Bio-energetics of Life Processes
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Lecture – 07
Biological order and energy – II

Welcome back to the 7th lecture or the second lecture of the second week you just put it down.

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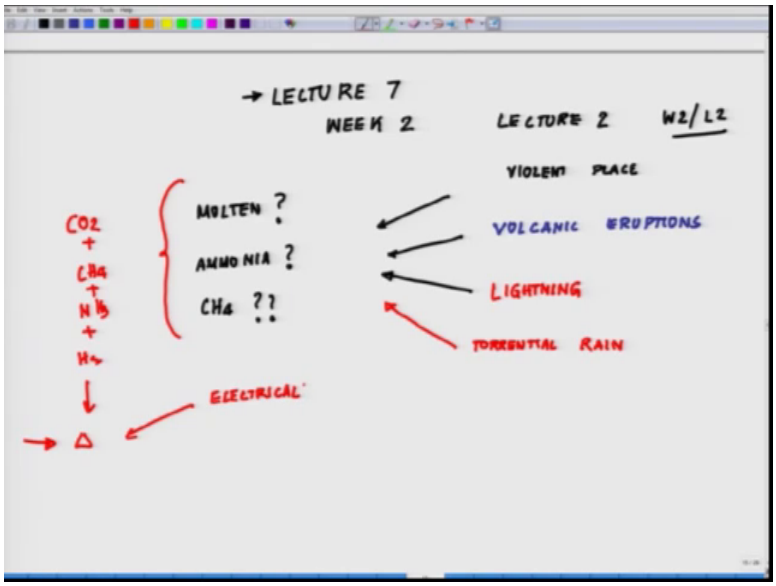

Lecture 7th or week 2 lecture 2: W 2 l 2 which is in summary the 7 lecture.

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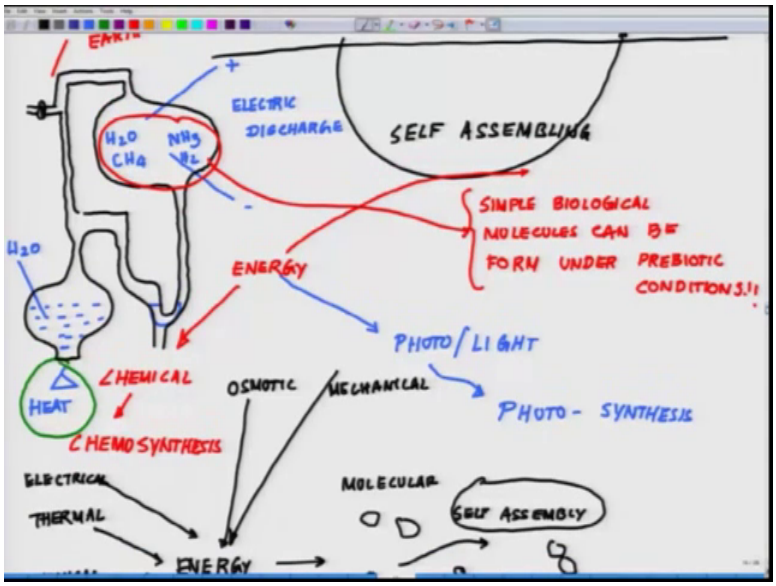

So, if you remember in the last lecture we talked about the primitive Earth. This is where we claim that the simple biological molecule can be formed under the prebiotic conditions. The condition that existed on Earth in it is first billion years are still a matter of dispute. Was the Earth initially molten? We really do not know.

So, these are some of the questions which are unanswered did the atmosphere contain ammonia. We are uncertain how these first set of molecules were formed did the environment contain methane we do not know, but everyone seems to agree; however, that the Earth was a violent place with what we had in terms of the energy we know, whether these molecule existed or not we are not sure we know it was a very violent place.

Because the reason why we mentioned this is if you see we have kept all these molecules here what it is of course, you know have operating and going here, but these molecules we added, but we do not know fundamentally how these molecules even where there or not because there are questions that whether these molecules are there or not. So, that is why this question continuously comes as a critique to (Refer Time: 02:24) stuff.

So, but everybody agrees that there are volcanic eruptions, there are lightning, violent places, volcanic eruptions, there was lightning and all sorts of their torrential rains it is a different kind of world. This is how the most primitive Earth was, simple organic molecules that is molecules containing carbon are likely to have been introduced under

those conditions. So, it is believed again this is all belief the best evidence for this comes from laboratory experiment if a mixture of as we have mentioned a mixture of CO 2 plus CH 4 methane NH 3 ammonia plus hydrogen are heated.

