Nanotechnology in Agriculture
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Lecture-31
Skeletal Muscle Development and Nanomaterial Intervention

Welcome back to the lecture series in roles of nanomaterials in agriculture. So we are into the animal production section, so in the last class if you recollect we talked about the role of cerium oxide nanoparticle in changing the muscle mass.

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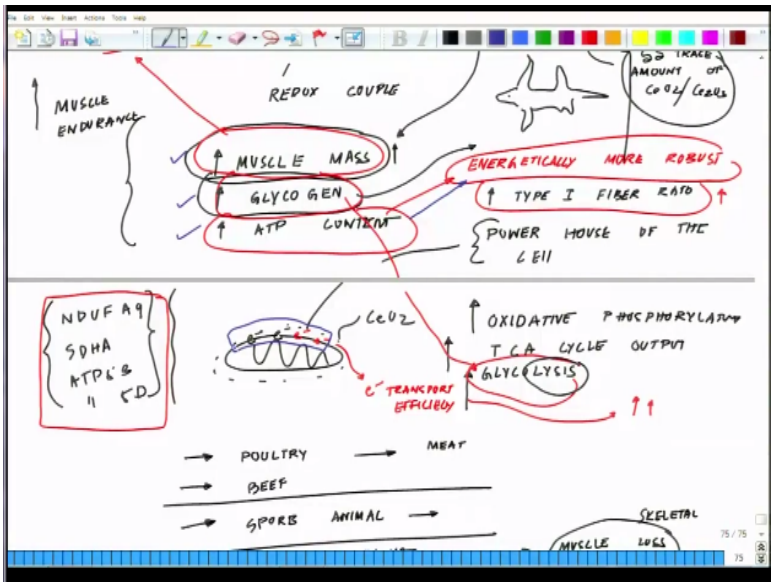

In as a matter of fact there were 3, 4 things what we gathered from it was that there is an increase in muscle mass, there is increase in glycogen concentration, there is a increase in ATP concentration. So, in other words these muscles are energetically more robust and there is a increase in the type 1 fiber ratio as well as there is a increase in the proteins or membrane proteins involve in electron transport chain across the mitochondria, while going through this I did not mention about how really the muscle develop, in what context really these things changes.

So what we will do today is we will talk little bit about the muscle I will kind of give you an idea that how really the whole biology works and how these nanomaterials makes a difference ok.

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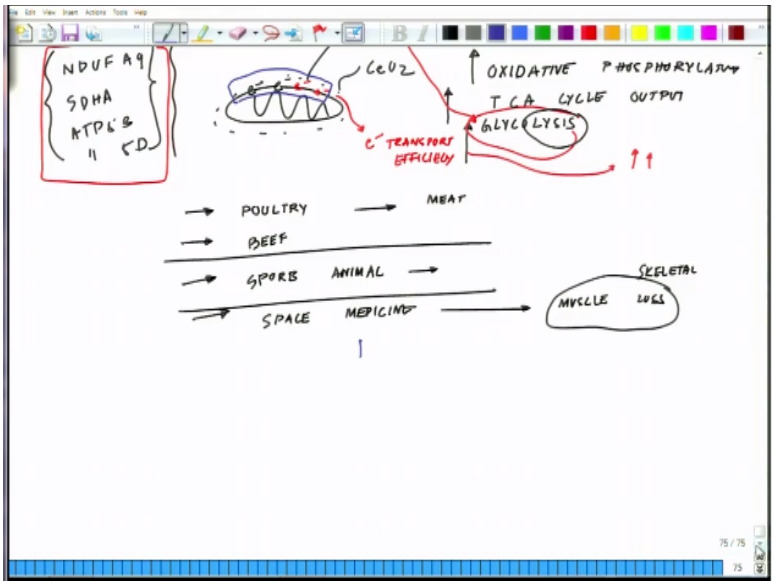

So, if you look at any of the muscles very carefully, so if you have to, so since all these are dealt mostly with the muscle.

