Bio-energetics of Life Processes
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Lecture - 03
Iron-Sulfur world

Welcome back to the lecture series on bio energetics of life processes. So, if you recollect in the previous lecture, we talked about the different level of transitions which may have happened or must have happened or what we speculate may have happen is in the earth was formed. And that is also a very challenging question, how it was formed, it was a very harsh environment, rich in U V high temperature, extremely high pressure possibly. It was something where what we call today's life form could have never survived. In those harsh conditions, as the earth was cooling down, the rich in sulphur, iron, sulfur dioxide and things like you know hydrogen sulfide so on and so forth, possibly in that milieu as earth was cooling down, certain molecules started to self assemble, and if you recollect what we talked about in the last class in terms of the chemical evolution.

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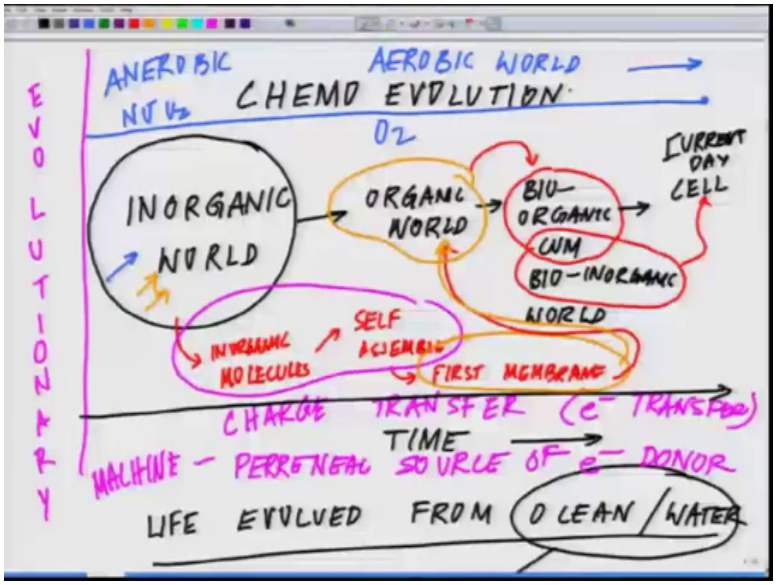

So, this is where we were; so, this was an inorganic world as the evolutionary pathway is moving through, and this is where some of these inorganic molecules started to form. So, compounds were getting formed. Then something happened, we do not know what it was, but there was certain form of a self assemble properties of molecule which evolved,

molecules which prefer to self assemble to form definitive structures, why this part is very important is. So, this is where we were talking about in the last class. So, let us start the lecture 3, lecture 3; 20.

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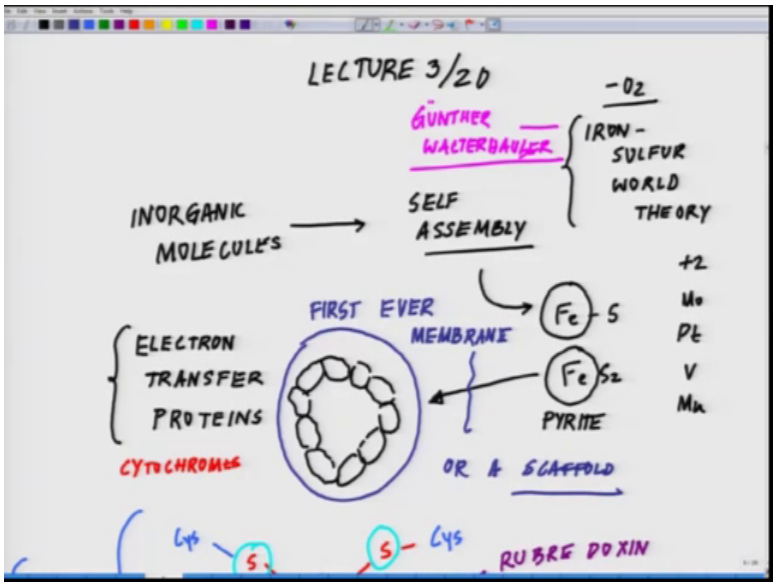

So this point where we are in a world which is rich in inorganic molecules. So, these inorganic molecules started to self assemble, to form definite of structure and this self assembly, what kind of inorganic compounds which are involved in it. We really do not know, we have a guess, we have a fair guess. And based on the fair guess, it is believed most of these compounds where. Again there are a lot of controversies you will find literature by different people who do not accept this kind of theory, but there is something called a iron, sulfur world theory. This was postulated by Gunther Wacterhauser. So, according to this, if you follow the Gunther Wacterhauser theory. According to this, this kind of self assembly which occurred was mostly of iron and sulfur compounds in the form of F e S 2, F e S so on and so forth. And if you look at the valency of iron, either in F e S or F e S 2, they are all at a lower valency plus 2. As you know the iron could remain in ferrous and ferric state. So, these were all plus 2.

