Introduction to Cell Biology
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Lecture 48
Endomembrane System of Cell - Part 1

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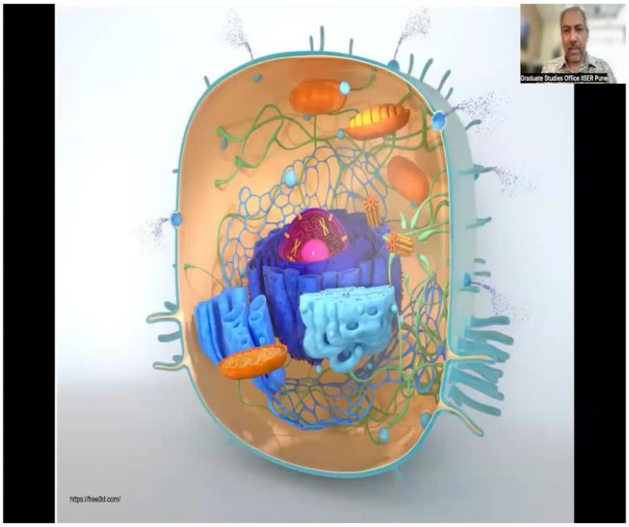

Among the systems that we are going to look at next, we began from the Cellular Membrane, we went through the cytoskeleton. We talked about the mitochondria. And then, we now come to an important set of intracellular organelles which are referred to as the endomembrane system and they are all here. And when we see this image later, again, you will be able to recognize many of those pieces as well.

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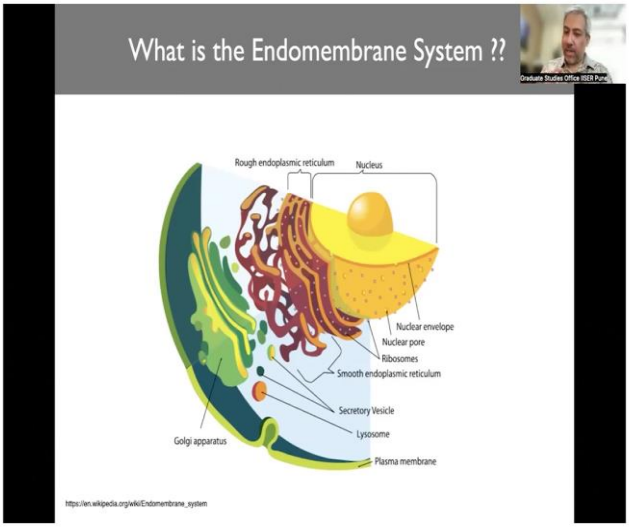

And, and it is an important thought to have when we think about the endomembrane system, the same thought that we have been we have just discussed which is, why is this setup, the way it is set up, what kind of pros and cons this could have, and why not any other way. And so, one important element to consider when we think about the endomembrane system, is as the name suggests, it is an it is made up of membranes and membranes we are all aware are made up of lipids and they have proteins and other components that are embedded in them. And it is an internal membrane system.

So, when you look at this cell, a lot of these players in the cell apart from the mitochondria, are all part of the endomembrane system. Now, very clearly, they are membranes that are inside the cell and which have all come together in very distinct ways to make organelle structures which now, do very important and unique cellular functions. And as this slice of a cell shows you all of this connects to the plasma membrane,

So, it is highly possible that the evolution of the endomembrane system and the fact that the endomembrane system exists in the form that it does, is governed or is determined by the fact that the cell boundary or the perimeter of the cell is something that evolved as a lipid membrane. And so, the fact that boundary of the cell which is the interface between the cell and its external environment is made up of membrane lipids means that things that have to be brought to the membrane, delivered to the membrane that need to talk with the cell membrane.

It will greatly benefit if these are integrated in lipid membranes. And so, the cell has evolved this complex network of membranes that begin from the nuclear envelope go to the rough endoplasmic reticulum, the smooth endoplasmic reticulum, and then to the Golgi, and then eventually, to the plasma membrane. And these are all membrane bound organelles. And one of the reasons they exist this way, is because they are the interface that they need to talk to which eventually influences all of cellular behavior which is the plasma membrane is also made up of membranes.

So, this is an interesting point to consider that whether these membrane structures would have existed, had it not been for the fact that the plasma membrane is made up of lipids.

