Basics of Biology
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Module 3: Cells in Biology
Lecture 13: Basics of Cells (Part- III)

Hello everyone. This is Doctor Vishal Trivedi from Department of Biosciences and Bioengineering, IIT, Guwahati. And what we were discussing? We were discussing about the cells and what we have discussed is that the cell is the structure and the functional unit of the life. In the previous two lectures we have discussed about the prokaryotic cell and as well as the eukaryotic cell.

Within the prokaryotic cell we discussed about the different parts of the bacterial cells, we talked about the flagella, we discussed about the genetic material of the bacterial cell. And we also have discussed about the cell wall and we also discussed very briefly about the Gram staining.

And then in the previous lecture we discussed about the eukaryotic cells and what we have taken is we have taken the two eukaryotic cells, the plant cell as well as the animal cells. And we discussed about the several types of differences between the plant cell as well as the animal cell.

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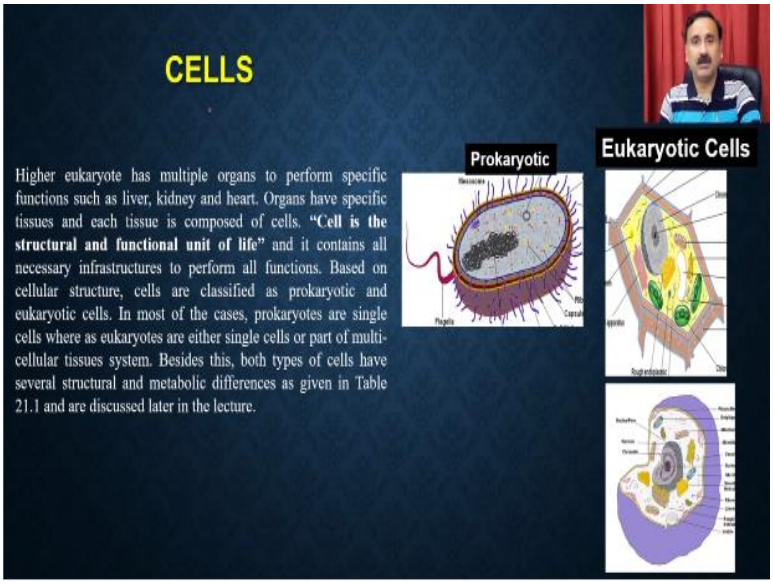

And subsequent to that we discuss about the cytosol, we discuss about the nucleus, we discussed about the mitochondria.

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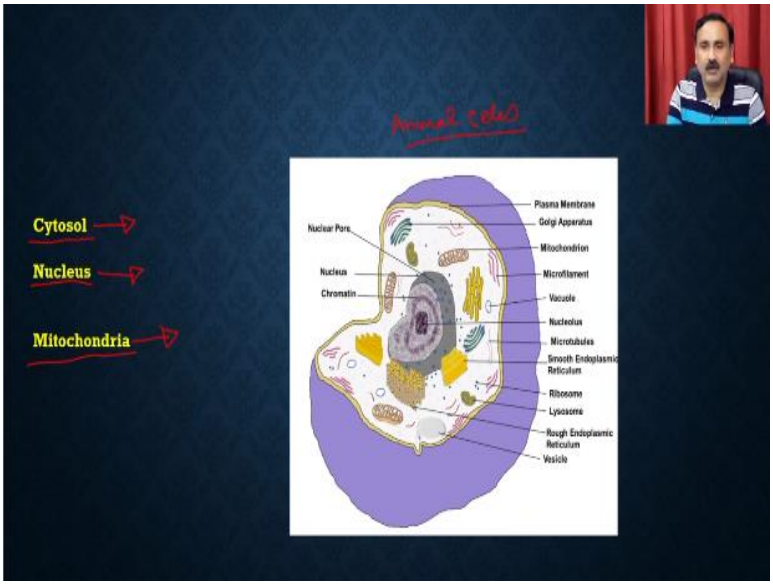

So in the previous lecture we started our discussion about the animal cell and within the animal cell we discussed about the three organelles, we discussed about the cytosol, we discussed about the nucleus and then we also discussed about the mitochondria. In each nuclei, in each of these organelles we discussed about their mechanism, their role in the cell cellular physiology and then we also discussed about the different types of structural details of that particular organelles and so on.

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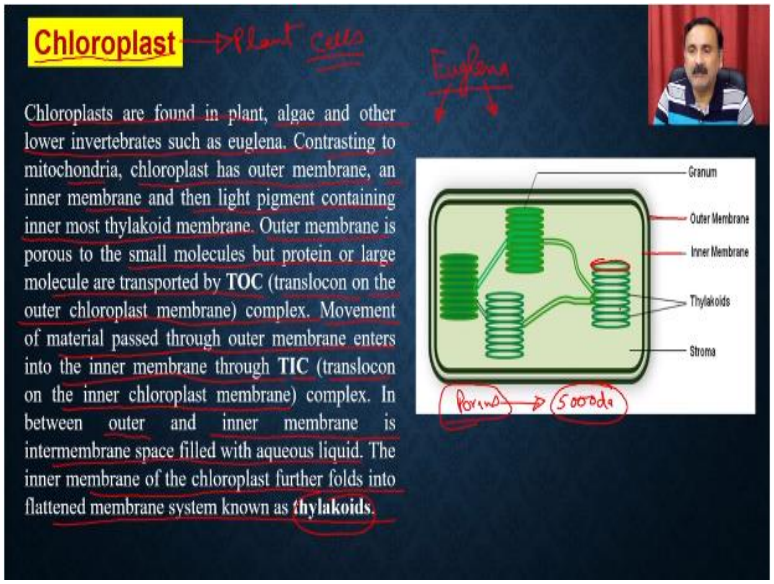

So now in today's lecture we are going to start discussing about the some more organelles from the eukaryotic cell. So let us start today's lecture. So, the first organelle what we are going to start discussing about the chloroplast. So chloroplast is present in the plant cell and it is completely absent in the animal cell except that it is also present in euglena, which is considered to be a primitive animal cell.

