Bio-energetics of Life Processes
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Lecture - 04
Evolution of complex cellular membrane

Welcome back to the fourth lecture of Bioenergetics of Life Processes. So, in the previous class we discussed about the iron sulfur world and I gave you three different examples of electron transport proteins where; iron sulfurs presence is very prominent.

And as a matter of fact, we systematically discussed about the Guntree Walterbauler's theory of iron sulfur world and why that theory is fairly lucrative? Or kind of very appealing for us in the sense that whenever we see the cellular structures of modern day; current day cellular structures, we observe most of the energy transduction processes are carried out by these iron sulfur complexes or iron sulfur clusters.

They are the one which allows the electron to move through from one spot to another. All the short distance electron transfer, long distance electron transfer happens through these iron sulfur chains or iron sulfur wires or iron sulfur cluster.

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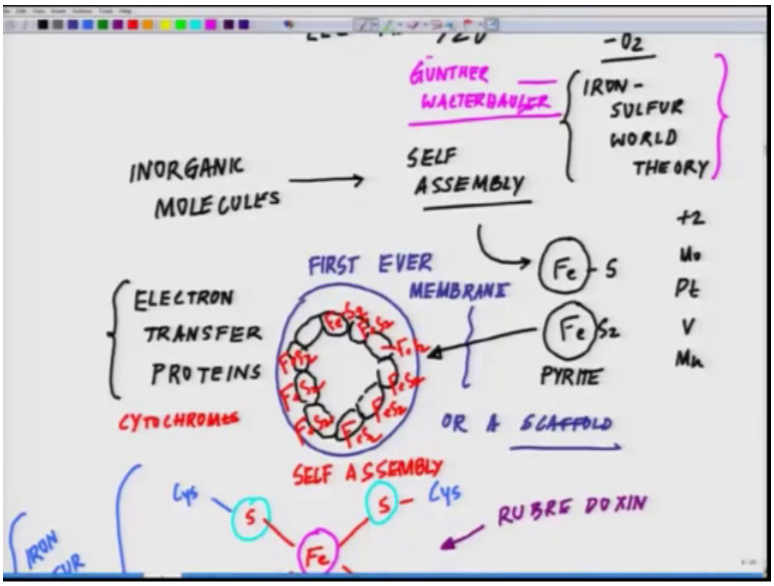

Like if you look at the iron sulfur clustering, if you look at it very carefully from a perspective.

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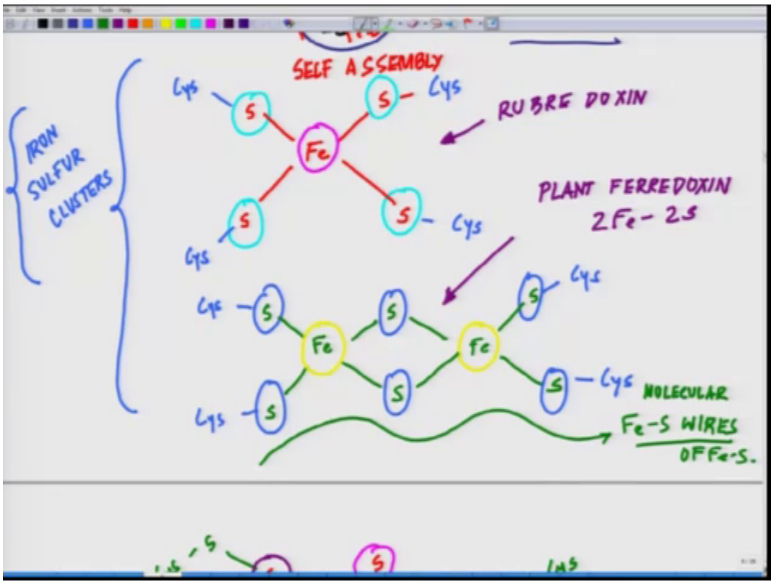

It will almost it will look like; something like iron sulfur wires as if these are the molecular wire of iron and sulfur.

So, from there today what we will do? We will discuss about. So, we talked about in the last class about the possible self assembly of the iron sulfur compounds to form a confine a structure; which acted as a template for further organic synthesis; by an organic synthesis, much more complex molecules of assembling the carbohydrates and all and possibly on the network of iron sulfur (Refer Time: 02:42).

