Nanobiophotonics: Touching Our Daily Life
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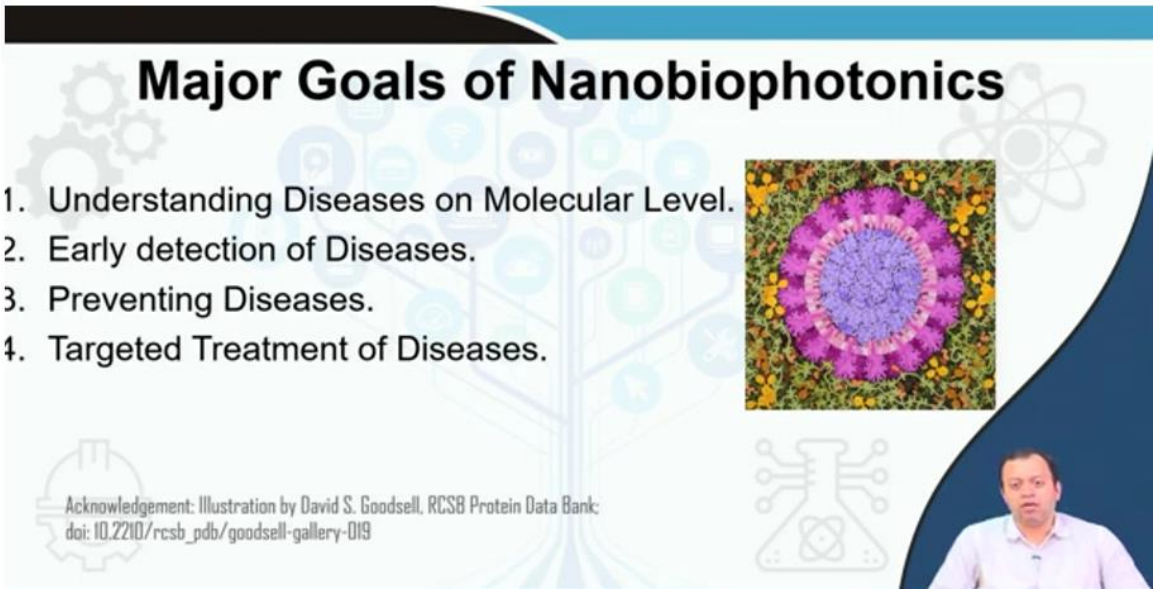
Lecture No. 60
Summary & Revisiting Few Topics

Hello, and welcome. This is probably the last time I will be saying that in this course because we are at the very end drum roll please. This is the last lecture of the course of nanobiophotonics where I will simply present a summary and I will revisit one or two topics and thereby it will be adios, it will be goodbye from my side. So, that after having been a complete knowledge almost substantial amount of knowledge no knowledge is complete you can go on in your own merry way and try to decide how to utilize this information that I have tried to impart you on to your future endeavors.



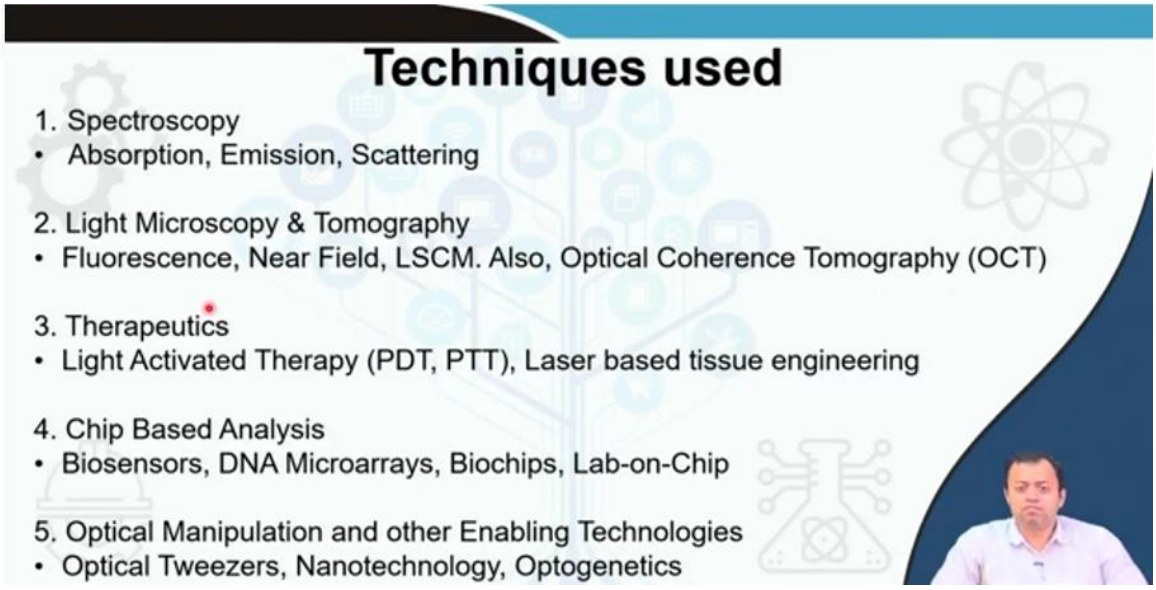
So, what were the major goals of nanobiophotonics? The major goals of nanobiophotonics were actually understanding a disease at a molecular level right. Thus far the problem that medicine suffers from is that it has become too much symptomatic.

