Bio-energetics of Life Processes
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Lecture – 15
Photosynthesis-V

Welcome back, to the fifth lecture of the third week on bioenergetics of life processes. So, if you recollect the previous lecture we talked about, the structure of the chlorophyll I talked about, the concept of the polyenes where, you have alternate single and double bonds the molecules, which are exceptionally good in trapping light and photosynthesis or the structure of chlorophyll and it is compact polyenes like, structure is an inspiration for a lot of organic and inorganic chemists to emulate these molecules by making synthetic chlorophylls and other molecules ok, which can trap light and can be used for harvesting solar energy or any form of light energy.

So, I will just request you to think slightly more bold if you think of it today we talked about, all these solar panels, silicon crystalline, silicon based solar cells as a matter of fact nature has been harvesting solar energy since, time immemorial in the form of these molecules, which are complex molecules, which are extremely beautiful molecules.

So, nature solar cell is driven by chlorophyll, which is has a reason why I put up that, structure for you the complex structure of chlorophyll in front of you, that kind gives you a feel that this is where, nature has developed order out of simple atoms and ions and put them together by putting some energy. So, that is what I am repeatedly trying to tell you nature is all about order out of chaos by some form of energy, which is being put into the system.

So, following up on our lecture series. So, before I move on to the how the light falls on these chlorophyll molecules? And how the chlorophyll molecules get excited? I wanted to give you a scheme of things what we are going to follow in this light harvesting process? So, to start of it let us ok.

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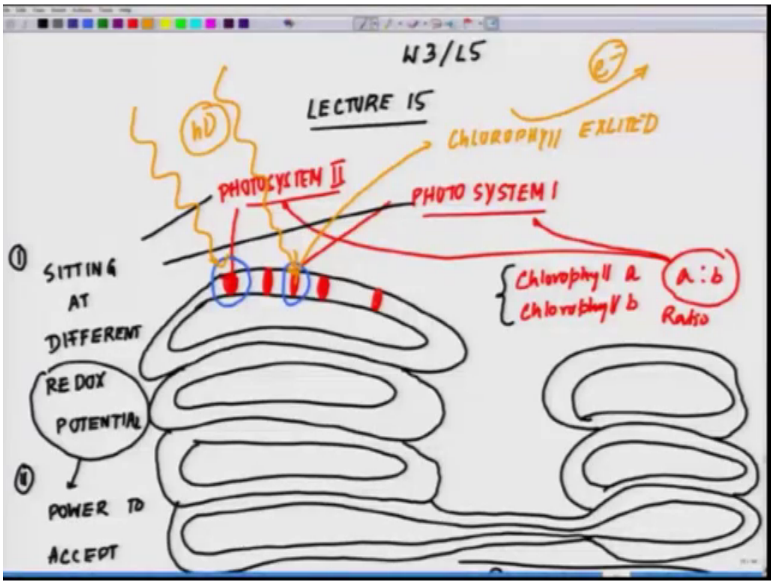

So, this is our week 3 lecture 5 W 3 L5 and in sum total this is lecture 15 and now, going back to this structure what where, I started this week structure of the thylakoid membrane, if you look at the thylakoid membrane.

