Indian Institute of Technology Kanpur

National Programme on Technology Enhanced Learning (NPTEL)

Course Title

Bioenergy

Lecture – 06

Basic Biomass Technology

(Resources & Production)

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Welcome back to the lecture series in my energy so we have finished the module one a week one with our five lectures initial lectures on the energy comics and we have introduced ourselves to the whole domain of x energy so today we will be starting the module to the week two so where the thrust area will be the biomass production and the different kind of biomass so biomass production of the floor of Earth whether it is in the water bodies whether it is in the ocean floor whether it is in the land where so ever is governed by the process of photosynthesis as we have discussed in the module one.

So these five lectures what we will be dealing with we will be talking about this fundamental reaction of photosynthesis and how photo synthetic efficiency can be improved and what are the different research areas which are flourishing in order to understand this process so overall you have to understand photosynthesis as I have mentioned in the module 1 I am just reiterating it just to give you a recap it is a process it is a as it says photo means light and synthesis means

manufacturing it is a process of manufacturing food by using light and while using light the raw material or raw components which are converted into food are carbon dioxide which is abundant on earth and water.

Essentially the reaction is basically carbon dioxide plus water making carbohydrate and the byproduct is oxygen it is as simple as anything so though this reaction looks very deceptively simple will come to this all these things just giving end up giving you an overview the apparatus and the process is being carried out by series of proteins and small molecules and they are arranged in a structure of chloroplast where the whole thing happens in a amazingly beautiful manner it is probably one of the most advanced nano machines what one can think of which has been evolved by nature through billions of years of evolution.

So to start with the lecture today I will just show you a simple video where you see on the water bodies the sunlight is falling and that is leading to the biomass and the biomass it is kind of flourishing all over the water body that will kind of give you a feel that why this kind of reactions have kind of you know called the attention of mankind for so long.

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So let me just put the video in front of you kind of give you an idea so you see a biomass in the center of the water somewhere okay and the sun rays are falling as you could see you know you will see that they are hopping the light dots are kind of in a changing positions you look at it carefully along the edges of the leaves it is just to kind of help you to kind of get a feel of the whole thing that exactly something like that is happening when the light falls on the lease so the leaf is actually acting as a solar panel on this solar panels the lights are falling and some slight is being trapped and that solar energy in the presence of water and carbon dioxide is converting it into carbohydrate.

So this is in the most simplistic way and just to kind of give you a visualization I am just showing you this video okay.

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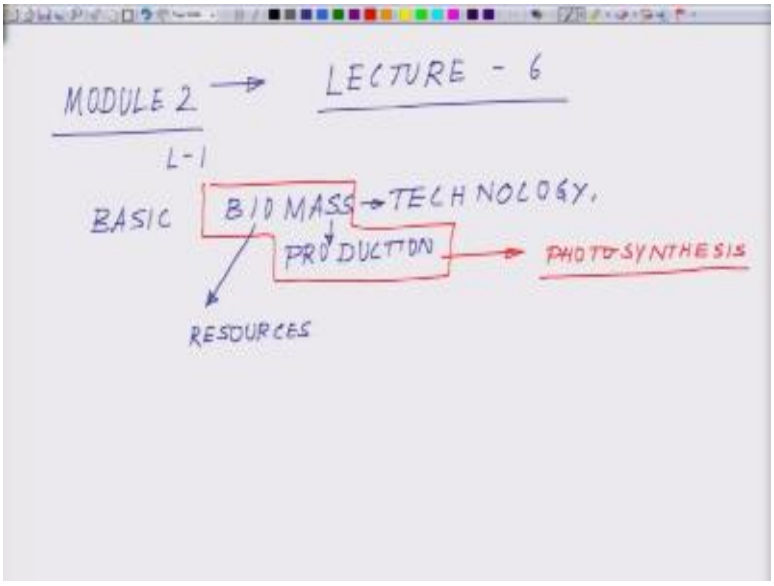

Now from here we will move on to the lecture so the start of it we are into this will be our lecture 6 and this is our module to module 2 lecture 1 of course and in sum total this is the electric sex and the section what we will be dealing with is basic biomass technology production so biomass production by mass technology and biomass resources what are the different resources so the

most critical among all these things to is to understand the biomass production process this is what we will be dealing significantly in the next four or five lectures what we will be dealing out here.

