Bio-energetics of Life Processes
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Lecture – 14
Photosynthesis-IV

So, welcome back to the lecture series on bioenergetics of life processes. So, today is the 4th lecture of the third week, lecture 4 of week 3.

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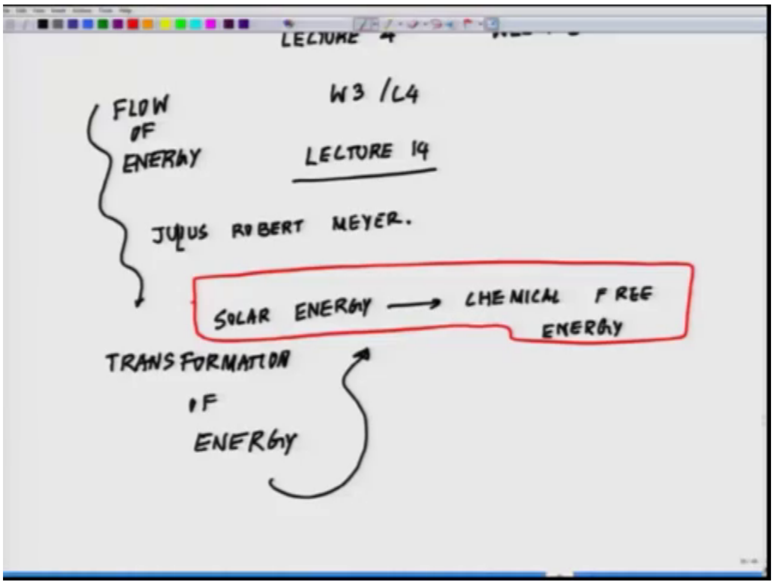

So, W3 and 4 and this is in summary this is lecture 14.

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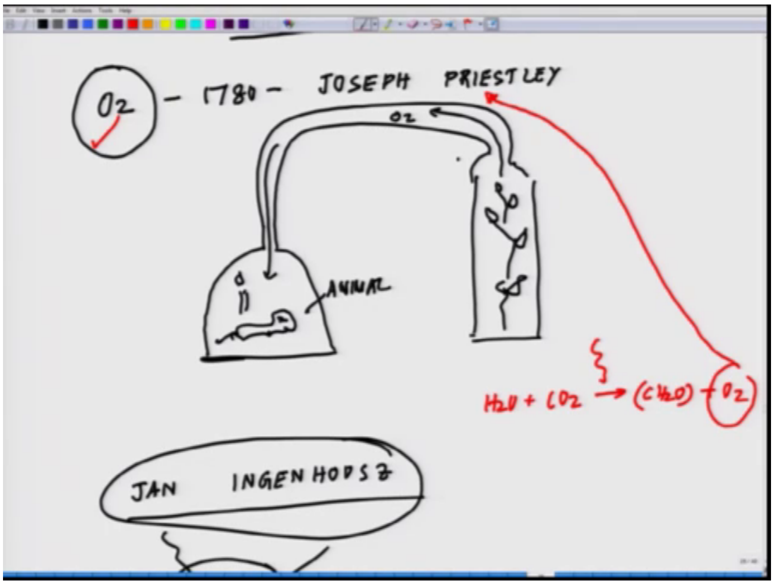

So, as of now we talked about the history historical the discovery. So, we talked about the discovery of oxygen. So, as we remember H 2 O plus CO 2 making CH 2 O which is carbohydrate plus oxygen.

So, oxygen is getting liberated was discovered by Joseph Priestley and this process needs light.

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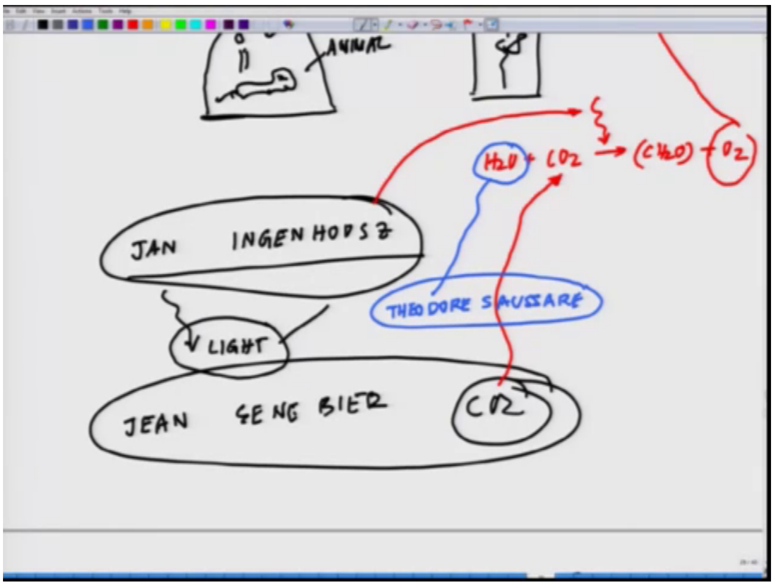

