Oral Biology
Dr. R. Ramya
Department of Oral Biology
Saveetha Dental College
Indian Institute of Technology, Madras

Lecture - 21
Biomimetics - Part 1

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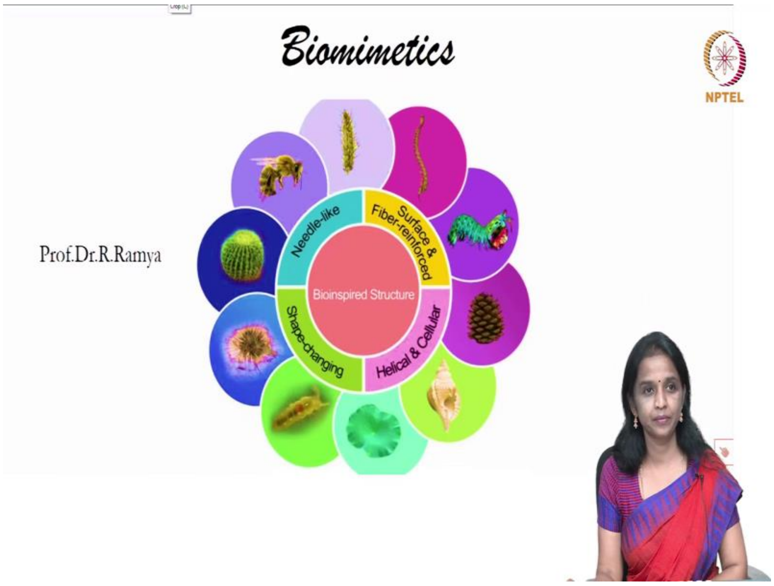

Today, we have a very interesting lecture on Biomimetics. The word biomimetics itself sounds really amazing or inspiring and now we go on to study this beautiful subject of biomimetics.

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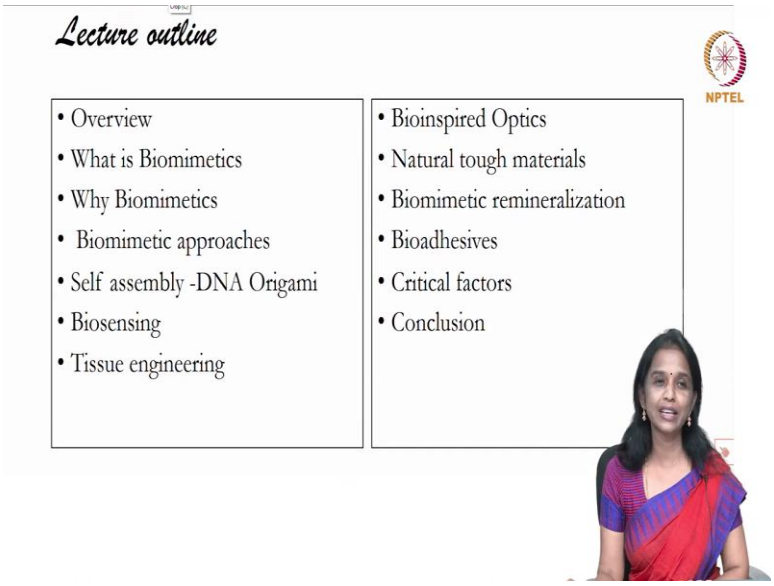

So, this lecture would give this is a lecture outline and we have a quick look of what biomimetics are.

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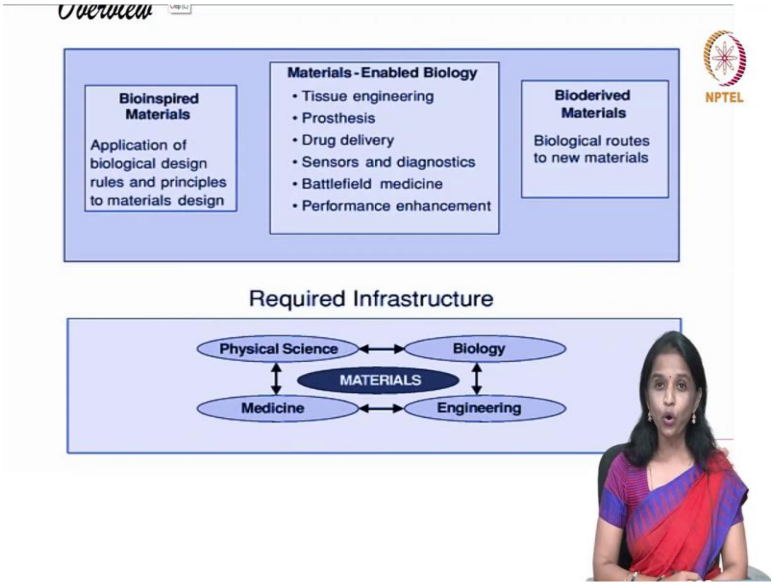

So, the overview of biomimetics is that we would quickly do about what bioinspired materials are and what are bioderived materials. And again this beautiful topic on the discipline of biomimetics is actually an interdisciplinary field which involves physical sciences, biological sciences put together medicine and engineering field as well.

