Nanobiophotonics: Touching Our Daily Life
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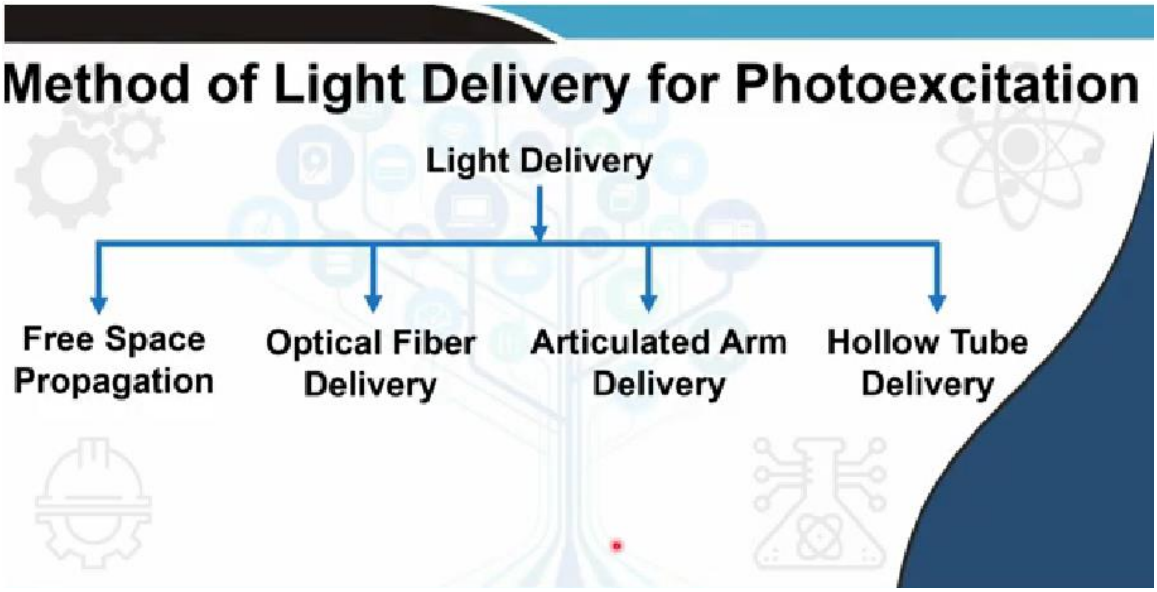
Lecture No. 33
In Vivo Photoexcitation

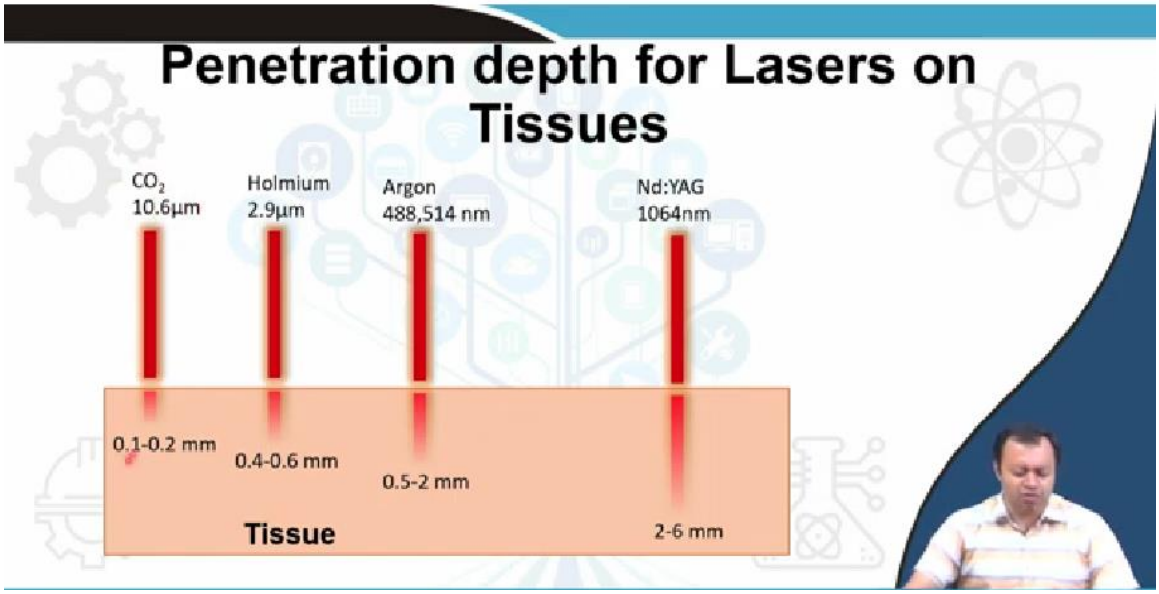
Welcome back. We are discussing Lasers and in the previous two chapters you have seen ah the basic idea of how laser is generated and secondly, the bizarre notion of non-linearity. In today's lecture we are going to discuss about the how to put lasers inside the human body. At the end of the day you need to utilize laser for various medical applications. Here we will try to see how lasers can be brought in close contact with human body or any other ah mammalian self, mammalian body and what are the different types of applications you can utilize by using laser in medical field. Now let us understand this.



