Introduction to Cell Biology
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Lecture 51
Endomembrane System of Cells: Discussion Session 2

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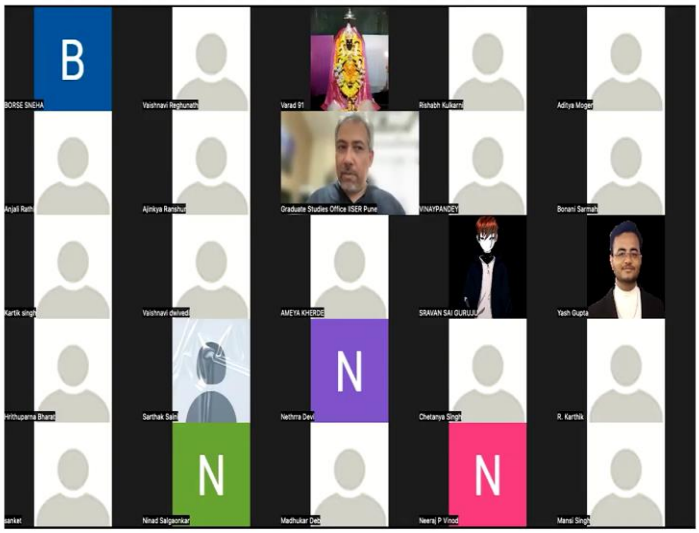

Professor Nagaraj Balasubramanian: We will take questions. I am going to begin with Sneha. Sneha go for it.

Borse Sneha: Sir, I have a doubt in smooth endoplasmic reticulum. It is rich in enzyme. So can you tell which enzymes are rich in?

Professor Nagaraj Balasubramanian: There are many enzymes that are present, if you really want to know, just go look up. I am not discussing any specifics here. Any standard textbook, if you pick up, it will tell you all the different enzymes that are present there. Some of the enzymes, we do know. And we have characterized them, many of them are enzymes that actually synthesize lipids for example.

Some might be those that actually modify proteins in ways that allow for them to now be integrated into the membrane or bound to the membrane, allowing for their delivery. So I am not getting into specifics on any of these. But you are welcome to go look this up. And the textbooks that you have, will tell you a little bit more about what enzymes and what exactly they do.

Borse Sneha: Thank you.

Professor Nagaraj Balasubramanian: Vaishnavi, next question over to you.

Vaishnavi Dwivedi: Sir, different organisms with different requirements would have different Golgi apparatus or their contents would vary, would they?

Professor Nagaraj Balasubramanian: So, could you say that, again, different organisms, as in?

Vaishnavi Dwivedi: From unicellular to multicellular, they would not, would their requirements change? So, would the contents of the Golgi change?

Professor Nagaraj Balasubramanian: At a single cell level, the functionality of many of these components is conserved. But depending upon the type of cell that you are looking at and the kind of proteins that are being processed. Like for example, the Golgi in a neuron may have slightly different composition proteins that it is seeing enzymes that, you know, it uses, as compared to Golgi, say, in the liver. So, there will be differences, depending upon which cell type you are looking at. A significant part of the architecture and the mechanisms that are in place are conserved, but the way these mechanisms are used, what kinds of proteins are being processed will obviously be different.

Varad Lele: Sir I did not understand the when you are saying that the forward and backward moment according to Golgi, What are you really saying I did not understand under?

Professor Nagaraj Balasubramanian: So, this is, again, you know, something that is hypothesized, we do not fully know whether this actually happens. See, the challenge with a lot of this has been being able to image these structures. So, to be able to look at a Golgi or an ER, as much as you know, I showed you images of confocal images, you can see their architecture to a certain extent. If you really want to see the stacks of the Golgi, you will have to go to something like an electron microscope.

And one of the challenges with electron microscopy, electron microscopy, initially, the challenge was that you were able to look at only one plane. But now there is Em tomography, where you, like you do confocal sections, you can do sections in an EM image, and also put the sections together.

So the ER image that you saw of, you know, these the parking lot image, is made possible because we were able to they were able to process a stack of electron microscopy images, the challenge, so the EM tomography has allowed us to see these architectures a little better than we originally did.

But the challenge still remains that we cannot look at live events as they are happening in here. So, it is hypothesized that there are vesicles that are being moved to the front. And they go from as I said, the one of the hypotheses is that everything just goes through. And one hypothesis is that there are actually vesicles that are peeled off from one go to the next go to the next go to the next. And it is thought that there are certain vesicles that may also move back.