So, that makes this particular topic a very interesting topic which actually touches upon both medicine and engineering together and what is biometics all about.

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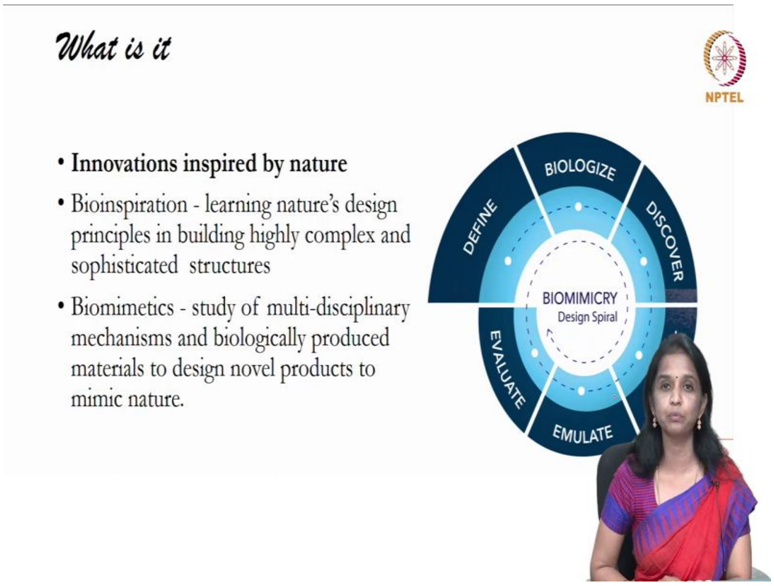

So, this biometics is put in a simple word it is innovations inspired by nature. I do not think there is anything beautiful to say about this more than this particular statement. So, nature has already innovated for us it is our duty to just absorb observe absorb and then emulate and then just keep mimicking what is already there in front of you and create newer things or just derive things.

So, that is all about biomimetics and this is a very beautifully given schematic. So, just understand what is there in nature and then try to emulate what is there and then evaluate what is exactly all about the nature has to offer to you. So, when you get inspired by nature you are just learning the natures design when you are trying to exactly mimic and replicate what you really want that is biomimetics why and how biomimetics.

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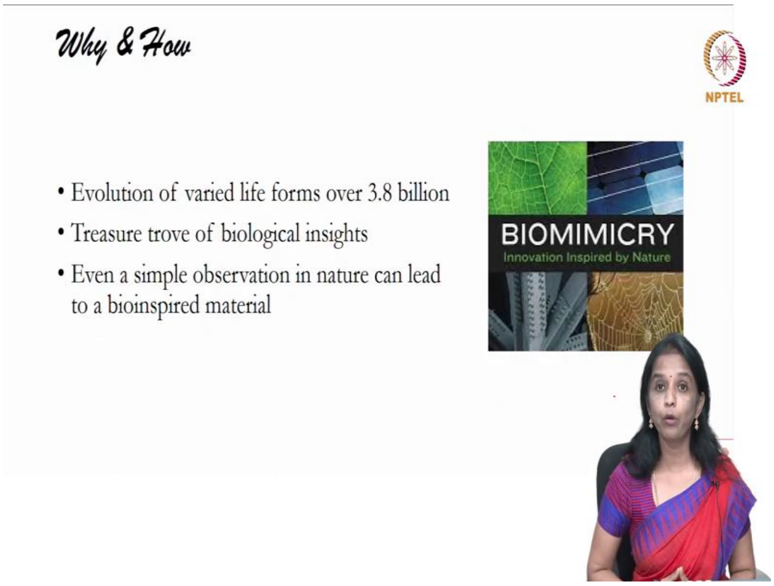

The most impart important thing as already mentioned; it is an innovation inspired by nature and we all know that as far as our knowledge is concerned we approximate that the evolution has begun over 3.8 billion years. So, so much of work has already gone earlier and it is our duty to just observe and then mimic what is already there done and made and executed.

So, it is a treasure trove of biological insights even a simple observation in nature can lead to a bioinspired material just open your eyes and then observe nature or just glimpse just have a look at it have a sneak peek on it and nature has. So, much of information to give to you; in other words, it is a treasure trove and all that you need to do is just keep observing and then relishing and then reproducing what is already there.