So in terms of the biomass production the critical area will be photosynthesis so well will we talking about photosynthesis there will be two phases will be dealing it today I will give you an overall outline or the roadmap of photosynthesis as we did in the previous module where at the end of the lecture I talked about the road map here I will start with the road map because it's a fairly complex reaction so unless we divide it in two different components it is really difficult to follow okay.

So after the road map one by one next three lectures we will go one by one exploring each one of the components and at the end again we will integrate the whole road map but by the time you will be wise enough to understand where it all sits in a global scheme of things and where futuristic research is going on so coming back to start off with our compared to the flight okay.

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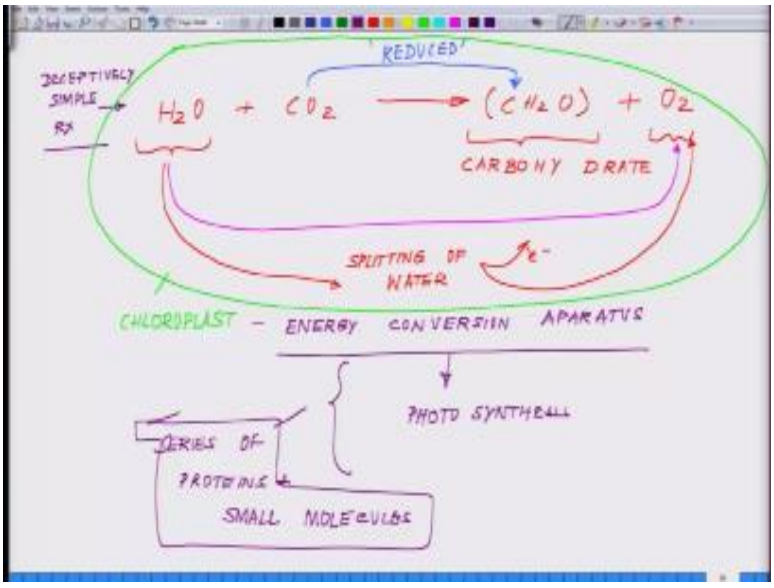

So the basic reaction as I was telling you it's very deceptively simple basic reaction is water plus co2 forming CH 20 which is your carbohydrates and as a by-product as oxygen and this is your carbohydrate and here you have the water so it is interesting to note and all these have taken place over the oxygen what you see out here actually come from the water so and this whole thing and if you see out here because another reaction which is taking place out here which is carbon dioxide is getting reduced to carbohydrate okay and out here h2o is getting oxidized and getting rid of the oxygen is getting removed from all from here okay.

So now you look at this whole thing this whole stuff is all happening inside one organelle called chloroplast or actually I would say you can term this as in other words here what you are happening instead of occasional use this word should use flitting of water ok and a splitting of water is generating will come where I am writing an electron and an oxygen out here so now this whole thing is happening inside the chloroplast which essentially is called as energy conversion apparatus so talking about chloroplast, so as I told you this is one deceptively simple reaction and there are lot of proteins this whole process of photosynthesis is carried out by series of proteins and small molecule series of protein and small molecules okay.

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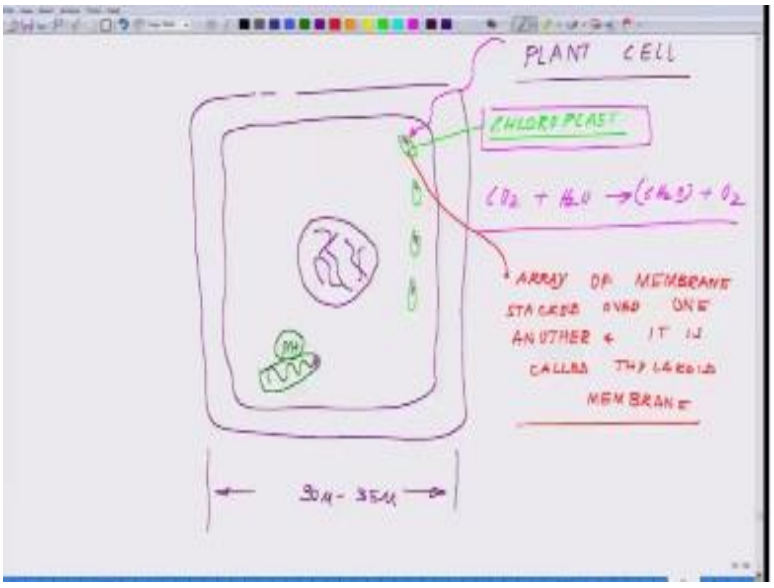

