Nanobiophotonics: Touching Our Daily Life
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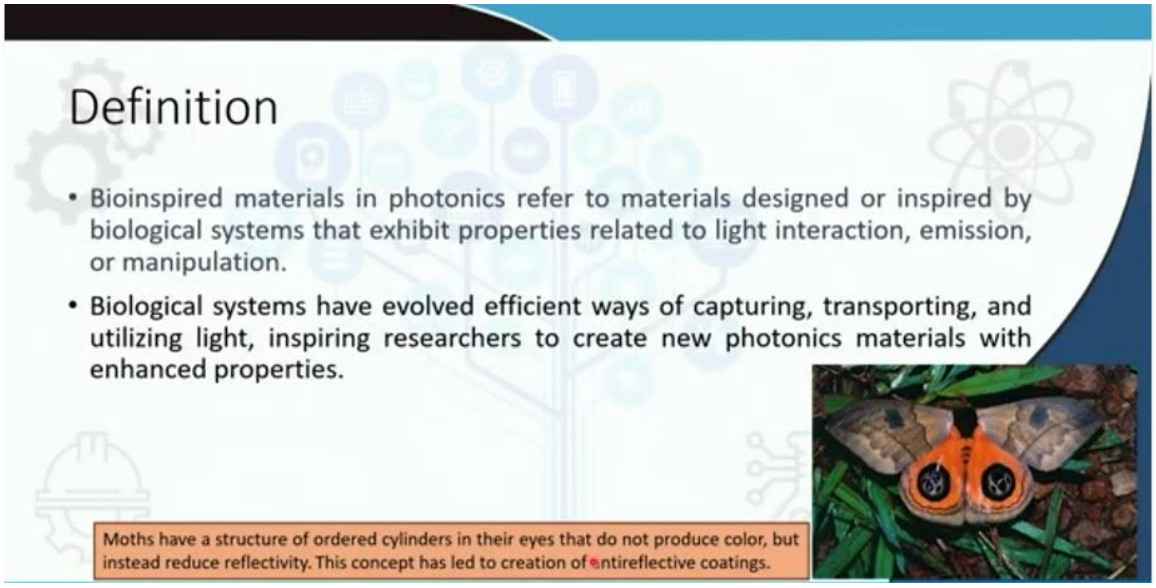
Lecture No. 58
BIOINSPIRED MATERIALS

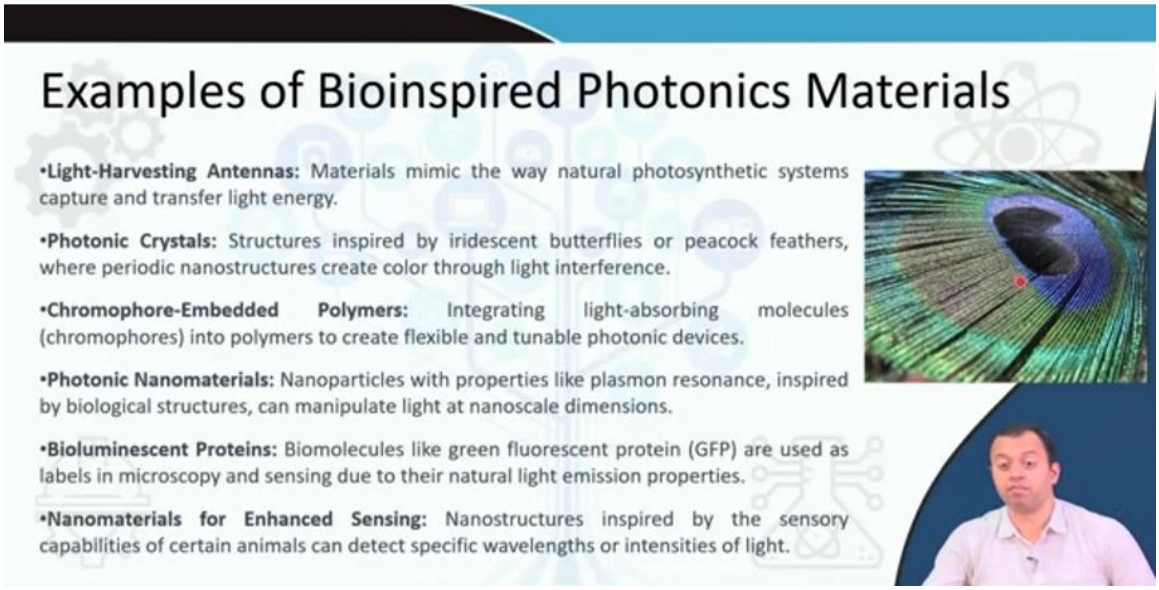
Hello and welcome. So, we are still thinking about the future, the future of nanobiophotonics and today let us discuss bio inspired materials. Bio inspired materials in the sense that the material can be artificial it can also be natural, but it can be artificial mostly inspired by the hierarchy, the organization, the complexity and the variety that is available in naturally existing material.