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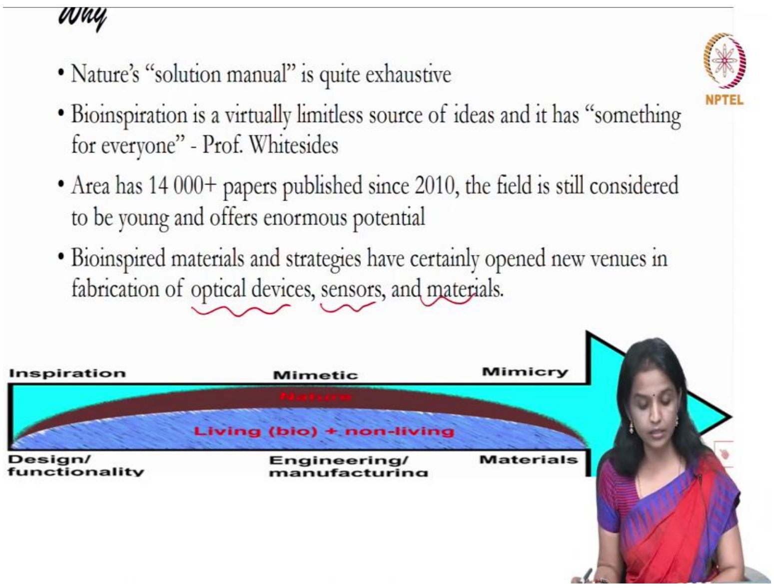

This is another beautiful schematic diagram over there and the statements are so beautifully given and drafted. So, it says nature is already a solution manual it is very exhaustive all that you need to do is just flip through a few pages and then create your own the creator has done all and all that you need to do is just pick up and then get inspired by them.

So, bio inspiration is a virtually limitless source of ideas and it has something for everyone and that is very very important it has something for everyone and it is; so, exhaustive and available for all.

So, having said that the most important point here is from a past one two decades the number of papers on biometics are really huge, but still there is lots to be done and there is enormous potential for newer insights and newer strategies to be drawn from this biomimetic thought process. So, bioinspired materials have really opened up and we have numerous applications which we will be discussing optical devices, sensors and materials. So, we actually inspire and then we try to mimic and then produce a novel design.

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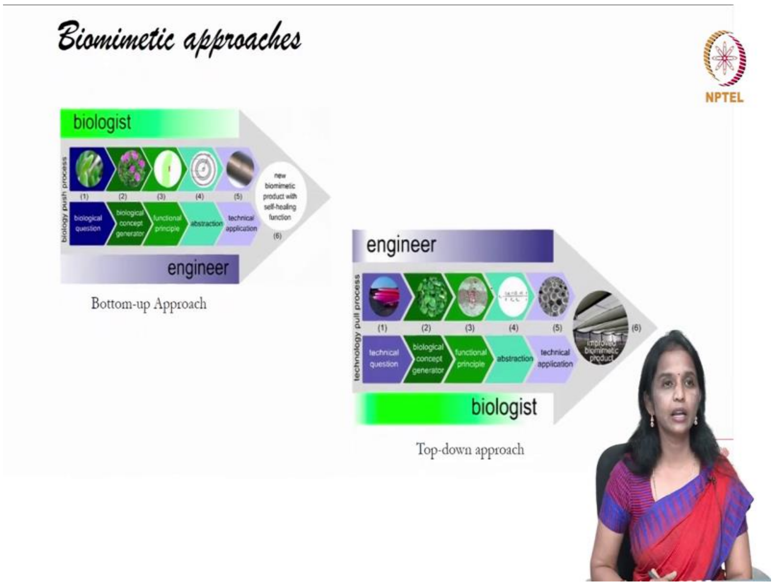

So, biomimetic approaches can be bottom up or it can be top down approach. So, there is that is always there in biomaterial fabrication either it is a bottom up approach or a top down approach.

If it is going to be a bottom up approach, it is going to be a background starting from the biologist and then the engineer takes it up and then brings out a new biomimetic product whereas, if it is going to be a top down approach the engineer takes a question a technical question start analyzing it and then he goes comes down to deeper aspects or the baseline aspects and then he derives the product which he really wants to. So, that is the two approaches.

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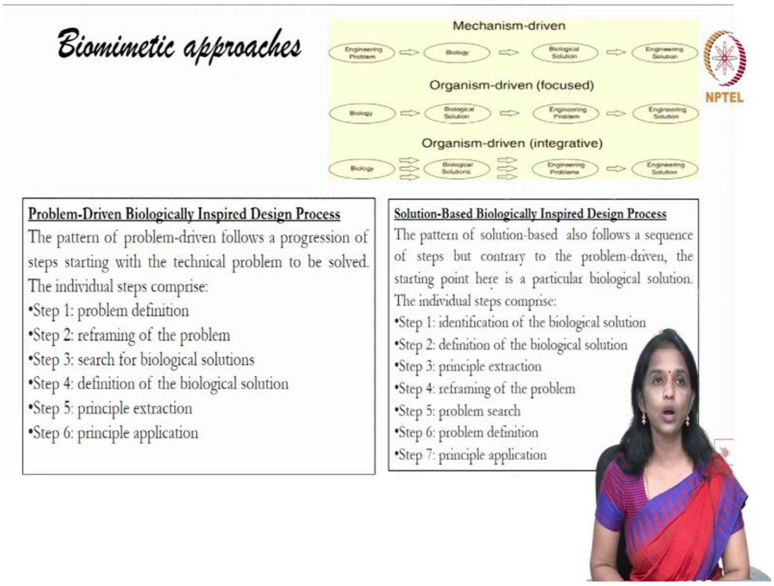

And then further, we have more in depth explanation of what biomimetic approaches are. So, there is something called as problem driven approach and there is something called as solution based approach. So, these are how the biomimetic approaches are handled.