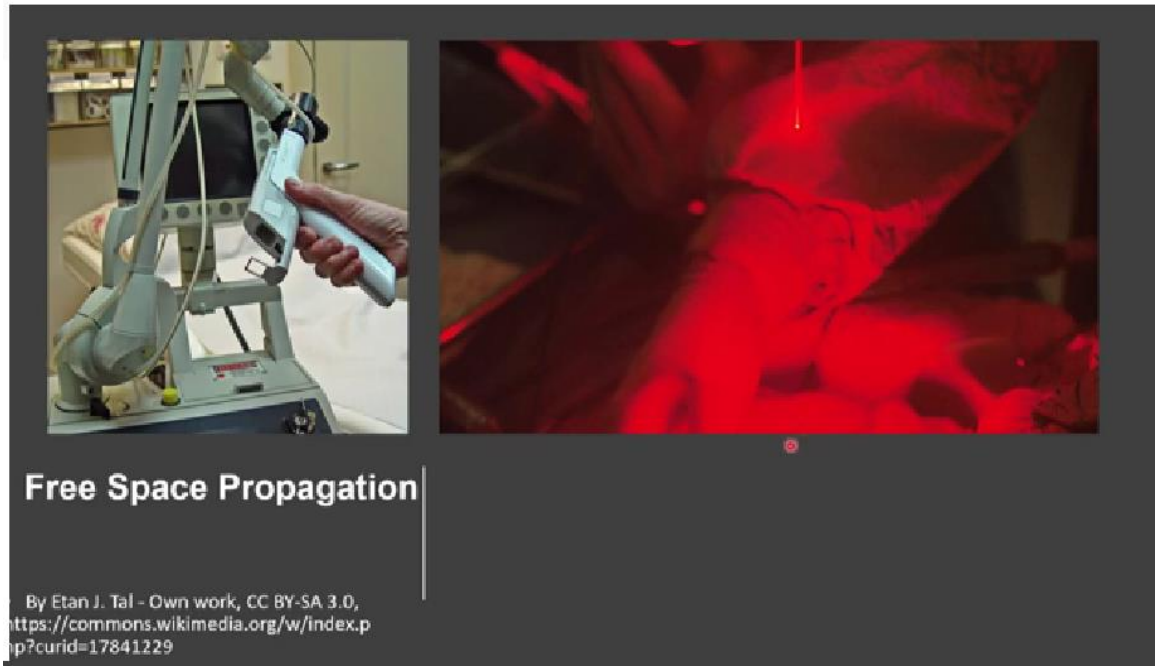
So there are four ways in which you can bring in light close to human body which will result in photo excitation. Light will excite a particular area, particular section, particular region of the body which will result in some sort of a chain reaction. So, light can be delivered into the human body either free space propagation, free space propagation is where the medium is simply space you illuminate a person's body with light shining torch light onto a specific area, shining laser light onto a specific area, free space without any medium. Then there is optical fiber delivery you utilize or you send light onto a specific region of the body using optical fiber that optical fiber goes either inside the human body or very very close to it.

