Bio-energetics of Life Processes
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Lecture - 02
Bioenergetics: Origin of life

Welcome back to the lecture series on bioenergetics of life processes. So, today is our second lecture. So, in the first lecture if you recollect we talked briefly about the different sources of energy the sun or the stars like sun for earth of course, sun is the nearest the star and which is the perreneal source of our energy till the sun cools down similarly we talked about chemical sources of energy or chemosynthesis and we briefly outlined the 4 weeks what will be dealing and this these are the important point. So, week one we are dealing with bioenergetics and.

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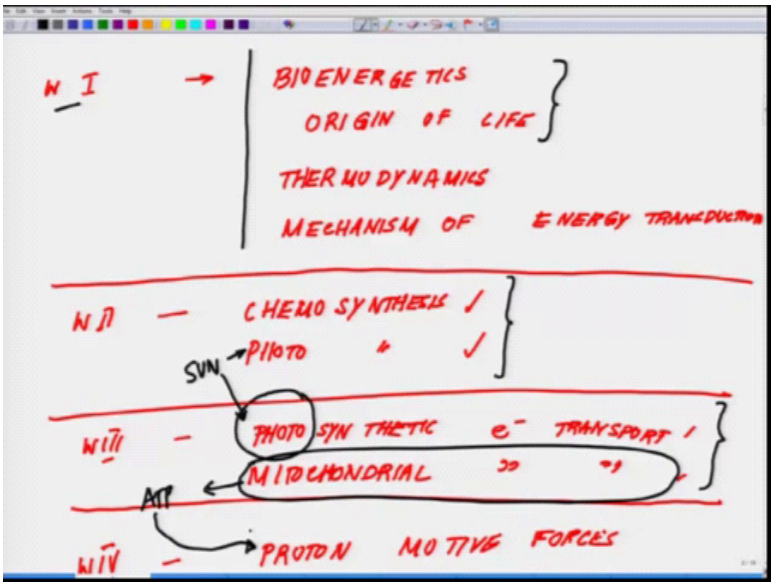

Origin of life along with partly along with the thermodynamics and mechanism of energy transduction; so, this is what will be dealing for next 4 classes then the week 2 we will talk a little bit in detail about chemosynthesis and photosynthesis and exactly how these things are kind of throwing light to our understanding of the core energy transformation processes which were happening on the floor of earth or underneath the sea bed or the ocean bed which is governing

much of our ecosystems at different conditions starting from extreme ecosystems to you know normal ecosystems on the floor of earth.

Next we will go for the electron transport what we talked about in the photosynthetic electron transport on another word the one which is driven by sun similarly that electron transport how that helps the mitochondria to synthesize molecules like ATP and which will take out to the most fundamental thing which is essentially your ATP synthesis or glucose synth synthesis. So, to start off with today is our second class.

So, bioenergetics and the origin of life this is where we are startings.

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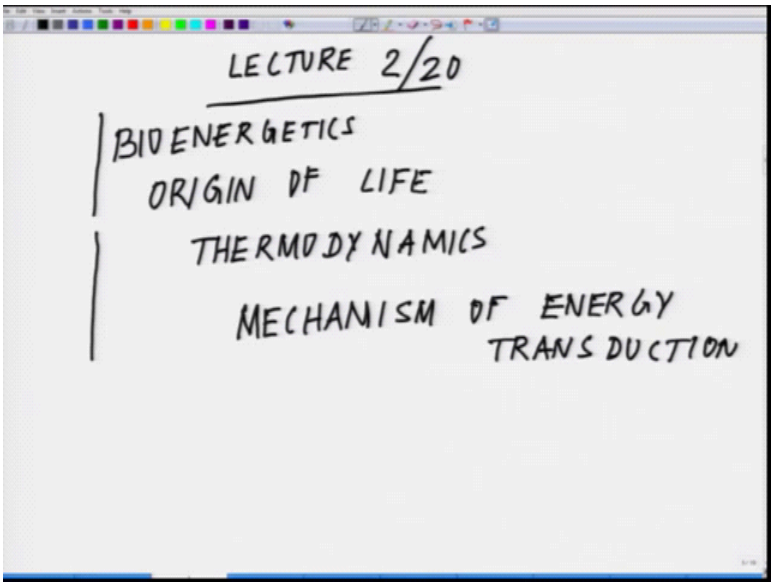