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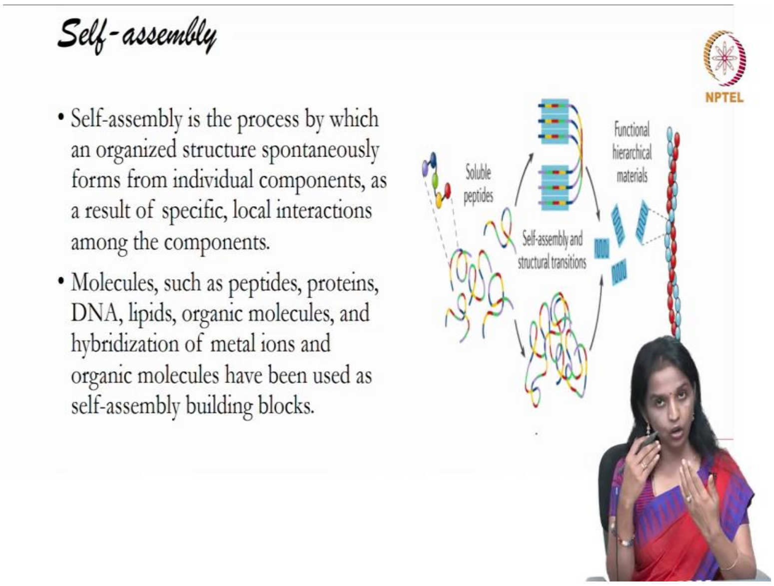

So, as we see here the self assembly is actually the beginning of what biomimetics is all about and how biomimetics can be done and used for innovations and used in multiple approaches. So, having said that self assembly as the word says it all self assembly is where there are some molecules which have the potential to form newer compounds by assembling on its own. So, it is have it is got the capability to form newer molecules or newer structures with smaller units.

So, the best example for this self assembly is they are enormous in nature and the best ones are your peptides the proteins, DNA, lipids, organic molecules and hybridization of metallic ions.

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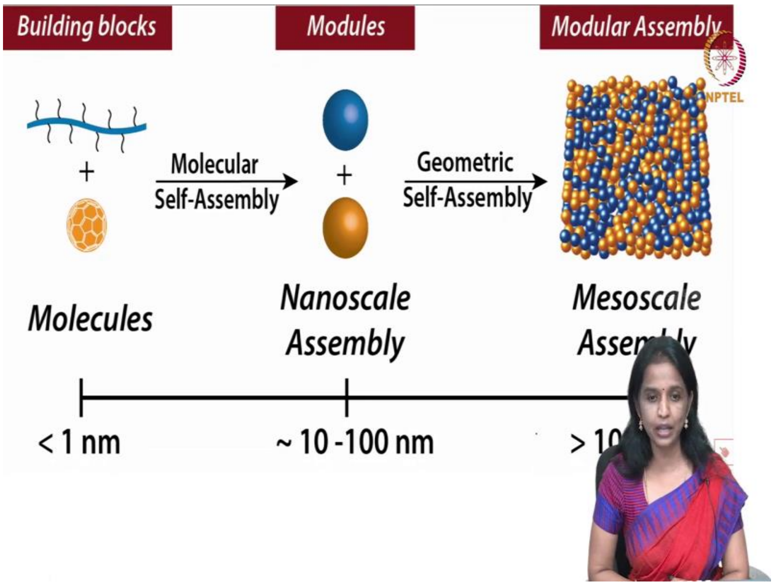

So, having said that how do we go about using this concept of self assembly? So, the concept of self assembly moves from molecules to nanoscale and then to mesoscale. So, it just goes on and then building to form a larger structure.

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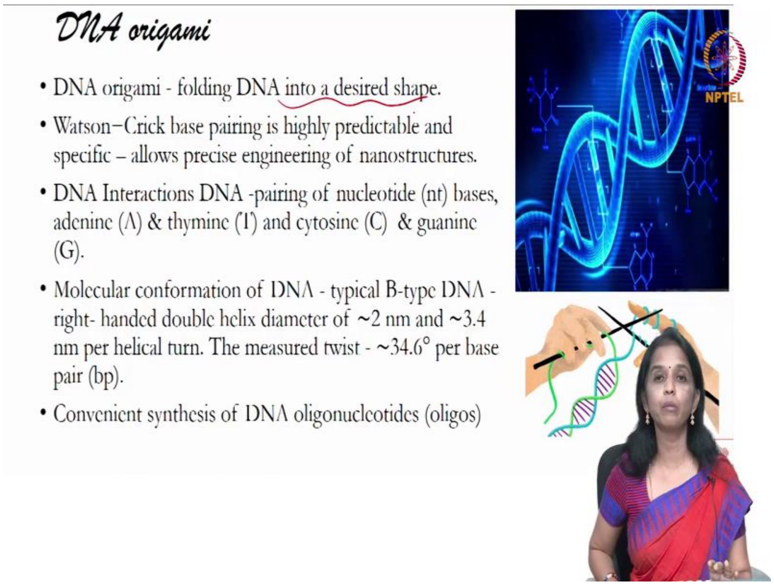

So, the best one in this particular self assembly is doing your DNA origami. DNA origami as the word is so beautifully described; origami we all know it is a method to take any structure into a desired shape. And this DNA origami specifically when you have the prefix DNA over there in front of origami all that we need to know is the structure is being made with DNA as the model. So, we are just trying to mimic DNA and we are trying to derive a structure which is similar to DNA.