Because the euglena has the two abilities to synthesize the food and it also can have the ability to trap its prey and it also can be able to take the food from the external sources. So chloroplasts which are found in the plant, algae and the other lower invertebrates animals such as euglena, contrasting to the mitochondria chloroplast has the outer membrane and inner membrane and then the light pigment containing innermost thylakoid membrane.

So what you see here is this is the typical structure of the chloroplast, what you see here is it has the outer membrane, then it has the inner membrane and inside this inner membrane you have this thylakoid membrane. So these thylakoid membranes are actually containing the light pigments. The outer membrane is porous to the small molecule but the protein or the large molecules are transported by the TOC.

The TOC is stand for the Translocon on the Outer Chloroplast membrane complexes. So similar to the mitochondria if you remember the mitochondria is having the porins, which are allowing the proteins or even small molecules which are off lower than small 5000 Dalton; compared to here also the outer membrane is porous to the small molecule but it is not porous to the large protein or to the and that although large protein has to be moved through the facilitated transfer.

The movement of material of pass through the outer membrane enters into the inner membrane through another complex which is called as the TIC, which is called as the translocon onto the inner chloroplast membrane, so this is the TOC which is present on to the translocon, which is present on to the outer chloroplast membrane whereas the TIC which is present on is a translocon which is the present on to the inner chloroplast membrane.

In between the outer and the inner membrane is the inter membranous space which is filled with the liquid and the inner membrane of the chloroplast further folds into the flattened membrane system such as the thylakoid. So this is just a simple, this is the structure wise the chloroplast is following the similar kind of structure what is being present in the mitochondria.

If you recall the inner membrane in the mitochondria is getting folded and it is forming the cristae and all other kind of structures, whereas in the case of chloroplast it is actually forming the thylakoid membrane. So these thylakoid membranes are actually containing the photosynthetic pigments and these pigments are actually being responsible for harvesting the sun energy and that is how that energy can be utilized for the dark reactions.

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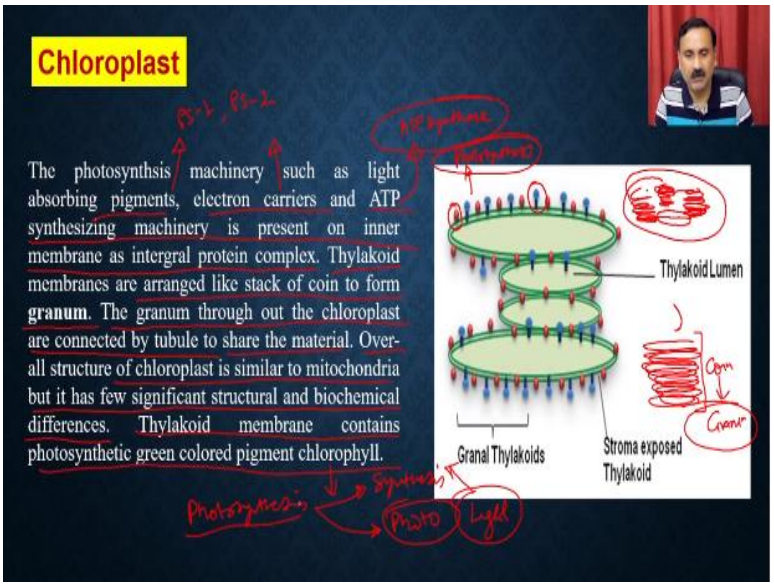

So let us understand about the photosynthetic pigments. So the photosynthetic machinery such as the light absorbing pigments and the electron carriers and the ATP synthesizing machinery is present on to the inner membrane as a integral protein complexes. So these are the thylakoid membrane where you have the integral membrane proteins and all these integral membrane proteins are actually having the complexes.

Which are responsible for the light absorbing complexes like the PS-1 as well as the PS-2 and then it also has the electron carriers like the cytochrome C and other kinds of electron carriers like the Q electron carriers and then it has the ATP synthesizing machinery similar to the mitochondria. So it also has the ATP synthase which also going to participate into the ATP productions.

Thylakoid membranes are arranged into a stack of coins which are called as the granum, so all these thylakoid membranes, so this inner layer is actually being folded into the thylakoid membrane and then these thylakoid membranes are stacked to each other, they will be stacked one of the other and that is how they are actually going to form a coin like structure and that coin like structure is called as the granum.

These granums are actually going to contain these light absorbing pigments, electron carriers and the ATP synthesizing machinery. The granum throughout the chloroplast are

connected by a tubule to share the material. So these granums are present in a chloroplast, so you see that, if you have this like a chloroplast, so the inner membrane is actually going to fall to form one set of granum.

Then it is going to be connected and then it is going to form the another set of granum and then it is going to be connected and it will form the third layer of granums. So, these molecules are going to be connected to the tubules and that is how they are actually be able to share the material between the different granums.

The overall structure of the chloroplast is similar to the mitochondria but it has few significant structural and biochemical differences. For example, the thylakoid membrane contains the photosynthetic green color pigment which is called as the chlorophyll. So let us discuss some more about the function and the major function of the chloroplast is that it is actually going to be participate into the reaction which are called as the photosynthesis.