For example, if and how this is controlled, what is the mechanism. We do not know, what decides that something should move forward, or go back. We do not know. So it is thought that the way they are moved back and front will determine the residency time. That means how long a protein that is in this vesicle stays in this compartment could be determined by how quickly it leaves and how often it comes back. So, what if there is a forward back forward back, that is constantly happening.

And if all the processing that a protein needs to undergo in this compartment has been done, then you know, it moves forward and then does not come back and then moves further, could that be a way of doing this and ensuring that all the changes that are required are actually have happened on the protein before it actually leaves.

So one of the questions here to think about is, what is the regulatory mechanism that looks at a protein? What is the quality control mechanism? That looks at a protein and say, okay, all modifications are done isko jaane do aage. Or looks at everything and says aare this particular modification has still not been done, we should send it back to that compartment, is there such a a mechanism to check for the modifications that proteins are undergoing?

And we actually do not know, at this point of time, we are only just beginning to understand how changes can happen. Simple things, like the amount of time that a protein spends in the compartment could change the architecture of the modifications. So, a protein that will take, you know, I am just saying these numbers of the top of my head, that takes, you know, 30 seconds, 30 seconds, 30 seconds, will be modified one way. A protein that takes 1 minute, 1 minute, 1

minute, 1 minute, same protein will be modified differently. This we have understood, or at least, you know, we have been able to now model, you know, use mathematical models to suggest this is possible.

And this has happened in the last maybe 5 years or so. So, we are just beginning to understand the complexity and the kind of regulatory mechanisms that exist here. So, I know this is not much of an answer. But, you know, that is where the understanding of the field lies at this point of time. Aditya, next question from you.

Aditya Moger: Sir, can you hear me? Like neurons are really big cells? And they have many synapses.

Professor Nagaraj Balasubramanian: So they have, they will have one synapse, they do not make multiple synapses.

Aditya Moger: No, like, at the end. Let us say, oh they have only one synapse?

Professor Nagaraj Balasubramanian: Yes.

Aditya Moger: Also, does the synapse have a broken part like piece of Golgi or something. A localized Golgi, so that it is easier for processing to happen before it is released?

Professor Nagaraj Balasubramanian: So whether there is a piece of a Golgi that sits right at the end, I do not think there is. So, the Golgi is here, actually, these motor proteins carry make they travel long distances in the neuron to actually take things all the way to from one end, where they are made to the end that they are actually delivered.

So, the way motor proteins work in neurons now is the basis of very extensive studies to essentially characterize this. You should look up there is a lab in TIFR Bombay, Sandhya Koushika, Sandhya studies, these motor proteins, and she studies how, in cytoskeleton components in neurons, things are actually moved, how do they bump into each other.

What is the level of crowding. You know, how does such a long cell navigate and carry information. Because, halfway through what if the vesicle forgets where it is going. Does that really happen? And how does the neuron maintain that? Because of the distances it has to travel. So the short answer is, there is not a Golgi like structure at the end, a things move actually long distances in the neuron. Anjali your query.

Anjali Rathi: Sir, what do we actually mean by processing of the materials in the Golgi apparatus like? What essentially does the Golgi apparatus do?

Professor Nagaraj Balasubramanian: So we saw, one of the big processings that they do is glycosylation

Anjali Rathi: Sugar addition.

Professor Nagaraj Balasubramanian: Glycosylation there could be post translational modifications. Like, for example, in some cases, proteins need to have lipid modifications. And this allows, there are you know, palmitoylation it is essentially a chain of lipid that gets attached to the protein at a certain point that now allows the protein to anchor to specific compartments in the cell using that lipid tail.

Those kinds of modifications can happen in the Golgi. You know, there could be phosphorylation of a protein that allows it to kind of go to or go to a specific compartment or bind something, which could happen at the Golgi. So many of the changes are actually at the level of the structure of the protein and the way the protein is put together.

Changes like phosphorylation, which are, you know, more transient, that can happen quickly and go away quickly happen after all this processing is done. So, glycosylation, for example, is a slow modification, and does not kind of go away. So the changes that happen in the Golgi, kind of stay and stay longer. And those are the kinds of changes that happen at the level of the Golgi. So there are many such modifications of the protein, which affect the structure and functioning of the protein that happened at the Golgi.

Anjali Rathi: Also sir, when we said that we detach the Golgi apparatus, it becomes spherical rather than the normal structure, I did not understand that part.

Professor Nagaraj Balasubramanian: Detach Golgi apparatus. No, that is not the Golgi, that is the cell. We are detaching the cell and when we detach the cell, the Golgi breaks up. That is what I showed. So, what was inside the cell is what is what is the Golgi that is broken up. Sneha your query.