So, why are we using or why are we inspired by DNA? That is because after Watson and Crick, decoded the DNA structure there has been enormous studies making so much of use from that particular Watson and Crick model and that model makes it so simple. So, why is it so simple? The scientist did a very fantastic job of bringing out the structure and this particular structure has the ability to be reproducible and not only reproducible can be multiplied many number of times.

So, there can be exact replication and then there can be multiplication. So, that is the basis of DNA and that is the basis of any formulation as such. So, how does DNA help in this; we all know that DNA is made of nucleotides and the pairing happens with a definite sequence and that definite sequence does not change at all.

So, this definite or specificity is what is actually making DNA origami a most sought after technique for biomimetics and not only that this DNA molecular conformation actually helps in a most important way in addition to the nucleotides. The molecular conformation of DNA is also very helpful and it is also having a specific sequence. So, that is being exploited to create multiple number of products.

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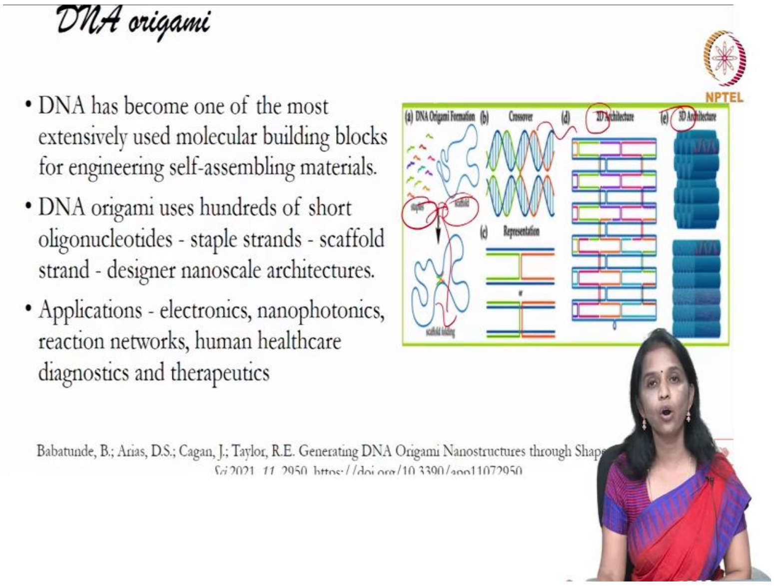

So, all you can see that the DNA origami is used for self assembly engineering self assembly molecules. So, this picture actually helps in a beautiful way there are two strands which can be derived the staple strand which actually goes into forming the scaffold strand and then this goes on to forming a bigger molecule.

So, all these are helped and then we derive more intricate twisting and pleating and that goes into formation of a 2D structure and further twisting and turning in a particular specific sequence results in a 3D architecture element whichever we need to such intrinsic specific creation of a self assembled molecule can help in many many applications, because we know that the sequence is going to be very specific and it is going to be repetitive and it can be multiplied in many number of ways.

With that concept this DNA origami is a typical example of biomimetics and has got numerous applications in electronics, nanophotonics, reaction networks human healthcare diagnostics and therapeutics. You can see the wide ranges there right from engineering to medicine DNA origami helps us in all applications.

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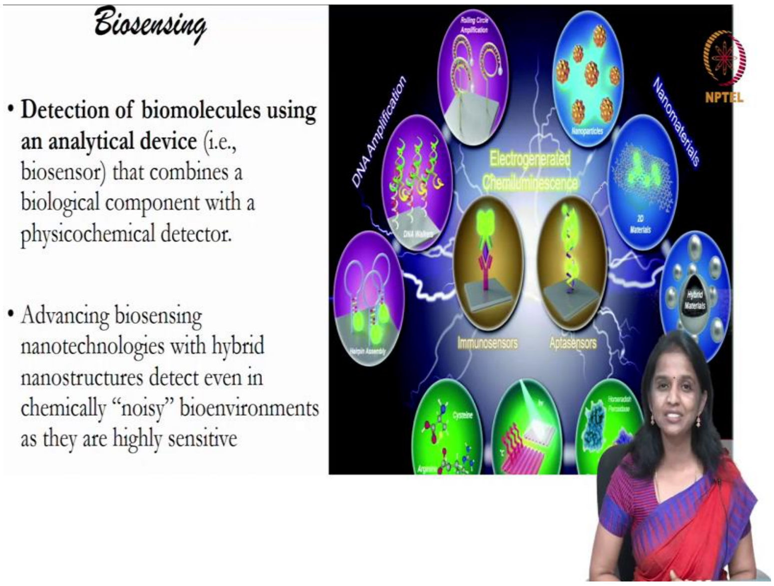

And then we move on to a very very interesting or most sought after term in recent times that is biosensing. Biosensing, we are all very very what to say passionate about that particular term the passionate craving for this particular biosensing comes because of that desire to have point of care diagnostics right in your arm so that you can actually diagnose and help yourself or the healthcare worker is quick enough to diagnose any particular pathology or any particular disease states.