Then there is articulate arm delivery, articulate arm is basically a robotic ah mechanical mechatronic structure that brings in light very close to the human body and then there is

of course, hollow tube delivery, ah hollow tube that ah delivers light using sets of lenses etcetera and light could be could be brought here when I am talking about light I mostly mean laser light laser light very very close to the human body. Now why do you need that because different types of lasers have different penetration depth when it comes to tissues. So, like for carbon dioxide laser working at 10.6 micrometer it can penetrate the tissue of 0.1 to 0.

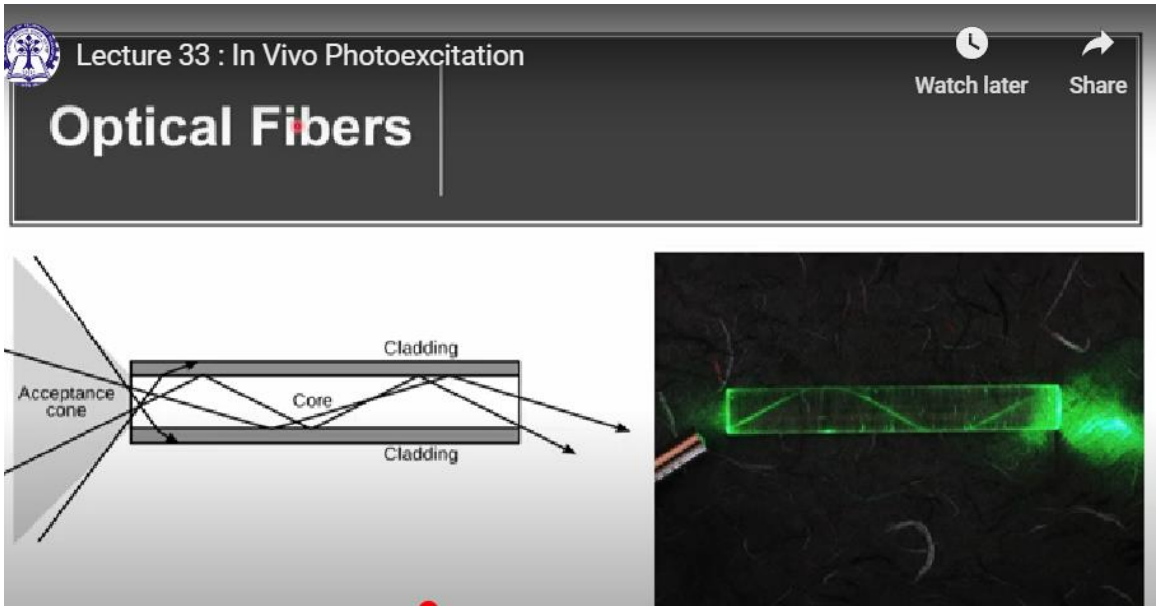


2 millimeter whereas, as compared to YAG neodymium yttrium aluminum garnet 1064 nanometer it can penetrate 2 to 6 millimeters. Different type of lasers has different types of penetration depth when it comes to tissue and this is very important when you are trying to perform a particular medical operation. If you are utilizing a cataract operation some sort of a cataract operation lens correction then CO 2 laser is more preferred whereas, whenever you are trying to melt a kidney stone or some sort of a blood clot or some sort of a tumor a high density energy or high penetration depth 2 to 6 millimeter believe you me this is quite quite ah deep especially if you insert some kind of a tube inside the human body locate the tumor and then send this kind of light with high intensity and then try to burn it. So different types of lasers have the capacity to penetrate different depth inside the tissue which is then utilized for different medical procedures operations and ah photodynamic therapy photo thermal therapy and we need to understand how these lights could be brought inside the human body or in close contact with the human body.