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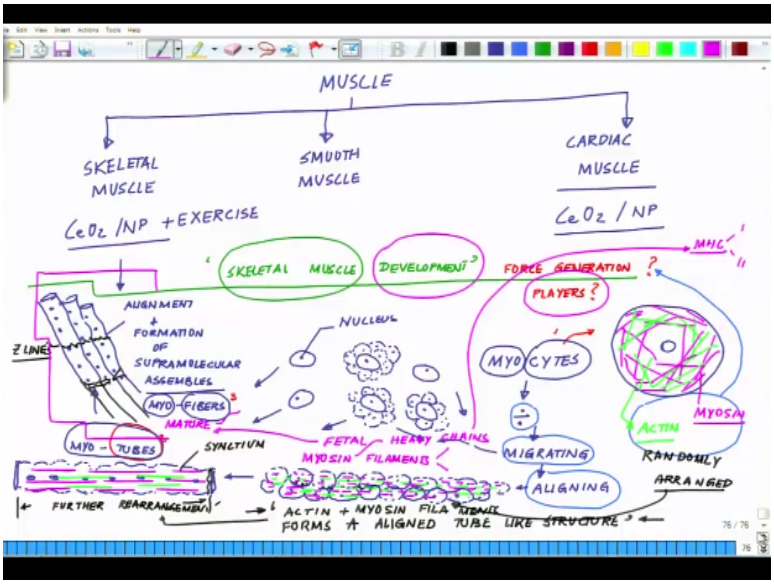

So, there are 3 ways you can classify the muscle and we have only talked about 1 muscle at least 2 different kind of muscles we are talking about. So we talked about skeletal muscle yesterday in the previous class skeletal muscle with their the muscle which are lining our gut or making or gut or the elementary canal and everything those were smooth muscle and then you have cardiac muscle.

So, we have talked about the repair of cardiac muscle and a positive effect of cerium oxide nanoparticle ok CeO2 nanoparticle. And we have talked about a positive role of CeO2 nanoparticle along with exercise in improving the skeletal muscle performance. So essentially what happens is when the muscles are formed, so I will take you back bit of the developmental biology when the muscles are formed in the mother's womb.

The way it starts is there are the single cells which are destine to become muscle any kind be kind of muscle okay. Because all the 3 muscle development is similar, these are those single cells and these single cells are called myocytes, myo means muscles, cytes means cells ok. Cells which are destine to become muscle cells, so these cells over a period of time they form, they start to divide like this.

So, each one of these muscles starts to divide, so finite number of division they go through at a time something like this, followed by this division process it is a myocytes going through division, followed by this division process they started to move and align, align like tubes, so they align like this. This is very essential for you people to understand because all the reference papers I will be giving unless you understand this process you would not able to appreciate how those muscles are formed.

That the reason why we are taking as a special fragment of our course where we are talking about the muscle development ok something like this. These are long arrangement long linear kind of arrangements which happens. So, these cells are now migrating and aligning, migration or migrating followed by alignment as you could see here they are aligned and this is basically telling that the migration happening.

Once they are aligning there is an interesting process which happen, these cells started to lose their individual boundaries and what they form is something like this and all the nucleus. So, these are the nucleus which are present, all the nucleus, so this is how the structure almost becomes like a tube, all the nucleus are arrange like this. A very typical often skeletal muscle I am talking about ok.

So, these tubes are called myo-tubes ok which is the smallest unit of muscle. Now these myo-tubes, then several myo-tubes like this align with one another and form what we called as myo-fibers okay. So, second develop alignment and formation of supramolecular assemblies, and these supramolecular assemblies are called myo-fibers. As you see the word myo remains common, now from cyte out here it forms tubes, out here and then it forms fibers.

