

Bio-energetics of Life Processes
Prof. Mainak Das
Department of Biological Sciences & Bioengineering & Design Programme
Indian Institute of Technology, Kanpur

Lecture - 01
Bioenergetics of life processes: An overview

Welcome on you all to this new course on Bio energetics of life processes. This is a small course constitute of 20 lectures. And the major thrust area of the course will be, how the biological system evolved and the basic processes or the basic governing dynamics of biological process whereby energy has been captured to self assemble the molecules and how this self assemble structure what we know at it is most preliminary form called a cell regulates much of it is function using 2 of it is own component; one is chloroplast the other one is mitochondria.

So, before getting into the details of this course, so this is our first lecture, let us think rationally. If we believe that life has evolved over billions of years, one of the fundamental processes by virtue of which life has evolved on earth or may be somewhere in universe, wherever it is, there are 2 things what must have played a critical role or what is playing a critical role in the very cause or for the very reason that we are alive is, the role of energy and how energy has been efficiently used to self assemble the molecules by using enzymes or without enzyme or using a template or without using a template; self assembling them in order to convert those matter into useable matter.

When I talk about useable matter, that means say for example, we all have seen lot of carbons; hydrogens all over the place but, you really cannot eat carbon and hydrogen right. You cannot just you know grab a chunk of carbon or a coal and you say I am getting energy out of it. You can burn a coal and get an energy, but you cannot eat a carbon coal and derive energy. In order to use carbon as a form of energy, you probably need to convert carbon into some form of carbohydrate, like if you are human being then glucose or fructose or some other long chain polymers which are only cellulose. So, the process by virtue of which, you can convert or nature can convert these kind of raw materials say carbon, nitrogen, hydrogen, sulphur needs energy and needs some unique structures or unique factories where you can convert it.

So, if we look at from your school day textbook, it has been always said the sun is the primary source of energy; from where we derive almost all our energy of the biological system. But, there was a paradigm shift which took place in the late 1970's or early 80's where it was observed that deep inside the ocean floor where pretty much the earth crust is formed, you see molten magma coming out from the core of the earth; there are fissures on the surfaces, there are cracks on the surfaces from there the molten magma used to come out. So, think of a situation where you are having the cold water of the ocean deep into the depth, high pressure and magma coming out from the crust from the fissures of the crust.

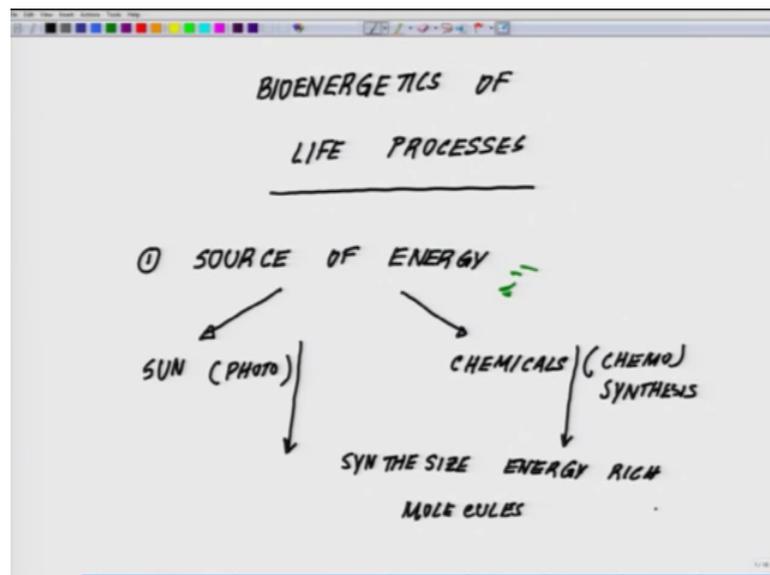
So, that magma is fairly hot, but the ocean is cold. So, it is a very peculiar interface. And in such interface where there is no light, absolutely no light, 0 light, we saw a wide array of life forms which are surviving there. That changed our way of thinking about what has been taught in textbook for all the years that sun is the primary source of energy. That means, without sun life also can evolve and that brought us to the second concept which is called chemosynthesis or chemical synthesis; one is a photosynthesis where light dependent synthesis of molecules, energy rich molecules. Similarly, chemo synthesis which is a process of chemical based synthesis of energy rich molecules.