So, let us get into it. So, as I was talking about butterfly wings in previous lectures, bio inspired materials in photonics refer to materials designed or inspired by biological system that exhibit properties related to light interaction emission and manipulation. Biological systems have evolved tremendously, the complexity is simply mind blowing the complexity of this of this moth's wing as you can see that different color, the different organization, the different structure none of them are because of some chemical dye has been used.

It is simply the nano structure is such that it is reflecting a particular light and rest of the lights are all destructively interfered killed off. Closely under the microscope they will probably look black and white or grayish or something like that, but when you look from a distance several bombardments of light produces a particular color. Look into them with one particular wavelength of light which basically you can do it in a microscope

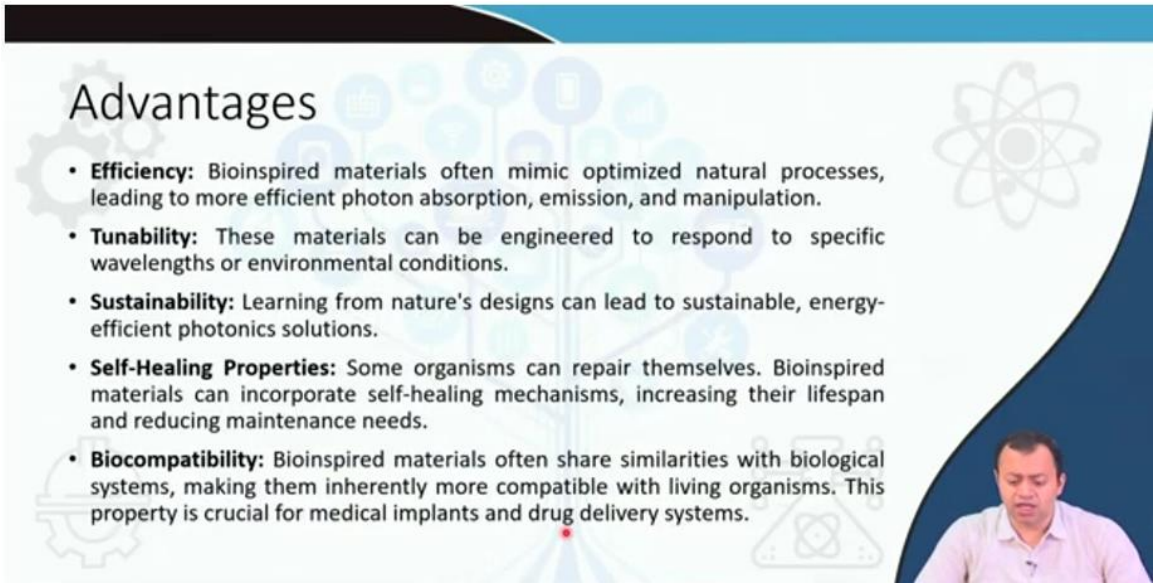
specialized microscope nonetheless and you will be able to see the inherent nano structures. So, moths have a structure of ordered cylinders in their eyes that do not produce color, but instead reduce reflectivity this concept have led to anti reflective coating as well.



So, this is another such example many of you have seen or use it or probably have it is available the wings of peacocks yeah national bird peacock and it has this wonderful color and it is not because of the presence of any dye it is because the structure the nano structure here is different than the nano structure here and this is different from this. Each nano structures allows only a particular wavelength of light to survive thereby this is blue this is whatever color you call it yellowish something grayish yellowish this is well I am partially color blind. So, this looks green to me. So, you decide what it is different shades of blue different shades of blue green whatever. So, the organization of these nano structures are not random they are in a particular pattern.