So, this is actually a most required area which has numerous scope in the field of medicine and not only in the field of medicine there are many many applications for biosensing more critically it is of great help in healthcare. So, when we talk about biosensing, all that we need to know is a biosensor has a sensory component or the sensing component that is a biological component and then there is a detector and that goes into detecting and then identifying what is exactly there.

the most important and interesting part of biosensing is the more accurate it is or the more specific it is to even detect a very small molecule of interest biosensors will be of greater help. So, biosensing has grown really well in the past two decades and we have so much of improvements and advancements in the field of biosensing, where we have point of care diagnostics in our hand.

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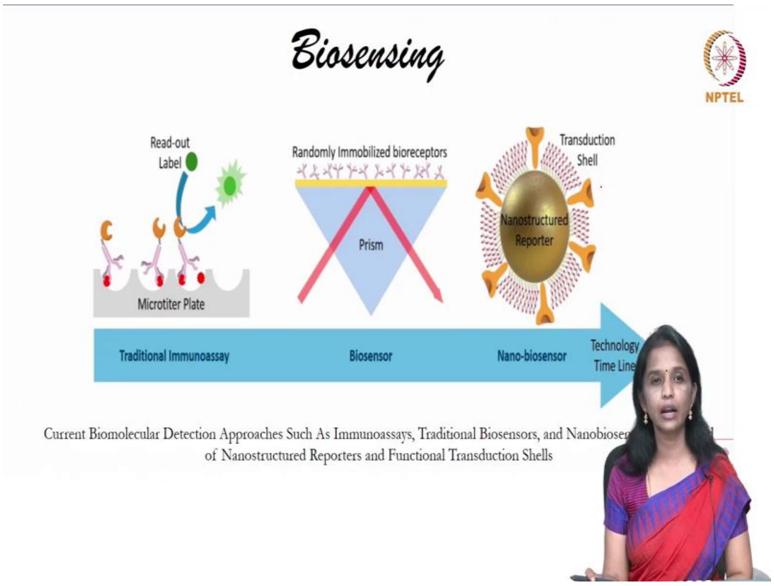

So, traditional immunoassays involved a lot of procedure whereas, your point of care diagnostics is all there in the hands of the specialist or sometimes even in the hands of a Layman who can help themselves.

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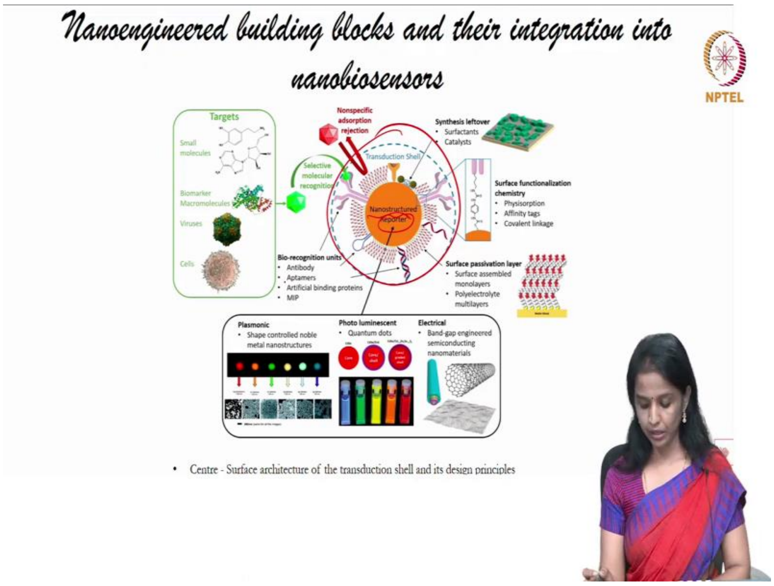

So, this particular schematic diagram helps in letting us know what exactly these biosensors are. So, this centrally placed diagram here clearly illustrates that there is a nano structured reporter molecule which is actually the transduction shell. So, this transduction shell helps in actually having very clear bio recognize recognition units and surface passivated layers. So, this is actually of very great interest.

So, as nanotechnology keeps progressing to a great level the molecules at the center part or which is the key molecule becomes involved and involved and then it becomes more advanced and it becomes more specific the more the specific the point of care diagnostic the more reliable it is and that is when we keep doing or trying newer molecules. So, here we have the list of targets which we are constantly working on and we are constantly looking for to create newer devices.

