Bio-energetics of Life Processes

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Lecture – 11
Photosynthesis-I

Welcome back, to the lecture series on bioenergetics of life processes. So, we have finished first 2 weeks and we have talked little bit about or sufficient enough of thermodynamics parameters; which comes handy while we talk about, some of the transformation of molecules and we have a brief introduction about photosynthesis and chemosynthesis.

So, today we are starting the 3rd week where, these 2 weeks 3rd in the 4th week we will be dealing with 4 different kind of energy conversion processes where, trust area will be on the 4 topics what we will be dealing with we will deal with photosynthesis the light reaction and the dark reaction we will deal with the process of generation of ATP in the mitochondria the second energy harvesting or energy utilization system and the governing principle, which is dictating both this chloroplasts and mitochondria is the chemiosmotic hypothesis and the synthesis of ATP. So, this all this process will go hand in hand it is not that, will be standalone except we will talk about the role of mitochondria and role of chloroplast separately.

So, to start with our 3rd week and the first lecture of a 3rd week as we have already talked now, we are not talking about chemical synthesis we are talking about photosynthesis light dependent synthesis and in between we will always have the comparative pictures of chemical synthesis coming into play.

So, to start off with the perennial source of energy is the sun. So, we need it some way or other to trap the sunlight and use that, solar energy to conduct or do some useful work. So, in nutshell if I had to put it photosynthesis is a process where, the solar energy is being used the energy of the photons is being is being used to do some useful work using all the natural ingredients. So, the photosynthesis the raw material for photosynthesis probably one of the most elegant and one of the most genius move of nature it uses carbon dioxide and water to start off it is photosynthetic machinery, but here having said that, carbon dioxide in water I must say the second component water this component

come much later into the play of photosynthesis because, water as a matter of fact act as a source of electron what does that mean.

So, what essentially photosynthesis does in nutshell if I if you have to see a photosynthesis, photosynthesis is a process where, carbon dioxide from nature is being taken up by plants and it is converted into carbohydrates. So, once CO2 is transforming into carbohydrate you are adding a lot of hydrogen into it ok. Now, that process of conversion of carbon dioxide to carbohydrate is a reduction reaction.

In other word you are adding a lot of electron into the carbon moiety. So, that reduction reaction requires a supply of electron from somewhere, which will govern the system ok. So, essentially in the process where, CO2 is getting self assemble to a much more larger much more energy rich molecule, which is carbohydrate requires an extra piece of energy, in that in terms of it needs electron to make this process happen and this electron source is the first electron source in this game is the water molecule.

But, if you replace water with another molecule, which can be a source of electron you can always conduct this process as a matter of fact there where, times and even there is situations where, even H2S can do that H2 H2S ok, it is the same thing as splitting both the molecules. So, let us start getting down all the points what we are going to deal with. So, this is our ok, So, this is our week 3, lecture 1 and in overall this is lecture 11.

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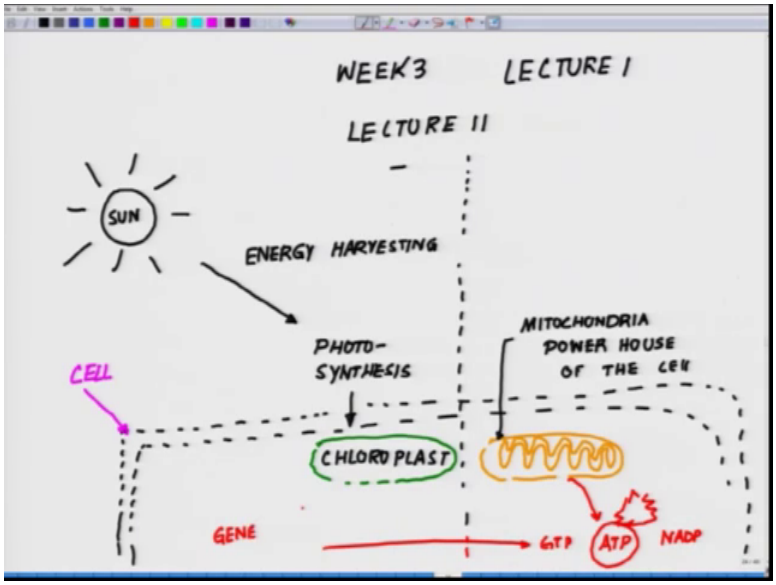

So, what we will be dealing with is this is our perennial source of energy, which is involved in photosynthesis ok. Then we will talk about which happens in an organelle called chloroplast organelle, which is present inside the plant cells and it is believed that, billions of years ago or maybe millions of years ago this organelle parasitized into the plant cell and become part of it ok.

