Bio-energetics of Life Processes
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Lecture – 09
Summary of thermodynamical parameters-I

Welcome back, to the lecture series in bioenergetics. So, in the last class the 8th lecture or the third lecture of the second week, we talked about the classification of different bacteria eu bacteria and archaea bacteria, and we talked about iron sulphur bacteria, we talked about methanogens, we talked about the bacteria, which are loving the extreme salt environment and then with the eu bacteria, we talked about gram positive bacteria, we talked about photo synthetic bacteria, which have evolved in the anaerobic conditions, we talked about the bacteria, which like blue green algae or the cyanobacteria, we talked about the purple photosynthetic bacteria and we talked about the spirochetes.

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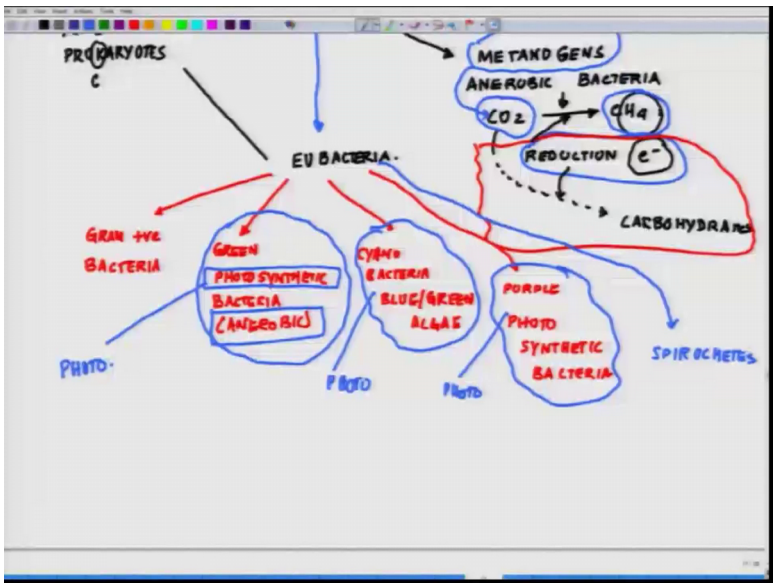

So, what essentially, we were highlighted, there was the light dependent and chemical dependent synthesis of molecules. So, today we will talk about the basic parameters of thermodynamical parameters, which in the first week we covered a little bit and I kind of giving a gap to pick these up because, these are some other concepts and what I

personally believe that, this concept should get into your system slowly. So, that you get time to you know digest and kind of figure it out this is what is happening.

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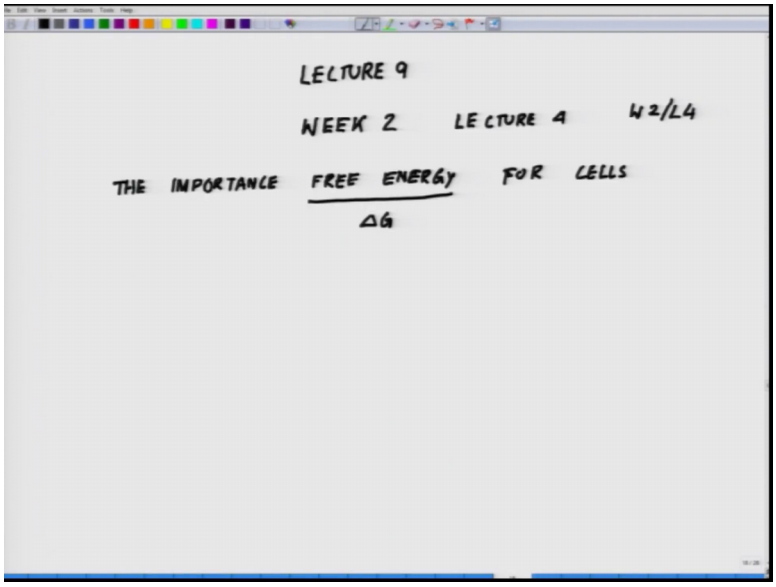

So, let us start the lecture 9, which is lecture 9 or we are into week 2 lecture 4 of week 2, so W2 L4. So, today we will be talking about, the importance of free energy for the cell. The importance of free energy we have talked about lot of our delta G. So, today we will talk about little bit more free energy for cells delta G. So, whenever a reaction occurs. So, we have talked a lot about, the self assembling. So, if you go back. So, this was one of the slides what I wanted to highlight here, if you follow this blue box.

