fine, but what we have in answer is how these electrical signals chemical signals than electrical signals reach to the mechanical force generation by the muscle and how from the surface it travels down all the way because theoretical calculations showed that given the time windows

So, for example, if you look at this picture given the time windows at t one when it is reaching here and if I call this as time t two when the chemical synapse given t two is taking place and considering t three as action potential of for t stands for time. So, if you follow these times by the time and muscle the mechanical motion of the muscle takes place mechanical motion of the muscle by the time mechanical motion of the muscle is taking place is being calculated that if this impulse from here to reach all the way down it will take more time by the theoretical calculation.

Then how this event is happening. So, fast. So, certain in a very nice way. So, what are the catch in this game and that is where is started ultra structural study of the muscle and which eventually clarifies lot of our understanding. So, today we will be trying to answer those questions which are known in this respect that how the signal from the surface of the muscle reaches all the way down in order to understand this we need to understand two concepts. So, mind it these are all figure out by electro physiological recordings.

So, for example, you have a electro dolt intercept you have a electro dolt here if i cal this as e one and this is e two. So, the stimulus which is generated here will lead to an electrical signal on the electro tube and that need us all the theoretical calculation to figure out that there must be something else what is that something else in order to understand that something else we have to go in to the ultra structural or the real fine structural details of the muscle. So, coming back, so we will be talking about now the structural details of skeletal muscles.

So, I have already discussed with you in very brief that how the skeletal muscles are been formed. So, when individual cells come in close to each other they align they form mayo tubes and these mayo tubes super coil with each other to form mayo fibers these mayo fibers eventually super coil with each other from the muscle fiber. So, what will be

talking about the ultra structural of individual mayo tube. So, if you look through a prospection of a skeletal muscle you will see lot of striations something like this.

This is the skeletal muscle prospection you're looking at you see something like this these are striations this you can see in any regular ordinary microscope and do not need any and something like this and of course, neatly you are sitting in between out here this is a classic striated skeletal muscle and one more observation which you people will see it let me will see this muscle here something like this muscular structure is bit of like this gorge like a structure.

And of course, on that you have these striations all over the place these are the striations and we have the new place sitting this is how the structure overall looks like. So, now, we will get into the molecular details of the structure. So, when the development takes place. So, when we talk about individual mayo sites coming close like this these are the individual mayo sites what i am drawing now and they divide just to get a recap and dividing. So, the in all of them and and here they dividing like this and then this one aligned from the what we have already discussed are the mayo tubes fine and now in this mayo tubes formation of taking place what is reorienting thing is that what i haven't talked to you people is this.

There are two sets of proteins which are present on them and interpreting two protein in two different colors taking up one as is very thin filament like this these are called actin filaments there are lo lot of actin filaments and they are thinner as compared to another set of thick filaments like this these are those thin filaments which forms the skeletal and architecture of the muscle and when you have the thicker filament which are extra thin of the. So, you see there are thicker filaments which i am drawing now in.

turkuish blue color. So, muscle contains thick and thin filaments and these thin filaments are called thin filaments these are called actin whereas, thick filaments are called myosin broadly these are the two major protein both actin and myosin are specific fiber of protein and they are kind of you know very thin long strands of protein fine. So, now, when the myosin is getting formed these actin and myosin are realigning themselves they realign in a specific passion and they realignment essentially as something like this will come to the ultra structural after this as if they are inter degetated among each other.

And it is this realignment or this actin and myosin filament which leads to what you see in the previous slide this striated architecture now coming back it is the variation of the myosin which pretimize the size what kind of muscle it will be whether it will be a skeletal muscle whether it will be a cardiac muscle whether it will be a smooth muscle or it will be a muscle spindle or something. So, these myosin has a lot of sub types myosin heavy chain myosin light chain myosin extra light chain likewise and they all vary in their molecular weight of the protein are making these myosin chain.