What the photosynthesis mean is that photosynthesis is a very complex structure, photosynthesis means you have to do the synthesis and you are going to utilize the energy from the, you are going to utilize the light energy, which means you are going to use the light energy to synthesize, so that is called as the photosynthesis.

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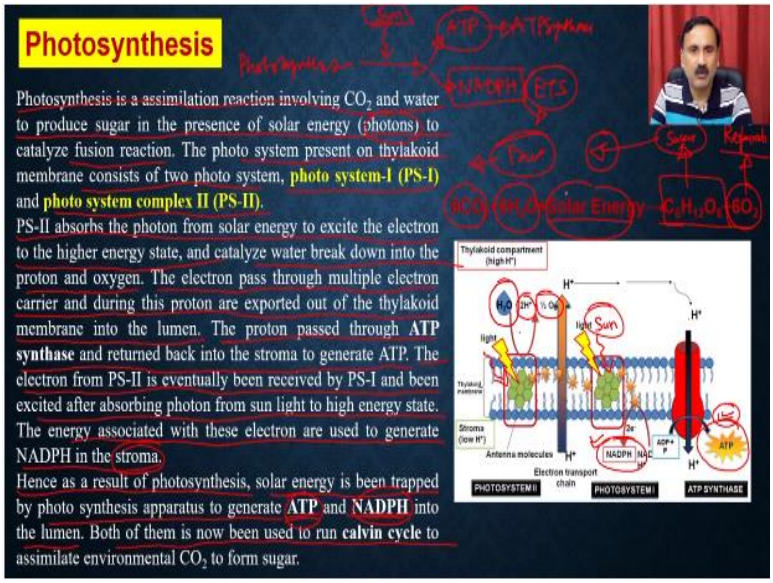

So let us see how the photosynthesis is happening. So photosynthesis is a simulation reaction involving the carbon dioxide and water to produce the sugar in the presence of solar energy or the photons to catalyze the fusion reactions. So this is the typical photosynthesis reactions where you have the carbon dioxide, water and then you also require the energy from the sun and that is actually going to be combined to give you the sugar and it also going to give you the oxygen.

So that sugar can be utilized for the plants, for its own growth and as well as this sugar can be stored in the form of fruits which other animals or other organisms are going to consume. The photo system present onto the thylakoid membrane consists of the two-photo system, you have the photo system one, which is called as the PS-1 and then you also have the photo system 2 which is called as the PS-2.

Now these two photo systems are working in accordance with each other so that the electrons or the light energy what they are going to absorb from the sun is actually going to be utilized for the generation of the ATP. So the purpose of the photosynthesis is that it is actually going to be used for synthesis of the two molecules, it is going to be utilized to synthesize the ATP and it is also going to be utilized for the reducing equivalent which is called as the NADPH.

This ATP is going to be synthesized by the molecule which is called as the ATP synthase whereas the NADPH is actually going to be formed by the electron transport chain or the electron transport system and both of these molecules, the generation of both of these molecule it requires the energy and that energy it is going to get from the sunlight. So PS-2 is actually going to absorb the photon from the solar energy to excite the electron to the higher energy state and catalyze the water breakdown into the proton and oxygen.

So this is what it is going to happen, so the first complex what is going to respond to the sunlight is actually the PS-2 and PS-2 is actually going to take up the sunlight and that is how it is actually going to catalyze the breakdown of the water, which is called as the water lysis and that it is going to generate the proton as well as the oxygen.

This electron passes through with the and it also going to have the electron, so the electron which are going to be produced during this water lysis is actually going to be passed through from the multiple electron carriers and during these electrons are exported out of the thylakoid membrane into the lumen. So this is what you see here.

It is going to do the photolysis of the water, that is actually going to generate the proton as well as the oxygen and on the other hand the electrons which are going to be excited from the PS-2 are actually going to be carry forward throughout the lumens and throughout thylakoid and that is how it is also going to be utilized.

The proton passed through the ATP synthase and the return back into the stroma to generate the ATP. So what happen is that the eight protons are actually going to be accumulated onto this side and then they will actually going to pass through to the ATP synthase and that is how it is actually going to generate the ATP into the lumen.

The electrons from the PS-2 is eventually been received by the PS-1 and been excited under the absorbing proton from the sunlight to high energy state, so that is why the electrons are going to be passed through with the different electron carriers and then it will reach to the PS-1 and at the PS-1 they will reach to the PS-1 then again the PS-1 is actually going to again receive the sunlight.

And then that is how it is actually going to excite these electrons and ultimately these electrons are going to be utilized for production of the NADPH. The energy associated with these electrons are used to generate the NADPH into the stroma. So in the stroma what you are going to generate, you are going to generate the two molecules you are going to generate the NADPH and you are also going to generate the ATP.

So ATP and the NADPH both are actually being utilized for the dark reactions, hence as a result of photosynthesis the solar energy is being trapped by the photosynthesis operators to generate the two molecules, one is ATP which is the energy currency and the NADPH which is called as the reducing equivalent into the lumen.

Both of them are being used to run the calvin cycle to assimilate the environmental carbon dioxide to form the sugar. Now this is what is going to happen, so these two

molecules are going to be utilized, so the purpose of the photosynthesis is that it also it actually wants to synthesize the ATP and the NADPH and then these two molecules are going to be supplied into the stroma where they have the enzymes for the calvin cycle.