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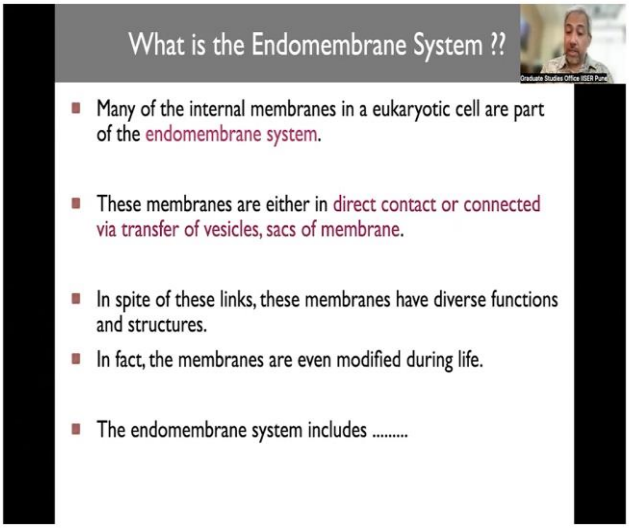

So, the endomembrane system is essentially, many internal membranes in a eukaryotic cell that play a vital role in regulating synthesis, processing, and delivery of proteins and other lipids to specific parts of the cell. The membranes are either in direct contact, or connected via transfer of vesicles which are essentially sacks of membrane and you are now familiar with the idea of a vesicle that is being moved around the cell. And so, these compartments are all connected and are talking to each other in a way through the fact through these 2 direct connections or through these vesicles.

But the fact that they are all made up of membranes allows for them to come in contact, talk to each other, communicate with each other, and allows things to move through them in a way that would not have been possible otherwise. In spite of these links, these membranes

have diverse functions and structures. And in fact, the membranes are even modified during life.

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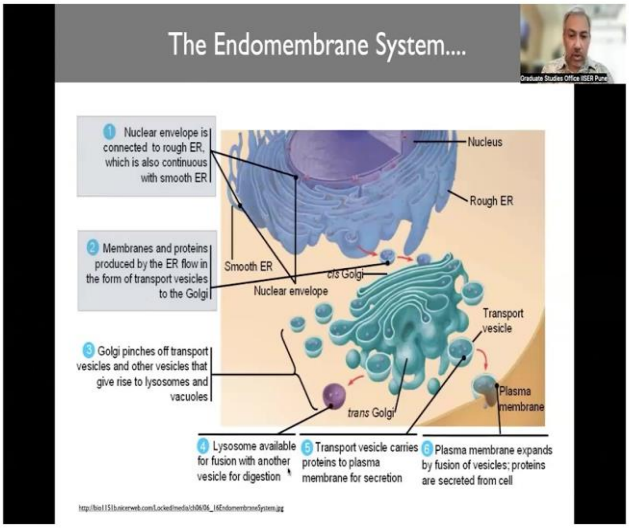

The endomembrane system effectively includes this group of membranes. It includes the nuclear envelope which is then immediately connected to the rough endoplasmic reticulum. The rough endoplasmic reticulum is the site where protein synthesis is happening and it is called rough because it is lined or covered by ribosomes that are making proteins. It is the site where a lot of the protein synthesis happens.

And from the rough endoplasmic reticulum membranes produce and proteins that are produced in the ER move as vesicles and come to this organ organelle which is called the Golgi. The Golgi is an interesting organelle because the Golgi receives content in the form of vesicles from the recycling sorry, from the rough endoplasmic reticulum and then processes all of this.

So, this content actually moves through the Golgi. So, this is the interesting thing because this is all membranes components begin their life in the membrane and they are carried from one membrane to another and they see different things when they are in different compartments. So, the Golgi, for example, has very interesting segregation of membranes, it is a stack of membranes effectively one put together, one above the other and these stacks of membranes have very distinct class of enzymes that are present in very different compartments.

So, there are certain enzymes that are present in one compartment, then a different set of enzymes and another compartment. Now, the compartmentalization here could essentially be

determined by the presence or absence of many of these components. So, it is not like the compartment was decided first and you say okay, let us put the enzyme here. The fact that the enzymes are present, in this case certain enzymes are present in this compartment is what also defines that compartment.