Now if you look at the plant cells so the plant cell kind of in the hexagonal structure you have the cell wall like this so this is structural diameter is around sorry the cross section is around 30 micron 30 to 35micron okay and within the plant cells so you have the nucleus out here having the DNA and all other components yet there are some very small components like this lot of them which are present there which are called chloroplast what we have just shown on previous slide chloroplast is the site.

Where the for synthetic reaction is taking place evolutionary there are a lot of debate over it whether the plant cells which are formed whether they had chloroplasts in the beginning or not it has been postulated by different evolutionary biologist they say that chloroplast was an independent organ oat some point or other and it parasitized the plant and became part of the plant cells.

The reason to say that is if you look at the chloroplast carefully chloroplast also carry with own DNA in it just like the other organelles which is another energy transduction molecule which is the mitochondria empty I am just showing in mitochondria which also carries its own DNA into it just like the chloroplast mitochondria also have its own DNA and there are a lot of debate over it whether these were originally part of the cell plant cell or they have been inherited and under what conditions they have been inherited if at all they have been parasitized not inherited it is not the right word they have been parasitized under what conditions they have been parasitized and how they have kind of became part of the plant it is a long run mystery we really do not know it.

But it is willing to be like that but what is important for us if by the roll of dice that is something which has happen in nature then this one translation has changed the course of our understanding or course of energy transduction so within this chloroplast come back to this structure within this chloroplast so what happened essentially is the light falls out here and the reaction what we discussed in the previous page takes place out here now in order for this reaction to takes place this particular structure what you see it has a area of membrane we will talk about this later in detail.

So in the next lecture it has area of the membrane which is stacked on it so structured stacked over one another and this called thylakoid membrane and we will talk about the detail structure of the thylakoid membrane or the site where this energy transduction is taking place so before we get into the thylakoid membrane let us understand certain things so the clothes as contained I specific light trapping pigment called chlorophyll they are arranged along on the thylakoid membrane when the light falls chlorophyll molecule absorbs a certain quantity of light and eject an electron this electron further travel through and reaches a particular reaction Center and from there this electron does something very interesting. So coming back to the slide it is something like this second okay.

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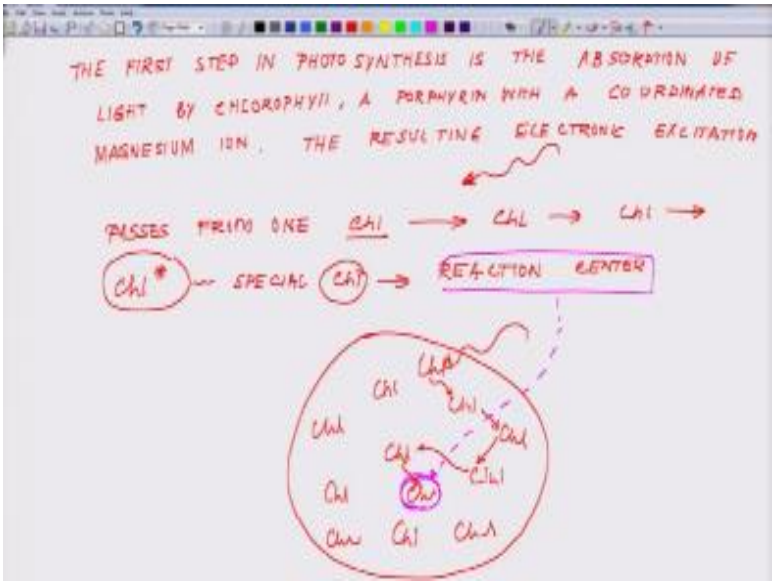

So the first step so what I just now told you is something like this the first steps in photosynthesis is the a option of light by chlorophylls okay absorption of light by chlorophyll we will talk about the structure of the chlorophyll later which is essentially a poor file in and when you talk about the chlorophyll as a poor firing complex let me just give you another idea just to make you understand this whole thing if you look at the hemoglobin it is also a poor firing complex with the iron in the center which gives a red colors in the case of chlorophyll there is a magnesium in the center.