So, myosin chains are one of the rate limiting factor in describing the phi no type or the muscle type in our body with this background now what we will do we will go into this picture and we will have a microscopic view of this how really this looks like what is the exact pattern, so there is a pattern.

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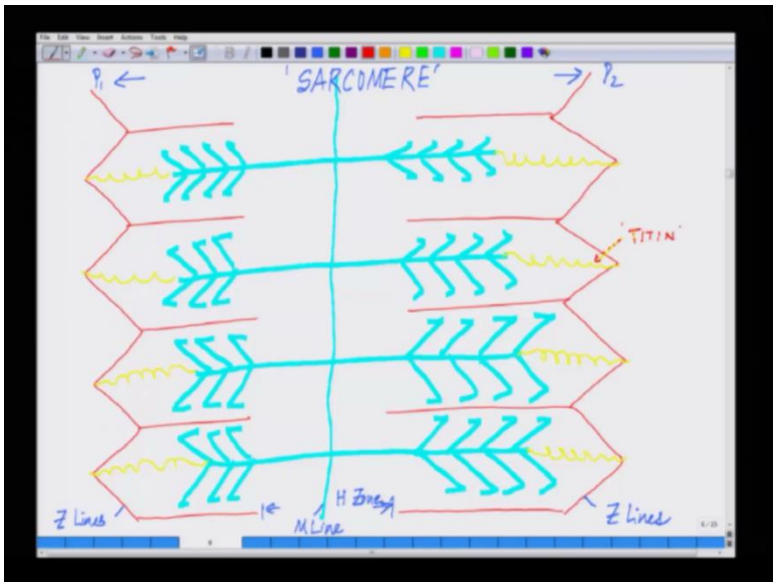

So pattern, now we are going to talk about a pattern. We have already decided the color code. Since we have decided the color code, so these are arranged if you another microscope it was observed, the thin filaments and the thick filaments are arranged in a very interesting way, they are arranged something like this. And I am following the same color code what I have followed just a I just drew it wrong, actually I should have drawn in such a way at hold on, give me one minute, let me finish this drawing, and then I will get back to you people, these red ones what I have drawn. So, now, you are looking it under a very ultra high microscope with very high magnification, these red ones are the

actin filaments what we decided in the previous slide. If you look at it, we represent this thin filament as actin.

Now, where are the myosin standing, now we will introduce the myosin will change the color code now. So, the myosins are sitting like this, now these are the thicker lines and these thicker lines have myosins sitting like this, and mind it this is exactly the same thing what I was trying to draw out here. So, this is the arrangement what I am drawing now if you look at very carefully. These myosin's have something like this as if there is something edging out like this from there surface, and arrow kind of things which are popping out from them. So, these are the thick filaments. So, let me just finish this drawing then I will explain some of the final details which are as of now I have not introduce.

So, this is the initial a structure, this is the smallest unit of something called sarcomere and I am coming to that now I will try to introduce the specific terminology where there are. So, over all if you look at this picture carefully, you will see there are zones where both the proteins actin and myosin over lapped. Yet there are zones where they are not over lapping, there are zones were only myosin; and there are zones where it is only actin. You could see that, so if you look at this picture coming back to the slide. So, if you look at this part out here, where I am circling, this is only myosin. This is the zone where there is only actin. This is the zone, which is overlap zone of actin and myosin. So, down this whole unit is termed as from here, so point one to point two, this whole unit is called sarcomere - first terminology, which lap to remember, Sarcomere.

Next these lines are called z lines, the center line is called m line, and this zone which is divide of where you do not see any actin over lapping - this is called h zone. So, we have introduced z lines, m lines, h zone. And if you look at it carefully, there is more introduction I will do that is out here, there is certain connecting structure like this, and there is new for these specific proteins which are kind of you can call them like a spring spring kind of connectivity, these are called titin. Let me use the black color just using titin. So, these are quelling kind of protein as if like you have a spring which pulls something, this is the basic architecture of a cross section of a muscle.