Which was said by Jan Ingen House Jean Sengbier showed that this process needs carbon dioxide that was the discovery of Jean Sengbier and followed by that followed by

Jean Sengbiers discovery, the distinctive contribution was to show that the fixed here namely CO_2 is taken up in photosynthesis. The role of water in photosynthesis was demonstrated by Theodore Saussare. So, role of water by Theodore Saussare figured out the role of water and the final contribution to the basic equation of photosynthesis came nearly a half century, later by a gentleman called Julius Meyer Julius Robert Meyer Julius Robert Meyer

So, Julius Robert Meyer discovered the law of conservation of energy in 1842 and Meyer recognized that plant convert solar energy into chemical free energy, solar energy into chemical free energy. The reason to tell you the history is, that you must have been realizing that like if you are going by the Julius Meyer statement the plant take in one form of power that is light and produce another power which is chemical for the chemical difference.

So, what I wanted to highlight here is, pretty early much earlier, during 18th century itself. The concept of bioenergetics in the life processes is what we are discussing today, through these lectures took it is root. Hopefully, realizing that, there is a perennial source of energy stream of light which is coming which is making this life form survive. So, it means the whole spectrum of life, the whole distinctness of the ecosystem which is surviving.

There is a continuous flow of energy and this flow of energy and leading to transformation of energy. Essentially this is what is contributed why these contributions are becoming textbook is there is a transformation, solar energy to chemical free energy for Julius Robert Meyer to tell that. So, early that tells that these concept of bioenergetics have continuously getting invite what we are formally studying today.

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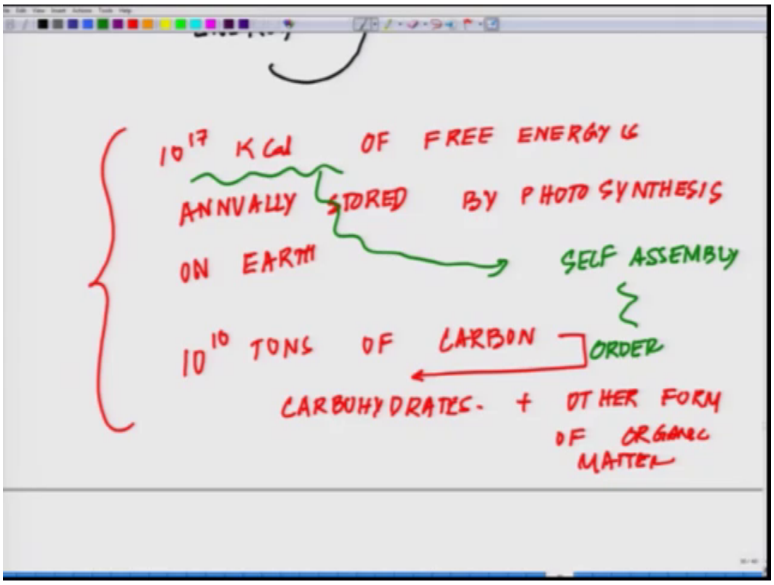

Now, if you look at the natures spectrum the amount of energy stored by photosynthesis is enormous more than 10 to the power 17 kilo calorie of free energy stored annually by photosynthesis on earth. 10 to the power 17 kilo calorie of free energy is annually stored. Store annually by photosynthesis on the floor of earth, which corresponding correspond to assimilation of more than 10 to the power 10 Tons of carbon into carbohydrates and other form of plus other form of organic matter.