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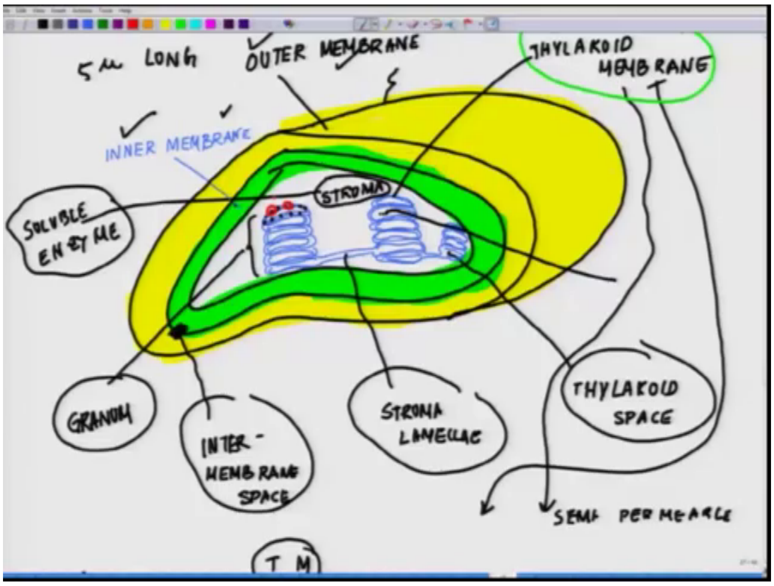

So, you have to keep this a structure in mind. So, your chlorophyll molecules are sitting here, where I am putting the dots and I told you that, there are 2 different reaction centers, which have different proportions of chlorophyll a and chlorophyll b molecule sitting there. So, those reaction centers. So now, are out here. Now, let me just draw it having shown you this let me again come back.

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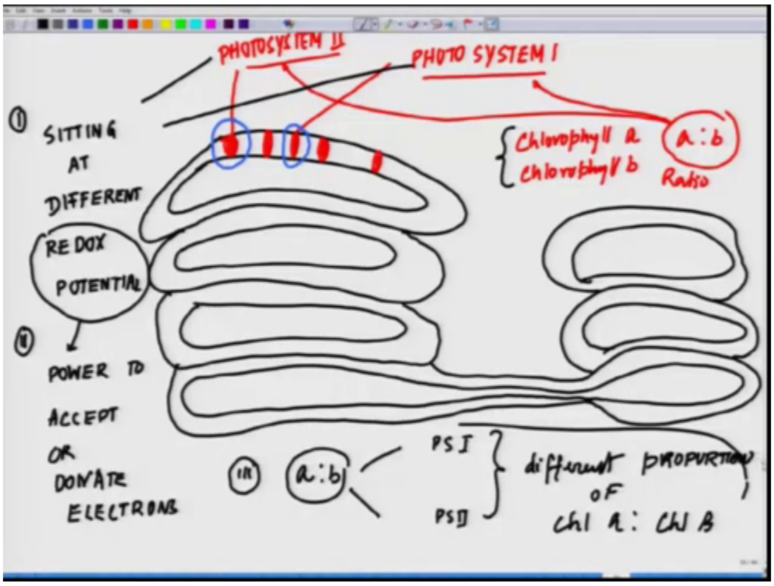

So, if this is the thylakoid membrane ok, this is how the thylakoid membrane is arranged something like this ok. Now, on those thylakoid spaces and the thylakoid membrane; so this is where, your reaction centers are sitting and there are 2 different kind of photosystems, which are involved in it one is called photosystem 1 the other one is called photosystem 2 and this photosystem 1 and photosystem 2 are decided by I told you that, chlorophyll a, chlorophyll b. So, the a is to b there are different ratios ok.

So, these have different ratios of a s and b, which are making these photosystems and these 2 photosystems are physically at different coordinates ok. So, these are some of the things, what I wanted to highlight before you should not miss the global scheme of things and both these photosystems and this is the typical case I am talking about in the plant. So, there are other modification to it there where, you have only one system, which is functioning and like this one and so forth, or almost the 2 systems are closing so, but this is the typical one I am talking about.

Where, the photosystem 2 and photosystem 1 are standing at a different kind of reduction potential or oxidation potential. So, I am introducing a concept here. So, what that essentially means is these 2. So, you have to understand certain things these 2 say photosystem 1 and photosystem 2 if I say that, they are standing at different reduction potential or oxidation potential; that means, that both these systems have different power or different ability in terms of a number of giving away electron or accepting an electron, which server scale wanted to follow whether, electron acceptance is your scale which; that means, reduction or electron donation is your scale, which is oxidation.

