**Oral Biology**
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**Lecture - 28**
**Biomaterial Applications**

The topic which we would be discussing now is Biomaterial Applications. Where and how in which area do biomaterials, applications are required.

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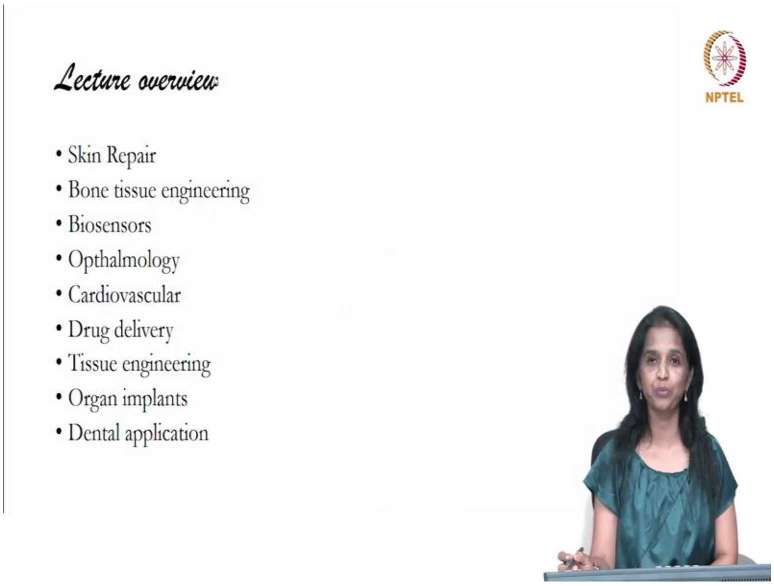


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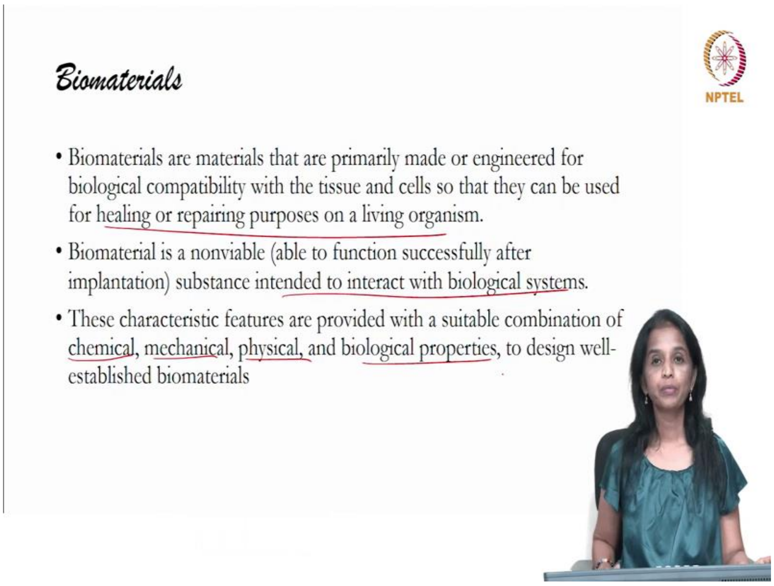

So, this is a chapter overview and we move on to again quickly recollecting what biomaterials are. So, biomaterials are primarily made of engineered materials or engineered for biological compatibility with tissues and cells so, that they can be used for healing and repairing purposes of a living organism. In other terms, when you are creating a biomaterial, you are actually standing closer to the creator himself because, you are helping the existence become better, you are repairing the damage which has happened.

So, you are at par with the creator himself. So, the moment you start applying biomaterials and you are able to derive something great it becomes a great help to the mankind. So, biomaterial is a nonviable substance intended to interact with the biological systems and these characteristic features are provided with a suitable combination of chemical, mechanical, physical and biological properties.