So, this is where the energetics comes into play with water and energized with electrical energy remember, i mention or i enumerated all the different forms of energies which are available.

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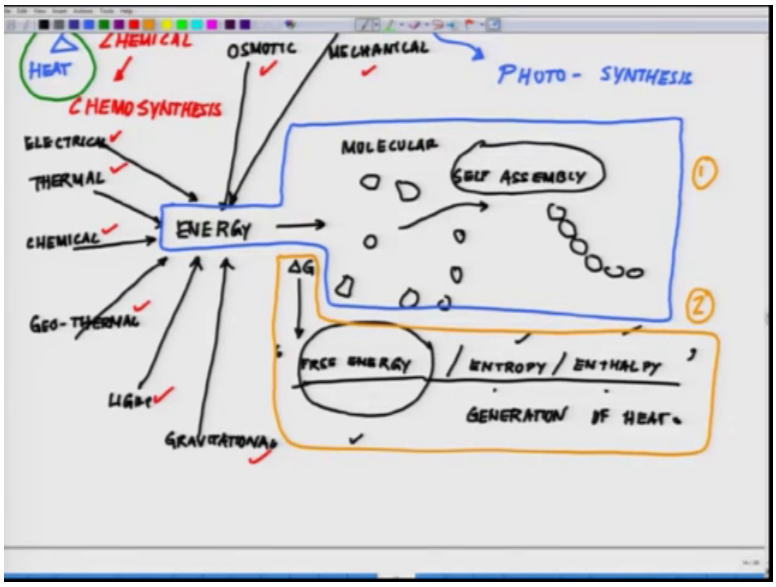

Mechanical, osmotic, electrical, thermal, chemical, geothermal, light, gravitational so on and so forth. So, if you provide all these different kind of energies and or the ultraviolet rays of course, you can use.

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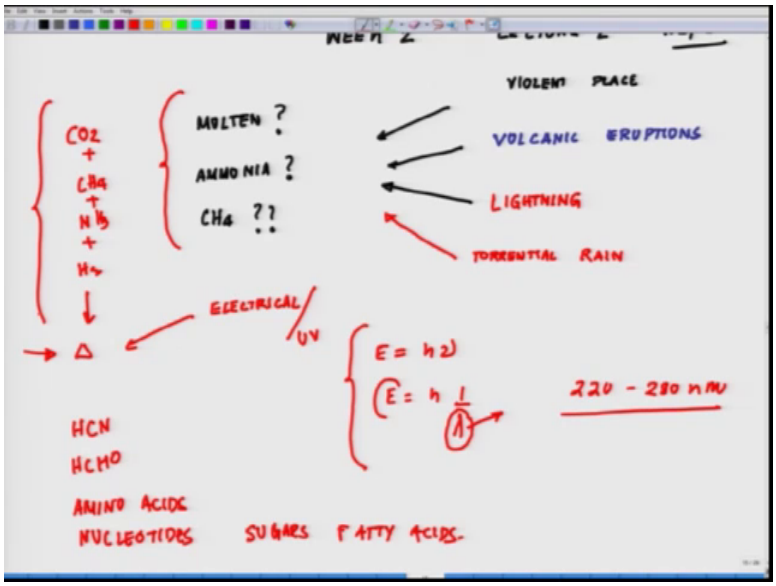

UV is also UV is a high energy. If you remember E is equal to h nu, where if you go by the wavelength of it. So, basically E is equal to h 1 upon lambda. This lambda the higher the lower the lambda is higher is the energy value and UV is around 222 you know 280 nanometre. If you remember that hardy wheeze and the soft wheeze they may be the numbers maybe slightly left or right, but this is where it ranges.

So, UV has extremely high energy. So, if you provide all these different kind of energies this is capable of making some of the very early biological molecule among these products or number of compounds like hydrogen cyanide HCN, formaldehyde HCHO and it is possible that they may lead to formation of amino acids, nucleotides, sugars, fatty acids.

So, this is the other way of looking through Urey miller eyes that this is possibly may have happened, but for us barring aside living aside all this controversies how life probably have evolved. What is important for us to appreciate and understand is that it really does not matter to get into that controversies, but what is important for us is to realize that the key point what we wanted to highlight here is this drawing, that get me this part of the story. A molecular self-assembly govern or carried out by energy and in that process the second aspect what we have to be careful is this part.

