Bio-energetics of Life Processes

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Lecture – 08
Biological order and energy – III

Welcome back to the lecture series in bioenergetics. So, today is our 8th lecture, so or the third lecture of the second week.

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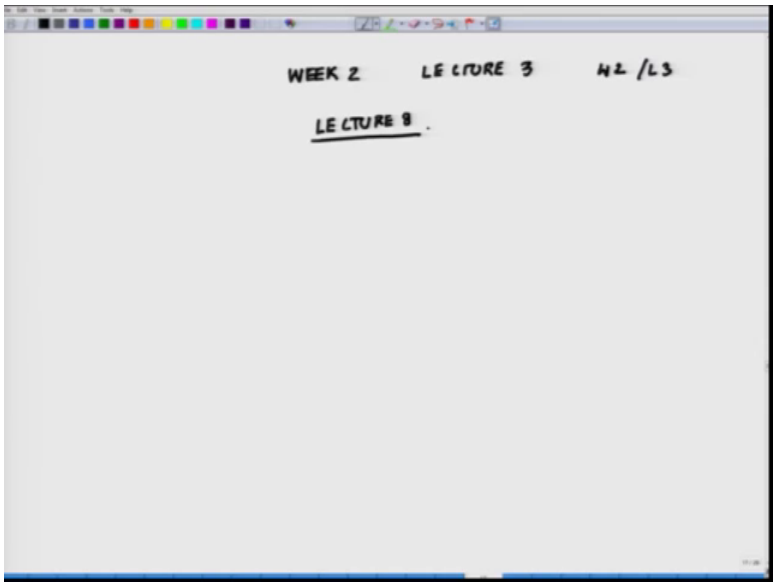

Week 2, lecture 3, W2 L3 and this is our summary sheet wise this is our lecture 8.

So, in the last class if you remember.

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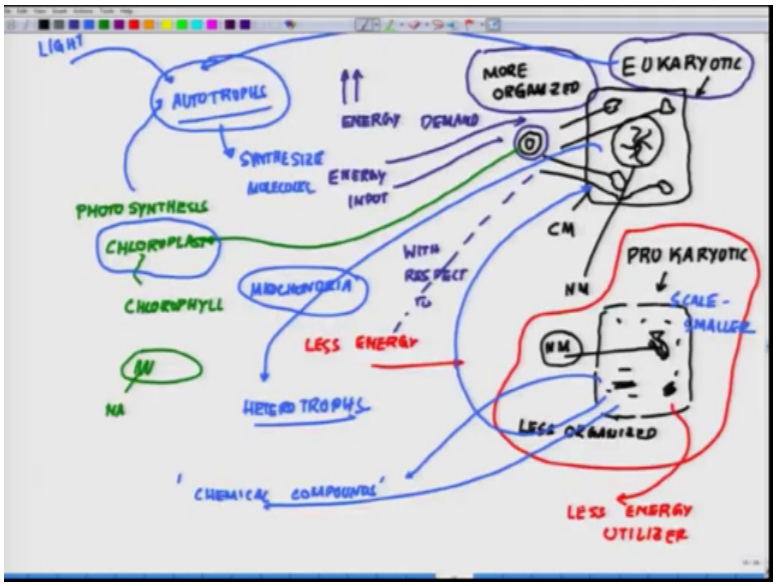

We talked about the concept of the prokaryotes and the eukaryotes and how. We introduce the simple concept that cells and their organizational assemblies, could be defined in terms of their energetics in terms of their energy requirements, and how come some of the cells are capable of harvesting energy whereas, the others are not. So now as a follow up we will talk about the classification of some of the ancestral prokaryotes.

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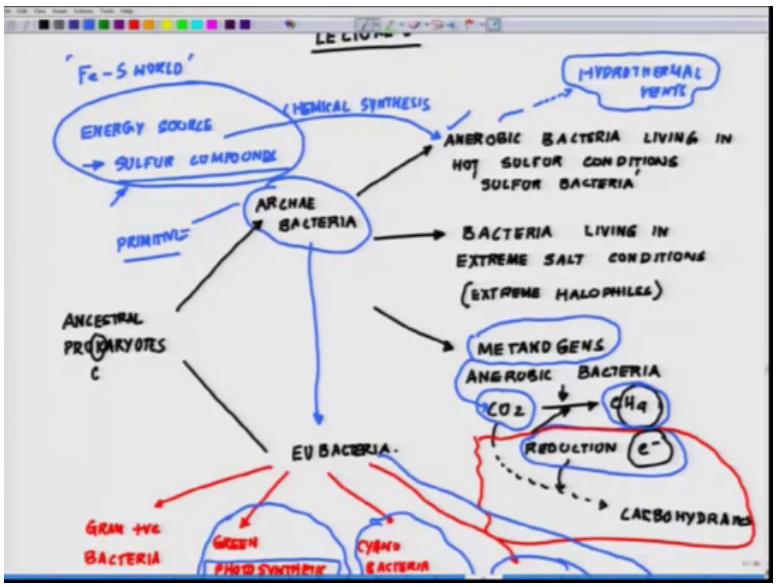

Which in the chemical synthesis or chemo synthesis, will help you to understand. So, ancestral prokaryotes so, there are different people some right it is a not k or as c. So, do

not get confused. So, ancestral prokaryotes could be classified into 2 groups one group is the archae bacteria. Archae bacteria which is a prokaryotes, and then you have eu bacteria.