Now, we will go to some more, final details; now coming back to the structure. So, there are something which is called dark band and light band. So, if you look at it, this is the

zone where there is the maximum if you look at this zone where both actin and myosin are over lapping, these are in a contrast picture if you would see, you will see those are darker as compare to next section which is much more lighter.

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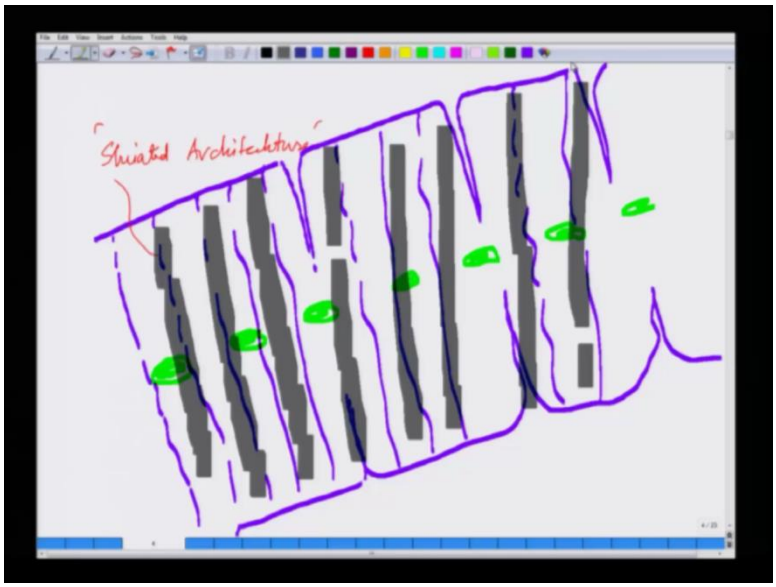

So, if you now go back and see this picture, you will see, there are kind of you know something like, you will see a dark and light bands, and those dark and light bands are something like this. So, if you look at these dark and light bands, now you can understand from where those dark and light bands are arising. They arising because at points, there are two proteins which are over lapping with each other, at points there are single proteins. So, when the light falls, where we have two proteins over lapping one another, they show a darker contrast as compared to the zone, where there is single light is passing through. So, that is why you see dark and light band. Now coming back to the further molecular details of these actin filaments how they really look like. So, now, we will be talking about the ultra structure of this actin filaments.

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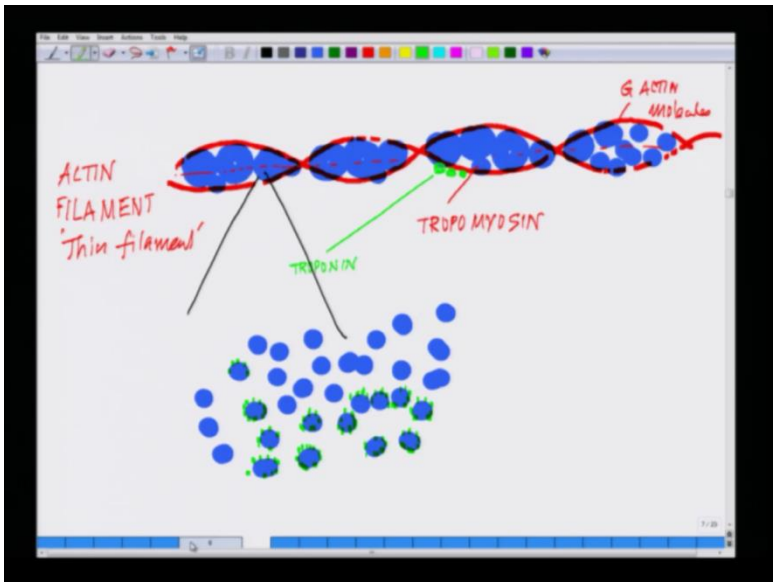

So, next slide. So, now if you look at these actin filaments, so they are not that simple as they look like. They are in final details they are something like this. Those straight thin lines what I have drawn they are super coiled structures of proteins like this; and within that they have bunch of molecules and we will name them they have physiological and anatomical significance. So, they have something called active sight what are those. So, these balls what you see, so just recap this is an actin filament or the thin filament. So, whenever I talk about thin filament, it is with respect to the myosin.