You go to a medical professional a doctor because you have a fever or some other kind of ailment, the doctor measures the temperature, the doctor takes tries to do some test and based on that symptom clinical symptom prescribes a medicine. But what exactly is your body going through when you have a fever? Now almost all disease has some sort of a feverish reaction right. Malaria has fever, dengue has fever, covid has fever, sometimes cholera and diphtheria bring in fever, influenza has fever. So, can we not try to understand

what exactly is happening at an individual molecular level to describe the disease or describe the fever is? Fever is common in almost all diseases right.

You get the similar amount of temperature 101, 102-degree Fahrenheit and so on and so forth. But what exactly is happening at a molecular level in your body? Is it because of a pathogen has interacted? Is it because your own body is going through some kind of an immuno response? Is it something else? We need to understand the disease at a molecular level. Of course, if we are able to understand the disease at a molecular level, we have been able to detect the disease at a very very earlier stage at certain cells have had been detected, certain couple of cells have had been detected or certain subcellular organelles have been detected and that will help us treat it much easily and in a much faster and rapid manner. And from that can we prevent the disease from spreading? We localize the disease to certain cells only and the worst-case scenario remove couple of these cells, your body is robust enough to replenish to create new cells in its place and then you know create it heal it completely without having any scar left. And of course, a targeted treatment of disease.

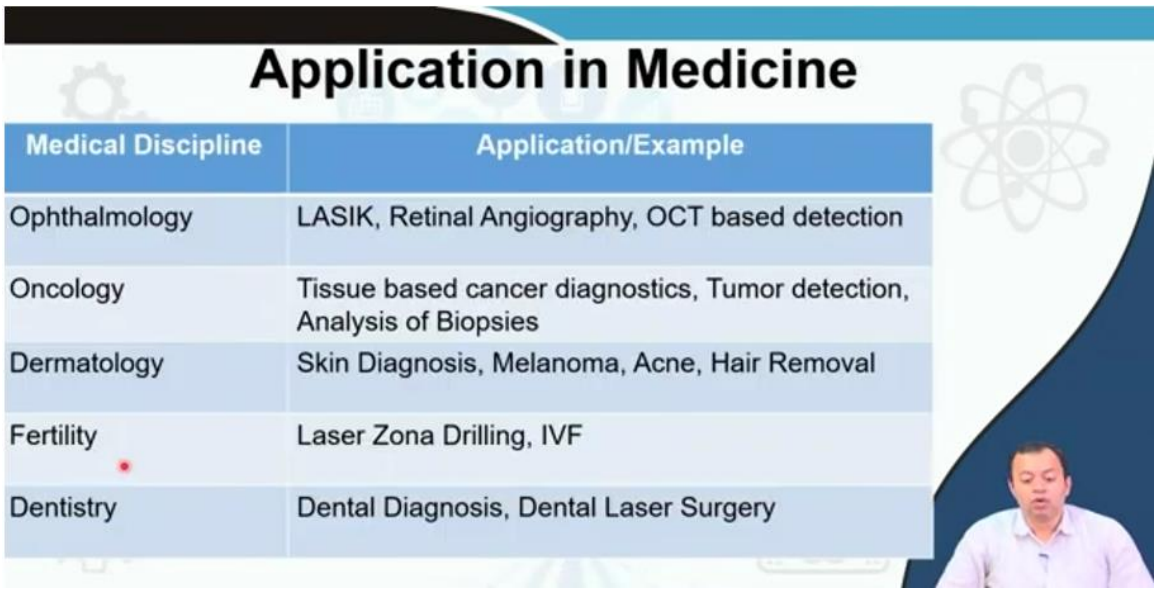
Suppose we have identify the presence of a particular pathogen in a certain corner of a cell of your body, we are precisely targeting that cell that pathogen at that specific place instead of you know sending medicine all over the body either by injecting it through blood vein through your veins or by consuming tablets which will then get digested and then mixed with the blood stream and what not there by spreading all over the body. Yes, we have got pharmacology has pharmacy pharmacology has increased tremendously and as a result we can precisely target certain areas of the body, but can we target individual cells inside a living dynamic body.