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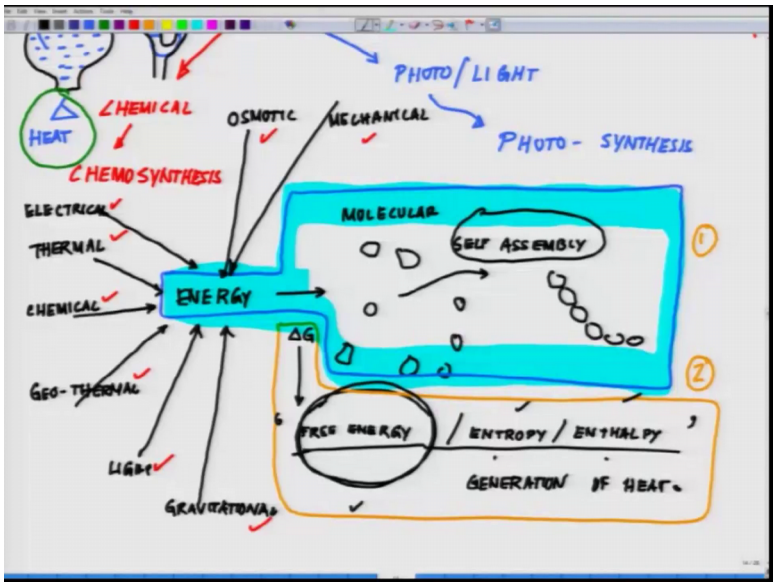

If you follow this blue box this blue box is, so this process of self assembling whether, it will happen or not is a function of whether, it will happen spontaneously or you need to infuse energy into the process depends on this parameter the free energy. If free energy is negative it means, it will happen spontaneously and if free energy is positive it means, you have to put energy into the system.

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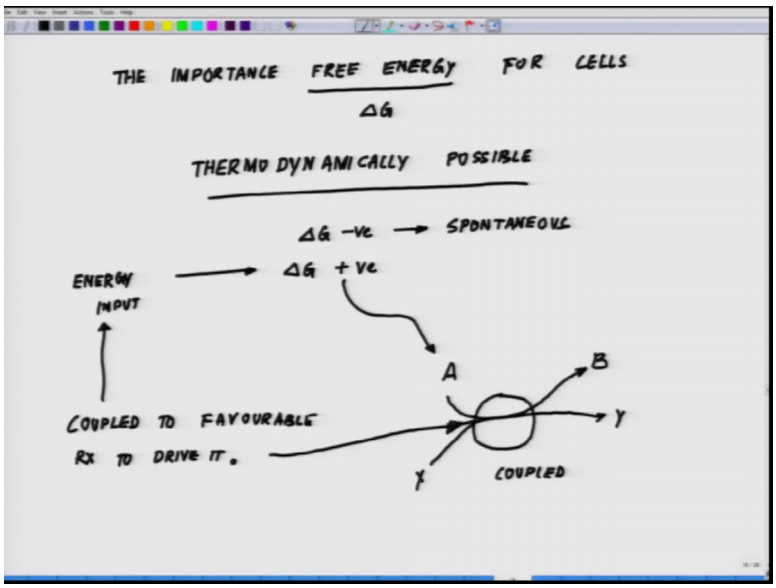

So, today in the light of that, we will talk about the significance or the importance of free energy for the cell, life is possible because of the complex network of interacting

chemical reactions occurring in every cell. In viewing the metabolic pathways, that comprise this network one might suspect, that the cell has the ability to evolve an enzyme to carry out any of this reaction that it needs, but this is not. So, all the enzymes are powerful catalyst, they can speed up only those reactions which are thermo dynamically feasible, dynamically those which are thermodynamically feasible or thermodynamically possible.