Which gives it is a green color and if you remove both of them remove the iron as well as magna magnesium what you will get is the for firing complex itself has a yellow color and that is exactly what you see when the leaves become CEO low that is essentially its chlorophyll molecules are getting damaged because of continuous exposure to light so they turn out to become your land so that is the situation where the magnesium moiety once we will talk about the structure the magnesium moiety is not present and because of the photo damage has been removed from the profile molecule okay.

Coming back to the slide which is essentially a poor firing with a coordinated magnesium ion coordinated magnesium ion present at the center the resulting electronic excitation essentially it is something like that resulting electronic excitation passes from one chlorophyll seriously I am just putting one chlorophyll molecule to another chlorophyll molecule and so on and so forth and eventually it read reaches a chlorophyll which we call as are action Center okay until it reaches something and this chlorophyll is very special chlorophyll special feature which is also called the reaction Center and to your surprise as of now nobody can really tell by looking at a leaf and looking at the matrix of chlorophyll on the thylakoid membrane to pographically which is the reaction center.

So it is something like that just try to visualize I'm just drawing it is a fifth example this is where all the chlorophyll molecules are present CHL each one of them the chlorophyll molecule okay CHL CHL CHL CHL CHL okay, now say for example light is falling so light falls here so the excitation passes excitation process excitation process and maybe somewhere out here this one the one which I am putting a pink. So now no one can say with certainty that this is the reaction center or that is the reaction center we really do not know and we will talk later that how this reaction centers right discovered okay.

So coming back to the flight so it reaches to the reaction center which have shown you like this okay so reaction center and at such reaction center there is something essentially happening.

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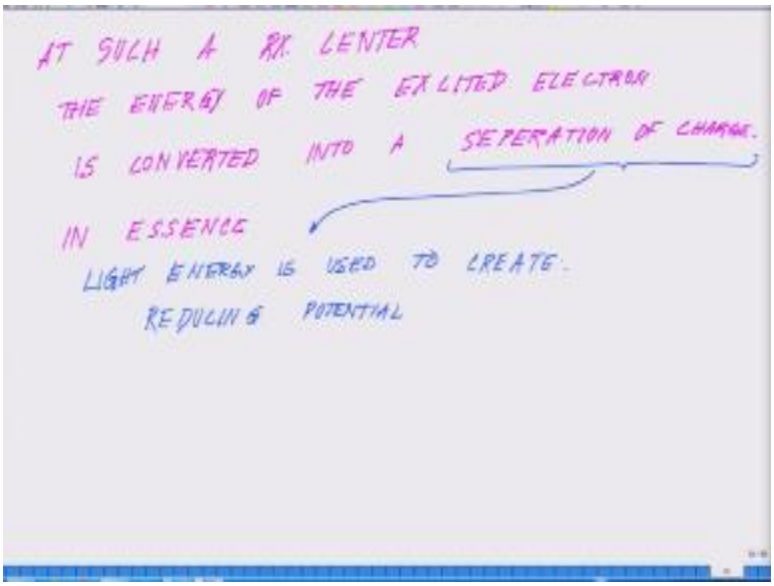

At the reactions interact at such the RX is the reaction center okay at such a reaction printer what is happening is excited electron the energy of the excited electron energy of the excited electron is converted and be careful at this point converted into separation of charge separation of charge and in essence what does this mean so here the keyword or key letter is this separation of charge and in essence the separation of charge is the one we generates the what we call as the reducing potential in a sense what we are doing is that we are using light energy is used to create the separation of charge.

So by a large this is the most critical reaction in photosynthesis where the light energy falls on the chlorophyll molecule and it eject an electron but just think something differently now total number of chlorophyll molecule is finite say for example just for the understanding say I say there are ten thousand molecules so at any point after ten thousand molecules get excited it will get damaged so eventually what will happen the very moment you are losing an electron you are getting oxidized.

So unless otherwise I donate you an electron you will not be able to come back to your ground state try to understand so let me just step go to the next slide.