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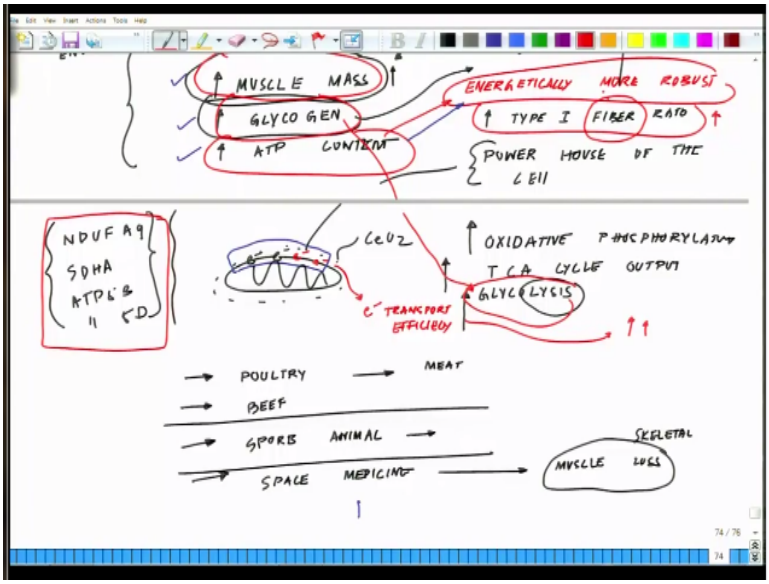

So, when I told you in the previous class there is a change in the fiber ratio I essentially mean this fiber ratio. Now there is something which I have not mention as of now that is what I am going to come. So, this is your skeletal muscle development, now there is something else which is happening. Now each one of these, so we know that these skeletal muscle generates force, if you recollect when we talk about exercise as a double digit or we talked about the ROS reactive oxygen species which is generated during exercises essential for force generation right.

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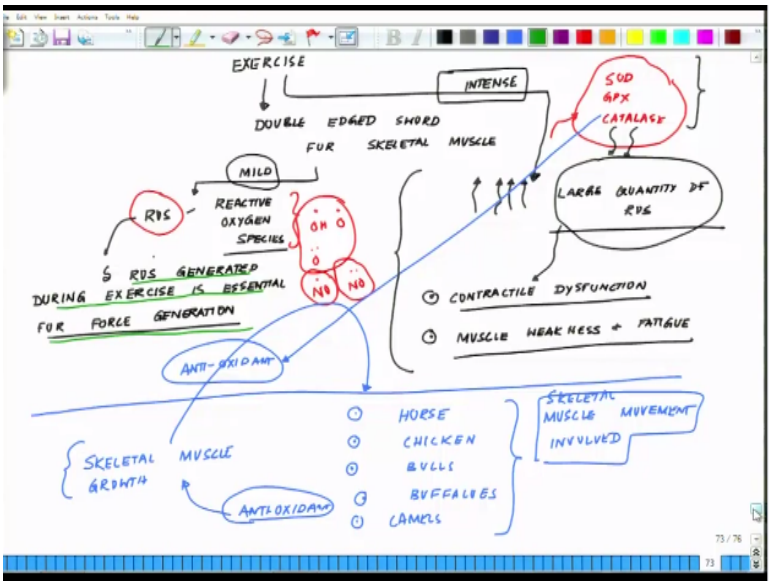

So, now coming back to this part, so who is generating the force, how the force generation is happening, force generation how it is happening and who are they can be players in force generation ok. Now when we look at these myo-cytes, now if I take a single myo-cyte here enlarged one ok.

So, this myo-cyte here is a nucleus it has lot of these crisscross proteins in it, coming to those what are those in it is cytoplasm and along the periphery ok. And these proteins are termed as actin and myosin, these proteins are the smallest unit, these are the ones which are the key players in generation of force, how is it so. Now this actin-myosin filaments are randomly arranged inside the cytoplasm.

Now what happens when these cells come divide again they are randomly arranged, then when they are migrating it is perfectly fine. Then once they align still they are randomly arrange but then slowly there is a molecular supra assembly happens where these actin-myosin filaments almost arrange like this ok, something like this, almost they align like tubes. So, you have these cells something like this.