So, just this number itself tells you how unique this process it that which has evolved through billions of years. And it has learned to inner transform the huge amount of carbon sources into much more meaningful much more organized structures. So, this is where you see there is an creating an order or a old thing what I have mentioned in the previous classes self-assembly. And this is where the free energy comes into play.

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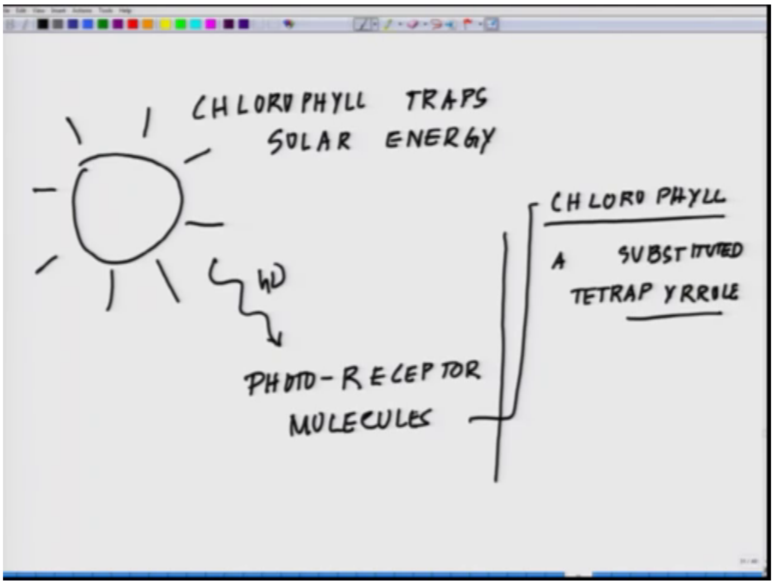

Now, next thing what we are going to discuss is the chlorophyll trap solar energy. So, you need that first source who has the ability to tap trap solar energy or chlorophyll traps solar energy. So, going by my erst words nature has put itself the problem of how to catch in flight light streaming to the earth? And to store the most elusive of all power in the rigid form; what is the mechanism of trapping this most elusive of all powers which is your solar power. How to trap it? The first step is the absorption of light by photoreceptor molecules photo or light photoreceptor molecules.

The principle photoreceptor is the in the chloroplast of most green plant is called chlorophyll. Chlorophyll A substituted tetrapyrrole then we will come to that what does that mean substituted tetrapyrrole. So, if you look at the structure of chlorophyll which is essentially the 4-nitrogen atom of the pyrrole are coordinated to a magnesium atom or nitrogen atom of the pyrrole or is the coordinated compound as soon as I draw the structure it will make sense coordinated to a magnesium.

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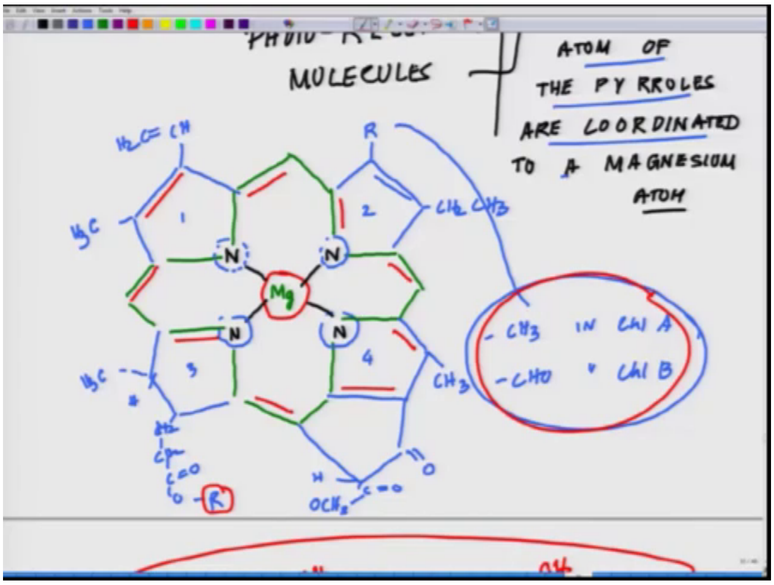

Now, let us put the structure in place which will make more sense is these are the 4 nitrogen which are making a complex with magnesium sitting in the center. And these nitrogen are connected. Now, and then you have now, you have these nitrogen. So, what I said for nitrogen atom of the pyrroles are coordinated to a magnesium? So, this is where the for-pyrrole nitrogen this is nitrogen this is that again this is the 3rd this is the 4th and this is the coordination what it is doing. Then you have out here you have R group which is which varies that R group varies for chlorophyll A and chlorophyll B.