So, this is there the craving is there in almost all fields of medicine and in fields of engineering as well.

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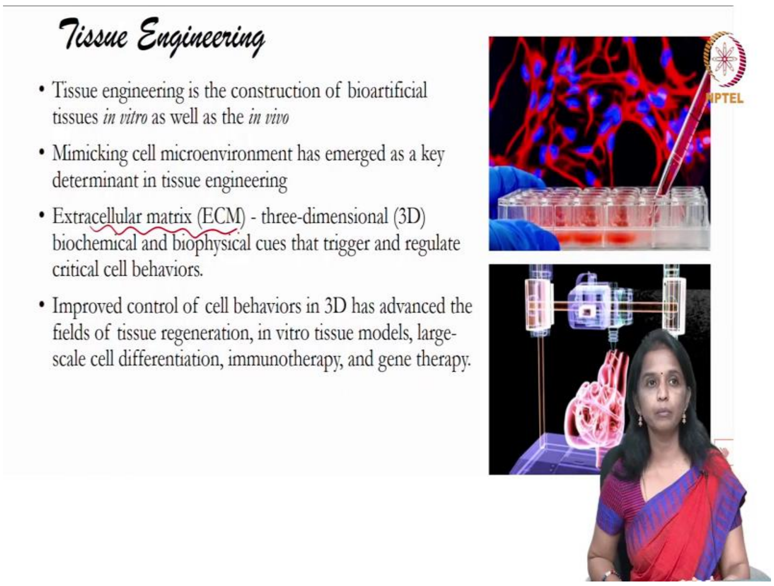

Now, again there is another interesting field in biomimetics where the biomimetic aspect is so strong that we just want to replicate what nature has already created. So, that has made this a wonderful world of tissue engineering where we try to create organs or we try to just replicate what nature has already done few thousand years ago.

So, tissue engineering is all about creating bio artificial tissues in vitro or even in vivo. So, here in tissue engineering we all know about the basics the tissue engineering needs the cells the scaffold and the micro environment. Here the more challenging aspect of tissue engineering earlier was about the scaffold, but now the scaffolds have really advanced really well and now the more key element which is of great interest is your extracellular matrix.

Because it is that extracellular matrix which actually has a definitive role in achieving what we really want by creating that bio artificial tissue or bio artificial organ because the basis or the foundation or the matrix is actually created by that extracellular environment. So, if you can actually control the cell behavior by placing this or by controlling the extracellular environment then you can tune the behaviour so well and it is that cell behavior which is very critical.

So, cell behaviour does not rely on the cell alone it is very much dependent on the extracellular environment also. So, as we keep controlling the extracellular environment in a perfect way then the effects on the cell behavior would be really better controlled and the outcomes would be really very specific and more desirable. So, that is why mimicking the micro cell environment is very important.

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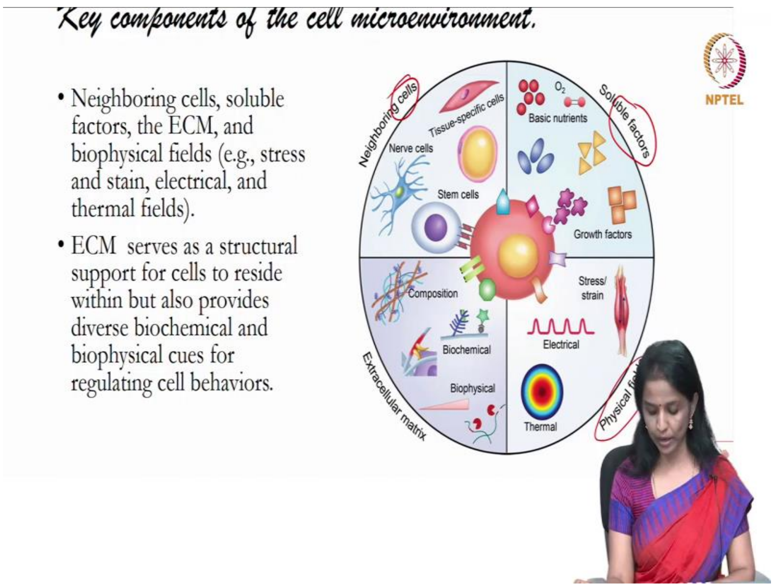

So, here this micro cell environment is actually made of neighbouring cells, the factors that are very important and then we have the physical fields which they are subjected to; putting together all these, then we have a very strong control over the micro environment and this are very important to defining the bio artificial structure which you are going to create too, because they would be applying a lot of biochemical aspects bio mechanical aspects to the cell and that behaviour is actually perceived and the organ can be made to function as though in a natural environment.

So, that is what is actually being done and being improvised upon over the past few years.