Now once the myo-tube is formed they follow this arrangement like this something like this and there are discontinuities which you could see as something like this. So, if you see a muscle fiber you will observe something like you know we will come to that what are those discontinuities

are it looks this continuities. Actually those are not discontinuities, those are something like this structures like this which are also called Z lines.

Now what you observe, it is kind of I will go little bit slowly for you to realize these actin-myosin initially where randomly arranged ok. These were randomly arranged then while it is forming a supra molecular assembly out here now actin+myosin filaments forms a aligned tube like structure, this alignment and formation of a tube like structure is one of the finest program arrangement of proteins which happen.

And it is very very unique to look at and then once these individual cells looses their boundary and form something like syncytium, it is a continuous structure something like this. This arrangement continuous and not only they form further rearrangement ok. And it has been observe during development while we are developing in mother's womb and you know about to come out.

These myosin filaments changes their type, so some of these myosins which are found while we human or any of the species which grows in their respective mother's womb have a different kind of myosin protein during their fetal stage ok. So, they have a fetal myosin and myosins are heavy chain ok, so these are called fetal myosin heavy chains and as the mature as it taking birth they become much more mature and there is a change in their protein confirmation.

They become more like mature more like adult like myosin heavy chain and they are also sometime in biological literature you will come across this word called MHC myosin heavy chain like 1, type 2 likewise there is white array of subtypes of myosins which you could see in the literature. So, during this development as these tubes are forming aligning their myosin heavy chain type changes.

And it is one of the most beautiful example of development ok and there are cassettes of gene families which are involved in regulating this process, what is important for you to realize. This rearrangement of a structure this is where I am coming.

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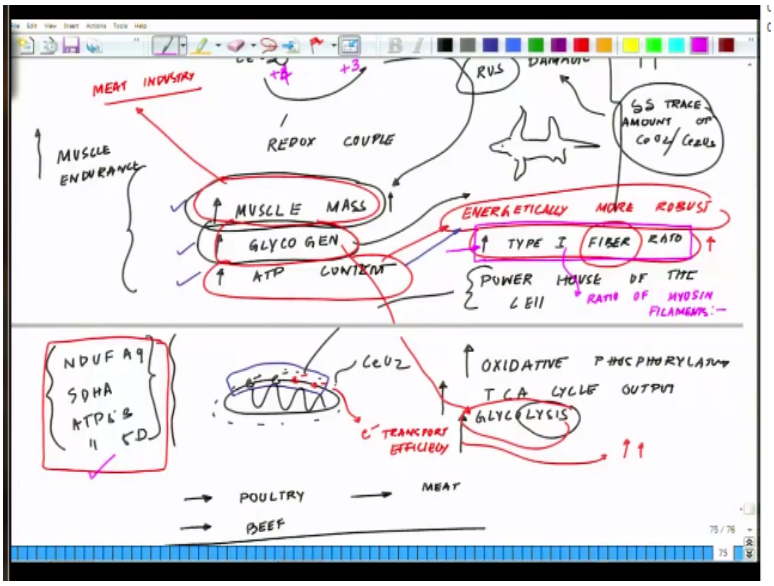

If you again if I take you back whenever we talk about change in the fiber ratio because of the application of cerium oxide nanoparticle. Then we are talking about hitting upon the ratio of or type of myosin filaments, it is bad deep while the impact is being observed. That is why I am taking this extra step backward to teach you that you have to appreciate that this is not something ordinary, this is something out of the world to really look at wow.

This is effecting all the way up to without doing any kind of genetic manipulation, this is the simple you are giving either in the diet or through blood or intervene or subcutaneous into the muscle.