And that is how the calvin cycle is going to run into the C4 plants and that's how it is actually going to synthesize the sugar molecule. So ultimately the carbon dioxide is going to be fixed by the plants into the sugar molecules and it is actually going to oxygen. That oxygen is going to be used by the animals for respirations and this sugar is actually going to be used by the plant for its own growth and the extra sugar is going to be stored in the form of fruits and that is going to be consumed by the other animals.

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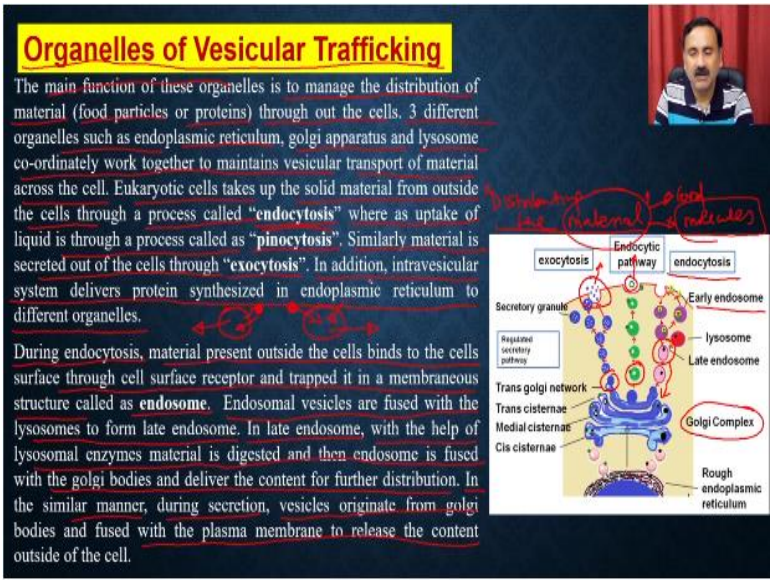

Now let us move on to the next organelles, so the next organelle is the organelles of the vesicular trafficking. You know that every cell just like as we are also having a very, very good trafficking system, so that you can, you know that what is the destination of this particular road, if you want to go from, for example, if you want to go from Guwahati to Mumbai, you know that what will be the roads, I should take to reach the Mumbai.

Or suppose I want to go to Delhi or Kolkata or any other place, similarly, if you want to distribute the material within the cell then also it also has the vesicular trafficking system.

So there are organelles which are responsible for distributing the material within the plant, within the cell, this could be for the plant cell or it could be for the animal cell.

This material either could be the food particles or it could be the signaling molecules, so this could be anything. So the main function of these organelles which are actually the organelle which are part of the vesicular trafficking is to manage the distribution of the material, whether it is a food particle or the protein which are be a part of the signal transactions throughout the cell.

There are three different organelles such as the endoplasmic reticulum, golgi apparatus and the lysosomes which coordinately work together to maintain the vesicular transport of the material across the cell. Eukaryotic cell takes up the solid material from the outside the cell through a process which is called as the endocytosis.

So if it is taking up the solid material then it is called as the endocytosis, whereas the uptake of the liquid is known as the pinocytosis, which means during the nutrition, during when the cell is taking up the nutrition it can actually take the particulate matter that process is called as the endocytosis, if it taking the liquid, for example, if it taking the water or any other kinds of vitamins and minerals and all those kind of molecule then it will be called as pinocytosis.

Similarly, the material is secreted out of the cell which is called as the exocytosis, so inside entry is called as the endocytosis, if the cell is producing some byproducts which are not good for the cell, then it also going to throw these cells and that process is called as the exocytosis. In addition, the intravascular system delivers the protein synthesized in the endoplasmic reticulum to the different organelles.

Apart from these two, these three processes like two processes where the cell are actually going to receive the material, if it is solid, then it is called as the endocytosis, if it is liquid then it is called as the pinocytosis and if it is a byproduct then it is called as the exocytosis. Apart from these three moment of the distribution of the materials you can also have the distribution of the material to the different organelles.

For example, you know all the proteins are being synthesized either inside the endoplasmic reticulum or inside the cytosol, but these proteins probably may not be required for that particular organelle, it may be required for the lysosome, it may be required for the mitochondria, it may be required for the chloroplast, so that movement is also be a responsibility of these organelles which are part of the vesicular trafficking.

During the endocytosis the material present outside the cell binds to the cell surface through the cell surface receptor and trapped it in a membranous structure which is called as the endosome. The endosomal vesicles are fuses with the lysosomes to form the endosome. In late endosome with the help of the lysosomal enzyme material is digested and then the endosome is fused with the golgi bodies and deliver the content for the further distributions.

In the similar manner during secretion the vesicular originate from the golgi bodies and fuse with the plasma membrane to release the content, so this is what you see here. Here we have shown the all the three processes, one is the endocytosis, so if it is a food particle it is going to be take up inside and it will be going to engulf and then it is actually going to be first present into the early endosomes.

These early endosomes when they will fuse with the lysosome but is going to be present in the cytosol, then it is actually going to form the late endosome and then these late endosomes are actually going to be fused with the golgi complexes and then the golgi is going to process this particular material what is being taken up from the outside.

And that is how it is actually going to be delivered to the endoplasmic reticulum or it is actually going to be given to the other organelles. Same is true for the if suppose the something has to be secreted out, like for example, if something is has to be exocytosis or something has to be secreted out then that material is going to be come out in the form of the vesicles and then these vesicles were eventually going to fuse to the plasma membrane and then this material is going to be go out.

Same is true for the exocytosis where the golgi is going to pack this material in the vesicles and then these vesicles are going to fuse with the plasma membrane and then it is actually going to release this particular content.