So, these are some of the major goals that nanophotonics want to understand, want to achieve and want to you know avail itself avail itself for that. And because in order to do that we use a plethora of techniques bio nanophotonics, nano biophotonics takes borrows ideas and technologies from vastly different field it is an interdisciplinary subject. So, we utilize spectroscopy tremendously both absorption emission and scattering, scattering is Raman emission is fluorescence, absorption is of course, FTIR infrared absorption spectroscopy, we use light microscopy and tomography and entire module was dedicated for microscopy of the brain, you have fluorescence microscopy, near field microscopy, laser scanning confocal microscopy, optical coherence tomography etcetera.

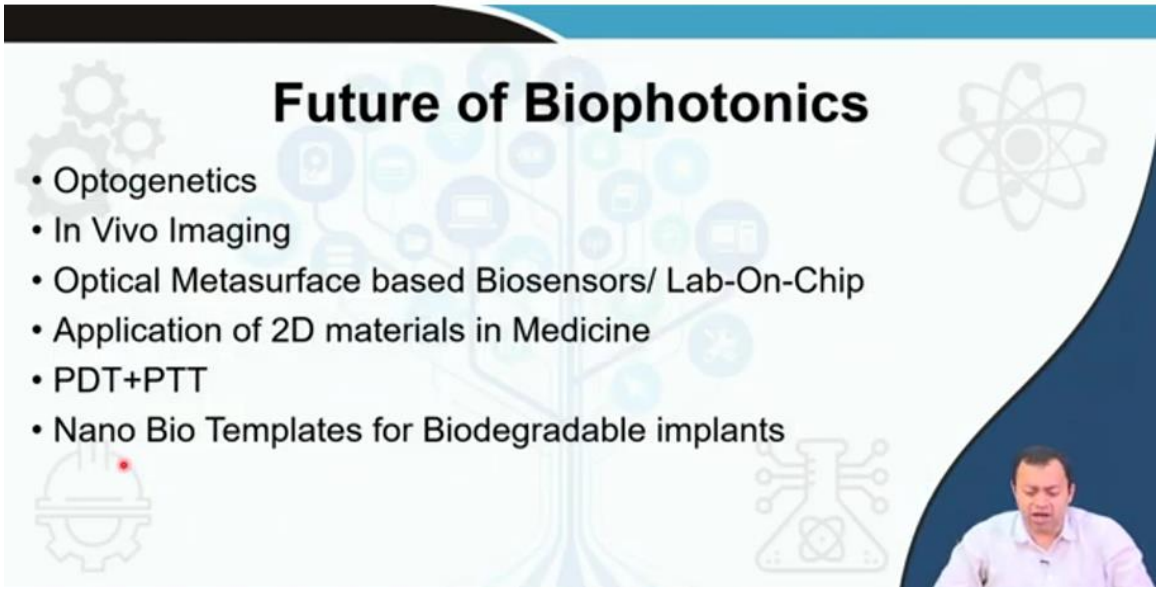
Not only you want to see image understand, but we also want to interfere we want to modify and we want to produce cures and thereby we have light activated therapy, where you have photo dynamic therapy, photo thermal therapy, where you inject nanoparticles. These nanoparticles create some kind of a reactive oxygen species, those reactive oxygen species either you know eat up tumor cell or they can simply upon absorption of light these nanoparticles emit heat very very localized heat and this heat then burn the nearby area thereby destroying pathogens or cells that has been affected by pathogens or tumors that has that has that has metastasized. Of course, you can directly put laser-based tissue engineering a high intensity good enough laser that could be utilized for contouring the tissue you will see that in eye, lactic surgery similar type of other surgeries like hair removal, tattoo removal we are utilizing it for IVF fertilization, artificial fertilization all of those things you can directly use laser. Then of course, comes the very hot topic of sensors, we can have biosensors I told you electromagnetically active nanostructures they will have a specific electromagnetic response and upon their interaction with a biological molecule their response change and the change of response is directly related to the species that it has detected thereby it can it can be utilized as a sensor. We have discussed a lot about DNA microarrays, biochips and so called lab on chips these microarrays are the future we can have large number of areas with complementary DNA that will be attaching large number of external DNA if it matches then it attaches if it does not match if the covalent bond is not there it can be washed away.