So, it moves from the proteins and lipids move from one compartment to the other and eventually make it out of the Golgi in vesicles. Now, as it moves through these compartments, this is the interesting thing. And this brings us again, back to this idea of things being regulated in space and time that the rate at which. So, where the vesicle is originating from the relative localization of that vesicle is going to determine where it also goes to in some of these cases.

So, that spatial arrangement is very vital, you have the nucleus, you have the endoplasmic reticulum, the rough and the smooth, and then you have the Golgi. And remember all of this is sitting around the centrosome, and they are all connected and held in place by this elaborate microtubule and actin cytoskeleton network. So, when we talked about the fact that the cytoskeleton components are required to keep organelles in place, one of the reasons this is important is because you have this floppy cluster of membranes that are floating around. And there has to be a way to kind of tie them and keep them together.

So, there are studies, for example, that we in the lab have done where and others have done to of course, where the Golgi if you add something to break up the microtubules. The Golgi that is a nicely packed structure just breaks up and gets distributed throughout the cell which essentially says that all these packets of membrane being held together in one compact structure in such a way that they can all communicate with each other is mediated by the cytoskeleton.

So, the cytoskeleton becomes particularly relevant to the functioning of the endomembrane system because this is just a sea of lipid membranes that have certain unique properties that are distributed throughout the cell. And just, we know about the spatial arrangement that is important, the time something takes to go through these compartments makes it significant impact on how that particular protein or lipid is processed.

So, the fact that a protein can start from one end of the Golgi and make it through Golgi compartments and go all the way out from the other end. It is seeing different enzymes as it goes through not all enzymes will act on that particular protein. The protein has to have

certain characteristics in its amino acids which will say this particular enzyme can actually act on that protein.

Now, so, there is some selectivity because of that. Then, there is selectivity of course, because of the fact that, how long the protein resides in one or more of these compartments, could make a dramatic impact on how it is modified. So, a protein for some reason being stuck in one particular compartment slightly longer could change essentially the kinds of modifications that it has, and eventually can affect the functionality of the protein.

So, not only is where these proteins are originating and how they are moving important, the rate at which they are doing this also becomes particularly important, So, the third member of this series is the Golgi and the Golgi also pinches off, of course transport vesicles things that are carried to the plasma membrane that but these could also give rise to lysosomes and vacuoles.

Lysosomes are available for fusion with other vesicles and play an important role in digesting components content that is present in other vesicles. There are transport vesicles which carry proteins to the plasma membrane and come and fuse with the plasma membrane and will now deliver stuff. And the plasma membrane obviously acting as the perimeter of the cell but not just that it also acts as a place where a lot of these components can be delivered.

And now we will talk to the external environment. I think we spoke about this earlier and this is another important thought to have that when proteins are made remember that finally, when they have to be delivered. This protein essentially has to be present in a form that can be seen very clearly on the outside. So, I am going to use this coin and just illustrate this where if the coin is to be displayed like this. And this is where it is I hope you can see it. And this is how it should be displayed on the plasma membrane.

Imagine, when it comes in a vesicle, it is actually inside the vesicle most of this protein. So, what is eventually going to be out is actually in, and if the protein is a transmembrane protein and there is a part of it sticking out at the other end this end is going to be inside. So, you have this protein that is in a vesicle. it comes and fuses with the plasma membrane and opens up and now the protein is present here in such a way that it can talk to things from the outside.

So, remember the orientation, when the protein is synthesized, the orientation is such that things that are eventually meant to be out, are on the inside. And this is how it moves as

vesicles from one compartment to the other all the way out to the plasma membrane. So, that is the arrangement of the endomembrane system. And this works in the context of the plasma membrane and uses this cytoskeleton network to drive everything.

So, even though this image, for example, shows the endomembrane system and all these compartments talking to each other, none of that would be possible without the cytoskeleton. So, on top of all of this now, you have to mentally superimpose the image of the cytoskeleton. And the architecture of these endomembrane systems, their ability to talk to each other and carry stuff, process stuff is all mediated because of the cytoskeleton.

And that is why these 2 components are very integral to each others role in cells and work very closely with each other to drive cellular function. So, in the interest of time we will stop here. Next time we will look at each of these components in a bit more detail and talk a little bit about endoplasmic reticulum, the Golgi and all the other vesicular structures that come out from the Golgi so, we will stop here.