So, we are into lecture 2 of 20 bioenergetics and origin of life. So, and the next will be following the thermodynamics in that line thermodynamics and that will be followed by it is a 4 point we will be dealing with the mechanics of energy transduction yes mechanism of energy transduction. So, when you talk about origin of life. So, probably one of the most challenging question for philosophers for biologists for natural scientist for all of us irrespective of which domain of knowledge we are pursuing this question is haunted as how we arrived in this form currently and is that the final frontier or are you going to keep on evolving. So, we really do not know the future where we are heading and we do not know the past from where we have come

we know the present and standing at the present we make some I would say within human limits of rationality some rational guesses they may be wrong they may be right, but since we cannot travel back in time and we cannot travel in future as of now we do not have a time machine.

So, the our only machine what we have is our brain and we have this earth as our experimental lab where we do some experiments which tries to mimic an earth which as per the guests of the geologists is some billions of years old. So, probably life has evolved as they say some 4 5 billion years ago some form of how was the earth at that time now think of it we cannot even think properly how was the earth hundred years back we do not have that many data.

Set on based on that currently I see you know the ice caps are melting and they are pollution problem there are this issue that issue sometime wonder that well these are just hundred years in a span of billions of years where only truth which has happen is the change is the only thing which remained permanent all throughout these processes how really we can make some bold remarks which I see all over the media time and again, but well keep that aside if we think of a earth or at least we try to think of a earth, which is some billions years old how was the earth.

So, when we have to talk about the origin of life we have to pinpoint some of those critical events what mankind believes are critically may prevent those who have done some degree of research believes that possibly these were the events which govern who we are today.

So, today if we look at today where we live. So, this is our story we live in an environment. So,

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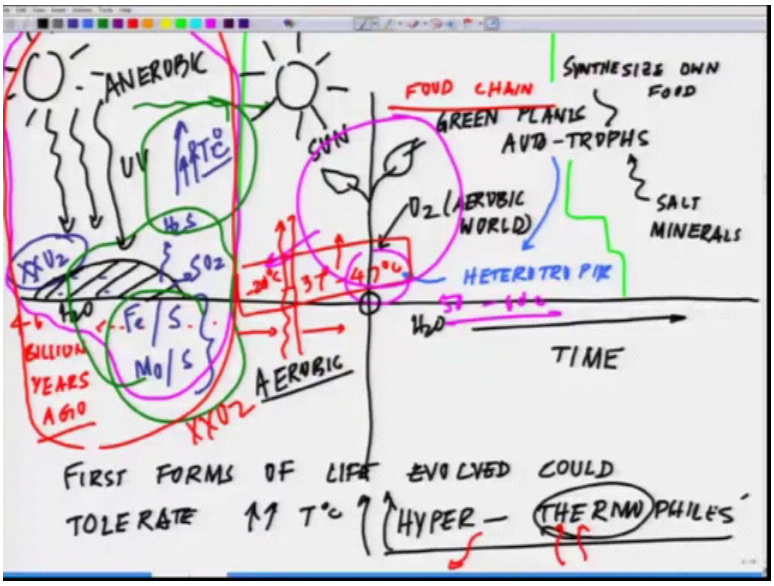

This is time present. So, this is the arrow of time moving forward and this is where we are standing at this point this environment is rich in oxygen. So, we live in aerobic world and our major energy source is sun we have green plants as auto trophs or in other word they can synthesize their own food using sun synthesize own food using solar radiation and salt and minerals that they are deriving from the roots.