Other reactions proceed in cells only because, they are coupled with favourable reactions to drive them. The other way as I told you that, either delta G will be positive or delta G will be negative and if it is negative, that this is then a spontaneous reaction and if it is delta G is positive you need energy input. An energy input in terms of coupled to favourable reactions to drive it. And will come later about it. Coupled to favourable reactions to drive it.

So, when we talked about coupled to a favourable reaction to drive it this is very significant because, biology will observe this is and this will come time and again. So, it will be something like that say, for example, a reaction say A to B has to occur and that is an energy intensive process. You will see this reaction will be coupled with another reaction, which will ensure that.

So, this may be X to Y. So, this coupling is a common process in biological modules this is not something which is seen somewhere else, but in the biological world and the life in the world of life we are this kind of coupled reactions are extremely important. So, coming back about the delta G and in thermodynamics the question is whether, a reaction can occur spontaneously or instead that needs to be coupled to another reaction and especially this coupling happens, when delta G is positive is a central to most of the things the answer is obtained by reference to a quantity called free energy, the total in other word the total change in free energy during a set of reaction determines, whether or not the entire reaction sequence can occur.

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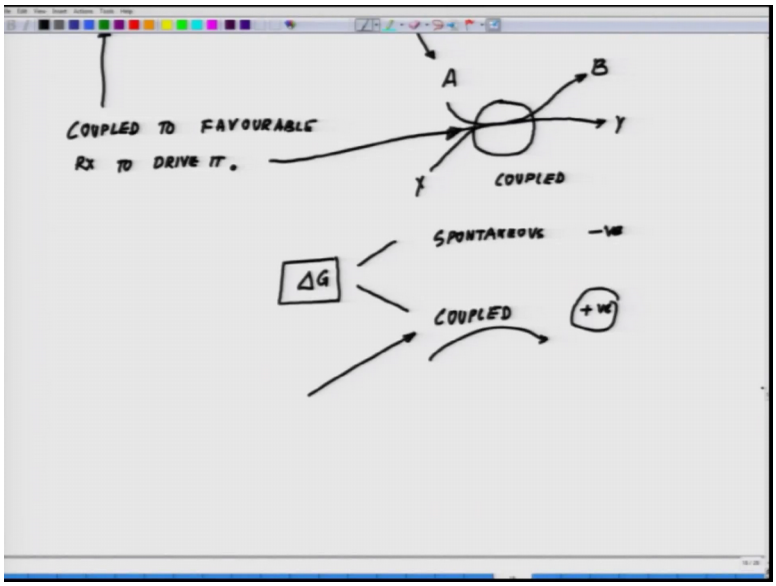

So, what essentially is that, this thermodynamic parameter delta G is exceptionally critical for you to realize whether, it is spontaneous the take home message is whether, it is an a spontaneous reaction or whether, it is a coupled with something. Because, it is a positive it needs an energy input needed an energy input and energy released by change in chemical bonding is converted into heat.

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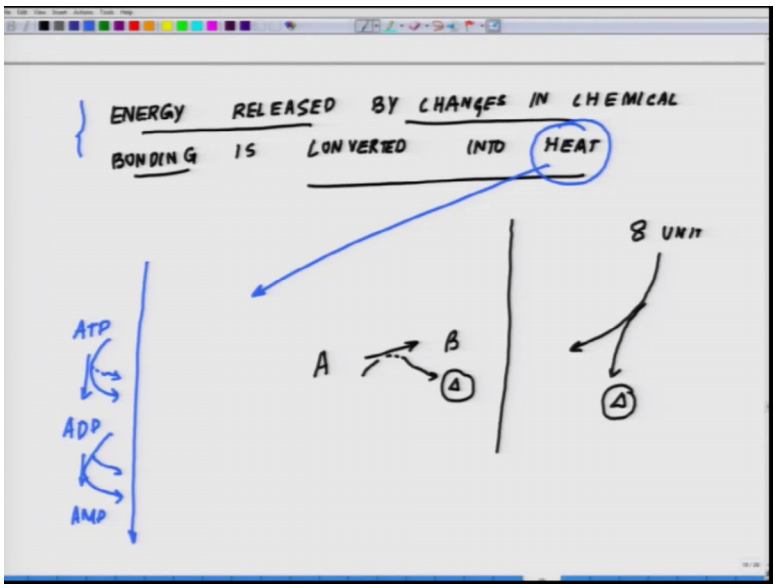

This is the next concept what is important is that is where, the enthalpy and the entropy concept comes is energy released by changes in chemical bonding is converted into heat.