So, you can thereby see from the fluorescence which one is quenched which one is present those areas which are quenched you can thereby say that a particular DNA species have been found and thereby you can identify a particular pathogen. This has been utilized significantly this has been utilized significantly in the last few years for large scale um coronavirus strain infection detection. Then of course, you have optical manipulation and enabling techniques optical tweezers we discussed you can noninvasively pick up a particular molecule group of molecules a particular cell group of cells put it at any localized place nanotechnology and optogenetics where you use light to modify genes of a living organism right.



Bio photonics bio nanophotonic find application in medicine, ophthalmology, lassac, retinal angioplasty, OCT based detection, oncology that is cancer detection tissue-based cancer diagnostic, tumor detection, analysis of biopsies. I told you we work directly on analysis of biopsies tissues using Fourier transform infrared spectroscopy, dermatology skin diagnosis, tattoo removal, hair removal, acne removal, rejuvenation of skin you you dry away the moisture content thereby the skin become more you know robust rigid tight and thereby you look younger.

Fertility laser zona drilling IVF um in vitro fertilization where you artificially fertilize the ovum and the sperm and the zygote that is formed is then transplanted into the uterus of the mother and thereby you have you have full reproduction you have full pregnancy. Dentistry is also being used dental diagnosis and dental laser surgery where you can you know try to try to detect either oral lesions some types of mouth cancer you can also do um dental surgery and cosmetic surgery related to this is also also also possible.