The thermodynamics rules which are governing it and the key a word which is essential if this is one concept which i want it you to people to understand, this is what we will be

dealing time and again and the philosophy what we are going to talk or what will be our central theme of the course all throughout will be this.

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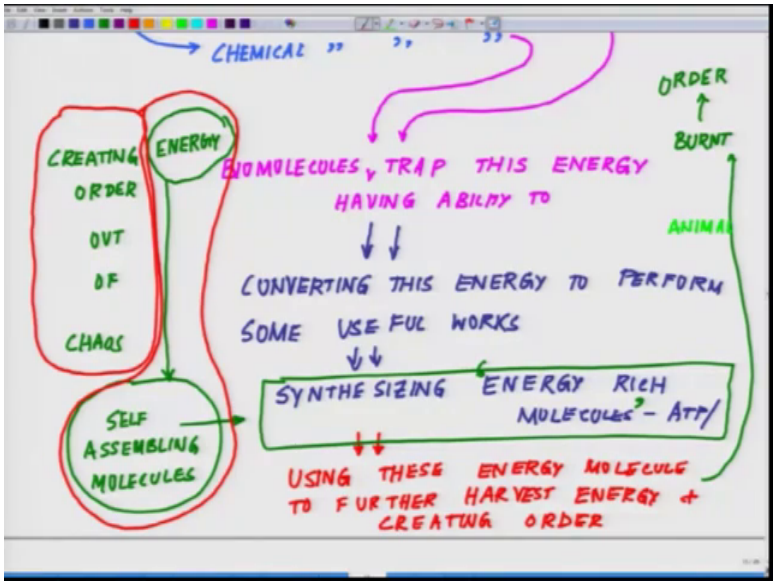

Creating order out of chaos or in other energy self-assembling the molecules. So, we will keep our eyes exclusively on this instead of getting into the controversies which are which will exist because none of us can go back in time, to figure out what possibly have happened, but we without any doubt can appreciate how thermodynamical parameters have lead to evolution of different kind of molecules.

Now, from here I will just go a little bit off now in highlighting some of the very early species or in the evolutionary cascade and the species from the bacteria to the higher organism, where they stand the family relations between the present day bacteria and what all role they have played because the reason why i am highlighting this is the chemosynthesis, remain a 40 or very old bacteria like Archie bacteria and all those sulphur reducing bacteria and all those are the ones, which are really good at it and some of those chemosynthesis organisms now can be seen under the sea under the deep down into the ocean floor that is where we can see them.

So, let us draw a evolutionary chart for your knowledge, that how things are evolved over a period of time from where chemical synthesis to photosynthesis which is done by chloroplast and chemical synthesis which is done by very, very old primitive bacteria

which are most of them are extinct or may be seen in very rarest of rarest places on the floor of Earth or somewhere deep inside the Earth.

So, let us put a flowchart of those different kind of microbes. To start off with the ancestor so as a biologist most of you are aware of there are 2 forms of cells eukaryotic cell prokaryotic cell. So, eukaryotics are the ones what we are carrying and prokaryotics are the ones which bacteria carries. So, prokaryotes are the ones where so for those so.

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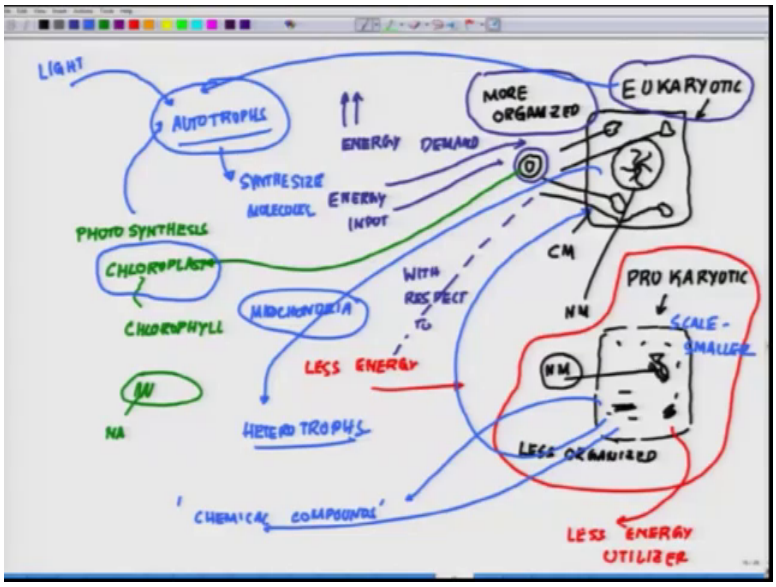

A simply as drawing is something like this. This is a eukaryotic cell with a well-defined nucleus DNA and the different organelles very, very well-defined structure all over the place. This is your e eu kary otic and then comes pro kary otic. So, very simple they indeed have a not as well-developed membrane, but they do not have anything called a nuclear membrane. So, this is cell membrane CM, this is nuclear membrane these are the different kind of organelles i am just putting it is o.