There is something protein called tropo myosin, and there are specific proteins which are embed out here like this, which are called troponin, and these are called G actin molecules. This is basically where troponin and tropo myosin are on top of each other it. It is something like that if I have to get a further ultrastructure of this it will look like this. These are the tropo myosin molecules, and troponin molecules are on top of this like this on all of them something like this. All the green dots you are seeing, those are the troponin on top of tropo myosin. So, this is one piece of information, which you have to remember because will be coming to this all this connectivity and what exactly happens.

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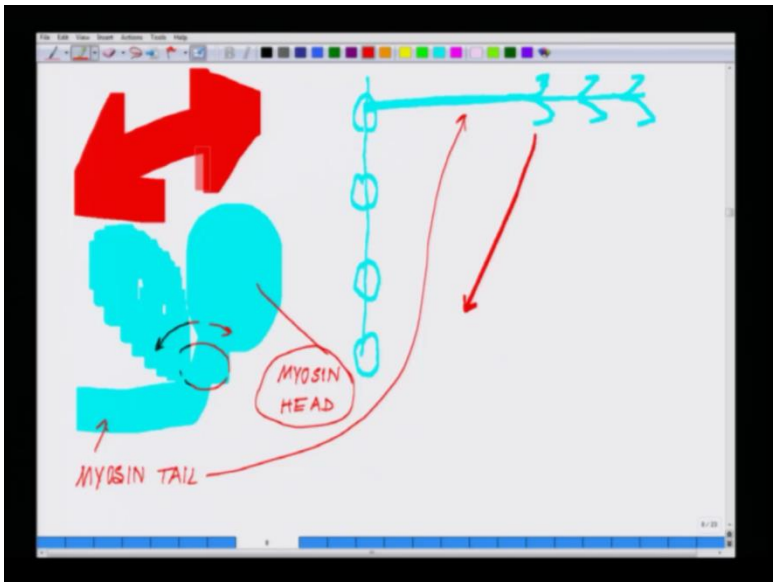

Next thing we will be talking about the ultra structure of the second component which is this component, we have not talked about this yet. So, talking about this component, this component if I again recap the z line. So, the z line looks like this. On the z line, you will see super coiled structures and those super coiled structures have something like this kind of things what I have drawn before. This is what these structures are exactly and this is the m line which is from both sides you could see, so at different level they have. So, these are basically called if I make it in further details what I have drawn here that extension. So, it is essentially that extension is nothing but something called myosin tale, which is here, which is here also and here you have something called hinge kind of situation here on which something can move like this something can come back to its original position, and this is called myosin head. This head what do you see can almost like this, it can move like this. So, essentially this head can take a situation like this also. So, in other word, it can move like this.

So now going back recapping, what we have talked about as of now. If you see this picture, so essentially what is happening, this head can move both the directions; it can move like this, it can move like this. But if it moves like this something also happens will be coming to that this where we are getting into the sliding filament theory now we are entering to the little trickery parts of the game.