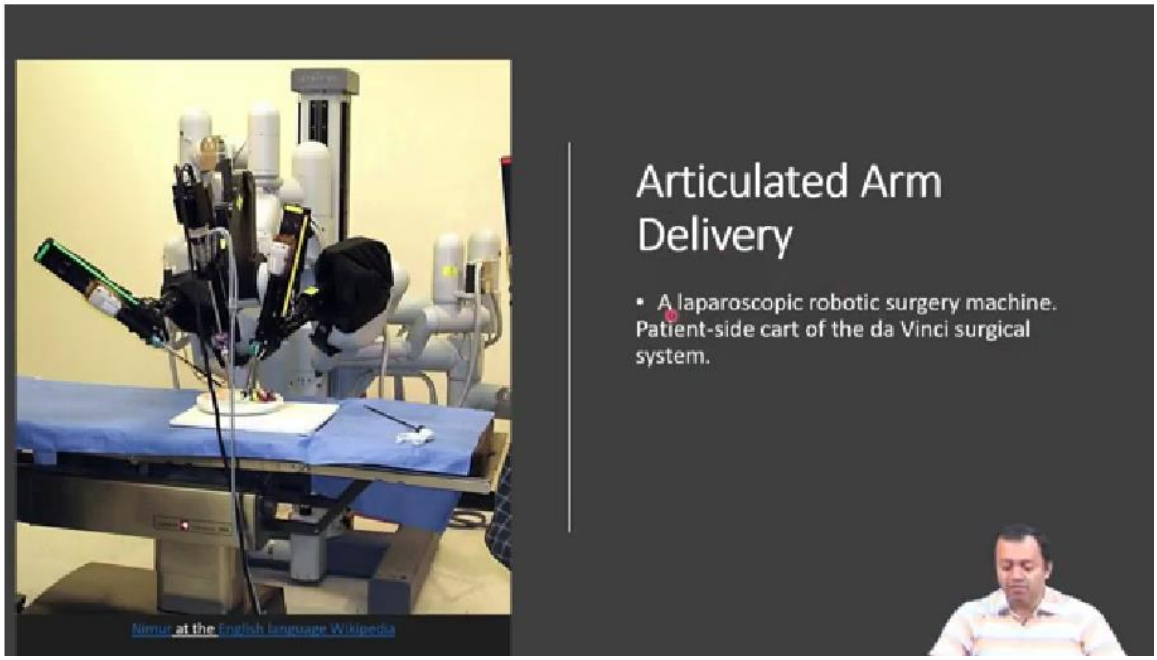


So, the first one is the free space propagation you basically bring a laser light very close very close to the human being say for example, some kind of a skin diseases happened you have applied some kind of a photo exciting ointment into the skin photo exciting ointment into the skin is then added ah you then shine light this light excite the ointment excite the cream this cream then then generate some sort of ah additional photons and that photon can destroy the skin lesion the skin tumor the skin pigmentation sometimes hair removal is also done in this particular type.