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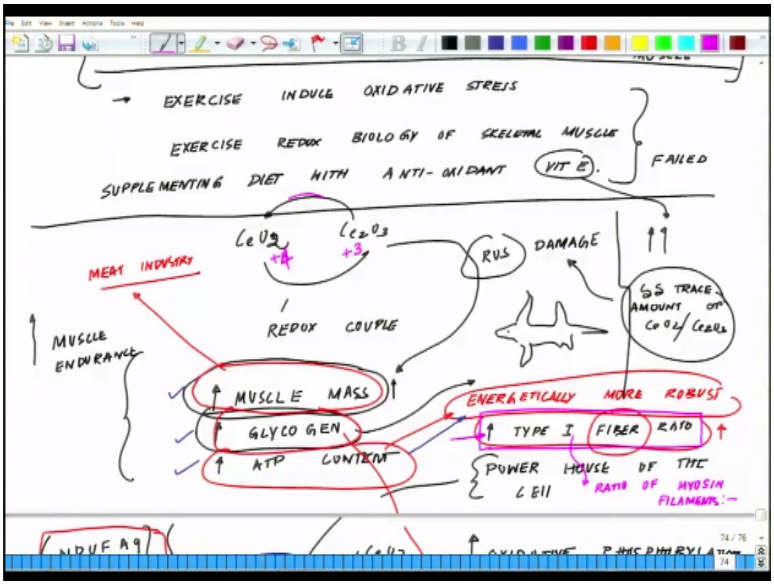

If you give these kind of nanoparticles which essentially a simple redox couple which is there like you know +3 to +4 sorry +4, +3 ok or +3 to +4 autocatalytic redox couple is bringing about changes which whenever when taught of it is something mesmerizing when you see the pattern why is because this will be able to appreciate better once I will provide you the relevant literature where you will see that changes are drastic really drastic.

I mean that something never ever people thought that without doing any kind of genetic manipulation or anything they will see. These kind of changes like think of the change in these kind of you know mostly these are iron, sulfur, proteins across the mitochondrial membrane these ones. It is something phenomenal. So, now coming backward I was so it is out here the fetal myosin have been changed transformed into adult myosin heavy chain in these kind of muscle ok.

Now how this arrangement really looks like that will be our next class what will be talking about is now we have already talked about who are the players.

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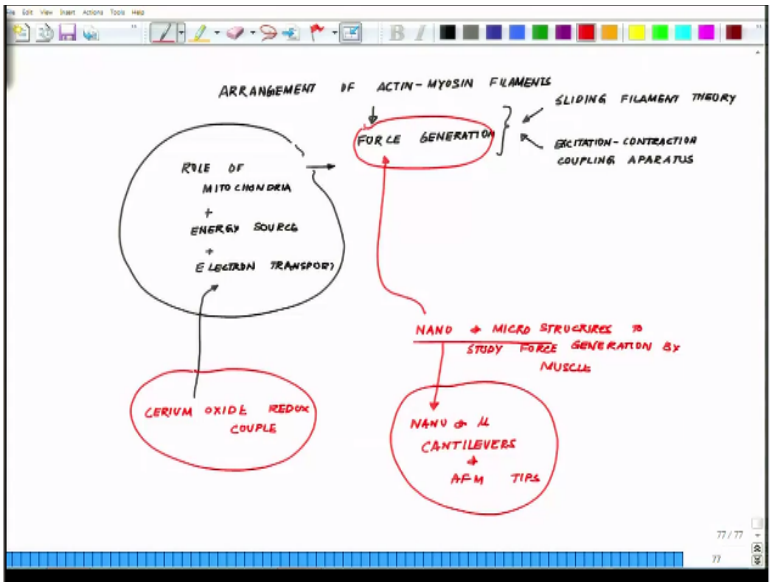

Now in the next class what we will do is we will talk about the arrangement of actin-myosin filament which are involved in force generation and role of mitochondria in this whole process. And this force generation will be govern by 2 basic biological processes sliding filament theory and excitation, contraction, coupling apparatus ok. And role of mitochondria energy source,

electron transport and in this whole process how our target cerium oxide redox couple plays a critical role.

And next what we will do nano and micro structures to study force generation by muscles and in this fragment we will talk about nano and micro cantilevers and AFM atomic force microscopic test, how these could come so very handy to study the force generation. So, I am closing here we will resume our journey on this part in the next 2, 3 classes thank you.