So, energy released by changes in chemical bonding is converted into heat. So, in other word a molecule A is converted into B. So, the energy released by the change in the chemical bonding part of it is liberated as heat. This concepts is really essential for us to appreciate because, as we will move through you will realize. So, why this whole concept comes into play is whenever we talk about, an engine a cycle or energy involvement we always talk about that, how much energy is lost in the form of heat?

Whenever, there is a conversion whatever what so ever it is a inorganic world, organic world by organic world or the world of patrol or the energy rich molecules in terms of like, you know inflammable gas. So, we always talk about how much in that conversion it is lost as a heat. So, as a matter of fact most of this process one needs to really. So, whenever, there is an change in the chemical bonding pattern. So, you know some double bond become a single bond or likewise. So, forth there is some energy which is converted. So, there is never an absolute conversion of energy.

So, for example, I say I started with 8 unit and a part of it will be lost while conversion or something will be lost as heat. So, there the efficiency of an engine, efficiency of a conversion, the energetics efficiency is considered in a situation by the basis of what is the least amount of heat which is liberated. A efficient system is the one, which liberate extremely low amount of heat as compared to a system, which liberates a lot of heat. So, what is the amount of heat, which lost in that whole process says that, you know the system is not energy efficient because, the problem is see you have to always realize.

So, say for example, your brain does like try to understand it is by an analogy a different kind of analogy your brain is processing information at a rapid pace a computer is doing the same thing you are running processors, after processors and a computer you are adding processors and everything and it is converting, but a computer gets heated up if you keep on increasing the number of processors like whereas, you think so many things still your brain can withstand.

So, biological modules what have evolved over the years over billions of years have ensured, that the evolution of heat could be compensated some way or other, but energy released by changes in the chemical bonding is converted into heat, that is a common phenomena and based on that if you somewhere or other can quantify this heat, then you

can tell about the efficiency of that conversion, the lesser the heat evolved the more is the efficient conversion into it or rather maximum utilization of the energy.

So, say for example, ATP molecule gets broken down say to ADP and eventually to AMP. So, in this whole process, there is energy which is released and some form of heat is also released during this process.

So, depending on which molecule liberate least amount of heat one can say the how efficiently it is converting into the process. So, this is one concept which I will be talking further in the next class where, we will talk about energy release by chemical changes chemical bonding is converted into heat. So, and in order to understand like, this is something like this say for example, a enclosed system if you considered a enclosed system like this and here, you have a box and here, you have a cell and here, you have a sea and here, you have the universe.

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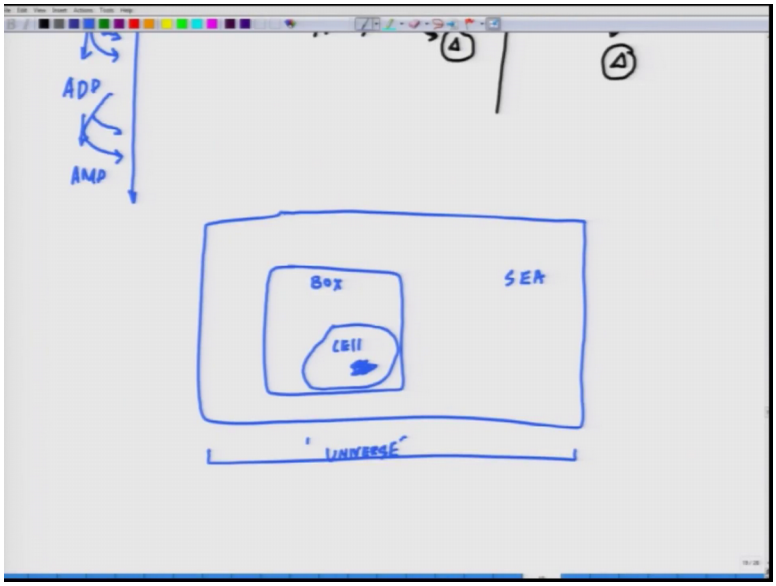