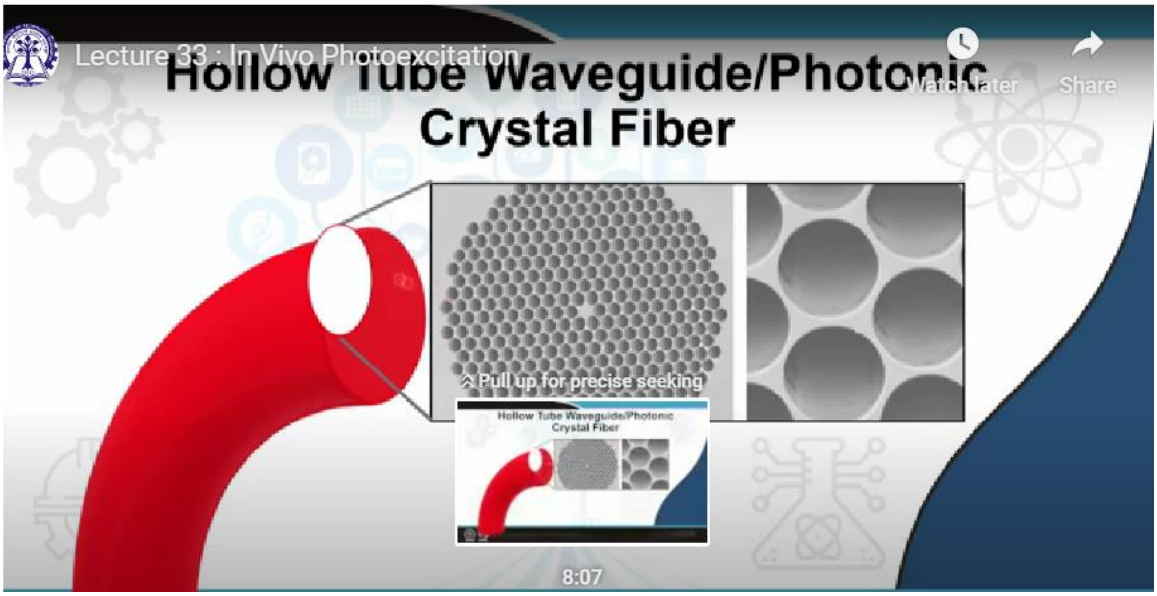
You are simply shining light laser light very close to the skin free space propagation very close to the skin to excite certain area of the skin and perform and and some sort of performance takes place. Remember free space propagation mostly happen externally if you want to deliver light inside the human body ah free space propagation you will get into difficulty. So, this is a laser gun that shines laser light into the body and it is difficult to put this inside inside ah the human body for that you need optical fiber optical fiber



as you know it has a core versus cladding high refractive index material what is surrounded by low refractive index material light with falls through it it is constantly bounced off constantly bounced off ah from it is boundaries and it returns back to it is or to to to the output without much of a loss you have all seen this happening optical fibers are the one that is bringing you your internet connection at your home. So, ah from which your Wi-Fi router is connected. So, the optical fiber brings in light signal laser signal ah especially at a particular frequency 1. 55 micrometer and you can make them to carry different other frequencies of light like this optical fiber is used to carry the green light they simply bounced off from the from the ah these two surfaces and returns back to the output you can utilize them you can utilize them this this this this type of optical fiber cable you can utilize them to go inside the human body switch it with particular laser and if you know where this ah tube is optical fiber cable is going through if you have charted the path then you can bring in light very close to that section.



We have all articulate arm delivery it is a robotic surgery machine where patient sits and it has some you know mechanical appendages ah some of it goes inside the human body some of it stays outside. So, it is basically robotic surgery robotic arm which produces optical light ah for different types of ah medical procedures medical operations that needs to takes place ah in particular conditions.



Then you have hollow tube or photonic crystal fibers photonic crystal fiber this has to be inside photonic crystal fibers they have hollow tubes and thereby they can filter out a specific specific frequency of light. So, large number of light wavelengths are being sent these are little bit thicker in this only one particular wavelength is being sent in hollow

tube more large number of wavelengths can be utilized they have ah these periodic structure at the mouth and they could be utilized to filter to filter out a specific wavelength of light.