Then we have next class of species what we are heterotrophs we consume them and further this cycle goes on as we term famously the food chain now the question is what was it if we pull the time arrow back to say you know 4 to 6 billion years ago how was it was it like this on all likelihood origin of life was not that beautiful or not what you see today the earth as is being predicted 4 billion were years ago this sun was way more intense radiations on earth there was no UV protection there was no UV cover there was a lot of water of course, which is.

Now, also it is there and the whole earth mass was filled with different kind of current day what we call most of those hazardous gases like H 2 S sulphur dioxide and there are several transition metal like you know sulphides and there was no oxygen this was probably the earth which was in a very high temperature degree centigrade very very high as compared to the current day where we kind of live around you know 37 to 47 degree to you know some places like minus 20 degree this is the range where we are living minus 20 to minus 40 now there are places where at particular time of the year the temperature really falls down and at particular time of the year the

places that temperature shoots up to say 47 to 48, but 4 billion years ago the earth was a different ball game altogether and it has travelled like this.

Now the question is under those conditions if these conditions had to be emulated how possibly life has evolved was all these things were it possibly does not look like they were there why because that is where it comes your rational guess because most of this plant would not be able to survive a certain temperature beyond say you know 50 or 60 degree would not be able to survive similarly they would not be able to survive a very low temperature too. So, they survive within an optimal temperature range. So, Now, the thing is that if the ambience. So, either there are 2 possibilities the first form of life which evolved could tolerate high temperature possibilities are there.

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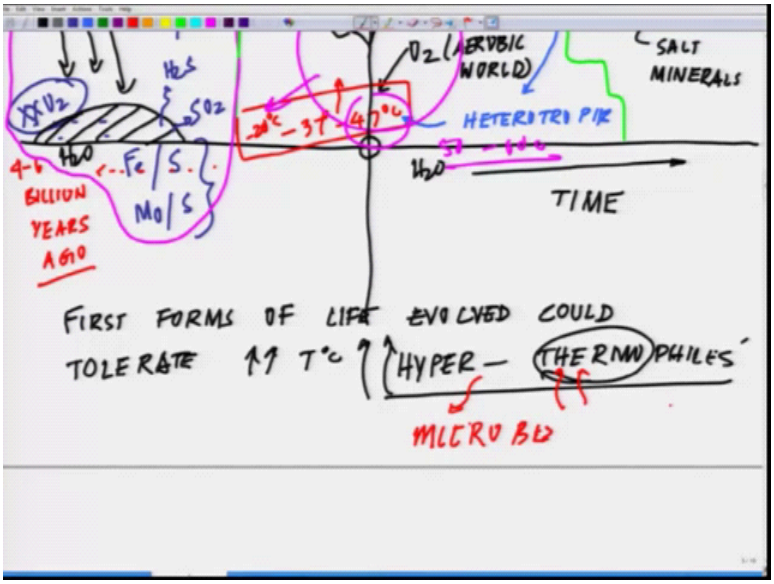

So, if we put that first forms of life evolved could tolerate very high temperature interestingly if we write this line that brings us to a very interesting paradigm that essentially means these were some kind of hyper thermo philes something hyper means higher very high thermo means temperature. So, something which can tolerate high temperature and having said this think of it there are such microbes which are hyper thermophiles and these microbes could be found it is not that they are extinct could.