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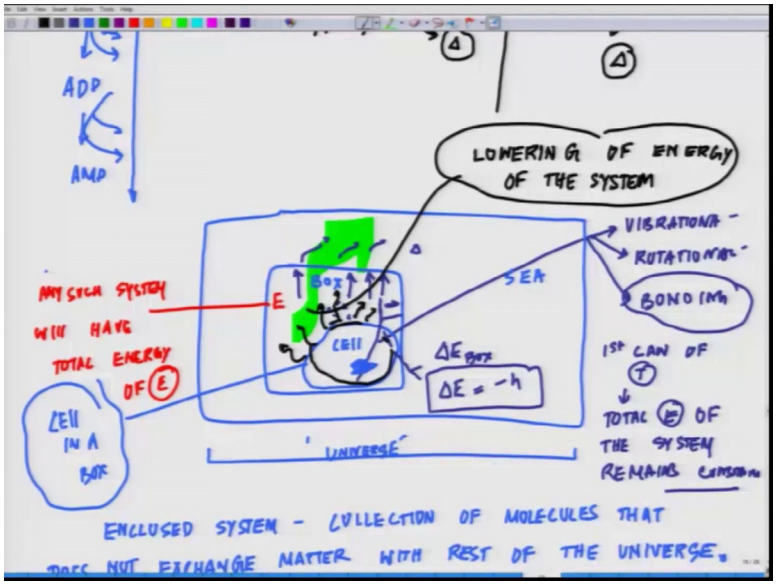

Now, an enclosed system is defined as a collection of molecules that, does not exchange matter with rest of the universe. So, this is a enclosed system what we are talking about. So, enclosed system is defined as collection of molecules that, does not exchange matter with rest of the universe. So, keep that in mind it does not exchange any matter with rest of the universe for example, this is a case of a cell in a box. Any such, system will contain molecules with a total energy of E such, system will have a total energy of E. Any such, system will have and always remember that this is not exchanging any molecules from outside total energy of E.

This energy will be distributed in a variety of ways some as translational energy of the molecules, some as the vibrational energy, some of the rotational energy, but most of that will be the bonding energy between the individual atoms that, make up the molecules. So, this will have your let us enumerate the energies just in case you forget vibrational, rotational vibrational and the bonding and the major chunk will be the bonding these will be the minor ones, that makes up the molecule.

Suppose, that reaction occurs in the system the first law of thermodynamic places a constraint on what type of reaction can occur in the system it is states that, in any process the total energy of the universe remains constant, whatever be the process this is what the first law of thermodynamics says very clearly first law of thermodynamics that total energy of the system remains constant.

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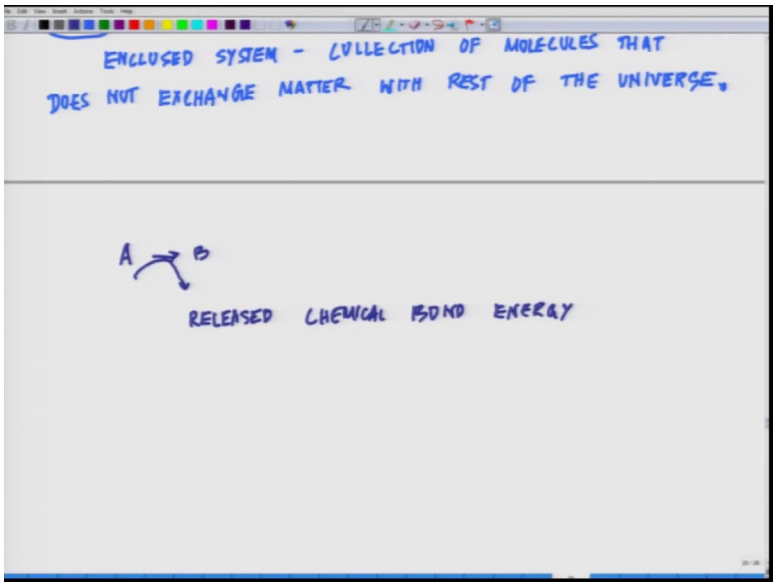