So, where is if you see the prokaryotes. So, here you have nuclear material NM you have the, they do not have any well-defined organelle all the chemicals are scattered around. So, this is prokaryote is much less organized. So, this is a less organized. So now, why I use the word less organized and more organized, there is a reason why i use the word. I very purposefully picked up this word. The reason being whenever we talk about organization, organizational skill or organized what you know in our colloquial terms we

always say look such organized city or such organized group of people such organized industrial setting.

So, when you talk about organized; that means, you have to invest a lot of energy in ensuring organize the structure, otherwise if there is a chaos and you keep something here and on things are moving around you really do not have to spend a lot of energy. So, if you keep this analogy in mind then you realize in order to have a more and more organized structure you have to invest a lot more energy as compared to say. In other word if you go back what i am trying to tell you that self-assembly of molecules or atoms to form organized structure by investing energy.

So, the more the organization of it will be, the more energy it will be needing. The more will be it is energy expenditure and most likelihood those have evolved later, as compared to the prokaryotes if i go by the energetics rule in order to organize a prokaryote if i am just putting. In order to organize the prokaryote, you need less energy and the energy consumption of it is energy utilization of it is less energy utilizer. As compared to of course, with respect to with respect to the eukaryote.

So, eukaryote on the other hand if you have to have such a more organized structure you have to have very high energy demand and very high energy input. So, you see how a structure 2 different structures a prokaryote and a eukaryote can lead you to think from a very energetic perspective and as we will move we will realize that much of these structures of eukaryote have hired special organelles to perform this energy activity and what of the thing, what now when we talk about this o i said i am talking about the organelle i will just take little floating into that aspect which attract me a lot is possibly, most of these eukaryotes in case of say photosynthesis if we talk about it is being done by chloroplasts right having the pigment of chlorophyll.

Now, chloroplast as an organelle has been believed to have been parasitized into the eukaryote because the chloroplast has it has a nucleic acid in it. So, in other word a chloroplast essentially (Refer Time: 15:14) have been a prokaryote which parasitized on this cell and becomes part of it. And by the way one more thing since i drew it the scale wise these are far more smaller. So, as a matter fact you can explain it in a way in order to maintain a higher organized structure of eukaryote, it probably have hired a prokaryote. A prokaryote called chloroplast, a prokaryote called mitochondria which

became part of this eukaryotic cell and like a powerhouse, like energy harvester, like our solar panels cell has this prokaryotes into it.

So, what is important for us to realize whenever in the textbook we write this is eukaryotic this is prokaryotic, i always used to wonder. You know then when i studied about this and i am thought that is this classification. So, very correct instead if we put it from the energetic space factor we can say you know there are some word like this, there are some who have taken over some of the prokaryotes into them and became autotrophs. So, those who are having this eukaryote with this chloroplast they became autotrophs. Who can synthesize we can harvest light and synthesize molecules of or energy rich molecules.

Whereas some never became never got parasitized by those prokaryotes and they remain heterotrophs. They depend on the autotrophs to harvest the energy and then they consume that some form or other to you know harvest it is own energy and then comes your prokaryotes. So, this fundamental concept i wanted to highlight for you people to realize to appreciate that, in this whole system there are different ways you can look at this whole thing and most of these prokaryote very early prokaryotes if we talk about they have harvested energy by or from chemical compounds.

So, this is one interesting concept which i wish to imbibe in you people to think slightly differently about these prokaryotes, eukaryotes and the role of chloroplast. Which is essentially possibly was a prokaryote at some point or other and got parasitized into eukaryote to make what we call as the autotrophs and similarly mitochondria which also has a nucleic acid in it or a genome into it, which remain within the eukaryote as ATP molecule synthesizer, but it does not have the ability to harvest solar energy.

So, I will close in here in the next class we will go into the classification of those prokaryotes and we will move further from there.

Thank you.