So, what we see here, emerging concept is that you need some form of energy to bring about this synthesis of different molecules; either it can come from physical searches like sun or any other sun or any other stars, like sun or it can come from chemicals which are abundant on earth. So, if we talk about those hydrothermal vents where there is no light and life evolves at it is brim. So, those are the places where most of the energy is supplied by different form of sulphides which are present there, could be hydrogen sulphide, it could be iron disulphide; there are so many molecules of different transition metals which form sulphur rich compound in those regions. They form the basis of chemical synthesis. So, what we see is these energy sources help to self assemble the molecules to form energy rich compounds which are usable. Similarly our body functions, it needs different currencies of energy. So, all of you have heard about the easiest currency of energy used by body is ATP: adenosine triphosphate and where the phosphate moiety breaks down and generate significant of energy.

So, it becomes ADP: adenosine triphosphate to adenosine diphosphate. And if again you remove the third one, then it becomes, the second one sorry, then it becomes adenosine

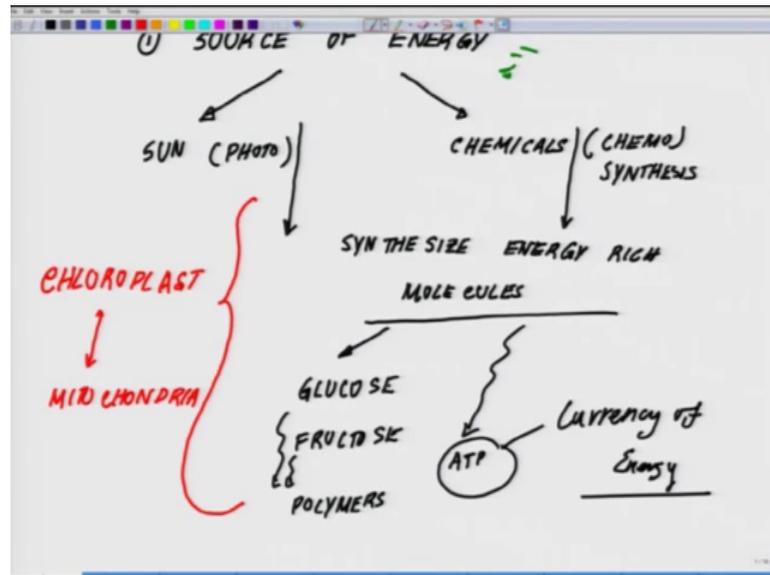
monophosphate AMP right and each one of these breaking of the bond leads to generation of sufficient amount of energy which could be consumed for running the biological processes. Interestingly, the process of ATP synthesis, glucose formation or you know simple sugar formations are fairly linked and these are carried out by specialized organs, organelles rather which has evolved through billions years of evolution on the earth crust and possibly what we call today as the nanomachines; these are probably the very first of the nanomachines which were formed on the floor of earth at the onset of evolution of biological system. And as a matter of fact probably, the similar kind of situation what has been earlier demonstrated by urey and miller experiment, long back, long long long time back on the earth crust the first self assembly of the membranes or these energy synthesizing systems which evolved.

(Refer Slide Time: 09:42)



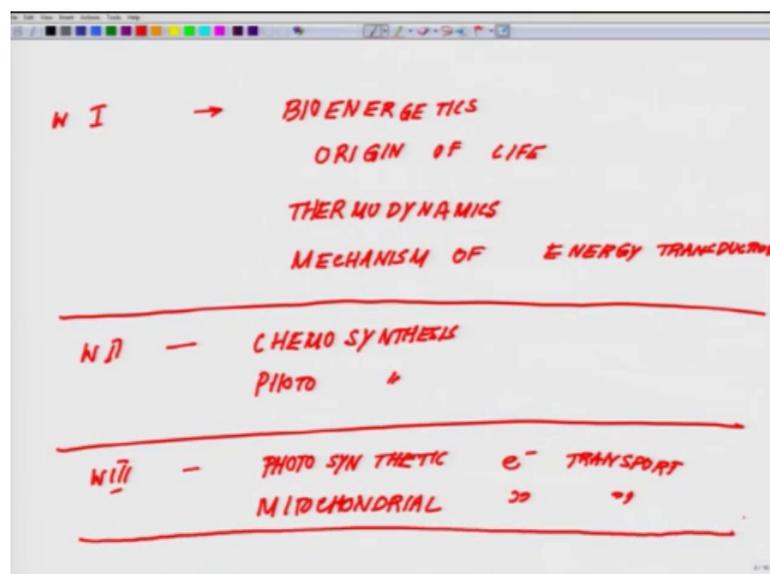
So, let us make a beginning into this; Bio Energetics of Life Processes. So, this is the title of the course. So, what we will be dealing here, I told you. So, the first thing is, Source Of Energy what we discussed. The source of energy could be Sun, Photo or Chemicals which breaks down and generate energy, Chemo Synthesis or rather the process where chemicals or sun has been used to synthesize energy rich molecules.