Then this is the first level of this is the energy harvesting part, what we will be dealing with energy harvesting next inside the cell, what we will be talking about. So, I am just putting it this double membranous structure what I am drawing is the structure of the cell and here, you have the structure of the chloroplast inside the cell. So, this is what we are talking about is the cell and then, you have another organelle which is close by to it, which is your mitochondria ok, which is the powerhouse of the cell , powerhouse of the cell and this process generates lot of energy rich molecules in the form of ATP and ADP, GTP the most critical one is the ATP ok.

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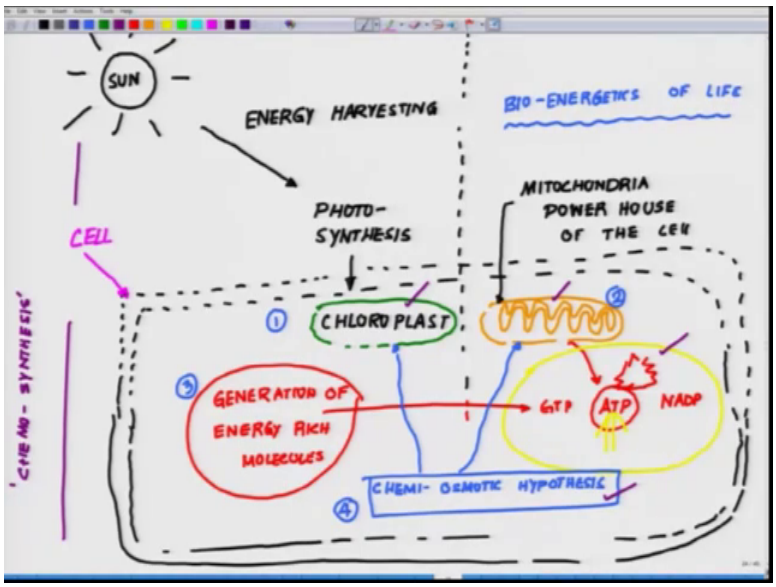

So, these are the generation of energy rich molecules in the form of GTP, ATP and ADP and critical one is the ATP what we will be dealing with and the interest ok. So, the semi-permeable membrane of the cell and this is governed by a hypothesis, which was given by Peter Mitchell for ATP synthesis it is called chemi osmotic hypothesis.

So, these are the 4 aspects what truly governs, what we talk about the bioenergetics of life tear the chloroplasts, tear the mitochondria and this is your ATP generation and

governing dynamics is the chemi osmotic hypothesis and earlier to that prior to that, was the world of chemosynthesis, which still survive and we will talk a little bit in between as we will go through.

So, as will be going. So, this is the overall framework what we are going to deal in the next remaining classes of the course or in the lectures is the chloroplast, mitochondria, generation of ATP and the governing dynamics a chemi osmotic hypothesis. To start off with if we look at the reaction of the photosynthesis just let me start out here, if you see the reaction of photosynthesis the reaction of photosynthesis is something like this.

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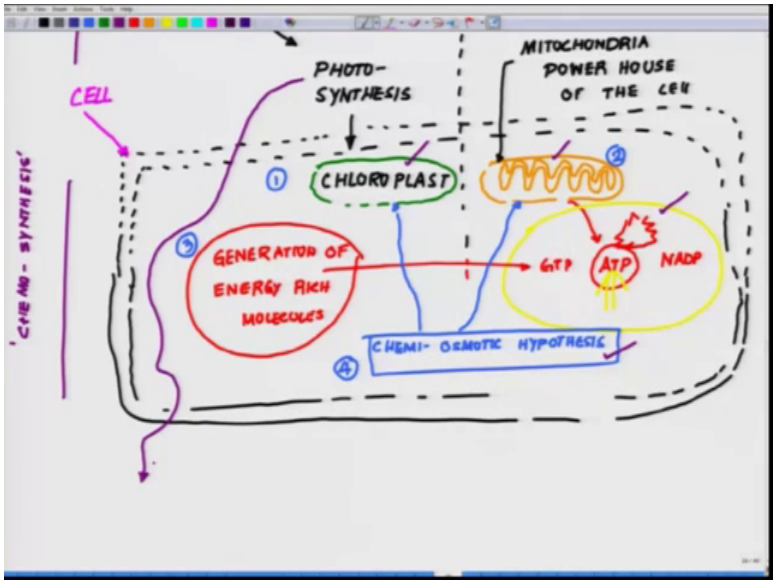