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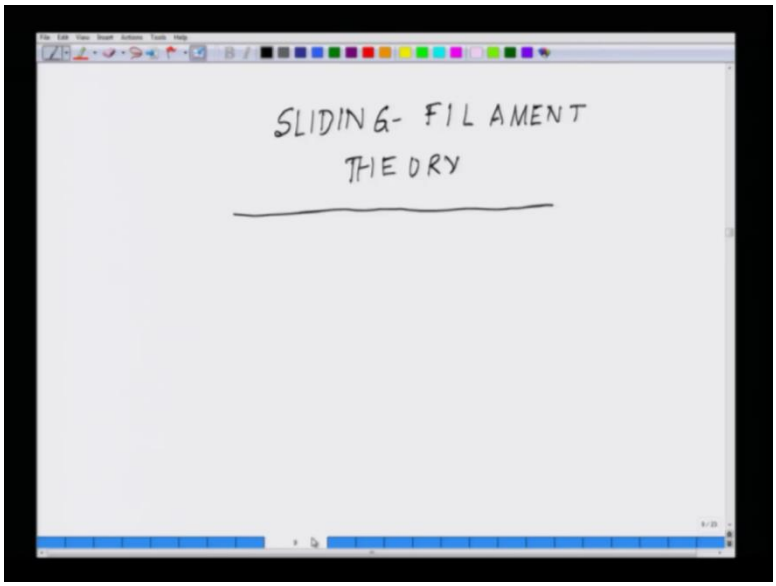

There is something called sliding filament theory. So, before I get into the sliding filament theory, what I will do is, I will kind of take you back here to give you some idea before I really explain this theory in details. So, what essentially happening is this; on the rails of these actin and myosin, you imagine something like this is an actin on the top, and this hand is an actin, and underneath you have the myosin like this. So, myosin can move it is head like this. So, when it moves it is head like this, they slide on top of each other; and the sliding motion as if there is a small ball like a structure which is the myosin head something like this. Muscle contraction is nothing but the sliding motion of two proteins which are parallel to each other, but one of them as a small ball like a structure which we call them technically as myosin head, which is moving like this something like this motion, this is my myosin on which I am waving my hand this thing.

How that is been done, where we get the energy, what regulates it, and that is where lies introducing the fact what was as of now accepted is called sliding filament theory. Sliding, because there are sliding on each other; and it is the filaments proteins, these are filaments, actin, myosin I am waving now. So, the filaments are sliding over one another and that is where it is got got name sliding filament theory.

So, now we will be talking about the sliding filament theory that will give you an idea how the muscle exactly contracts. Then we will talk about the tale piece that how that electrical signal actually leads to this contraction process. So, we are first of all we are

into the ultrastructure just to give you a recap what we all we have finished. So, we talked about the problem we define the problem that how the electrical signals reaches here, then we talked about the ultrastructure in overall ultrastructure. And from there, we talked about the light and dark bands, and then we talked about how these filaments are getting arranged and then I have given you over all sight architecture of the muscle.

We have showing the sarcomere out here, this is the sarcomere out here. You have the m lines which are the myosin, actually thus myosin which is vertical out there. You have the h zones, you have the z lines, and we talked about the titin protein, because this structure is very important and the single unit from one z line to other next z line is called the sarcomere. These functional and understanding unit is very essential and then we talked about the presence of some specific protein within this filament structure of actin which is tropo myosin and troponin. Then we talked about the presence of myosin and myosin; and myosin head, which is a moving head up to this we have talked about and then at this point I introduced you to the sliding filament theory what really sliding filament is all about.

So, at this stage, what I will do I will close here will start from the sliding filament in the next class and then we will move onto where the electrical signal actually influences the sliding motion. Before I do so, what I wish you people please go online on a Goggle just give a search about the ultrastructure of skeletal muscle, give any search what you essentially see is you will there are much better pictures which I cannot really draw on a slide like this. You will see much beautiful picture of this whole structure, very nice way and I expect you people really to go through that because that will help you to appreciate this structure in finer detail. Once I will be showing in the sliding filament theory, this will be a big help, if you take the time and go through it very carefully. So, I will closing here, will come back on sliding filament and about the sarcoplasmic reticulum and function of the sarcomere and that is what will be our closing in other first simple circuit of the brain which has been discovered by different bioelectrical phenomena different microscopic phenomena and likewise.

Thank you.