The molecule which is trapping the sunlight which is minus minus CH3 in chlorophyll A and minus CHO and chlorophyll B and you have CH2 and CH3 out here, then you have another CH3 out here and there is one small mistake I did while drawing this. Let me just correct it, 1 second there is a small mistake.

This is this is the mistake I did this is where your oxygen is connected, this is where you have the CH3 which is connected and out here; however, something slightly tight because I have to draw it in a OCH3 and you have a hydrogen here and out here, on this third ring if you look at it if I number them 1 2 3 and 4 to fill. In that context, if you look at here it is a CH with CH2. Here, you have CH3, here you have CH3 and there you have CH2 CH2 OO O and there is an R group I will talk about R group words hat R group is this R group we will talk later it is a complex structure it is taking a bit of a time to really put it across.

That is pretty much is the structure. So, you have a magnesium sitting at the center.

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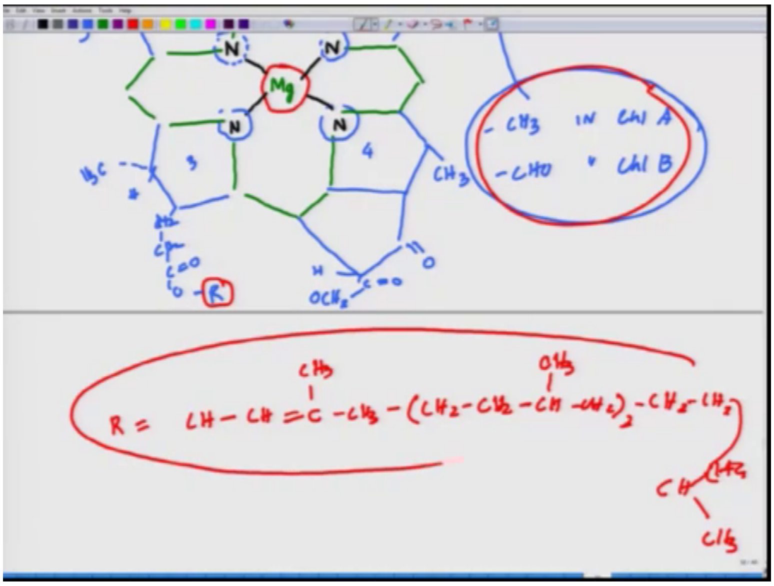

Now, that R Group what I mentioned is equal to yeah CH2 CHC CH3 and you have CH2 then you have CH2 CH2 CH CH3 CH2 CH2 CH2 CH2 and then you have a CH here and then have the methyl group attached to it CH3.

So, this is basically the form formula for chlorophyll A and chlorophyll B. Now, another distinctive feature of chlorophyll is the presence of a phytole a highly hydrophobic 20 carbon alcohol esterified to an acid side chain. So, you see there is a phytole group which is present and chlorophyll B differs from chlorophyll A is having a formyl group in place of a methyl group on one of the pyrroles.

So, this is what I wanted to highlight about chlorophyll A and chlorophyll B and apart from it chlorophylls are very effective photoreceptor, because they contain a network of alternating single and double bonds. So, if you look at this whole structure this is what is the beauty of these kind of structures. They have a lot of single and double bonds. So, if you if I start putting all the bonds out here. So, this is a double bond, this is a double bond, this is a double bond, this is a double bond.

So, these kind of structures in nature are invariably are very good light trapping agents. So, most of the people who synthesize these kind of molecules rely on this factor to have an alternate single and double bond structure which helps them. Do you know, obtain this kind of alternating single and double bond and such compounds are called polyenes.