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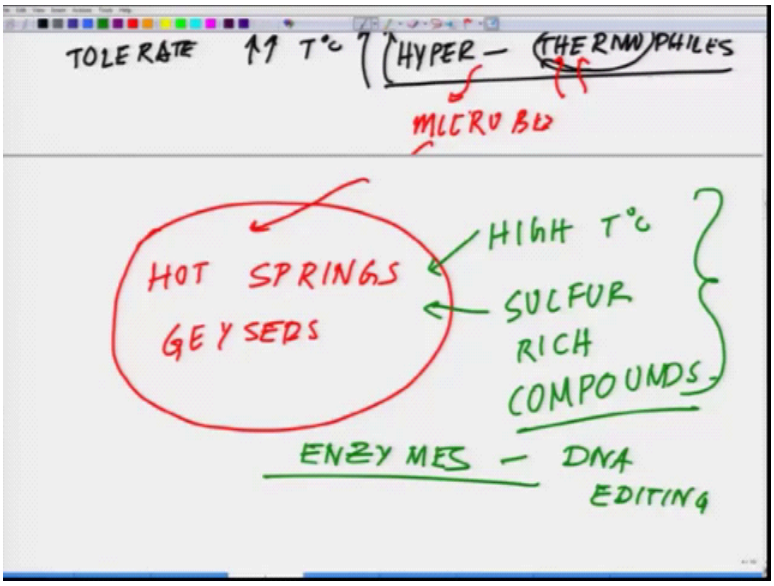

Be found in extreme environment on earth like you know hot springs geysers or deep inside the earth crust. So, essentially if you see these environment these are the environment what we are talking about something like this something like this in other word is still we have such situation where you have high temperature you have sulfur rich compounds and that is where life survives and when I said that we a make rational guesses based on experimentation based on observations that is how the origin of life story rolls we make guesses possibly how that may have happened and that is all based on within the framework of human rationality.

So, possibly that is where we lay the foundation stone that these hot springs or geysers are the source where life probably where have originated and as a matter of fact those of you do molecular biology must have seen that there a lot of research goes on these microbe because they can withstand such temperature and for all kind of DNA manipulation most of the enzymes which functions.

So, these are those enzymes which functions at those high temperature those enzymes which are related to you know DNA editing some more other extremely helpful as a matter of fact the whole field of molecular biology relies on those kind of exotic organisms their genome which helps to synthesize those kind of enzymes or proteins which can withstand very high temperature these kind of harsh conditions their mechanisms which they have developed , but even before

that if we look at it. So, this is were talking about where the organisms are formed Now, in this soup the first question comes if we talk about earth like this the first very first question.

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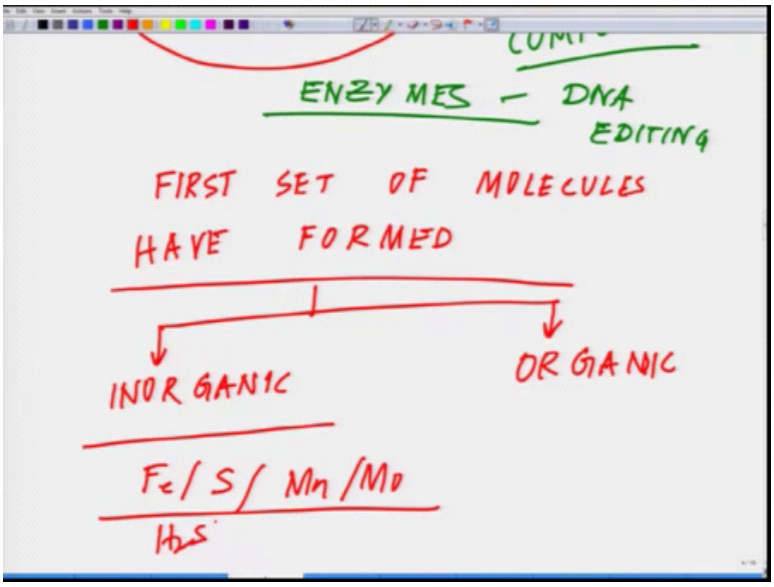

Comes is how the first set of molecules have formed and what were those molecules where the 2 questions which comes where they inorganic in nature or they were organic in nature because if you look at the earth some billions of years ago there were hardly any chance that they are organic molecules most of them would have been some form of inorganic compounds like you know most of those were iron, sulfur, manganese molybdenum these kind of things and lot of hydrogen sulfide.