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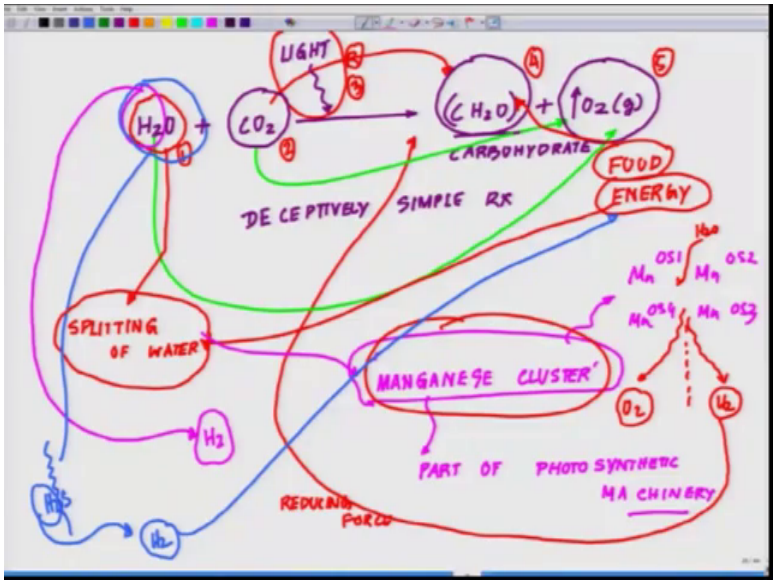

As I told you H2O plus CO2 a simple reaction in presence of light making CH2O, which is a carbohydrate plus oxygen this is your carbohydrate and this is the byproduct, which is gas which is the oxygen.

So, as some people say this is one of the deceptively simple reaction as a matter of fact it is funny that, nature is deceptively simple it does things in such a simple way that, it take mankind centuries to understand what trick nature has done? I mean if you look at it it is really straightforward you have CO2 and you have another product, which is fairly reduced now, the first question which strike always strike in your mind, that this oxygen which is liberated and it is strike everybody all those who have worked in that, area it always strike this oxygen is this oxygen coming from carbon dioxide or is this oxygen coming from water.

Because, if it is coming from water; that means, if this is true if this situation is true then, this is a situation where, water is getting split splitting of water and if water is getting a split if nature can split water somewhere or other; that means, if we could understand how nature split that water then, from here one of the byproduct, which mankind tries as a source of clean energy is hydrogen see how everything is linked to each other?

So, if some way or other while looking at the simple reaction if somewhere or other if this oxygen is being evolved by water, that it means water is getting split some way or other. So, that brings us purple from bioenergy interested in understanding people from chemistry, people from physics, people from energy studies, people from engineering,

biology by engineers they all are keen to understand as you move through you realize, that is the oxygen which is coming from water everybody is keen to understand how nature does it? And what do we know I am just giving you the framework what we know nature does it in one of the again deceptively simple way by something called manganese cluster, which is part of photosynthetic machinery.

And to the best of our knowledge, what we know about manganese cluster is it consists of 4 manganese iron sitting at different oxidation state and somewhere, or other it can entrap the water molecule in between it and could you know like a zipper can split it up unzip it and this hydrogen what is being liberated, is that reducing force which essentially reduces carbon dioxide to carbohydrate, that is what I was trying to tell you?

So, if you look at the simplest reaction this is essentially reduction of course, the assumption that, oxygen is getting liberated from water. So, though it is a deceptively simple reaction, but this reaction has inspired generations and it will inspire generations to explore further understanding the whole thing at the angstrom level and the challenge will be to engineers structures engineer something like manganese cluster, which can split water because, if the day mankind can mimic this whole machinery it can hit upon the food problem energy problem.

Look at that 2 things they need food and energy, that is what govern our life these are the 2-important thing and if you look at this reaction it actually generates both of them food in terms of carbohydrate energy in terms of so many reducing agent, which it is producing which is. So, that is why people have devoted their life in understanding photosynthesis from different perspectives from by an organic perspective from biologists pers perspective, from chemists perspective, from cyntha synthetic inorganic chemist perspective, from engineers perspective because, this deceptively simple reaction makes all the difference.

Now, what is the role of light we have not talked about, it there are 5 elements what I have drawn here, 1 so water, 2 is carbon dioxide, 3 is light, 4th is carbohydrate, 5th one as a byproduct, which is oxygen and I told you that if you replace this H2S H2 with H2S then, to the same thing could happen this may get split up and you still can produce hydrogen, which could be used as a source of energy as a source of very clean energy ok.

So, with this background I will close in this lecture and the next lecture we will go to the next phase of it. So, try to appreciate this simple reaction what all could be done? It is the dream, which is important for you to appreciate that; this is how the whole energetics rolls through.

Thank you.