So, in other word whichever scale you follow, they are sitting at different redox potential or different reduction or different oxidation potential, and that is governed by their light capturing abilities and based on that their electron emission. So, the scheme so the 2 concept what I just now highlighted is photosystem 1 and photosystem 2 are sitting at different redox potential one second this redox potential essentially means, that power to accept or donate electrons power to accept or donate electrons and the third aspect what I wanted to highlight here, is the proportion of chlorophyll a is to b is different for photosystem 1 and photosystem 2 different proportion of chlorophyll a versus chlorophyll b. Now, based on their abilities of accepting or electron or donating electron, they could be put on a scale and will come later on to that.

Now, when the light falls going back little up here, when the light falls on these photosystems both these photosystem a chlorophyll molecule gets excited and when the chlorophyll molecule get excited, chlorophyll molecule ejects an electron. So, basically light energy could help chlorophyll to eject an electron from it is from it is structure. So, this is that chlorophyll structure we talked about. So, upon receiving light this has the ability to eject an electron ok.

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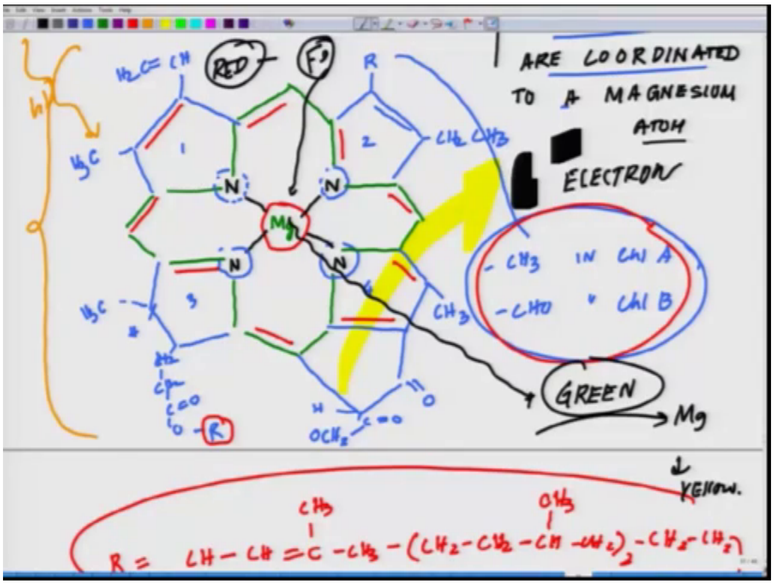

So, yeah so it can eject an electron upon absorbing light. Now, when it ejects an electron by absorbing light. So, essentially what is happening? CHO or chlorophyll as absorbing light ejecting an electron.

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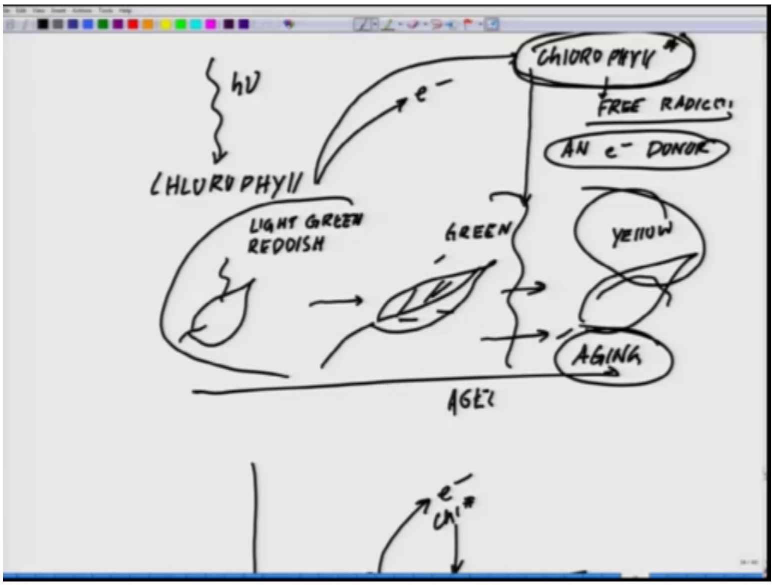