This specific wavelength of light could then be utilized to perform a particular ah operation a particular melting of a particular tissue burning of a particular ah lesion particular area laser based cutting or simply imaging or even spectroscopy. One of the common things that we use it is for endoscope almost all of you have heard of endoscopy yeah endo means inside scopy means to see microscopy small c endoscopy inside c. So,

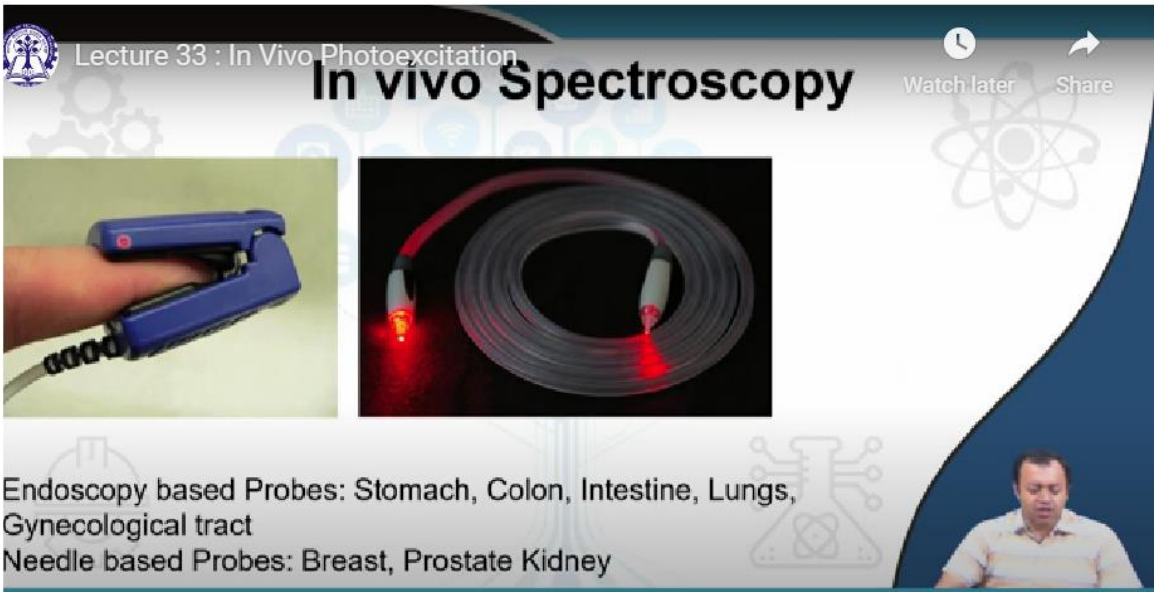
rumor has it that in 18th century late 18th century some guy was quite interested to see ah what happens when people swallow swords you know you must have seen it in television or in in in fairgrounds where there is a big sword type thing and the person just eats up this sword and then take it back actual steel sword goes inside. So, there is a person thought some German person thought that if that person can swallow sword and take it back what if I put a camera a small camera inside the mouth and then take it back. So, that picture of inside body can be seen.

However at that time it was cameras were pretty big you simply cannot put it inside somebody's mouth and how will you illuminate cameras require light. So, it was only in late 19th century at my alma mater in university of Glasgow Sir John MacIntyre at Royal Infirmary Glasgow he studied from my alma mater, but this discovery took place in royal infirmary he was both an electrical engineer as well as a medical doctor that time people can do both engineering and medicine simultaneously you are dealing with one and still finding it difficult this guy John MacIntyre of university of Glasgow studied both medicine as well as engineering and came up with this endoscope a self illuminating camera with

wires inside that could be put inside the human body to take pictures. What if you have a tumor which is not inside this ah human body I mean this this cavity right what it is inside this hand etcetera then they penetrate it like in the head they first make an incision ah small hole they press ah pipe and through that they deliver the camera to take photographs. The result is these kinds of endoscopy of a stromal tumor which is inside the stomach and this is colorectal cancer they have taken this image of this huge

huge tumor which is in the digestive tract which is in the digestive tract and you can see that and then you can prescribe the medicine how big it is can it be operated. So, this this this black thing black thing is the pipe and then with it outside of this ah you have attached camera that takes picture of this this this huge tumor that is inside your stomach inside the stomach.