Keep this in mind this is essentially, what the first law of thermodynamics states for example, suppose there is a reaction between A to B occurs in a enclosed system, which release a great deal of chemical bond energy you know this is what is being released we are trying to talk about this released chemical bond energy because, the breaking or the making of the bonds.

This energy will initially increase and the intensity of molecular motion, translational, vibrational and rotational in the system which is equivalent to raising it is temperature; however, these increased motions will soon be transferred out of the system by a series of molecular collision, that heat up for the walls of the box and then the outside world. So, what will happen. So, there will be lot of collision of the molecules. So, this is going to heat up the kind of heat up on these and this will eventually get transferred outside in the form of heat.

And then outside world represented by the C for in our example in the end the system returns to it is initial temperature by which, time all the chemical bond energy release in the box has been converted into heat energy. So, there will be rise in temperature and then, eventually it will fall, but during in this whole process most of the heat energy, most of the bond energy is converted into heat energy, converting heat energy and transferred out of the box to the surrounding.

So, according to the first law of change in energy in the box, so, if I talk about delta E of the box, which we shall denote by delta E must be equal and opposite to the amount of heat energy transferred and it could be designated as delta E is equal to minus h, which is essentially the change which is the heat energy, that the energy E in the box decreases when, heat leaves the system. So, in other word when the heat energy is going out as the heat energy is moving out of the system. So, what is happening out here, there is a this leads to a lowering of energy of the system.

So, I will close in here, I will pick it up from here, what are the connotations? And how we will move on to the second law? And the entropy and the Gibbs free energy from here. So, just for the timing just try to realize there is a reaction happening out here, and that leads to generation of heat generation of the molecules kind of you know getting disturbed and they generate heat and that, heat moves out of the system and in that process system lowers it is energy.

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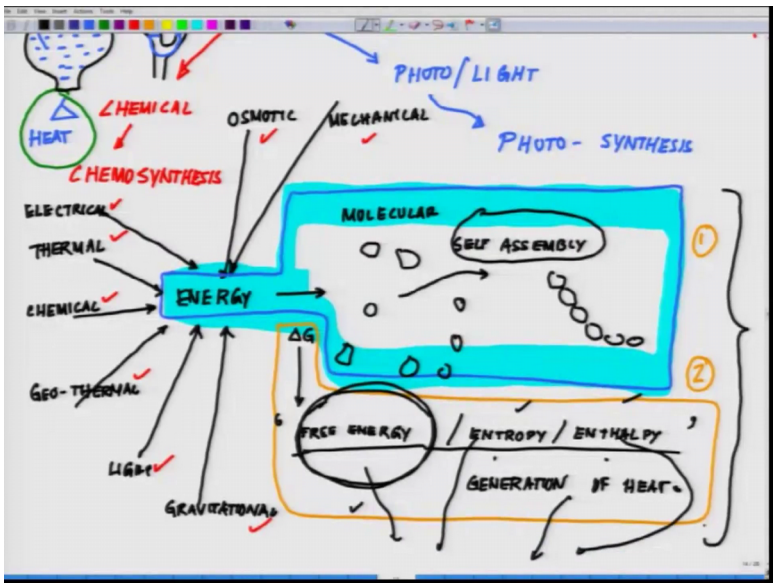

We will follow it up from here and we will move on to the second law of thermodynamics to the entropy and the Gibbs free energy, what we promised each other in this section. If you go back here free energy entropy enthalpy generation of heat, this fundamental drawing remember it in the next class we will follow it up from here.

Thank you.