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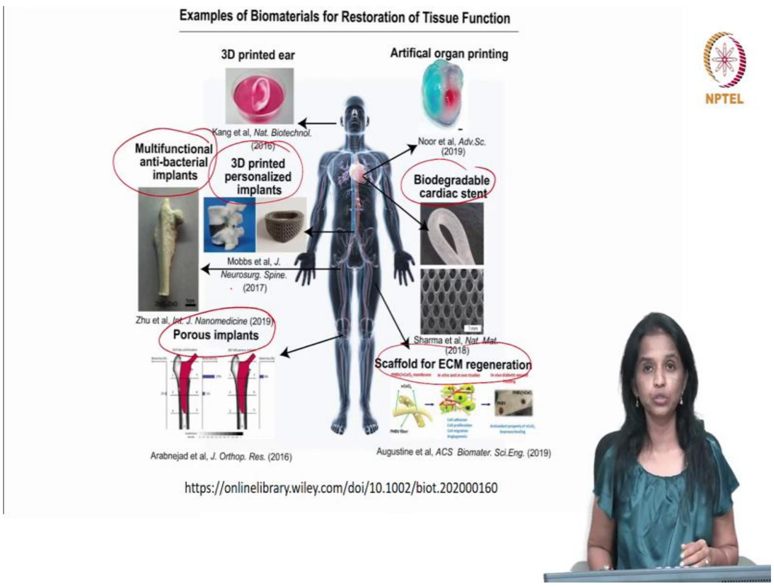


And all these make the ideal bio-material. And this is what biomaterials has to offer to you. It has got huge applications based for biomedical sciences.

So, this is a more illustrative application-based explanation for biomaterials, you can see a 3D printed ear over there is artificial organ printing which is possible, there is a biodegradable cardiac stent, there is a scaffold for extra cellular masseteric regeneration, there are porous implants, there are multifunctional antimicrobial implants, there are 3D printed personalized implants and so on.

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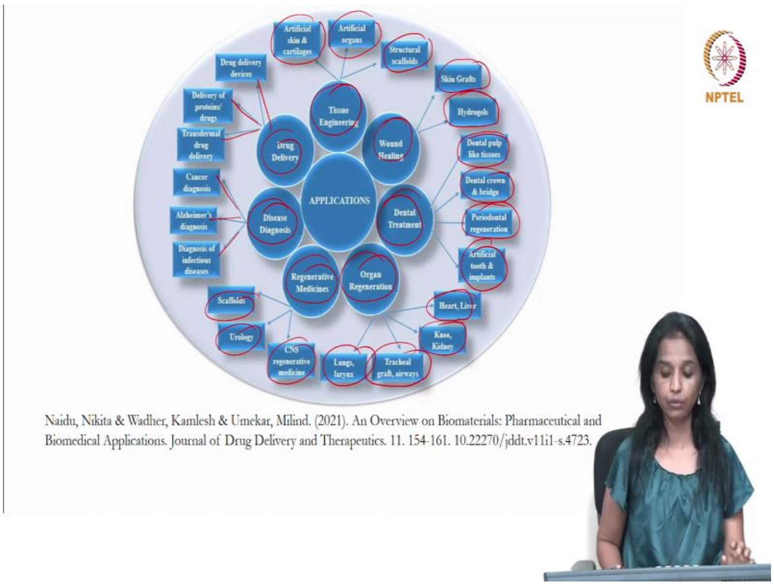


What not the world of biomaterials has a huge variety of applications to provide you and this again has it all and this would make you think that biomaterials is the most important thing which every health care person and every technological person, engineering graduate has to be aware because, both contributions are very vital in creating this very interesting piece of material.

So, a quick look at the application over here. So, we have tissue engineering approaches, wound healing approaches, dentistry, organ regeneration approaches, regenerative medicine, disease diagnosis and drug delivery systems. So, this is a broader overview of what your biomaterials can help derive and one by one there is a huge application which is actually listed.

So, in tissue engineering approaches you can end up doing creating an artificial skin, creating the artificial organ as well and then, you can also create structural scaffolds. Further in wound healing we know that, wound healing is very important any surgical procedure you have to open through the skin and then enter through the skin additionally there can be a trauma, there can be a burn where the skin is completely lost.

So, skin grafts are again very important, not only for therapeutic use, it is also used for aesthetic help skin grafts and also form a very big market in cosmetic industry as well. Hydrogels again are very helpful for wound healing and in dentistry.

We have dental pulp like tissues, dental crown and bridge, periodontal regeneration, artificial teeth and implants, organ regeneration we have capability to produce the entire heart and the liver, the knee and the kidney, the tracheal graft and the airways, the lungs and the larynx what not.

And then, further we have regenerative medicines, the scaffolds, urological tissues, CNS and regenerative medicines again are very important all of us know how much of difficulty a person with Alzheimer's would face. So, CNS degenerative diseases are very common because, we have the ageing population increasing now as the science is advancing.