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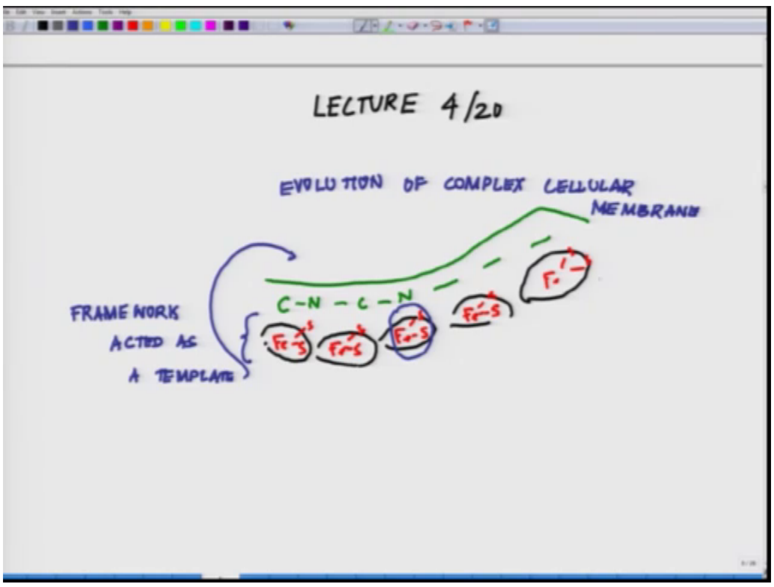

Lecture 4 of 20; so, essentially on the base of these iron sulfur compounds, we construct this; something like this what we drew in the last class. On the basis of this, we assembled a lot of carbon, nitrogen, carbon, nitrogen molecules and it is believed that this framework of iron sulfur cluster; acted as a template framework, acted as a template for evolution of complex cellular membrane.

And today whenever we looked at today's cellular structure, we observe the remnants of those iron sulfur which are sitting in between the protein. So, if we look at the modern day cellular structure; it is something like this say for example, we have a lipid bilayer.

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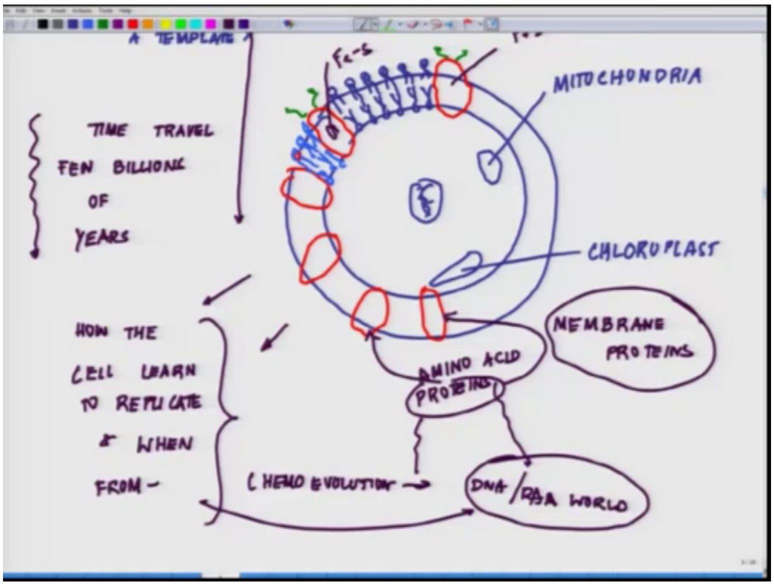

So, lipid bilayer is something like this see a cellular structure with a nucleus in the center; you have the mitochondria, which is; we will be dealing with, you have chloroplast in a plant cell and if we look at the membrane. So, membrane is something like this a lipid bilayer structure with polar head groups of lipids, but in between you see a lot of those huge protein moieties sitting like this.

And if we look at those protein moieties, one salient feature which will emerge and of course, these protein moieties have lot of carbohydrate embedded in them; as signalling molecules. And one interesting feature, which will emerge out here is; they will have these most of them if their electron transport or any kind of they will have these iron sulfur.

So, now if you try to place your imagination in place thinking about a room which was initially formed; a room in the sense a cell, which was initially form of iron sulfur on top of this over billions of years of evolution; the proteins or the complex amino acids, complex lipids, complex carbohydrate have synthesized as a template.

So, they now engulf the whole thing and it kind of developed a very unique geometry; which we see today. But from here to here, this journey is a time travel of few billions of years and in between there are lot, lot of untold stories; unexplored stories which are hidden in the very core of nature.

And that is what makes this subject; so, very interesting to understand that you know there are so many hidden stories about which we have absolutely no clue. We all are hunting in the dark to figure out one of those beautiful stories, which may have happened over billions of years of journey of who we are today.