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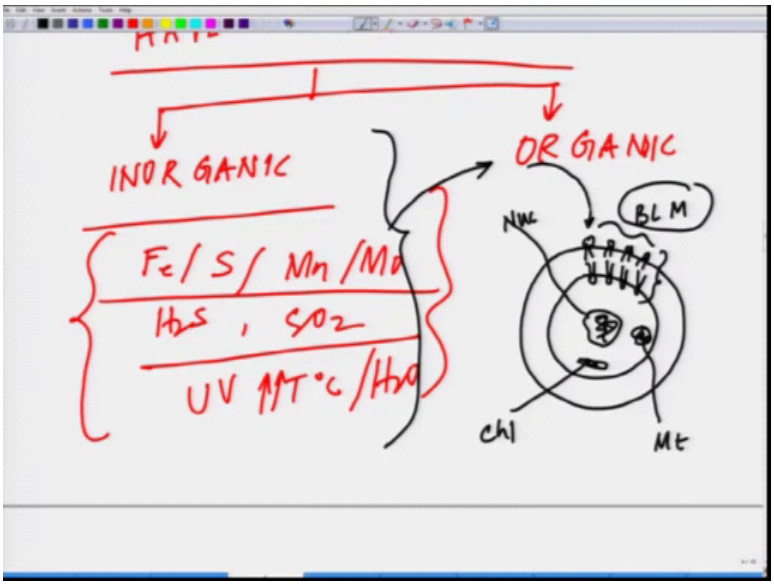

Sulfur dioxide a lot of UV rays high temperature these were the conditions and of course, lot of water likewise and most of those conditions as I mentioned here there were hardly any oxygen it is believed I will come to this it is believed that somewhere out here the oxygen came into picture in other word from the biggest transition which took place was from anerobic to aerobic landscape, but much earlier than that if we talk about how the first set of molecules our first set of self assembly which happened we have no clue we just have guess because when we write in biology we talk about when we draw a cell we draw a cell like this.

So, this is a mammalian cell all of you are aware of these are lipid bilayers and here is a nucleus with a DNA and there is small organelles like mitochondria Mt I am showing by then you have plant cells where you have chloroplasts and showing by chl and you see is the nucleus and bilipid membrane BLM another question which always haunted is how these self assembly happened. So, was those the first cells which are formed, but then there were things somewhere other from this inorganic milieu some organic compound has to form those organic compounds have to self assemble. So, if I put it in terms of chemical evolution. So, that is the term I wanted to you introduce first chemo evolution.

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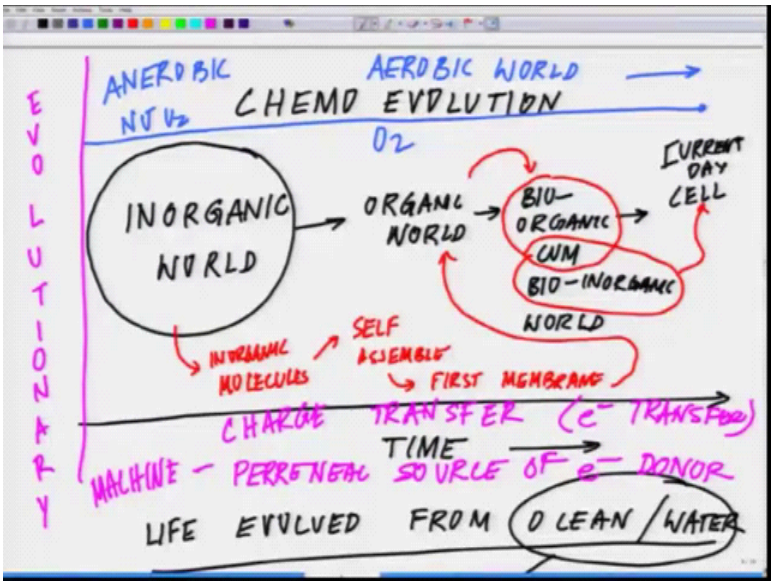

So, in other word in an inorganic world so, this journey as far as my limited understanding of it is that from an inorganic world of course, here is the time frame which is moving on your on my right hand side we moved on to an organic world from the organic world we move on to your bio organic cum bio inorganic world and possibly in that process we developed a first cell first current day cell why I said currently cell possibly there are other form of cellular structure which has formed, but for a cell to form biological cell what we just now I drew in the previous slide this has to form to realize it is been believed that life.