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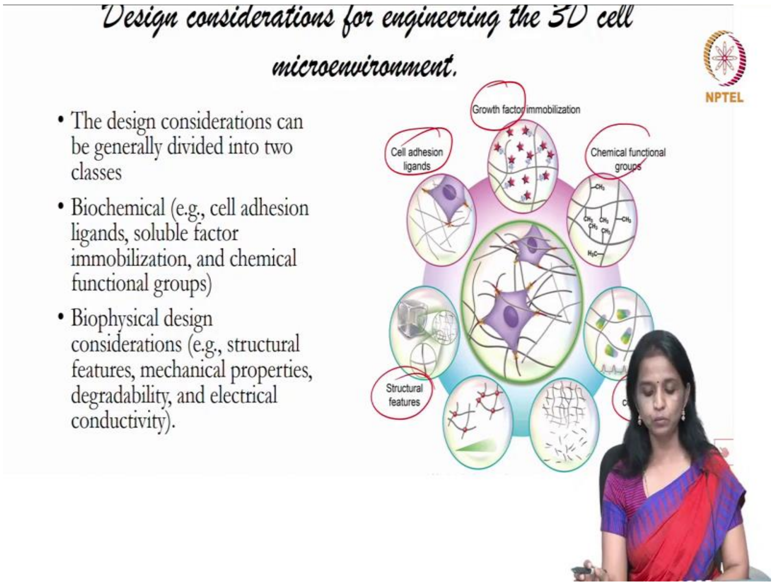

earlier we had two dimensional then the last few years we have about three dimensional micro environment. Three dimensional micro environment again involved a lot of aspects which involves a growth center, a growth factors, cell adhesion ligands, structural features, electrical conductivity, chemical functional groups and then we have mechanical properties and degradability.

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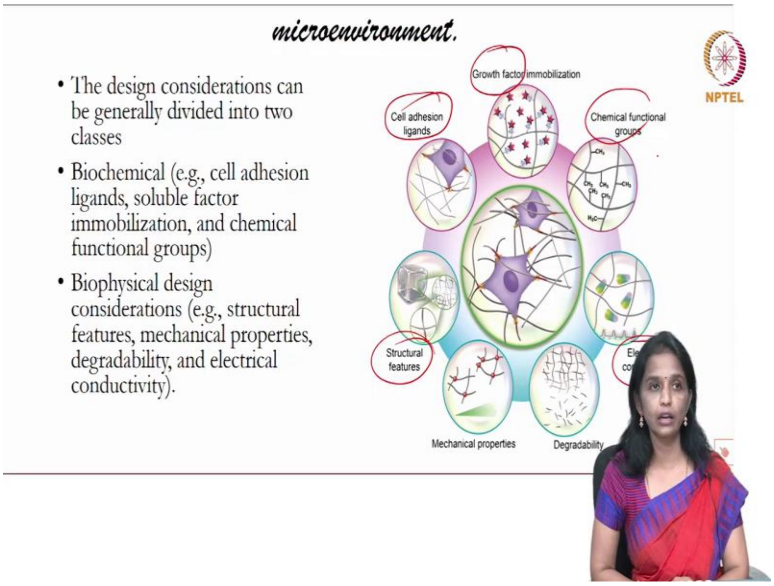

All these factors were actually defining the 3D micro environment.

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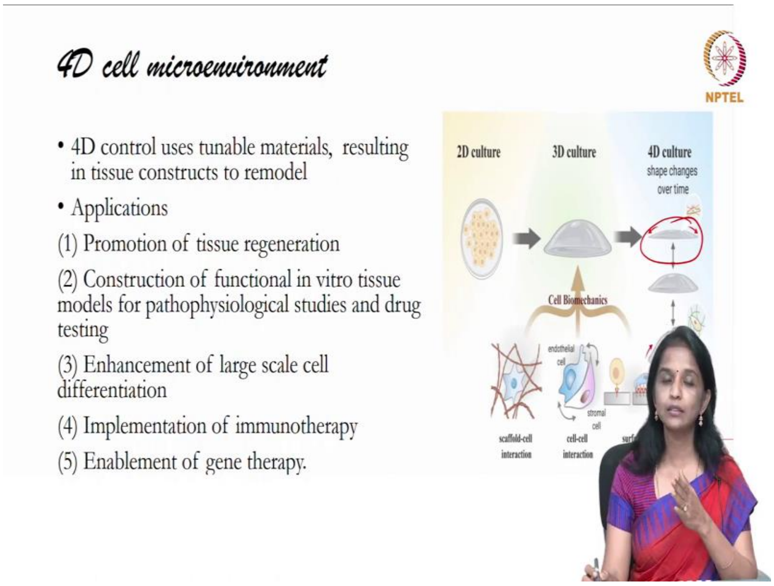

And now, the world has moved on to 4D micro environment. So, what is the difference between a 3D and a 4D culture, it is just simple difference which you have to remember. There is an alteration in the physical stimuli which is actually given through the cell micro environment. So, that is the major difference between a 3D and a 4D culture.

So, the physical biophysical cues on the 3D culture system makes the entire artificial organ more tuneable in the sense the more it can be tuned and it can be as close to the natural tissue the outcomes of that particular organ whatever is desired can be easily brought into. So, physically tuneable characteristics is that statement which actually makes 3D and 4D culture different.