Molecular Biology
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Module - 01
Basics of Biological system (Part 1)
Lecture-03 Cellular Structure (Eukaryotic cells)

Hello everyone, this is Dr. Vishal Trivedi from the department of bioscience and biotechnology 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 in the within the prokaryotic cell we discuss about the different parts of the bacterial cells we talk about the flagella we discuss about the genetic material of the antibacterial cell and we also have discussed about the cell wall and we also discuss very briefly about the gram staining. And then the in the previous lecture we discuss 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 discuss about the several types of differences between the plant cell as well as the animal cell. And subsequent to that we discuss about the cytosol, we discuss about the nucleus, we discuss about the mitochondria. So, in the previous lecture we started our discussion about the animal cell and within the animal cell we discuss about three organelles we discuss about the cytosol, we discuss about the nucleus, and then we also discuss about the mitochondria.

In each nuclei, in each of these organelles, we discuss about their mechanism, their role in the cell cellular physiology. And then we also discuss about the different types of structural details of that particular organelles and so on. 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 chloroplast which are found in the plant algae and the other lower invertible animals such as euglena. Contrasting to the mitochondria, chloroplast has the outer membrane and inner membrane and then the light pigment containing innermost thalakoid membrane. So what you see here is this is a typical structure of the chloroplast.

What you see here is it has the outer membrane, then it has the inner membrane and inside the this inner membrane, you have this thalakoid membrane. So these thalakoid 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 a stand for the translocosin, locon on the outer chloroplast membrane

complexes. So similar to the mitochondria, if you remember the mitochondria is having the porins right which are allowing the proteins or even small molecules which are of lower than small 5000 or 1000 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 passed through the outer membrane enters into the inner membrane through the 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 onto the translocon which is present onto the outer chloroplast membrane whereas the TIC which is present on is a translocon which is the present onto the inner chloroplast membrane. In between the outer and the inner membrane is the intermembranous space which is filled with the liquid and liquid the inner membrane of the chloroplast further folds into the flattened membrane system such as the thalakoid. 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 thalakoid membrane.

So these thalakoid 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. 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 onto the inner membrane as a integral protein complexes. So these are the thalakoid 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 PS1 as well as the PS2 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.

Thalakoid membranes are arranged into a stack of coins which are called as the granum. So all these thalakoid membranes so this inner layer is actually being folded into the thalakoid membrane and then these thalakoid membranes are stacked to each other. They will be stacked one after 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 fold 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 granum. 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 thalakoid membrane contains the photosynthetic green color pigment which is called as the chlorophylls.

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 simple complex structure. Photosynthesis means you have to do the synthesis and you are going to utilize the energy from the you are going to insulate the light energy which means you are going to use the light energy to synthesize so that is called as the photosynthesis. 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 actually we are going to which are which other animals or other organisms are going to consume. The photosystem present onto the thylakoid membrane consists of the two photosystems. You have the photosystem 1 which is called as the PS1 and then you also have the photosystem 2 which is called as the PS2. Now these two photosystems 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 utilized 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 PS2 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 PS2 and PS2 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 pass 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 this electrons are exported out of the thylatoid membrane into the lumen. So this is what you see here is 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 PS2 are actually going to be carried forward throughout the lumens and throughout the thylakite and that is how it is also going to be utilized. The proton pass through the ATP synthase and the return back into the stroma to generate the ATP. So what happen is that the proton are actually going to be accumulated onto the 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 PS2 is eventually been received by the PS1 and been excited under the absorbing proton from the sunlight to high energy state. So that is why the proton the electrons are going to be pass through the different electron carriers and then it will reach to the PS1 and at the PS1 they will reach to the PS1 and again the PS1 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 been utilized for the dark reactions. Hence as a result of photosynthesis the solar energy is been trapped by the photosynthesis apparatus to generate the two molecule 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 Kelvin 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 ATP photosynthesis is that it actually want 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 Kelvin cycle and that is how the Kelvin cycle is going to run into the C4 plants and that is 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 respiration 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 also is going to be consumed by the other animals.

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 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 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 organelle 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 a part of the signal transduction throughout the cell.