So, in that situation the chlorophyll molecule becomes, positively charged and starts behaving like a radical. Now, this chlorophyll has to be brought back to it is ground state because, you have finite number of chlorophyll molecule and if you see a leaf when it is formed ok. So, this leaf when it is formed start with initially the leaf is slightly reddish ok, if you look at it the leaf formation and very light green ok, and as days passes by as the leaf matures becomes, green and as this passes by as it ages over time this becomes, it is drooping it becomes yellow.

Have you wondered what has actually happened? So, I will come to this story just before I get into this story. So, when a chlorophyll molecule absorbs light, it ejects an electron and it becomes hyper excited. Now, there are 2 options either a leaf should have infinite number of chlorophyll every time a chlorophyll is ejecting an electron it gets destroyed, but the problem is that, if this is allowed to hang out there this will act as a free radical and it will damage many things. So, it has to be brought back to it is ground state and of course, there is a finite number of chlorophyll molecule into the system.

So, we need an and electron donor who will ensure to bring this chlorophyll back into the system. Now, having seed this let me tell you that, both photosystem 1 and photosystem 2 will be doing the same thing they will eject an electron upon absorbing light, but the thing is that, the electrons which will be ejected will be ejected from a different redox potential. This is the part what I need to tell you, if they will be ejecting an electron, but they will be ejecting an electron at different redox potential because, the electrons are harbored at different molecules. So, the electron will remain electron only, but they will be coming from different redox potential source. So, if I had to put in a scale out there, if I say that like you know I have not scale of redox potential.

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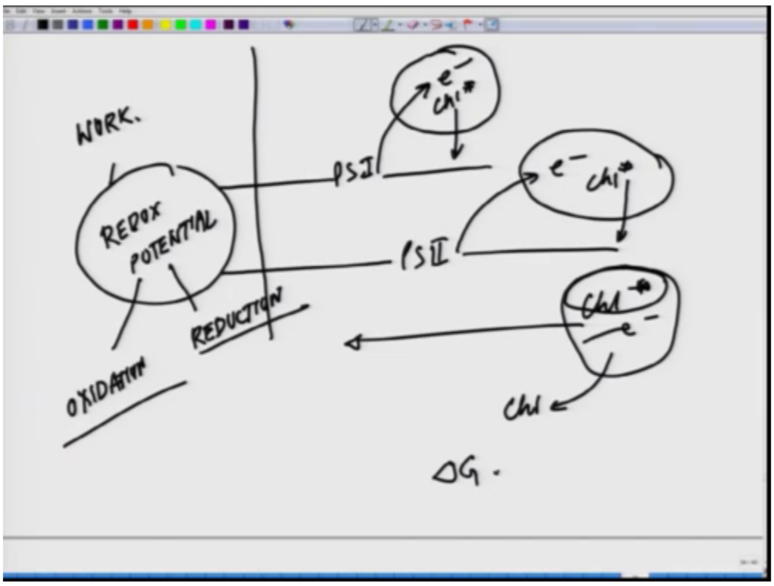

So, say for example, electron coming from say photosystem 1 an electron coming from photosystem 2 they, may be sitting at different redox potential. So, the electron ejected from here will be coming out from a different redox potential this is one concept which, I wanted to highlight at this stage before I proceed further and whenever from photosystem 1 or photosystem 2 or from both the photosystem electron is being ejected out, that chlorophyll molecule which is getting excited has to be brought back to it is ground state, how it is being brought back to it is ground state? There are 2 options when a chlorophyll molecule eject an electron. So, chlorophyll ground state, chlorophyll excited state and there is an electron it can recombine again and come back and make the chlorophyll there is a highly possible there is a recombination.