So, this was a world which was not having any kind of oxygen. This was an anaerobic world, the reason. And apart from it there are compounds in and around it like in a platinum, vanadium, manganese. There are so many such mixing, molybdenum likewise. And possibly. It is believed that this kind of molecules form a kind of say for example, a

framework of self assembly like this, which was the beginning of forming something what we call today's cell or a confined structure, something like this .Again this is all a speculation that this was the world where iron sulfur compounds f e s 2, pyrite which we know in today's world iron pyrite, they self assemble. They self assemble to form a confined structure. Why, it is still holding the fort, in spite of the fact there are many controversies to this. This is where we closed the last class the reason being, if we look at the modern days, especially while will be talking about the structure of chloroplasts and mitochondria, we will find a lot of electron transfer proteins.

will see a lot of electron transfer proteins, and as a matter of fact these electron transfer proteins will be the key molecular moiety, is what will be studying in this course time and again, as will be talking about chloroplasts, will be talking in mitochondria, essentially will be talking about the electron transfer which happens through this electron transfer proteins. So, if you look at these electron transfer proteins carefully. So, what you will you observed, whether it is; say for example, whether it is cytochrome or we talked about other electron transfer proteins; like for ferredoxin likewise. So, you will observe rubredoxin, ferredoxin. You will observe one unique feature about them, they are more like this.

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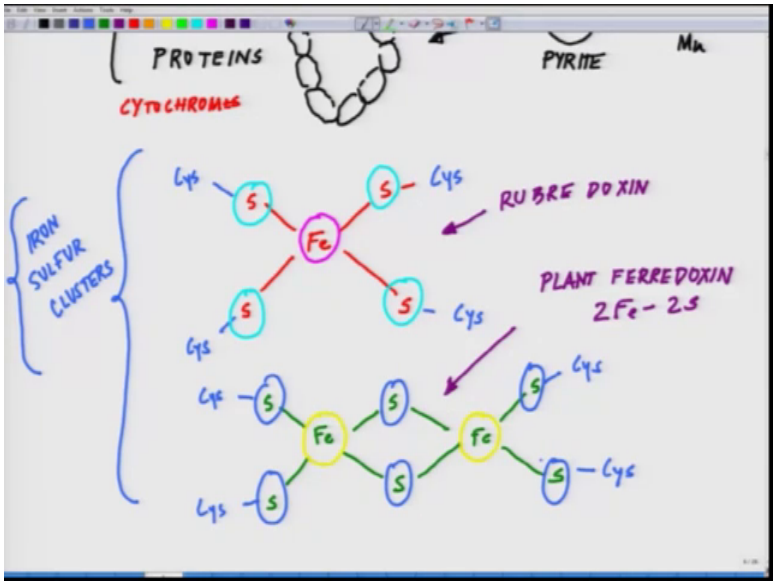

Say for example, iron, sulphur, sulphur, sulphur, sulphur. Here you have amino acids like cysteine, cysteine, cysteine, cysteine, or you will come across another configuration

where you will observe another interesting thing, where you have the iron, sulphur, iron, sulphur, iron, sulphur, sulphur, sulphur, sulphur, and then you are having the cysteine, cysteine, cysteine, cysteine.

So, these are basically what you observe are; iron, sulphur, clusters, and how they appear in the proteins. This is how you will observe that. This is, this example what you see out here, this is the classic case of a rubredoxin, rubredoxin, and the second one what you see here, what I have mentioned is a classic case of plant ferredoxin, plant ferredoxin and which is basically 2 F e and 2 S. And similarly there is another example I wanted to cite which is a very interesting structure.