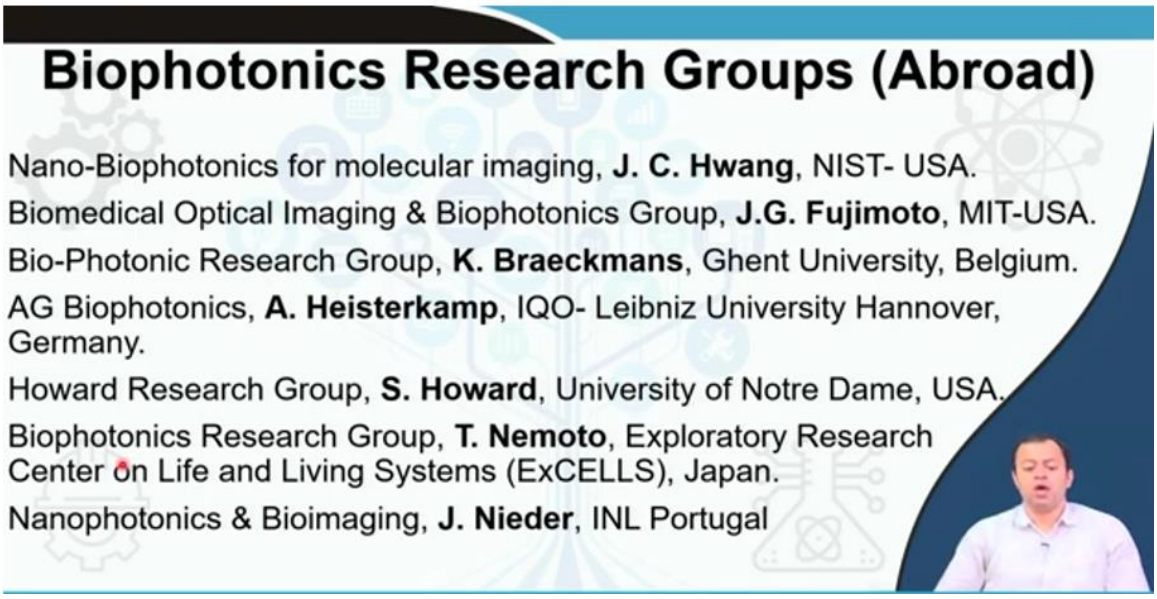


So, what is the future of biophotonics or future of nanobiophotonics? Optogenetics and neurophotonics is going to be my bet. So, in the future overall neuroscience is going to take over. Neuroscience will be one of the prominent areas because neuroscience is so diverse all of you have heard of artificial neural network or computational neuroscience trying to mimic the brain of trying to do calculations.

So, neuroscience if you have to ask me one area in general where you know more amount of investment research and development should be should we should be looking at is neuroscience and of that neuroscience my bias my opinion these are not fact these are opinions. Opinion will be towards optogenetics and neurophotonics where light is being used to understand brain modified brain mimic the brain. Of course, in vivo imaging live imaging from molecular level to the whole-body whole organ optical meta surface-based biosensors the biosensor should be more and more going to be sensitive where single molecule detection you just saw single molecule detection in the previous lecture single molecule detection. Two dimensional material are coming up very strongly, but the application of two dimensional material in medicine is still an nascent field it is still a growing field and I have yet to be convinced that two dimensional materials are something extraordinary when it comes to medicine in biology of course, they should be, but the research robust research on this regard application of two dimensional material in medicine especially optomedicine or bio photonic medicine has to be done by large number of groups working very very seriously very very cogently and I am asking some of you to look into this matter. Of course, a combination of photo thermal therapy photodynamic therapy combined it is purely therapeutic another thing that has recently come into my attention is differentiating stem cells you know stem cells this proto cells well technically proto cell is not the right term, but pluripotent multipotent stem cells they can differentiate into different types of cell same stem cell can differentiate into liver cell kidney cell blood

cell skin cell etcetera can you control it can you control it the idea here is to utilize nanoparticles and try to control by various means the presence of nanoparticle either on the surface or inside those stem cells and trying to control where it will differentiate into.

So, that is something that is coming up application of nanoparticles in stem cells and trying to see if we if we can control it is differentiation. Of course, what we read in last module nanobio templates for biodegradable implants you utilize biopolymers based on nanobio templates and then use some sort of a biodegradable implant implant made up of biological material bio inspired materials and you put it in the implant some kind of a pacemaker or some kind of implant in head that has similar properties at the present day printed circuit board based pacemakers, but after certain time I mean it is not that harmful or it it it will be attached with the part of the body and some after a later period it can it can it can simply degrade itself.



So, what are the biophotonics research group I have take specifically put biophotonics research group because this give me more hit more search than nanobiophotonics research group I have divided it into both nanobiophotonics group abroad as well as nanobiophotonics group in India right. So, if you are interested in nanobiophotonic research I strongly suggest that you could look into the research being taken by research being done by few of these groups by no mean I know them individually or I am recommending them they do not need my recommendation they are working tremendously and some of their work are you know the very best these are some of the groups that I follow to see what kind of research they are doing and I can recommend them to you. If you are looking for higher education, if you are looking for PhD or if you are just curious some of the works done by these groups abroad are fantastic.