So, to limit all those degenerative diseases from happening we have alternate approaches here and then for diagnosis of infectious diseases, we have been still reeling under the pandemic. So, faster the diagnosis, we know it is better and we know that newer versions are coming up.

So, diagnosis of infectious diseases has always been in demand and then we have Alzheimer's diagnosis, cancer diagnosis and then, further we have drug delivery system. We know that drugs are being taken in various forms and routes. So, the material should be good enough to handle all these routes. So, it should be capable of going through a trans-dural system a protein, mediated drug delivery system all that has to be there and it also should be part of a drug delivery device as well.

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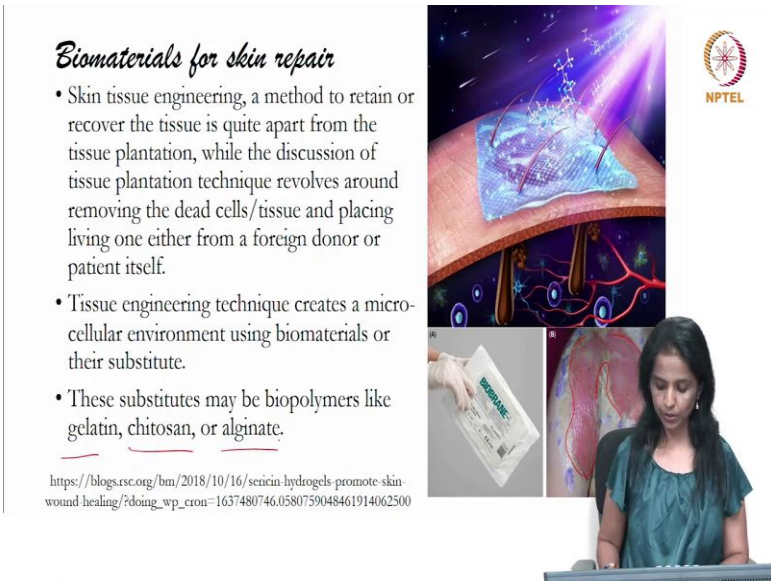

And then further we have to go into deeper of the most important applications of biomaterials science. So, here we can see a biomaterial shown over here as a replacement of a skin. So, skin is very commonly damaged because we know that it is the outer covering of the body, it is the first thing which is actually facing the external environment.

So, there are always chances of the external environment damages being borne by the skin. So, it is very often damaged. A single simple bruise might lead to removal of a very big patch of skin just falling down. Simple trauma itself can lead to a bigger larger area of wound defect.

So, all that needs a skin graft, a perfect skin graft which can actually replace the lost tissue; so, it is very commonly used and you can see a very big burn over here, a scalding burn which can be very easily managed with a skin graft. So, skin graft is usually made of gelatin, chitosan and alginate so, a quick recap. So, all these materials are predominantly your polymeric colloids.

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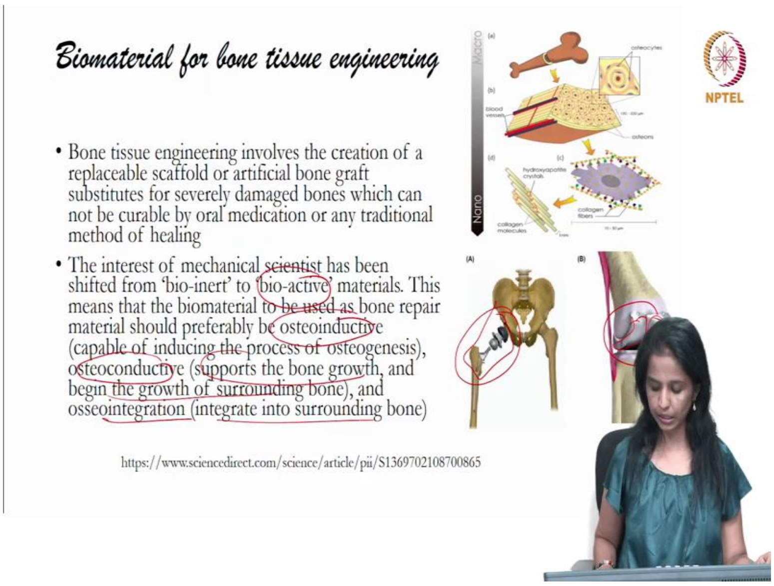


And then, further we have biomaterials for bone tissue engineering, this again as how it is mentioned for skin. We know that, the body is made of the hard tissue skeleton. The skeleton has a tendency to break very soon and this as it breaks or as it gets damaged; sometimes they damages so bad that the broken ends cannot be brought together.