There are three different organelles such as the endoplasmic reticulum, Golgi apparatus and the lysosomes which coordinate work together to maintain the vesicular transport of the material across the cell. Eukaryotic cell take 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 the 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 is also going to throw the 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 movement of the material distribution of the materials you can also have the distribution of the material to the different organelles. For example you know that the all the proteins are being synthesized either inside the endoplasmic reticulums 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 chloroplasts. 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 receptor and trapped it in a membranous structure which is called as the endosome. The endosomal vesicles are fused 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 secretions the vesicular originate from the Golgi bodies and fused 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 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 it 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 raffinoplasmic 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. Now let us study these organelles individually and understand their functions. The 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 a material which is suppose 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 they are 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 three different categories such as integral membrane proteins, proteins for the secretions and the protein designated for the other organelles. So the protein what is been synthesized inside the endoplasmic reticulum actually falls under the three 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.

Protein are synthesized with the N signal peptide and these signal peptides are recognized by the signal recognition particle on their target organelles. So the protein which are designated for the different organelles are synthesized with a signal peptide. So the 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. You remember that when we were talking about the last time when we were talking about the mitochondria that the pore in will not allow the entry of any proteins which is beyond the 500 Dalton. But if the protein is of beyond the 500 Dalton then that protein has to have a mitochondrial localization sequence. So you can put a tag like if 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 recursion 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. 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 transmittance. 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 it gives 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 glycosylation. So some of these things we 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. Then we talk about the next organelle and the next organelle is the Golgi bodies. The Golgi bodies are actually being forced to visualize by a metallic stain which is called as the Golgi stain invented by the Camellio Golgi and it is made up of the, so Golgi is made up of the flattened disc like cisterny 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 disc like structure. So disc like structure 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 zone. So 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 phase or the cis cisterny. Whereas the middle portion is called as the medial Golgi where in medial Golgi you are actually going to have the 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 kind of modifications.

And then the top portion what you see here is actually the trans Golgi. The trans Golgi is actually is the phase of the Golgi towards the plasma membrane and this site 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 designated organelle or to the plasma membrane. So these are the functions of the Golgi bodies. You have the protein sorting. So produce in the medial Golgi the proteins so it will actually receive the protein what has been 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 in within the ER it has to be received from the Golgi bodies. 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 all male. For example, you know if you are in a home if you are in your home and if you send a envelope or if you send a letter what happened this letter first go to the GPO.

Then from GPO it is actually will go to the different you know 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 going to the Delhi. There are parcels which will go to the you know Kolkata or other cities. So at this point it is actually going to be sorted and it actually going to have some kind of stamp that okay this will go to the Kolkata. This will go to the Mumbai.

This will go to the 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 a Golgi bodies. So even if the letter has to be come back again it has to be come back again to

the your home for example. Then also the GPU 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. Same is so that is the function of the this vesicular 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. Now we are talking about the third organelle which will 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 D.D.O.V. and they are popularly known as the societal back because the lysosome is filled with the different types of hydrolytic enzymes and its inner liquid is very acidic. So due to their role in the autophagy, autophagy means eating yourself. So autophagy is means eating yourself which means if you if you say 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 does not cannot produce the enough energy because it has to you know it is not getting a nutrition from outside then what will what will start doing is for example if suppose it has the 300 copies of some organelle.

So what it will do is it will start utilizing the 100 copies. So the it will actually going to be work with the 200 or copies of that particular organelle and the 100 copies it will going to you know destroy and that material it is actually going to use for its nutrition. That process is called as the autophagy but this is a societal pathway right and that is why the lysosomes are known as the societal 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 cytosolic cytolytic enzymes to degrade the ingested material. So if you have a lysosome and if you give any 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 know if you take the food particles from outside it is going to be delivered to the lysosomes and that lysosomes is doing to 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 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 to the into the you know to the lysosomes by the very well defined process and that anyway we are

going to discuss when we are going to discuss about the cellular processes.

And we are going to talk about 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 lysosomes and then how the lysosomes is actually degrading these bacterias. 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 a plasma membrane is made up of the two molecules it is made up of the lipids and it is made up of the proteins. So you know that the protein 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 the these chains are hydrophobic and because of this particular type of amphipathic character all these heads are actually arranging themselves and the lipids are the chains are actually arranged inside. So if you say this 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 sandwiched 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 a integral protein which is either be present onto 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 molecule which are being present on some of these peripheral proteins and that is responsible for giving the antigenic features to this particular plasma membrane. Now what is the function of the plasma membrane? So function of the plasma membrane is that it is actually going to protect the self 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 exit 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 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. The receptors could be taking

up the 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 not 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 3 the receptors are also going to be a part of the defense mechanism. So some of the receptors are going to function as you know 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.

So 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 discussed 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.