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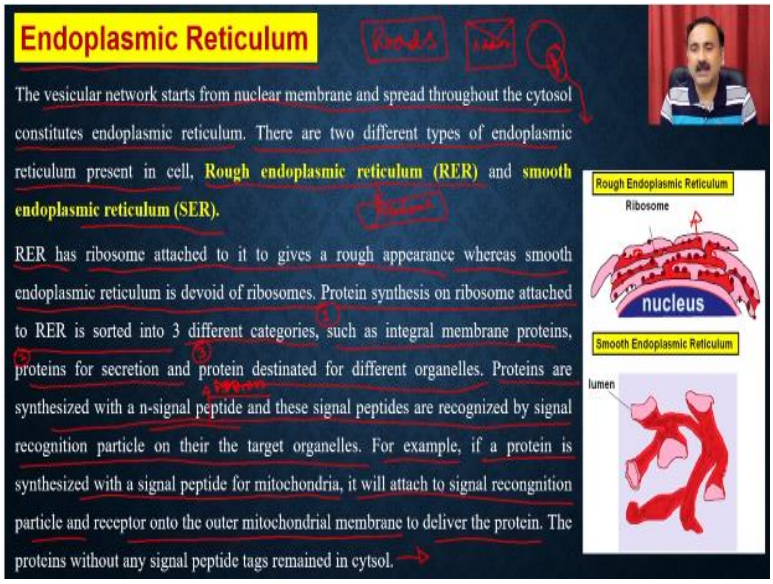

Now let us study these organelles individually and understand their functions. So first organelle which is be a part of the vesicular trafficking is the endoplasmic reticulum. Endoplasmic reticulum is nothing but the roads which are present inside the cell. So what you see here is the endoplasmic reticulum is present just outside the nucleus and it is forming a road like structure.

It is forming a road throughout the cell, so if you want to send the material which is supposed for the mitochondria then these roads are actually going to go to the mitochondria and that is how it is actually can deliver that material to the mitochondria. So the vesicular network starting from the nuclear membrane and spread throughout the cytosol constitutes the endoplasmic reticulum.

There are two different types of endoplasmic reticulum which are present in the cell. You have the rough endoplasmic reticulum which is actually having the protein machinery attached to it which is ribosomes, so you have the rough endoplasmic reticulum and the smooth endoplasmic reticulum. Rough endoplasmic reticulum is having the ribosomes

which are attached to it.. so because of this ribosomes their appearances look like as a rough endoplasmic or rough surfaces.

So the rough endoplasmic reticulum has ribosome attached to it and it gives the rough appearance, whereas the smooth endoplasmic reticulum is devoid of the ribosomes. Protein synthesis on the ribosome attached to RER is sorted into 3 different categories, such as integral membrane proteins, proteins for the secretions and the protein destinated for the other organelles.

So the protein what has been synthesized inside the endoplasmic reticulum actually falls under the 3 different categories, number one is the protein which is a part of the integral membrane proteins, number two the protein which is for the secretions and the number three the protein which is for the different organelles.

Proteins are synthesized with a n-signal peptide and these signal peptides are recognized by the signal recognition particle on their target organelles. So the proteins which are destinated for the different organelles are synthesized with a signal peptide. Signal peptide is nothing but kind of a address, so they are actually having a address.

So, you can imagine that if I want to post a letter from here IIT Guwahati to IIT Madras then what I will do is I will take the letter, I will have a letter and then I will write an address on this. Similarly, if I have a vesicle and if I want to send this vesicle to the mitochondria what I will do is I will put the mitochondrial localization sequence.

And that is what is called as the signal peptide, remember that when we were talking about the last time when we were talking about the mitochondria that the porin will not allow the entry of any proteins which is beyond the 500 Dalton but if protein is of beyond the 500 Dalton then that protein has to have a mitochondrial localization sequence.

So you can put a tag like or you put a signal then this vesicle will go to that destinations. For example, if a protein is synthesized with a signal peptide for the mitochondria it will attach to the signal recognition particle and the receptor onto the outer membrane to deliver the protein, the proteins without any signal peptide tags remain in the cytosol. So

any protein which does not have any kind of tag is actually going to remain within the cytosol.

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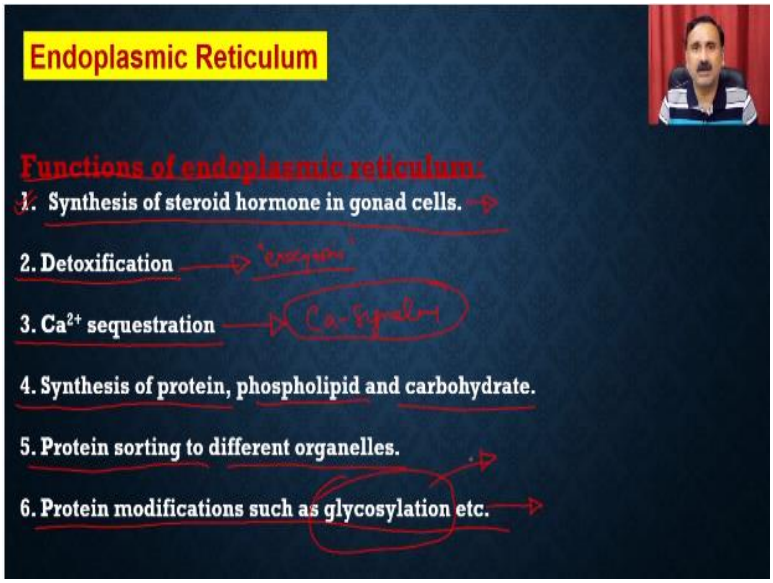

Now what will be the function of the endoplasmic reticulum? So the first function is that it is involved in the synthesis of the steroid hormone within the gonad cells. Then it is required for the detoxification, remember that the endoplasmic reticulum is a part of the vesicular transmitting, so it actually can do the exocytosis and that is how it is actually going to participate into the detoxifications.