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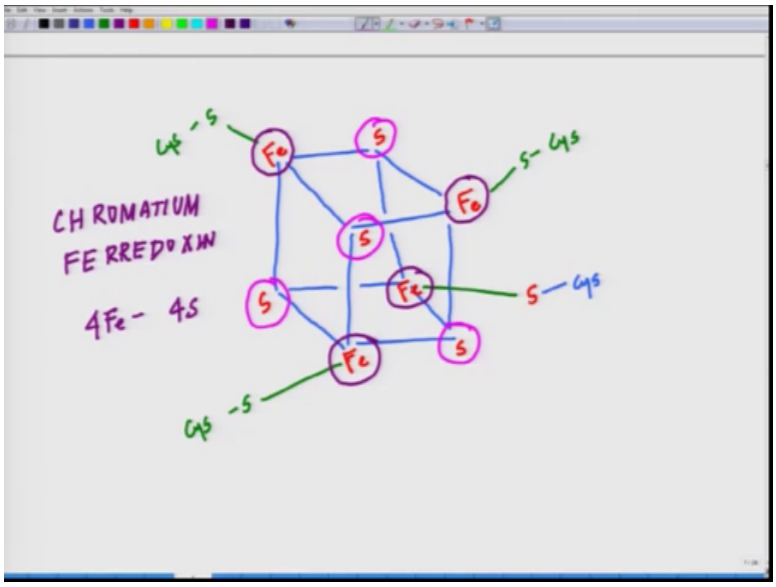

And these are some of those examples which are kind of highlighting the fact, possibly we have evolved in that iron sulfur world. So, here you have the iron, the sulphur, you have the iron, you have the sulphur, you have iron out the base, you have another sulfur out here, you have a iron out here, it was sulfur out here. And then from here popping out sulfur with with cysteine is a bond and out here, with this iron there is a sulfur connected to cystenie. Similarly with this iron there is a sulfur connected to cysteine, and similarly with this iron there is a sulfur connected to cysteine. This is the classic case of chromatium ferredoxin, chromatium ferredoxin, and this is essentially 4 F e 4 S. So, 4 F e you have iron 1 2 3 4, and 4 F e, 4 sulfur 1 2 3 4 in the core.

So what I wanted to highlight here is, much of these electron transport proteins are iron sulfur clusters. So, now, going back. So, this is the modern day what you observe. I have given you the three examples rubredoxin where you have one iron at the center, and you have these surrounded by sulphurs. Similarly a second example where you have one iron here, one iron here, and you have the sulfurs fiddling around here, 1 2 3 4 5 6. So, coming back where I was talking about this self assembly of inorganic, self assembly of iron sulfur clusters; so, this was believed that is where the iron sulfur theory by Gunther Wacterhauser. If we see the iron sulfur world theory basically says that these iron pyrite may have some way or other have self assembled, and on this self assembly on this matrix or this self assembly may have been in the primitive Pisa, may have been the first confined cellular structure, or first confined self assembly to form a membrane. This is possibly the first ever membrane, or scaffold on which things got synthesized.

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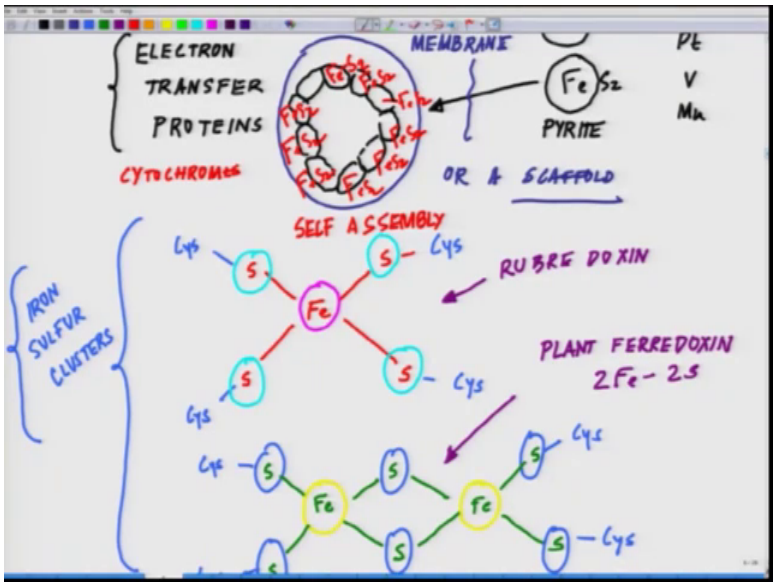

So, the next jump into the game is, if we considered these as iron sulfur moieties which are forming this confined structure. I am not showing you the bonding and everything, just kind of you know. So, this kind of clustering or self assembly which leads to this kind of confined structure, possibly acted as a template.