(Refer Slide Time: 11:23)



When you talk about synthesizing energy rich molecules, we talk about molecules like simple sugar like glucose, fructose and their individual polymers. Similarly we talk about energy rich molecules like ATP, which are being key to run the biological system, currency of energy. And these processes are done in those nano factories which includes your Chloroplast and Mitochondria. So, if you look at the course, the way I have designed the course is in 4 different parts will be dealing with this whole topic.

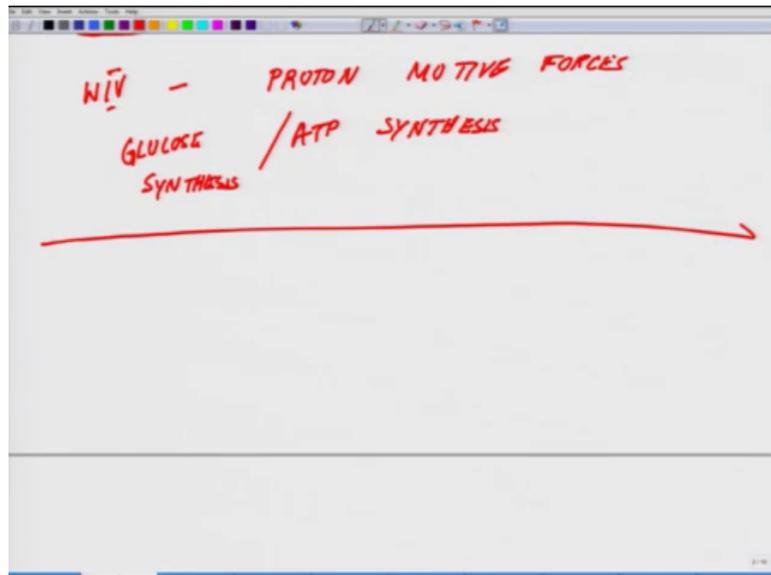
(Refer Slide Time: 12:38)



So, the first thing I will be dealing it will be, basic bioenergetics, that we part first week one, basic bioenergetics origin of life. Bioenergetics and Origin of Life which is basically this week what will be dealing with, then, thermodynamics aspects of bioenergetics, Thermodynamics basic bio thermodynamics and Mechanism of Energy Transduction.

So, this is what we will be dealing in next 4 classes; this is our week 1. Well about week 2 where we will be dealing with Chemosynthesis and Photosynthesis. Then will have a week 3, where we will be dealing with Photosynthetic Electron Transport and Mitochondrial Electron Transport, Photosynthetic Electron Transport And Mitochondrial Electron Transport.

(Refer Slide Time: 14:36)



And on week 4, we will be dealing with Proton Motive Forces and A T P synthesis. And of course, in that process, we will be talking about Glucose Synthesis. This is in nutshell what will be dealing these 4 different modules what will be you know dealing. Origin of Life terms of Bioenergetics, Thermodynamics of these processes, Mechanism of Energy Transduction, Chemosynthesis, Photosynthesis, Photo Synthetic Energy Transport, electron transport sorry, Mitochondrion Electron Transport, Proton Motive Forces, ATP and Glucose Synthesis.

So, these intense next 19 lectures, will help us to appreciate how apparatus like mitochondria, chloroplasts helps us to use the energy to self assemble the molecules to

form something which could be used by the biological systems. So, this is what will be dealing now. So, I will be moving slowly, one by one, take the concepts. So, what is most importance that understand some of this critical concept in the course so that you can build up your own story in terms of your research and in terms of your own career.

Thank you.