Then it also can do calcium sequestrations and that is how it actually can have the calcium signaling, so if the calcium signaling the endoplasmic reticulum is actually going to release the calcium into the cytosol and that is how it is actually going to start the calcium signaling. Then it is also important for the synthesis of the protein, phospholipids and the carbohydrates.

It is possible for the protein sorting for the different organelles and it is also responsible for the protein modification such as glycosylations. So some of these things are very, very complicated and we are not going to discuss, for example, the glycosylation itself is a big topic, so that we are not covering in detail in this particular course.

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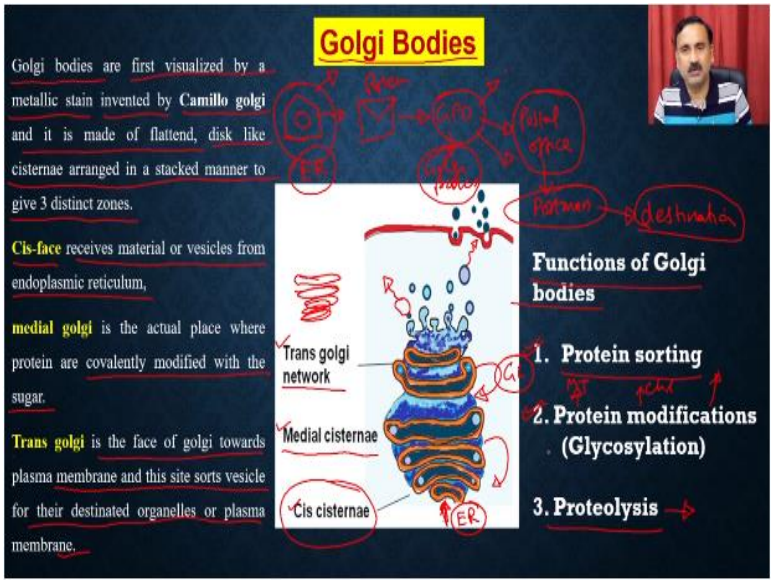

Then we talk about the next organelle and the next organelle is the golgi bodies. The golgi bodies are actually been first visualized by a metallic stain which is called as the golgi stain, invented by the Camillo golgi and it is made up of this, so golgi is made up of the flattened disk like cisternae arranged in a stacked manner to give three distinct zones.

So this is what you see, this is the golgi bodies where you have the disk like structures, so disk like structures which are attached to each other and that is how it is going to have a golgi bodies. You have the three different zone within the golgi bodies, you have the Cis zone, you have the medial zone and then you have the trans zone.

So this is the starting point, you have the Cis phase is actually receiving the material or vesicle from the endoplasmic reticulum. So this side with the side from which it actually receives the material from the ER is called as the cis-face or the Cis cisternae, whereas the middle portion is called as the medial golgi, where in medial golgi you are actually going to have all the processing.

It is actually going to have the covalent modification with the sugar, so it is going to do the different types of glycosylations and all those kinds of modifications and then the top portion what you see here is actually the trans golgi, that trans quality is actually is the

face of the golgi towards the plasma membrane and this side is actually going to release the sorted vesicles.

Whether these vesicles are going to be for different organelles or whether this is for the plasma membrane, which means whether these vesicles are for the secretory pathway or whether these vesicles for the other mitochondria and for their destinated organelle or to the plasma membrane. So these are the functions of the golgi bodies.

You have the protein sorting, in the medial golgi the proteins, so it will actually receive the protein what is being synthesized by the endoplasmic reticulum, then that protein are going to be sorted within these medial golgi and then by sorting these proteins are actually going to be modified by differentially, they are going to be tagged with the different types of destinations.

For example, it can be a mitochondrial localization sequence, it could be chloroplast localization sequence, it could be some other kind of localization sequences, even for the golgi itself, if golgi want to get some protein it also has to put a golgi localization sequences and ER localization sequences, although this protein is coming from the ER but it cannot retain within the ER, it has to be received from the golgi bodies.

So all the material will go into the golgi then it will be going to be sorted out and then it is going to be tagged with the particular address and then subsequently it is actually going to be delivered to that particular organelle. For example, if you are in your home and if you send a envelope or if you send a letter, what happens?

This later first go to the GPO, then from GPO it is actually will go to the different postal address or this will go to the postal office, from the postal office it will go to the postman and then postman is actually going to deliver it to the destination. So same is true for the vesicular trafficking. If you are in the home, this is actually the ER, so where the synthesis is happening.

Then what will happen? This is your letter, so this is a protein, so this is a protein. Now this protein will first come to the GPO, GPO is nothing but the golgi bodies. Now from the golgi bodies it is actually going to be sorted, it will actually going to be sorted as per

the destination for example, there are parcels which will go to the Mumbai, there are parcels which are go to the Delhi, there are parcels which will go to Kolkata or other cities.

So at this point it is actually going to be sorted and it is actually going to have some kind of stamp, that this will go to the Kolkata, this will go to Mumbai, this will go to Delhi and something like that, so then it will reach to the Delhi office and then from Delhi office it will be given to the postman and then postman will actually going to give you the destinations.

So this is the very important, this is the golgi bodies, so even if the letter has to be come back again, it has to be come back again to your home for example, then also the GPO has to tag accordingly then only it will come back. For example, if you are sending a letter to your neighbor, it will not go directly from your place to that neighbor.