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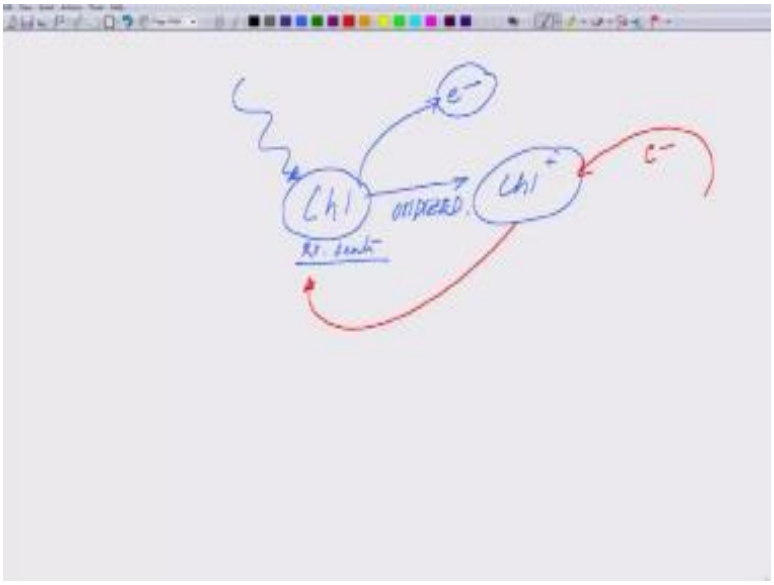

Say for example this is a closed cell molecule so light falls on it and it ejects an electron okay and just assume that this is the reaction printed one okay or irrespective of that, so once the electron goes out of it what is happening this chlorophyll molecule is now at a different state it is in it is it is something like this devoid of an electron so chlorophyll has got oxidized now in this oxidized stage this chlorophyll molecule will get damaged unless from somewhere or others we support or we throw another electron from some other source which will be sent out here which will bring back to its ground state.

So you realize that for such a reaction to proceed for a prolonged period of time we will be needing a perennial source of electron and as a matter of fact the global potential difference which is created is nothing but a gradient created across any forms of life by one perennial source and who is that perennial source so keep this in mind now what I will do I will put the roadmap in front of you let where each one of these component sift okay.

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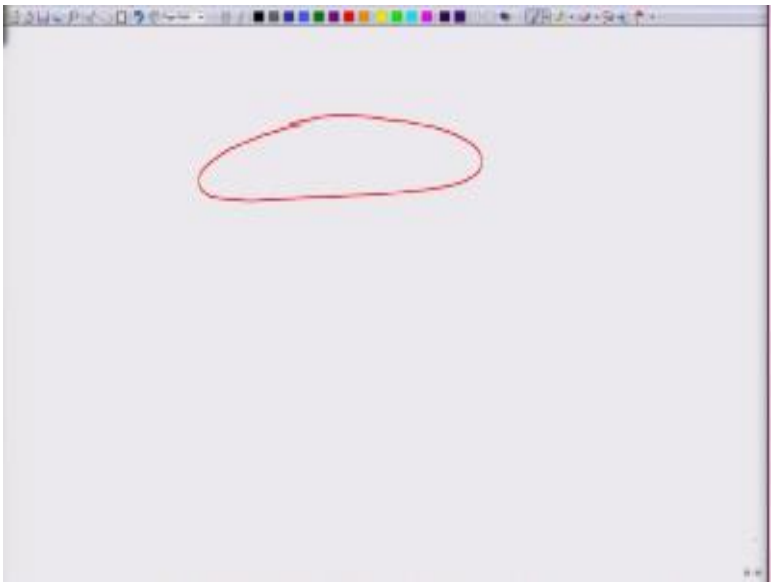

So moving to the next light so we talked about the structure of the chloroplast so there will be 23terminologies which will come to you and do not get scared we will go one by one there is a terminology which will come as for the system one there will be another terminology called photo system 2so when we talked about for system one and for two custom to just for your visualization so I showed you one picture just before in one of the slides let me go back to the site so I show you this picture.

So imagine out of this just I am adding one more a sum of the chlorophyll are sitting at physically at a different point say for example the one with the green I mentioned okay and I kind of saw a line like this and other chlorophyll which I am now putting them in with a dark blue border they are sitting at a different site okay so imagine on a membrane there are two colonies of chlorophyll molecules sitting at different point and those two different points what we call as for system one and what we call as photo system 2 so I will close in herewith this and we will take up each part of it in our subsequent lecture thank you.

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