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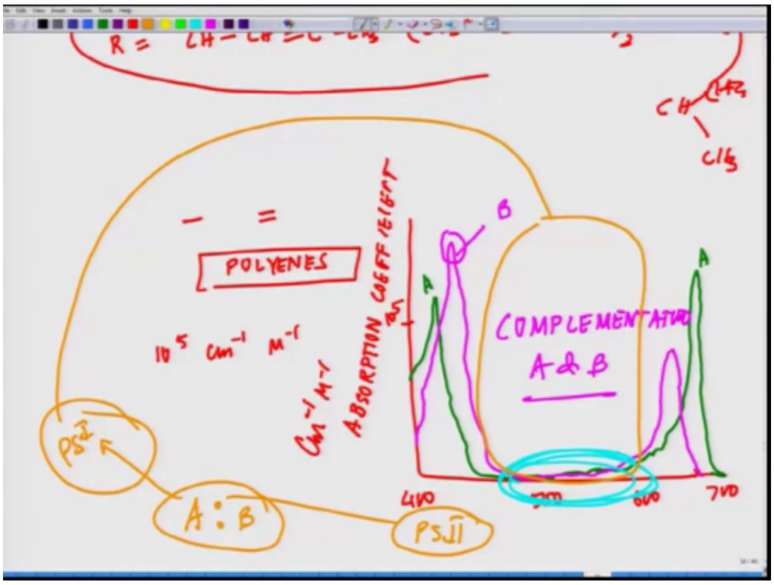

This is the word for that such alternate single and double bonded structures these are called polyenes. So, they have a very strong absorption band in the visible region of the spectrum, where the solar output reaching the earth also is maximal. The peak molar absorption coefficient of chlorophyll A and B are higher than 10 to the power 5 centimeter. Among the highest observed among the organic molecules and if I draw the spectra of it the spectra is something like this. Subs option coefficient coefficient which is starting at 400 and in the visual region 500 600 700 and this is around 10 to the power 5. Now, if you look at chlorophyll A Chlorophyll A s absorbance is something like this.

400 then it falls down it is a very unique kind of thing and then it reaches. This is for chlorophyll A the green color and for chlorophyll B it is slightly different. So, the chlorophyll B is a spectrum and what are the significance will come later into that? Something like this, again it follows the same pattern this is chlorophyll B. So, because of that small change the chlorophyll A and chlorophyll B has a different absorption of spectra the absorption spectra of A and B are different and the light that is not appreciably absorbed by chlorophyll A at 460 nanometer.

For example, is captured by chlorophyll B which is intense absorption at that spectrum. So, if you look at it at 460 and about if I put this as the 460, where you see chlorophyll B is doing better than chlorophyll A. So, thus these 2 kind of chlorophyll complement each other in absorbing the incident light. So, this kind of a complementation of A and B so, they are complementing each other in absorbing light and the spectral region from 500 to 600 is only weakly absorbed by this chlorophyll. And this is something very strange, if you look at this part there is hardly any absorbance taking place at that point, but this does not pose a problem for most green plants. By the contrast the light is often a limiting factor for cyanobacteria or blue green algae and red algae.

Because they possess accessory, the way it is being done the spectral region between 500 and 600 is only weakly absorbed by this chlorophyll, but this does not pose a problem for most green plant. By contrast light is often a limiting factor for cyanobacteria blue green algae and red alga will discuss about this matter why is it so?

Especially these plants possess accessory light harvesting pigments that enable them to trap light that are not absorbed strongly by the chlorophyll or photosynthetic organism lying above them. So, essentially this is the region where several accessory pigments could be helpful to absorb light.

So, we will come into this aspect that where this whole complementation thing starts in the chlorophyll and chlorophyll B. As a matter of fact, just to give you a hint photosystem consists of 2 parts photosystem 1 and photosystem 2 this photosystem 1 and photosystem 2 are 2 light harvesting spots or you can call them the hot spots of light harvesting. These 2 spots have differential composition of photosystem A and photosystem B. In other word there is different ratios say for example, if I put A as B as a ratio. So, there is a ratio of photosystem in photosystem 1 they have a different ratio as compared to photosystem 2. And this difference in the ratio leads to different from from flight absorbance at photosystem 1 and photosystem 2.

Will come later and once you enter into the photosystem 1 and photosystem 2, but I wish you to really look at this wonderful molecule, which nature has evolved just imagine how much orderliness nature has done? To synthesize a molecule like this and this is what I always been pointing out all throughout the course. There is an order out of chaos things have been put in an order. By some self-assemble forces and that is what the energetics is all about by energetic, where energy has been used to make extraordinarily beautiful molecules. I will close in here, in the next class, we will move on with the photon absorbance and the reaction centers.

Thank you.