It will go through this process; it will go to that particular postal office and then it will come back to your that neighbor house. So that is the function of this organelle what is involved in the vesicular trafficking. Apart from that the golgi is also involved in the proteolysis, so where it is also going to degrade the proteins.

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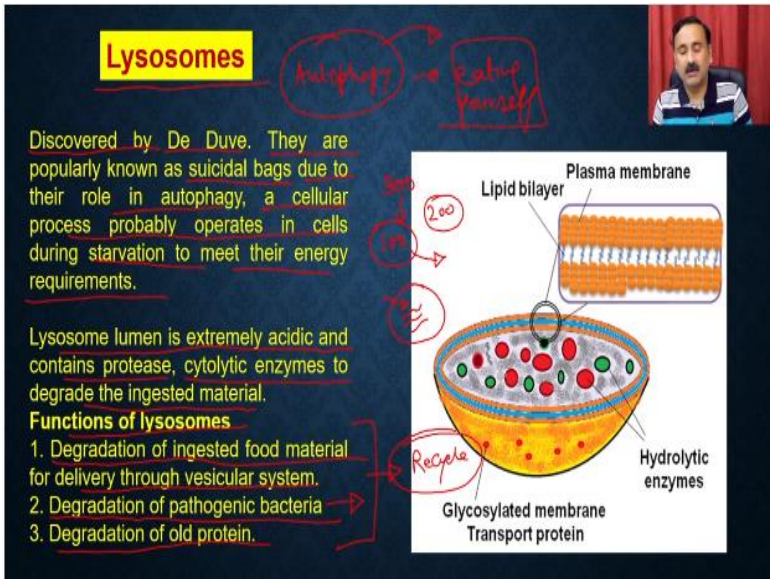

Now we talk about the third organelle which is also be responsible or be a part of the vesicular trafficking and that organelle is called as the lysosomes. Lysosome is an organelle which is discovered by the De Duve and they are popularly known as the suicidal back because the lysosome is filled with the different types of hydrolytic enzymes and its inner liquid is very, very acidic.

So due to their role in the autophagy, autophagy means eating yourself, so autophagy means eating yourself, which means you might have seen many people who are chewing their nails, that is autophagy actually, that is that you are chewing your own body. So same is true for the cell also, when the cell cannot produce the enough energy because it is not getting the nutrition from outside.

Then what will start doing is for example, if suppose it has the 300 copies of some organelles, so what it will do is it will start utilizing the 100 copies, so it will actually going to be work with the 200 copies of that particular organelle and the 100 copies it will going to destroy and that material it is actually going to use for its nutrition, that process is called as the autophagy.

But this is a suicidal pathway and that is why the lysosomes are known as the suicidal backs. Autophagy is a cellular process probably operate in cells during starvation to meet their energy requirements. Lysosomal lumen is extremely acidic and contains the proteases, cytolytic enzymes to degrade the ingested material.

So if you have a lysosome and if you give any molecule, whether it is a protein, whether it is a DNA, whether it is the bacteria, viruses any kind of molecule it is actually going to degrade and it will going to generate the proteins or peptides, that is why the lysosome has very well defined function.

It will degrade, it will degrade the ingested food material for delivery throughout the vesicular systems, so if you take the food particle from outside it is going to be delivered to the lysosomes and that lysosome is what is going to do, it is going to degrade that food particles, so that it would be present in the form of the simple molecules and that simple molecules it is going to deliver.

It is also been present in the defense cells and it is going to work as a defense organelle also, so it is actually going to destroy the pathogenic bacteria, viruses and yeast, fungi and all kind of pathogenic bacteria and then it is also going to degrade the old protein. So the major part of the lysosome is that it is actually going to recycle the material.

So, it is going to recycle the cellular materials and as well as it is going to recycle the outside material. So if there is a bacteria, if it goes into the cell it is actually going to destroy that particular cell, so that bacteria will be given into to the lysosomes by the very well defined the process and that anyway we are going to discuss when we are going to discuss about the cellular processes.

When we are going to talk about the phagocytosis that time we are going to discuss in detail how the bacteria or viruses or all these infectious organisms are going to be delivered to the lysosome and then how the lysosome is actually degrading these bacteria.

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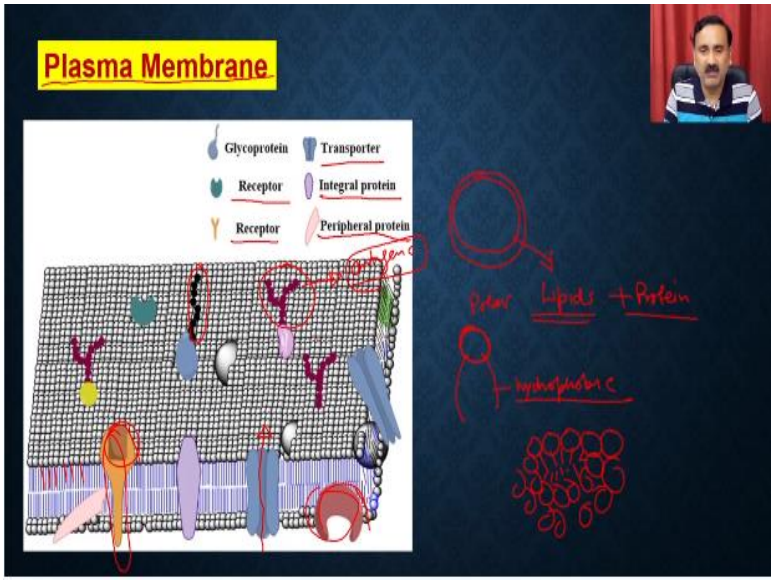

Now let us move on to the next organelle and the next organelle is called as the plasma membrane. So plasma membrane is nothing but the external membrane and the plasma membrane is made up of the two molecules. It is made up of the lipids and it is made up of all the proteins. So you know that the lipid has a head and then it also has the aliphatic chains, hydrophobic chain.