So, at that situation there might be a very bad multiple bone fracture where it is broken into pieces and those have to be removed and there has to be a graft. Imagine, if that kind of breakage was there in a load bearing joint. We can see the load bearing joint example here the hip bones and the knee bones which actually take up the entire body weight.

So, those areas are the ones which require very high strength biomaterial to be replaced and so that they can go on with their normal function; so, as we keep on talking about very high strength. As already mentioned in the previous lectures, the biocompatibility is the first and foremost requirement and further we also want it to be bio active.

So, a bioactive material would be osteoinductive. Osteoinductive means, it is capable of inducing the process of osteogenesis; osteogenesis is bone formation and further we have osteoconductive it supports the bone growth and begins growth of the surrounding bone and further osseointegration it integrates into the surrounding bone. So, all these are very important to be considered for bone tissue engineering. And we can see that there are metallic implants over this place and the entire joint is replaced by the metal.

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And this again are bone substitutes which are commonly used in small bone, critically small bone defects or even larger bone defects. So, all these are very widely used. So, they are used as injectables and you can see they can they are used as powders, they are used as paste, they are used as cubes and please note that they are very porous in nature and they are also used as sheets or membranes.

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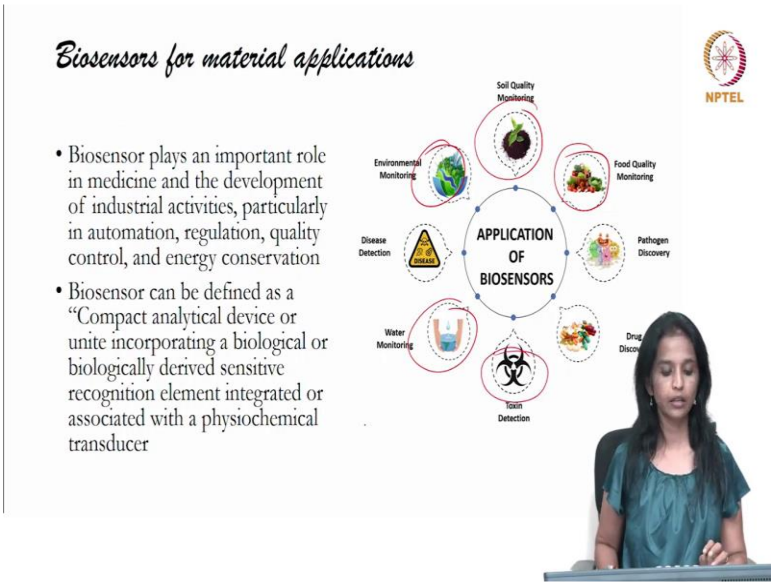


So, they are all very helpful in managing the damage. And next we go on to biosensors. Biosensors are again very important application for biomaterials as already said in the beginning of the lecture. The most important one which is most wanted right now is to diagnose a infectious disease. Of course, we know that the current pandemic we have many biosensor devices right now with us, but we know that there are many viruses coming out there, there are many mutations which are happening and every time we have to quickly devise a biosensor.

So, that would help in indicating or quickly getting us to identify a infectious agent. In addition to taking up an infectious agent, it not only helps to identify an infectious agent, it also helps us to tell about if there is any altered, electrolyte situation; if there is any altered enzymatic level and so on.

So, the applications are numerous in addition to the field of health care there are other applications for biosensors as well. That is your the sensing industry, that is soil quality food testing  environmental monitoring, water monitoring, toxin detection and so on; so, in addition to the health care devices.