Now coming back, if we look at the modern day cell and even the cellular structure; the cell itself could be classified into two. So, essentially a cell which got form have few unique characteristics which; by the way having said this before I can come with cellular structure, what we do not know how the cell learn to replicate and when; from this chemical world, when from chemo evolution, we move to the DNA, RNA world.

And we do not even know; whether amino acids or proteins came earlier or how they kind of developed a relation between them? These are all untold, unexplored, unknown stories of nature; we know they are there; how they have evolved over billions of years, we do not know; we just have one thing speculations and we are speculating.

So, whenever I start talking to you about these proteins which are present there; which are mostly; in this case we were talking about the membrane proteins, we have no clue how these membrane proteins really evolved there or as a matter of fact any protein evolved there. If possibly in this soup; in primitive pisa amino acid are formed, but how they learn to have a peptide bond forming? And where they set up a link with DNA and RNA world, we do not know these things.

And what was the template even for the DNA to form? What we know is a modern day cell like this and within this cell if we look at it; this is much more interesting. So, we do not know how it learned to replicate and when from this whole DNA world really came into existence. But what we know, the modern day cell has developed few unique features and those unique features are what we are going to talk about; it has a one it has a semi permeable membrane.

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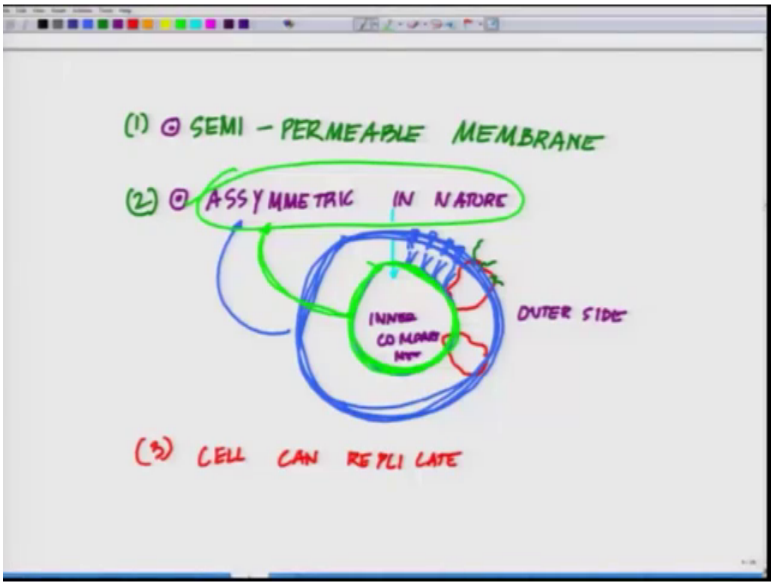

And it has; so, in terms of semi permeable membrane I am again drawing the cellular structure. If this is the cellular structure, which is; if this is the membrane we are talking about, a lipid bilayer membrane and you have the embedded iron sulfur proteins, iron sulfur clusters out there.

So, you have these carbohydrate popping out; so, this biological cell allows only selective things to float across it. It is semi permeable; one aspect of this, second aspect of this; this is a symmetric in nature, in other word this side; so, if this is the outer side and this is the inner compartment, the face is; this side this face. Now I am putting them opposite colour, the chemical nature of this face is different from the outer face.

So, that offers it an assymmetric existence; this is what we call as assymmetric in nature. So, cell membrane is asymmetric, cell membrane is semipermeable and the last thing, but we are not dealing here is a cell can replicate which we have taught, but we are not dealing with it at this stage. Because that is not our criteria or this is not we are dealing in this course.

And there is across this membrane all the cells maintain a unique potential difference.

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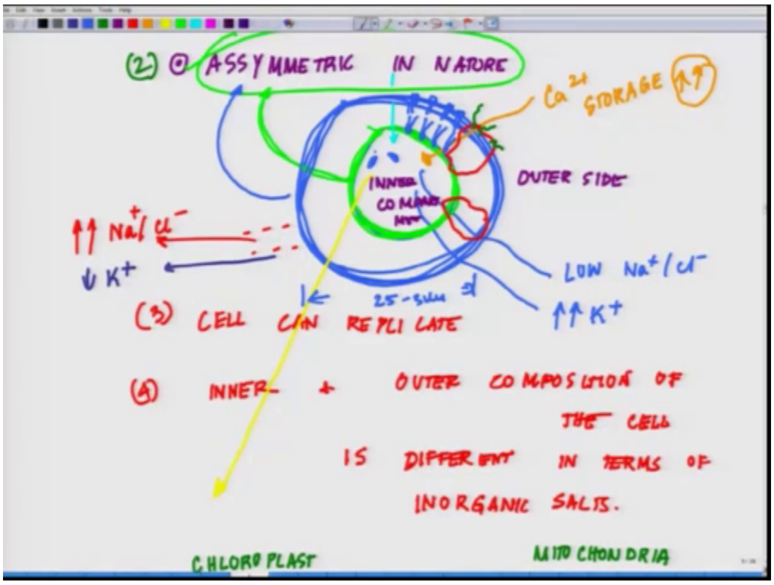