So, endoscopy utilizes light delivery inside the body to image endoscope inside see scope is to see to understand to analyze. So, yes microscope and telescope are all fine, but would you like to see what is inside of you right there can see colorectal cancer and this is direct ah you know photographs taken from inside it is not x ray from outside or MRI from outside it is small enough to go inside the human body and take images. We can also do in vivo spectroscopy where ah endoscopy-based probes like stomach colon intestine low and gynecological tracts you all know what this is right laser can be utilized for pulse oxetometer or these kinds of LED based structure light emitting based



structures with this pipe this pipe can be small enough to be swallowed or put an incision put a hole put inside. So, laser can be utilized to either measure the oxygen content in your body which basically is spectroscopy. So, not only it can be utilized for imaging, but it can also be utilized for analysis of the ah chemical processes that is taking place.

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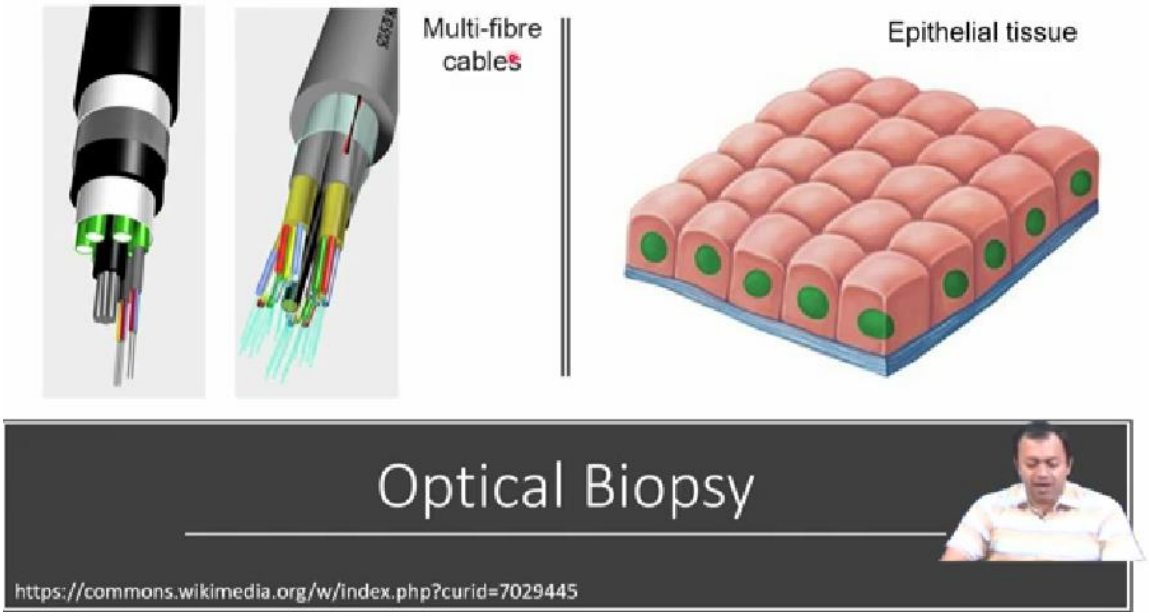

So, you can have multiple number of you know optical fiber they can be put near the tissue one of them or several of them will be exciting light this this this will this will this will be connected with a light source this light will fall onto the surface some amount will be absorbed some amount will be scattered some amount will be reflected that will be taken out by these output ah optical fibers they have multiple cables that will go into a

computer or a spectrometer that will churn the light and find out the image as well as the chemistry of the tumor to understand whether it is benign harmless or harmful. So, all of this is possible using optical biopsy or utilizing laser light close inside the human body.

So, these are the topics that I have discussed today in vivo photo excitation optical fibers endoscopy just to give you a glimpse of the several ways in which laser light could be brought in close contact with human body and you can both image and produce chemical information analyze something chemically to to to understand to cure the disease state that is going on.

In the next two classes we will take two very very specific examples of how laser can be utilized to perform specific functions these are my references I will see you in the next class. Thank you very much.