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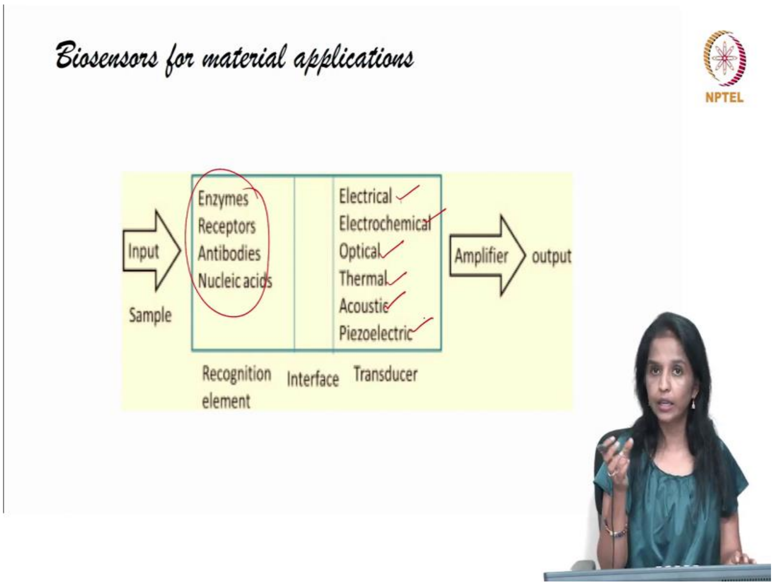


So, how does this exactly work? This is what exactly is the schematic diagram representation of what a biosensor is; so, what we are actually wanting to look at is are these. So, it can be a enzyme, it can be a receptor, it can be an antibody, it can be a nucleic acid and so on.

The method of discovering this elements can be electrical, electrochemical, optical, thermal, acoustic or piezoelectric. So, the biosensor can be any type. So, the transducers can be any type. So, further it amplifies, amplification is actually the key because, the agents which needs to be detected would be in very minuscule amounts and that has to be detected and amplified and then, it has to be diagnosed.

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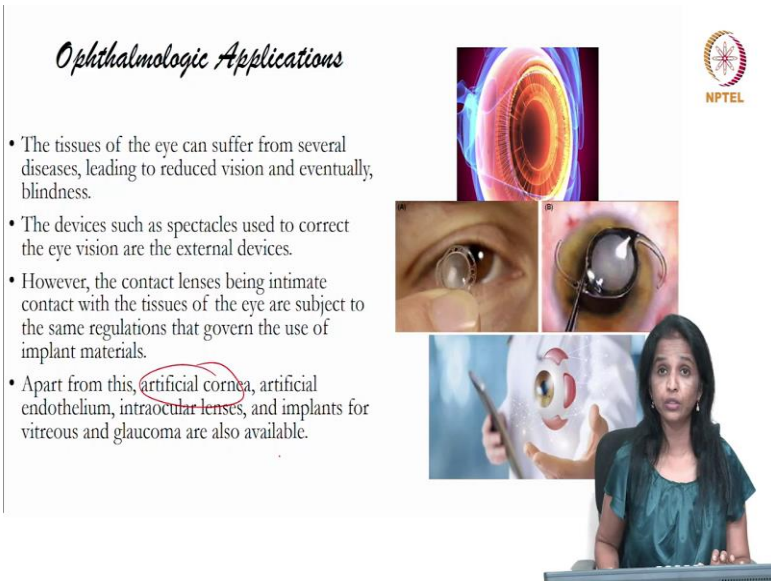


So, it is of great importance. And then, we go on to ophthalmologic applications, ophthalmology again it is a very important field, where regeneration is most crucial, because we know that it is the most important sense organ. So, as we open and see the beautiful colorful world, if there is a defect in this beautiful structure that is the eyeball, we need to replace it. So, there are many approaches of biomaterial approaches in ophthalmologic applications.

One is the artificial cornea, having heard that we know that there is a huge demand of eye donors and organ donors. So, if this biomaterials were good enough to completely eradicate the need for a human donor it would make a very big difference and it can be serving as an artificial endothelium, it can be serving as an intraocular lens. And in especially in patients with very high intraocular tension that happens in glaucoma. So, for those patients this ophthalmologic biomaterial devices are of really great help.