Now, archae bacteria could be classified into 3 different groups. First is anaerobic bacteria living in the hot acid conditions, or sulphur bacteria essentially anaerobic bacteria living in hot sulphur conditions, if you remember in the first week I have mentioned about some of these, and these are those bacteria which are source for sulphur bacteria. So, these are source for some extraordinarily stable DNA molecules, and lot of these polymerizes are tack polymerases, and all these things are isolated from these kind of bacteria, which could withstand high temperature, and are very powerful tool for all sorts of molecular biology activities. So, that also brings us to a very interesting aspect, what I kind of missed out to highlight is, life could evolve we always say life evolved.

Like you know life survives better within say 47, 48 or 50 degree centigrade. But apparently it looks like that as more and more our understanding is kind of getting into play, we are realizing that life can evolve under very harsh and harshest of the harshest conditions. So, it is not that life always needs a very optimal temperature, because whenever I kind of read about this, anaerobic bacteria living in the hot sulphur springs, and all that always strikes me that you know they can even live at a higher temperature.

So, it means stability of biological molecules is not really that optimal temperature it can survive at a much, much higher temperature, provided we know we understand how these biological molecules are designed to survive the temperature. This just a thought what I wanted to highlight that because under the hot situation, you always have a very powerful energy in terms of thermal energy, and biology has learned to utilize this kind of thermal energy, of course here we are not talking about the thermal synthesis, we are mostly talking about the chemical synthesis and light dependent synthesis which is a photosynthesis, but there could be something like a thermal synthesis essentially. Where you are utilizing the heat energy to you know develop compounds. So, this was the first one in that list of anaerobic bacteria.

The second one is the bacteria living in extreme salt conditions, because why this is very important explain you, these are called extreme halophiles, the reason being under such situation the osmotic pressure is very, very high because your solute concentration is

amazingly high. So, you have to utilize lot of energy to you know balance out that kind of osmotic pressure, otherwise suppose I put something in a very high salt concentration it is going to collapse, in order for it not to collapse because osmotic pressure will be. So, high because solute is going to put a lot of pressure onto the membrane.

In order for these bacteria not to collapse, it needed to develop some mechanism. So, it again seems like as I was telling about thermophiles, it again seems like nature can develop molecules by utilizing the energy available, under any harshest of the harshest conditions. It is just we are yet to understand where is the limits of nature.

What we say is the most optimal condition does not seems like, the more we are understanding about this prokaryote it looks like, that the story is much, much more in depth and much, much more complicated, than what we believe as the most optimal conditions, like 2 examples I cited hot water springs sited body, extreme holophiles, where we have lot of energies available in terms of osmotic pressure, osmotic forces, thermal forces, and you know they survive.

So, the third in that line what I wanted to highlight is the anaerobic bacteria that reduce c o 2 to methane that metanogens. They are also called metanogens or the anaerobic bacteria converting c o 2 to methane. So, in other word if you look at this reaction what is happening is that, there is some form of reduction which is happening, there is an addition of an reduction essentially means, you are needing electron.

Now you try to correlate when I was taking we have to talk about lot of these free energy changes and everything and so, you need in this whole process, a way to supply electrons most of these reactions if we talk about c o 2 making carbohydrates, c o 2 to say just for your understanding sake do not take that this bacteria can do that say if I talk about carbohydrates. So, I am taking the liberty to introduce something here. So, this means this is the reduction reaction c 6 h 6 right carbohydrate the first glucose molecule.

So, then; that means, c c of course, there are o h groups and all these things are attached. So, what I wanted to say, the carbohydrate itself is a reduction reaction process, and for the reduction to happen you needed a infinite source of electron keep this in mind, because this will come very handy this energetics is driven by the search of infinite source of electrons, keep this fundamental concept in mind this will come very, very useful. So, I just took this liberty to you know, just move out and do not mix it up with

this is totally on a different concept, it is and I will come later on to that. So, these are the 3 archae bacteria we talked about.

And what about the eu bacteria, about the eu bacteria there are gram positive bacteria, these are mostly the all the modern day the family relationship between present day bacteria indicating the probable path of evolution, and the origin of prokaryotic cell what we are talking about.

So, we have gram positive bacteria, we have green photosynthetic bacteria, anaerobic green. So now you see how we are evolving green photosynthetic, bacteria and this is an anaerobic one. So, it means this is not evolving oxygen, then you have cyano bacteria which is blue green algae, you have purple for the synthetic bacteria.

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Purple photosynthetic bacteria then you have spirochetes. So, here comes the first of what we talking about photosynthetic systems, and that to in an anaerobic world. So, it means what are those compounds, which help it to synthesize or do of photosynthesis. Then comes cyano bacteria or blue green algae, then comes photosynthetic purple photosynthetic bacteria.