There are equally good people both inside the country who are doing good work I will I will let them the next slide is for them. In abroad J C Huang's group at NIST USA National Institute of Standards and Technology they work in bio nanophotonics for molecular imaging they are the people who are looking for single molecular imaging single molecule detection single molecular imaging. So, please follow this Fujimoto group at MIT USA Massachusetts Institute of Technology biomedical optics research group and biophotonics group biophotonic research group at Ghent University Belgium I had a good fortune to visit Belgium and Ghent University, but I missed visiting their group. Libsnes University Hanover in Germany has this gentleman Hester Kump for biophotonics Howard group at Notre Dame very good work try to look into look into their work. It is the variety that professor Howard brings it is not just you know bio imaging or PTT or PDT it is it is it is a combination of several several work.

Nemoto work nemoto group at Japan biophotonic research group at the same time Jana Naiders group at Institute of Nanotechnology Portugal where nanophotonics and bio imaging work is being done they are working on diamonds nitrogen vacancy in diamonds and what not this is also very very interesting. So, all of them is somebody I follow you do not necessarily have to follow them you can follow your own biophotonics research group these are some of the one which has which which which which is quite popular they have large number of very interesting paper interesting for me. So, this is just an opinion this is just an opinion this under no circumstances is an endorsement or advertisement of any particular group I like this group because of the type of work that they have done I I myself personally find them find their work very very interesting and I am asking you to check it out if you do not like completely ok you might find far better group which aligns better with your own interest. So, it is just a mere suggestion. Similarly there is this group of you know fantastic research institutes as well as research groups inside India I am personal fan of professor Maiti at Tata Institute of Fundamental Research the work done is outstanding no doubt about this professors Maitis work at TIFR is outstanding.

IIT, Dharwad, ISR Kolkata has professor Nirmal Logosh and professor S P Singh bio optics and nanophotonics work is being done tremendously integrated bio photonics laboratory of S P Singh at IIT, Dharwad is doing some very good work Asima Pradhan at IIIT Kanpur her work is top notch then apart from certain groups handled by individual professors you have a center a laboratory multiple professors multiple researchers together. IIT Madras has this bio photonics lab at the department of applied mechanics and this is also quite interesting Mahi, Manipal Academy of Higher Education has a center for bio photonics they have a center. So, multiple number of people multiple groups working all together complementing each other's work and creating very good paper I I one of their paper got published I think in nature I was very very impressed by the work done at the bio photonics lab of Manipal. Then you of course, have bio photonics laboratory at national center for earth science Thiruvananthapuram Puram Kerala I have less interaction with them, but I assume they are also at at at the very high standards. And finally, I would like to bring your attention to my own research group I have my own research group of nano bio photonics at IIIT Kharagpur and these 4 or 5 people that you see these are the people I have the privilege to call my student and it is a completely interdisciplinary group of which I happen to be the P I.

Souvik is a PMRF fellow also happens to be the teaching assistant of this particular course. Souvik is from a physics background I have he is working on virus and pathogens trying to utilize light for detection of virions viral viral particles. I have Pranav who is electronics engineer who is working on oral cancer. I have Karthik who is a dentist MDS doctor who is also working on imaging he is working on meningitis and plural fluids and tuberculosis and what not. I have Subhanita she is a microbiologist her expertise is needed on a daily basis she is also an expert in molecular dynamics.

I also have Anagha has recently moved, but her work is top notch she is also from physics background basically quantum mechanics background and her work on both molecular dynamics artificial intelligence density function theory as well as her expertise in biological matter is unprecedented. So, this is our group logo this is our group website if you want to know more about my own research my own group please visit this lab you will have much more interaction much more information. We are also quite fortunate to get funded by national institutes national research bodies such as science and education research board SCRB Indian council of medical research ICMR department of science and technology DST so on and so forth and this is where we exist this happens to be my group. If you are interested in nano bio photonic research if you have your own idea feel free to contact me I would be available and if you are so willing to pursue higher education please feel free to go into the PhD entrance criteria of IIT Kharagpur. If you are eligible I would strongly suggest you apply and if you are able to clear the entrance exam obviously, like any other institute IIT Kharagpur also has its own rigorous PhD entrance examination followed by personal interview and from that if you so choose if both sides finds its necessary you can be among this group.

This group contains students colleagues collaborators and partners whom I am privileged to work with every single person here is a gem is someone interacting with someone helps

me increase my own knowledge I get to learn from them rather than they learning from me. So, with this I thank the course of nano bio photonics I wish you all the best in your future. Thank you very much.