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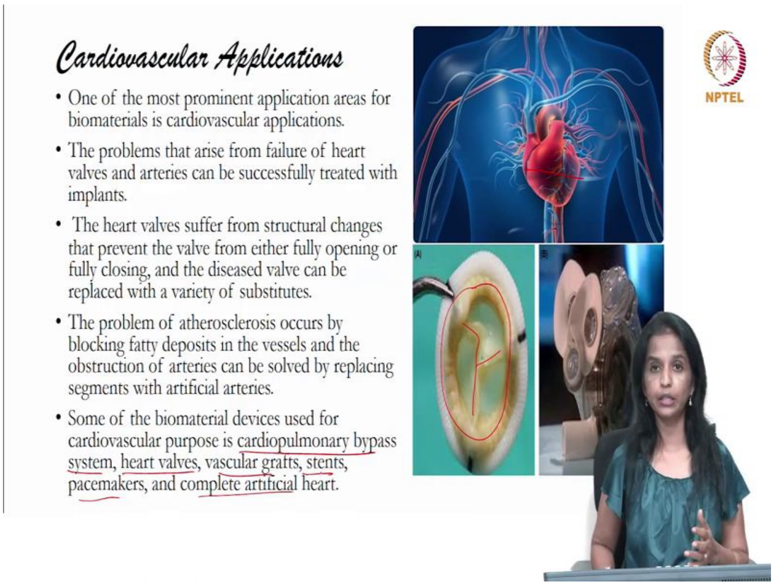


As mentioned for ophthalmologic applications, cardiovascular applications is no less and it is more crucial especially because these is the one which is actually a more what to say deterministic factor or a very important vital organ. We know that the CNS is got is more higher center for as a vital organ, but heart is next and very very crucial. So, the any problem any disease associated or any genetically defective areas of the heart can be very well replaced with all these biomaterially derived devices.

So, the picture over here is actually a tricuspid valve, you can see that it is a tricuspid valve. So, tricuspid valve we can even make a bicuspid valve and then, we can place it in between the artery I mean your auricles and the ventricles. So, auricles and ventricles would be there at this particular point and they are the ones which would push the blood from the right to the left and so on.

So, heart valves are badly damaged as a genetic problem or as an acquired defect. Whichever valvular defects are very common problems and in addition there can be atherosclerotic defects and so on and in case if the valve has to be replaced, it can be replaced with an artificially manufactured material biomaterial, based material. So, the examples of cardiovascular applications are with your biomaterials are your cardiopulmonary bypass system, heart valves, vascular grafts, stents, pacemakers, and completely entire artificial heart.

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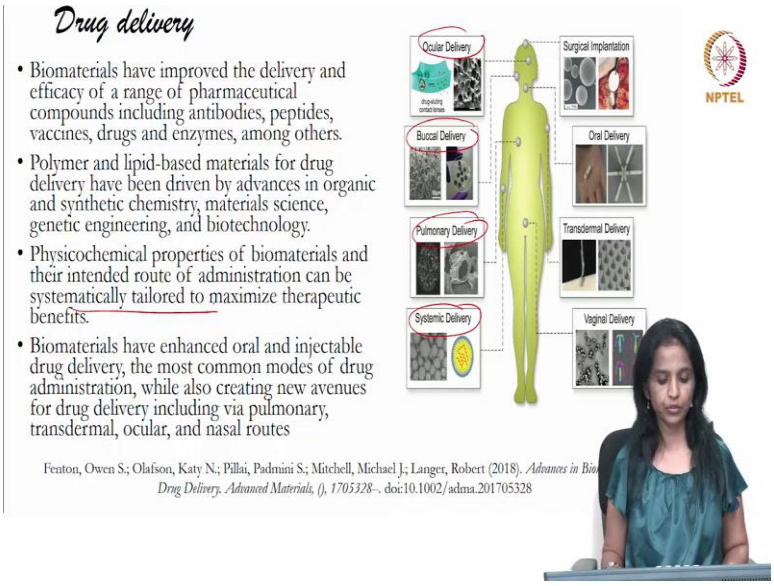


So, this again reduces the dependability of a human donor for all these applications. And drug delivery system again is very crucial, we are heavily dependent on targeted drug therapy and targeted drug therapy is going to be the order of the day in the coming decades and there is huge research which is happening in the field of targeted drug therapy; and all this is possible because of the nano-technological I mean innovations in the field of biomaterials.

So, you have ocular delivery systems, you have buccal delivery systems and pulmonary delivery systems and systemic delivery. Systemic delivery as it has gone through the oral route it spreads through the entire body. The ones which were mentioned earlier as ocular are all specific to region areas.

Buccal especially the mucosa inside is so thin, it can take absorb the drugs very quick and it can take it to the systemic circulation very fast. And then we have the pulmonary delivery, further it can be used as a surgical implantation material or an oral delivery material or a transdermal delivery system. Transdermal again is very important; we can have a long acting drug just embedded on the tissues.