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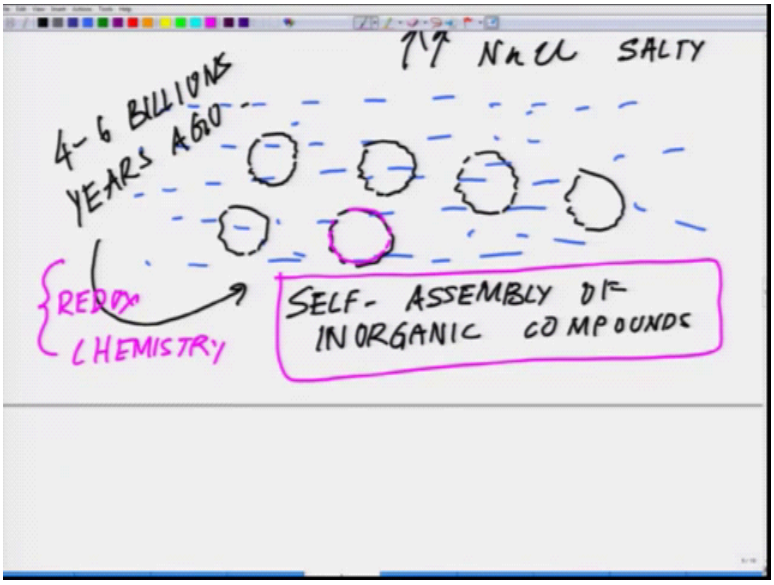

evolved from ocean or water now this ocean floor was extremely rich believed in it is a saline salty.

So, now in order to form any form of cellular or any separate compartments something which is not part of it you have to have some form of if this is your milieu of the high saline rich then you have to have somewhere other formation of a compartment like this and a compartment which somewhere or other manages to regulate the salinity inside. So, how the first cell has formed what form of self assembly of molecules have taken place we have no clue, but somewhere some 4 to 6 billion years ago what we call today's biological cell the foundation stone was laid by it is believed by the chem illusionist self assembly of inorganic compounds why is it. So, I am coming to that.

So, I told you that from the inorganic world certain inorganic molecules self assemble these self assemble structures form the first membrane on which it is believed much of this organic world developed and the further self assemble to something bio-organic cum bio-inorganic world which eventually tell us or presented us what he talked about the cell and of course, in that whole process we shifted from no oxygen to oxygenated environment in other word anerobic to aerobic world this had remained our journey.

Now when you talk about this transition and shift and all these things one common thematic which has evolved over the year or over billions of it is these kind of self assembly membrane formation of compounds have remained they have been governed by charge transfer or mostly electron transfer because most of the reactions are redox reaction which requires the electron transfer.

So, to govern or to drive the evolutionary machinery so, the evolutionary machine you need perreneal source of electron donor this whole process of assembling self assembling catalysis were governed by a world of redox chemistry somewhere other this all started now what will do is will talk about some of those first self assembly of inorganic compounds which form what we call as present day modern biological cells interestingly why we even talk that they must have formed from inorganic compounds.

So, in the next class we will again revisit the modern day cell and will pull the story back to 4 billion years ago why we think in that way what are those clues what are those small points or pointers which tells us possibly the evolution has followed a journey of something like inorganic world 3 inorganic molecule self assembly of inorganic molecules to the first membrane which act as a catalysis for forming lot of organic compounds bio-inorganic and bio-organic compounds which led to the evolution of the present day cell. So, I will close in here and the next class will again start our journey from this structure or the modern day structure out here and will again take a depth back in time with our rational time machine, but why possibly life has evolved from here ok.

Thanks a lot for your attention.