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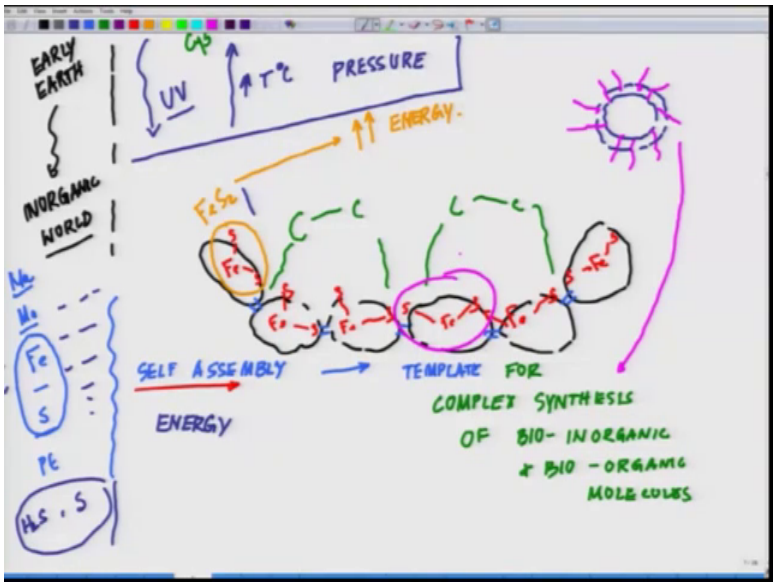

So, say for example, I consider these as the iron sulfur clusters which are forming in a structure like this, which is a 3 dimensional structure. So, these possibly have acted as a template.

So, the first step was for forming a membrane like structure was, or a confined cellular structure or any kind of confinement was self assembly. And will come to that what is the significance of these self assemblies. This self assembly of; in this situation, we are talking about iron, sulphur, platinum and molybdenum, manganese and a series of them. So, mostly we are confined with the iron and the sulfur. These kind of self assemblies acted as self assembly acted as a template, what does that mean is. On these templates the carbon molecules may have form complex structure. Or in other word, these acted as a template for complex synthesis of bio inorganic and bio organic molecules. How exactly this has happened. There is a very tricky question, but what we knew is. These molecules, if we considered molecules like F e S 2. These molecules upon broking breaking down could generate a significant amount of energy. A energy which is extremely useful to synthesize molecules.

So, in other words, though I have to realize there are few concepts which are emerging. So, first we talked about an inorganic world where the very early phases of earth, early earth, and this is where the earth was cooling down, and it was water all over the place and that is where possibly some where other, the self assembly of some of these iron

sulfur compounds happened. Of course, this was rich in compounds like H 2 S sulfur and so on and so forth. And possibly for this self assembly, one needed some form of energy input which the earth has in abundance, because of U V, high temperature, pressure whatever you call it. It is one heck of a turbulent system where this kind of synthesis possibly have happened.

So, these kind of self assembly of iron sulfur compounds led to believe, led to the first confine structure in terms of something on which, which has self assemble like this, on which the templates were developed to synthesize much more complex molecules, this. While talking about this, one has to realize these are all our speculations. The reason to believe this kind of aspect is, because the remnant of this could be seen, these kind of iron sulfur complexes could be seen in almost all the electron transfer proteins, and all the electron transfer proteins are present on the membranes.

So, if we talk about mitochondria, we talk about chloroplasts, we could talk about even cellular membrane, the whole cell membrane. They all are rich in iron, sulphur, electron transfer protein; like cytochromes, ferredoxin, rubredoxin likewise. So, that is why this theory of Gunther Wacterhauser of iron sulfur world theory, it still holds the fort. Of course, there are people who do not accept it, but of course, they will be always in speculations, and they are will be always can conflicting ideas, because none of us can really go back in time to figure out what happened, but for us, it is essential to understand this. The genesis of these electron transfer proteins could be as old as the evolution of the cell itself. So, I will close in here. In the next class will take up from there and see what are the different ways cell has evolved, and what are the basic thermo dynamical parameter what we have to take into account.

Thank you.