But that recombination could not happen, if this remains in this state for a certain period of time and will come later about that, what is that period of pico femtoseconds of time? You have to remain there at that state. So, that it could not recombine and these were experiments which have been done. Now, over this situation when I told you this light green and it is forming the green structure and becomes yellow, the yellowing comes because of 2 things, which happens as the plant ages the molecule what we talked about the nature solar cell? This magnesium gets moved out it gets injured and gets moved out and then, you are left with only the porphyrin ring, which has a yellowish tinge and it gets kind of distorted and everything and that gives you the yellow color.

Now, having said this a very similar molecule which gives this of course, the chlorophyll is green ok, and if you remove the otherwise it is green, but if you remove the magnesium it becomes yellow ok, but if you replace this magnesium with iron then, this is the famous molecule the hemoglobin which is red. So, so you are observing at the coordination complex you how the color completely changes? And you remove that magnesium, the spectrum and what you observe out here the yellowing and this is where, the aging of the leaves takes place.

So, what I wanted to highlight today is electrons are ejected into this system, but electron are generated from different redox potential, which you can define either as oxidation potential or as reduction potential. This fundamental concept I wanted to highlight today because, this concept will come very handy as we will be moving on now, to how the energy is being transmitted from this electron to different kind of energy harvesting molecules? And how this whole bioenergetics really comes into play? And this redox potential also brings you to the concept that, they are sitting at different work functions, and that was the reason, why? I told you that, we need all these values of delta G and enthalpy and all those kind of concepts to understand this.

So, today's take home message will be the existence of 2 kind of photosystem ejecting electrons from different redox potential and the chlorophyll molecule attains it is green color because, of the magnesium and when you remove with aging it becomes yellow and the photosystem 2 and photosystem 1 are sitting at physically distinct location on the thylakoid membrane and photosystem 1 and photosystem 2 are made up of differential ratio of chlorophyll a and chlorophyll b thereby modulating the spectrum because, the way you mix it the spectrum is going to shift either this side or shifting you on shift. So, there is always a shifting depending on the ratio of it.

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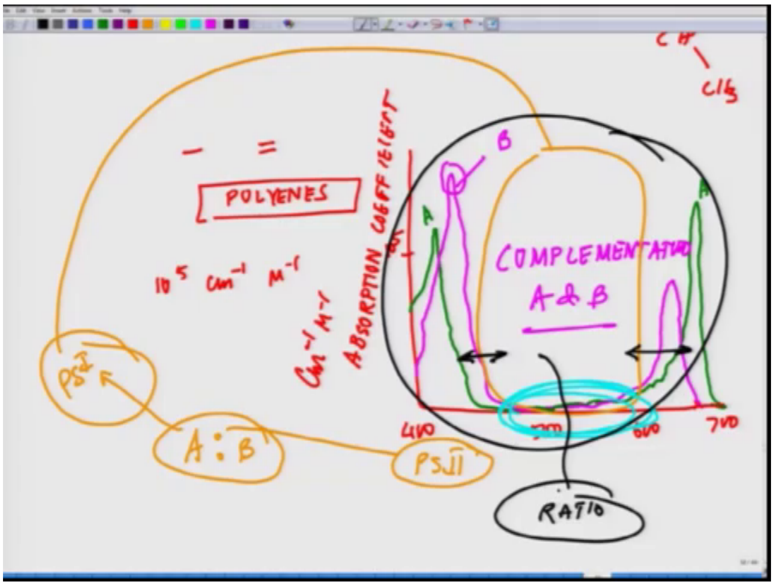

These are the take home messages, what I wanted to highlight in the today's lecture? And we will continue in the next week with the electron transport chain in chloroplasts and mitochondria and the ATP synthase and the chemiosmotic hypothesis.

Thank you.