Borse Sneha: Sir, I have a doubt on smooth endoplasmic reticulum. So how does it catalyse sir?

Professor Nagaraj Balasubramanian: I do not know what you mean by how, these are enzymes, the enzymes work on the proteins, like just as, you know, for example, enzymes that talk to proteins in the Golgi are like other enzymes, you know, they will need a bunch of cofactors. In some cases, they may need energy.

But when they run into a protein that they can modify, they will hold the protein and modify it. So, a lot of that happens very intuitively, it requires a bunch of cofactors, bunch of other players that are required, a protein by itself may not exactly by itself be enough to do this. And so that milieu in the environment, and what else is needed, is actually vital process . If you are curious, just go look up, you know, molecular biology of the cell, and how Golgi or ER processing takes place. And there is a lot of information there on how enzymes, which enzymes, and what kind of modifications they can feed.

Borse Sneha: And sir one more doubt, you which said that Golgi a spreads at a certain time. So, does it affects the cell?

Professor Nagaraj Balasubramanian: Spreads at a certain time as in? Did you say spread?

Borse Sneha: Yes sir as it moves away, as it and it take whole it catches up with the whole cell.

Professor Nagaraj Balasubramanian: The Golgi catches up with the whole cell? No, I am not sure I understood. Can you frame that question differently? Why do not you think about what you are asking and I will take the other two questions, and I will come back to you Sneha.

Borse Sneha: Okay sir.

Professor Nagaraj Balasubramanian: Aanandita.

Aanandita Kottisa: Sir so, even endoplasmic reticulum can modify the proteins just not Golgi?

Professor Nagaraj Balasubramanian: Yes, so there are some changes that can happen at the ER, there are some changes that can happen only exclusively in the Golgi. And the Golgi now we understand has a much more finessed, you know, and complex mechanism, then probably the ER. The ER, does make changes, it is not like it does not, but there are some changes that can happen only in the Golgi and the Golgi associated changes, you know, can be are more subtle in ways that allow or affect the functionality of the protein.

Aanandita Kottisa: Sir, thank you.

Professor Nagaraj Balasubramanian: AJinkya. We have last two questions.

Ajinkya Ranshur: Sir I have one question, does the Golgi apparatus change its shape for maturing different proteins?

Professor Nagaraj Balasubramanian: So I am not sure it changes its shape to allow for maturation. I think the change in shape might affect maturation. So I do not think the protein has a say in how the Golgi looks. But there are other things in the cell that will affect the organization of the Golgi. And, and that will mean that the protein can be modified this way.

Ajinkya Ranshur: So what decides whether, like how long a protein stays in the Golgi apparatus?

Professor Nagaraj Balasubramanian: We do not know. We do not know actually, could I. So there could be some signature in proteins that could influence this. For example, if vesicles are thrown out and then brought back and then go out and then come back again. You know, what is that mechanism, we really do not know, we do not know. Deep last query.

Deep Shah: Sir, you said that in like to study Golgi, we do not have to take it apart and like, you know, study things separately. But sir, like in division, it is already taken apart, no. So, why did not we study the Golgi apparatus while it is divided? Like. There are.

Professor Nagaraj Balasubramanian: The challenge with that is it is a very transient process. And, you know, the imaging capabilities that we have actually a lot of understanding of how the Golgi is broken up, you know, how it is brought back together has come from the dividing cell. But the challenge has been being able to visualize things at that stage.

And also being able to catch things as they happen in a dividing cell. Like we studied the dividing cell in the lab, and you know, just being able to watch the cell in a short period of time can be very challenging sometimes. So a lot of this is limited by actual data being generated. And then now asking, how do we look at the data and then analyse it. So, challenge has been being able to actually experimentally do things here. Sneha, come back to your question. Last question.

Borse Sneha: Sir, I could not frame property. But sir, in this slides, it was shown that it is most throughout cell.

Professor Nagaraj Balasubramanian: It is what?

Borse Sneha: It moves throughout the cell.

Professor Nagaraj Balasubramanian: Moves throughout the cell. So the Golgi can move around in the cell. The Golgi can open up, can come back together in a migrating cell, for example, the Golgi because it is tied to the microtubules comes to the front of the cell as well. And when I say front, it is not right at the front, but if this is the direction the cell is going, the Golgi will be here and not somewhere there, that difference we have. So, the Golgi can be organized and brought to very specific sites inside the cell to allow for it to support you know, transport and delivery of vesicles and components of the vesicles carry. So if that is the question, yes, it can be moved around inside the cell.

Student: Okay Sir.