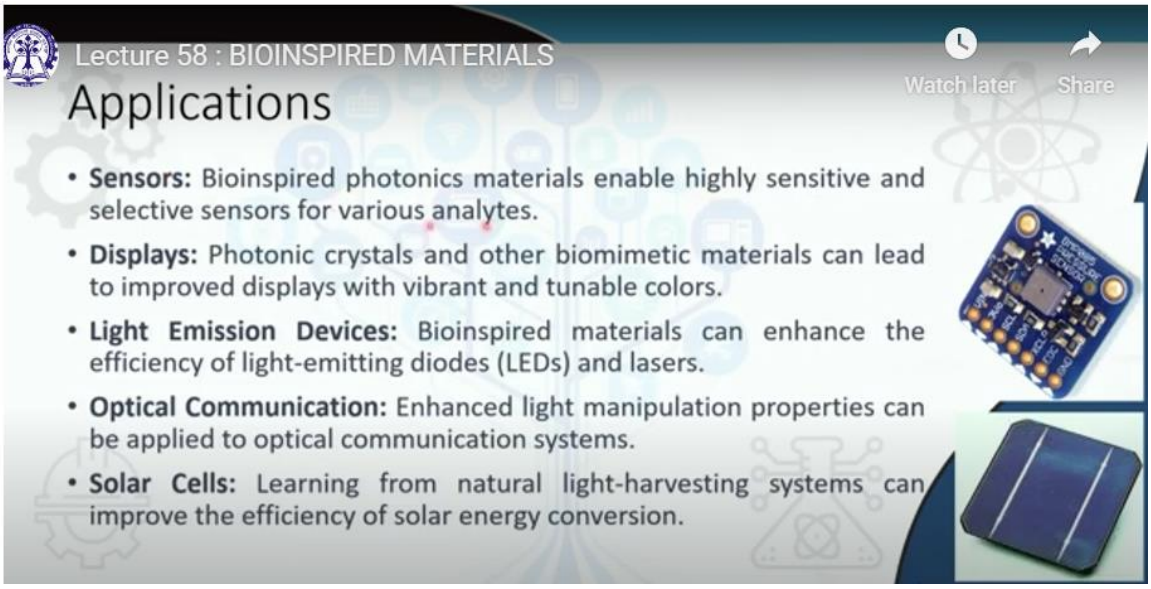
So, that the articular overall pattern particular design and overall design exist inside the wings of a peacock and we can utilize this organization this complexity for various application light harvesting antennas materials mimic the way natural photosynthetic system capture and transfer light energy. Photosynthesis basically capturing the light and converting utilizing that light to create oxygen at the end it is a photochemical reaction right photosynthesis can we artificially do it getting inspired by photosynthesis that small lamellas the plant cell the leaf cells do can we artificially make a photosynthesis in a chip. We have photonic crystals obviously, we discussed this chromophore embedded polymers integrating light absorbing molecules into polymers to create flexible photonic devices photonic nano materials nano particles with properties like plasmon resonance inspired by biological structure can manipulate light at nano scale dimension bioluminescence properties molecules like GFP and nano materials for enhanced sensing nano structures inspired by this sensory capability. So, for example, this is this nano structure is

specifically suitable for reflecting blue light we mimic that create an artificial material that will only work at blue light and then try to utilize it as some sort of a sensor some sort of a sensor and try to look into the different wavelengths of reflected by some some some other material utilizing it as a sensor.



The advantage as I keep on saying are plethora number one being biodegradable eco friendly, but having said all of that they are highly efficient the most important thing is efficient I keep on saying think how efficient your body is how much amount of signal your brain is processing per second how much amount of input at a time your brain is capable of handling plethora of sense organs it is talking about light it is it is processing light it is processing sound simultaneously at the same time there is touch there is smell and then it is all processed and finally, converted into some sort of a memory or some sort of attention some sort of concentration.