In other word, is a third property we are getting into of the cell which is the inner and outer composition of the cell is different in terms of inorganic salts. So, if you compare from inner and outer, you will observe that outside; the cell you have very high sodium and chloride; whereas, as compared to inside, you had low sodium chloride, but inside you have high potassium, outside you have low potassium and inside you have store of calcium; in calcium storage, which is high but you are not seeing calcium as free floating.

Apart from it; within this, so one unique feature of what has emerged in the modern day cellular structure is that; all the structures which are there, what we will be talking about here; they are all double membranous structure even within this. So, now if we look inside if we start looking inside it with our two organelle of major interest which is chloroplast and mitochondria.

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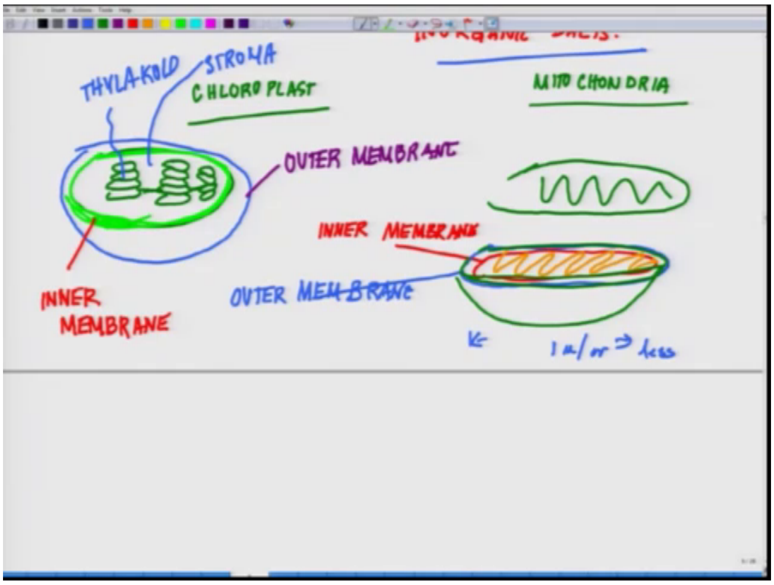

We will observe the same feature, as we observe in the individual cell. So, if you look at the mitochondria; the chloroplast in the case of mitochondria, we will observe; I am showing the cross sections. So, it is kind of; we draw it like this then when you show the cross section, it is something like this.

This is half cut structure of mitochondria and what you will observe is something like this. This half cut structure is essentially telling you, so this is the inner membrane and in the; red as, this blue line what I am drawing now is showing you the outer membrane. And if we look at the cell, you realizing that this cell; dimension, we talk about say now this is say 25 to 30 micron and within 25 to 30 microns; we are talking about structure which are probably 1 micron.

And this is the structure of mitochondria or chloroplasts; what I am talking about. This is possibly even 1 micron or less; this is how small these are, but yet what is important to realize it; these structures are also exactly following the same geometry or the same concealence; you can say, if you look at it; they are semipermeable, they are assymmetric in nature.

And these also can replicate; mitochondria can replicate an inner and outer composition of the cell or organelle. Now I am introducing these different in terms of inorganic salt and in terms of proteins.

So, you will see one interesting thing and of course, the last one; we will come into that. So, similarly if we look at this structure of the chloroplast; you will observe a very similar, stuff in the structure of the chloroplast; that is this is how the chloroplast structure looks like. These are thylakoid membranes; out there and this is that outer membrane of chloroplasts, I am just showing the cross section.

So, this is the inner core of the chloroplast; this is inner membrane, this is outer membrane. And these are the thylakoid membranes or the structure and the stroma and likewise. And again if we look at the chloroplast, it follows the same asymmetric paradigm. So, I will close in here; in the next class we will talk about some of the basic thermodynamical feature; what you needed to know.

Thank you.