So, if you look at the evolution here very carefully, you have anaerobic bacteria which is surviving in hot spring, possibly using as a energy source, must be some form of sulphur compounds, energy rich sulphur compounds may be the sources, then you have evolving

through you are having methanogens, which are using simple compounds like carbon dioxide, to make reduced it to methane and maybe further.

So, this is possibly, possibly they are doing some form of chemical synthesis, and such situations such could be further extrapolated to hydrothermal vents, we will go back to this soon about the hydrothermal vents, and the story of it. But then as we move to the eu bacteria. So, essentially this is how the evolution has happened with respect to time these are the primitive oldest, and as they move you started seeing light dependent synthesis photo.

So, what I wanted to highlight is, light dependent synthesis or photosynthesis aspects, came much later possibly as compared to the thermal or chemical synthesis. So, that brings us to a very interesting world of, why there is so much interest in understanding life form in geysers, hot water springs, in places like deep sea hydrothermal vents, these are extreme situations.

And these are situations where there is no light. So, if life has to evolve life is totally dependent on the physical in terms of physical energy, it is the heat energy and some of those energy sources, are some of those sulphur rich compounds. And this is what brings us to that iron sulphur world. So, there was one question which was asked, that what are the other theories as a matter of fact there is not very many theories there actually there is none, if you say which is kind of to critique because most of the biology starts so, the way the most of the biology starts is here, if we go back and to the urey miller experiment this is where.

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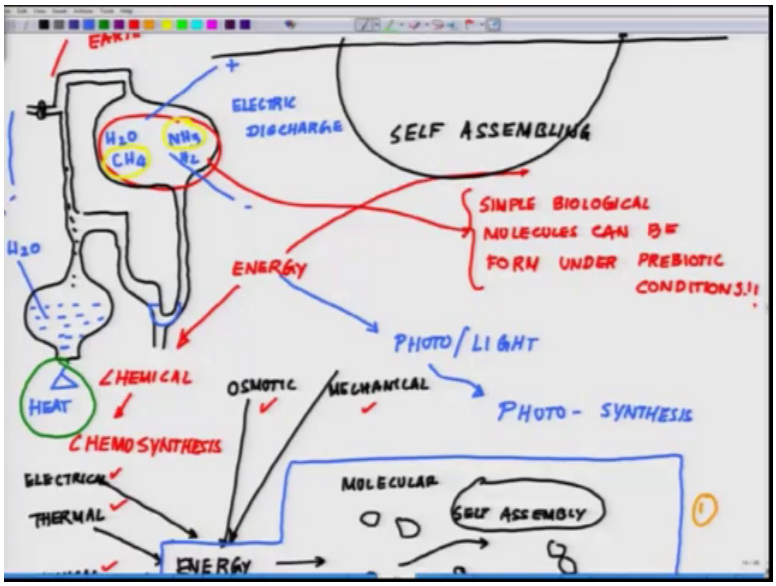

So, most of the biology it is believed after this. So, some of those very interesting molecules are formed because, after the urey miller like in a kind of urey miller, where urey miller try to emulate the primitive earth, they say the nucleotides were formed the nucleotide becomes self-assemble, and then some way or that the cell membrane was formed, and then this nucleotide went inside the cell membrane, and it is kind of a assumption itself is that the cell form much later and it is kind of a bit chaotic out there, it is not that I am critiquing it is just does not make real sense.

So, there is nothing before this in biology. So, biology starts with and soon after this if you follow any textbook, they will say urey miller experiment and then their formation of nucleotides, then the self-assembly of nucleotide, a nucleotide can give birth to another nucleotide, replication what you learn in biology replication of nucleotides, and replication your tie nucleotide followed by encapsulation of the nucleotide, inside a confined structure. But that is where the biology starts. So, this is one of the question which my t a asked me that, you know someone has asked this question, what are the other theories. So, here for that individual.

Prior to this prior to uerey miller if somebody says. So, the only other critic able theory I say because there are lot of critiques to that theory is the iron sulphur world, why because the reason being, now I have another point to highlight is now coming back to today's class, what we are talking about this these kind of bacteria, which are surviving

in places possibly in places like hydrothermal vent, but definitely they survive in geysers in hot water springs, and several places. In India if you go there are lot of hot water springs if you go to himachalane Pradesh, there are several places of water spring there is hot water spring, close to Delhi they are hot water spring, down south there are so many places.

So, if you go to these hot water springs, keep this in mind they are all bubbling with life, and something which where we cannot survive we are not you know capable of surviving there, but yet life does survive, there is lot of heat energy there is lot of sulphur rich compounds, and this is where the iron sulphur world comes very critical. So, for that individual who asked this question.

So, this is possibly the most accepted theory, currently that a most critique theory, that possibly the first cell must have formed through iron sulphur clusters. So, coming back where I was I just took a detour. So, this is where the, chemical and light dependent synthesis starts, it is journey maybe in those molecules then those very, very primitive organelles which have evolved billions of years ago.

So, I will close this class here and in the next class we will talk about some of the thermo dynamical parameter and order within the cell.

Thanks.