And these head molecules which are called as is actually the polar and these chains are hydrophobic and because of this particular type of amphipathic character all these heads are actually arranging themselves and the lipids are, these chains are actually arranged inside. So if you put this under the aqueous environment it is actually going to form a membrane like this and that is how the plasma membrane is made up of the lipids as well as the proteins.

So what you see here is this ball like structures are actually the polar head groups and what you see here is this tail like structure is the hydrophobic tails and they will be arranged and sandwich, so they will make a sandwich like structures and within these sandwich structures you are going to see the different types of proteins, these proteins could be the integral proteins or they could be peripheral proteins.

So what you see here is this is the integral protein because this is present throughout the plasma membrane, whereas this is what you see is actually an integral protein which is either be present on to the outer surface or to the inner surface. Apart from that the plasma membrane is also going to have the different types of receptors.

Like for example, this is a receptor, this is a receptor, it can also have the channels like it can have the transporter as well as the channels, these transporters and channels are actually going to use for delivery of the food particles or delivery of the small molecules. Apart from that it also could have the different types of the molecules which are being attached onto the lipids membrane and that is actually going to a part of the antigenic role, so they are going to be the antigenic molecules which are going to be attached.

So these are sugar molecules which are being present on some of these peripheral proteins and that is responsible for giving the antigenic features to this particular plasma membrane.

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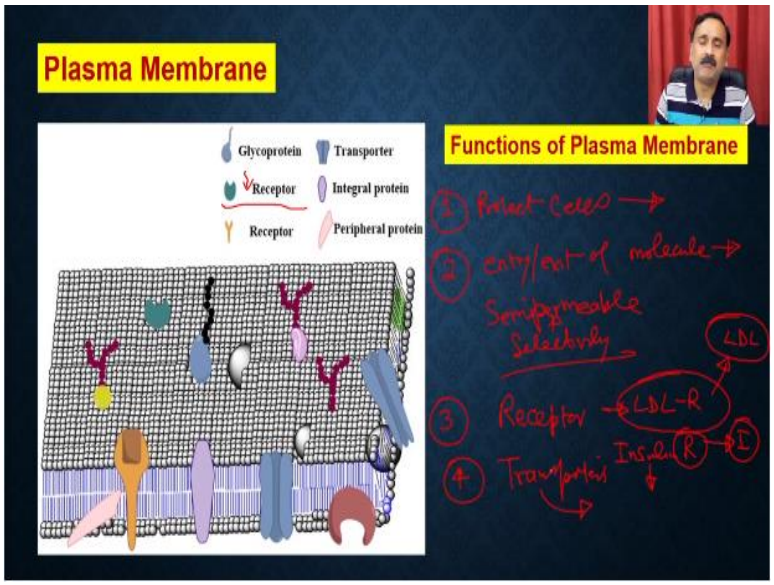

Now what is the function of the plasma membrane? So function of the plasma membrane is that it is actually going to protect the cells from the external infections, then number two is it is actually be responsible for entry or exit of the molecules, so it is a part of the regulatory system, so that it actually will allow the entry and exist of the molecule because the plasma membrane are semi-permeable.

So they will allow some molecule, semi-permeable so they will be selectively permeable, so they will be selectively permeable and so they will be having some mechanism, so that they will be very selective, whether they will be allow some molecule to enter or not that is actually going to be decided by the plasma membrane.

Apart from that the plasma membrane is going to have the different types of receptors, so they will be actually going to use that for many purpose, these receptors could be for taking up the food for example, you can have the receptors which is for the taking of the food for example, you can have the LDL receptor, so that LDL receptor is going to take up the LDL which is a lipid actually from outside and that LDL receptor is going to take up the LDL and that will be utilized for the cell for its nutrition.

Similarly, you can have the insulin receptor, so insulin receptor is going to use for detecting the insulin, what is present in the blood and that is how it is actually going to

lower down the blood glucose. Number three, the receptor are also going to be a part of the defense mechanism, so some of the receptors are going to function as the recognition particles or sometimes they are also going to work as a defense mechanism.

So they will be going to sense the external molecules and they are actually going to derive the responses from the cell accordingly, and apart from that the plasma membrane also has the transporters, these transporters are actually going to be used for the different types of delivery of the molecules or the delivery of the water or the solutes and small molecule as well as the big molecules.

So overall the function of the plasma membrane is that it wants to regulate the material entry and exit from the cell. So with this we have discussed about the eukaryotic cell, what we have discussed, we have discussed about the differences between the two different types of eukaryotic cell, we discuss about the plant cell and as well as the animal cell and we also have discussed about the different organelles.

What are present in the eukaryotic cell, initially we have discussed about the cytosol, then we discuss about the nucleus and we also discuss about the mitochondria and in this particular lecture we have discussed about the chloroplast, then the organelles of the vesicular trafficking system. We discuss about the endoplasmic reticulum. We discuss about the golgi bodies.

And we also discuss about the lysosomes and at the end we have also discussed about the plasma membrane and its functions. So with this I would like to conclude my lecture here, in our subsequent lecture we are going to discuss about the cell cycle and how the cell is dividing and increasing its number and some more aspects related to the cells.

So with this I would like to conclude my lecture here, thank you.