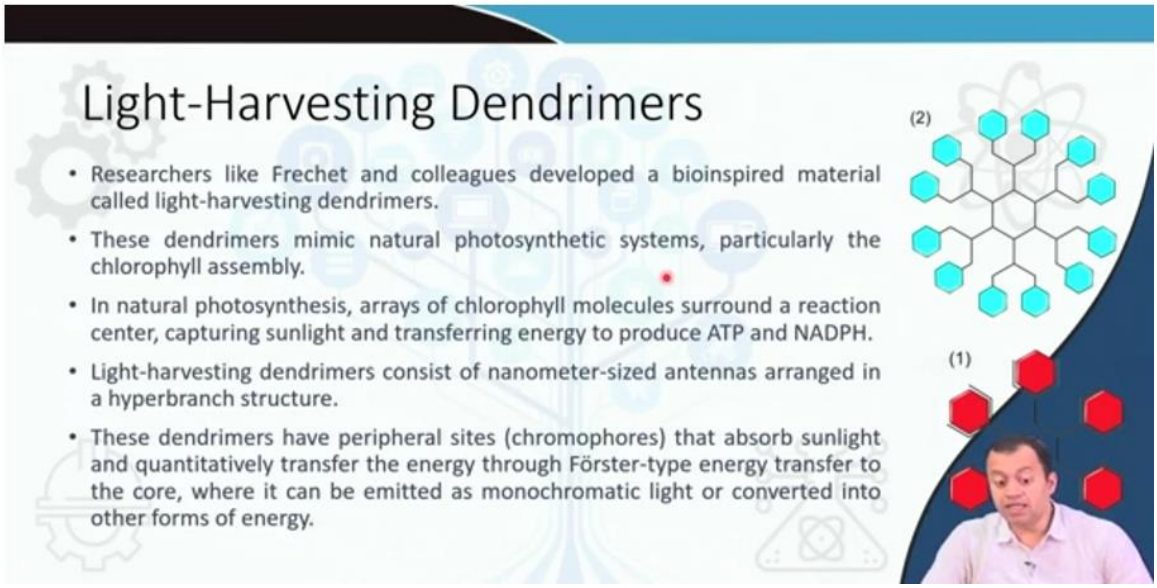
So, that the entire concept goes in. So, if this is not efficient what is efficiency how many computers do you think can be this efficient processing wise simply from a processing standpoint different types of data all process together computers can only process one type of data in the form of 0 and 1 yeah it cannot process different types of data give any anything to computer processor it will convert it into 0 and 1 and that is that is what you are getting. Anyways tunability these materials can be engineered to respond to specific wavelengths sustainability learning from natures design can lead to sustainable energy efficient photonic solutions self healing properties another thing some organisms can repair themselves bio inspired materials can incorporate self healing mechanism and of course, biocompatible bio inspired materials often share similarities with biological systems making them inherently more compatible with living organism.



Applications as I was saying you can make large number of sensors bio inspired photonic materials make highly sensitive and efficient sensors you can have displays photonic crystals and that that thing that you just saw the wing of a peacock can we make nanostructures and make a display with variable tunable colors

without having any chemical involved. Light emitting devices LEDs bio inspired materials can enhance the efficiency of light emitting diodes optical communication enhance light manipulation properties can be applied for optical communication I read a paper about from from I think Harvard Marco Loncher's group where they were discussing about on chip communication photonic crystal photonic wire based on chip communication and there was some sort of inspiration from biological materials.

Solar cells learning from natural light harvesting systems can be improved the efficiency of solar energy conversion of large plethora of solar energy is not absorbed only a small plethora is observed that is converted into electron hole pair in solar cells, but using these kinds of different nanostructures not only you can increase the absorption, but also make a variety of wavelength variety of light all the 7 colors infrared ultraviolet being absorbed and thereby converted to electron and hole pair. Light harvesting dendrimers.



So, dendrimers are these you know branch like molecules which has a core type structures and then they branch out they have a core type structure and then they branch out and this branch then opens into several branch. So, it is it is like this. So, researchers talking about these kinds of branched small molecules for for making artificial photosynthesis in natural photosynthesis arrays of chlorophyll molecules do these various biochemical reaction photobiological reaction the idea here is to make utilize of these molecules in chip and thereby create artificial photosynthesis artificial photosynthesis where presence of light will give oxygen yeah.

So, light energy is converted to oxygen. So, several different things are going up and the work is still under process maybe in 5 to 10 years you will see remarkable development in some of these areas some not all some areas will get lost and several new areas that I have not covered might come up this is simply looking into the future and trying to make a forecast.

So, in conclusion bio inspired materials draw wisdom from natures design principles by replicating natures optimization these materials often exhibit far improved properties than than what we can think of and create bio inspired materials transcend boundaries finding utility in photonics medicine architecture and beyond there is a building it is not part of nano bio photonics there is a building in I think Spain or somewhere where they try to mimic ant hill you know ant mole ants come together and prepare some sort of a colony usually underground or nearby some place where they live and that remains cool. So, people took inspiration from that and created a structure created a building which has

ant hill ant mole hill like structure and they found out that it is naturally cooling even at hot sun the interior of the building is naturally cooling. So, architecture have already utilized some of the design present in you know beehives or ant mole hills etcetera ant moles photonics why should photonics remain behind.

So, this is the end rhymer stands as remarkable example of precision in polymer design boasting intricate branching structures through controlled synthesis.

So, these are the concepts that I covered today and these are my references please go for

current opinion in chemical biology this is a fascinating paper that I read

light harvesting end rhymers by Balzanis also quite nice. Thank you very much.