So, that it can keep doing a slow release of a drug which needs to be there continuously for a particular patient. Instead of giving daily insulin shots, there can be a sensor based insulin device, which can release insulin when and where required. So, that would and reduce the pricks which the patient or insulin dependent diabetes patient would be needing. So, all these have really very effective.

We also have vaginal delivery systems, drug delivery systems, which are very specific to region wise. So, all these are possible because, the ability of biomaterials which can be in tunable to the particular area, particular route. Particular route is what we saw the routes are varied can be systemic it, can be site specific. So, based on that it can be tuned and it can be maximized. So in that way, the drug can reach the site more effectively and do it is work more efficiently.

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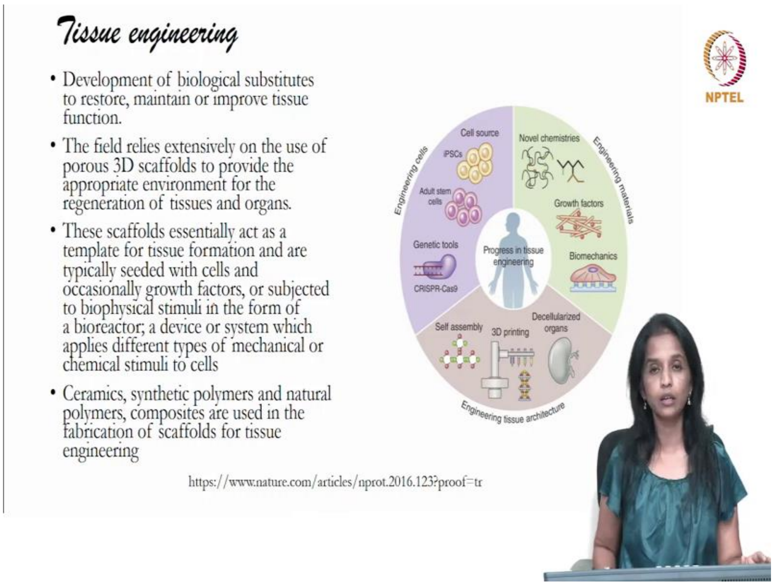


And next we come to tissue engineering. Tissue engineering again is vital for creating an organ or creating recreating whatever is missing, tissues which are missing. So, for a tissue engineering to happen, the most important role of biomaterial is to serve as a scaffold.

For it to serve as a scaffold it has to be so good that it is almost mimicking the natural naturally available body tissue. So, that kind of tissue together along with other growth factors and the cells which are seeded, then it makes into forming whatever tissues you are wanting to create. So, the most important part of tissue engineering is your scaffolds and the biomaterials actually stand to create them.

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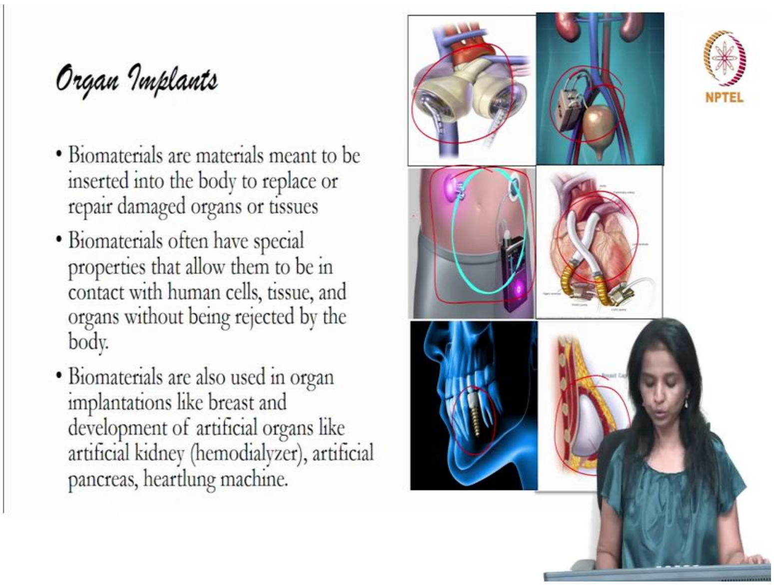


And the next thing is organ implants, specific organ implants. So, implants as already said very commonly are your dental implants, which is done for missing tooth structures. We also have the artificial heart over there and then we have the artificial kidney system. And then there is one more artificial heart system over here, these are breast implants and what we see here is actually a insulin pump system. Where there is a sensor which actually releases insulin when and where required according to the dietary intake.

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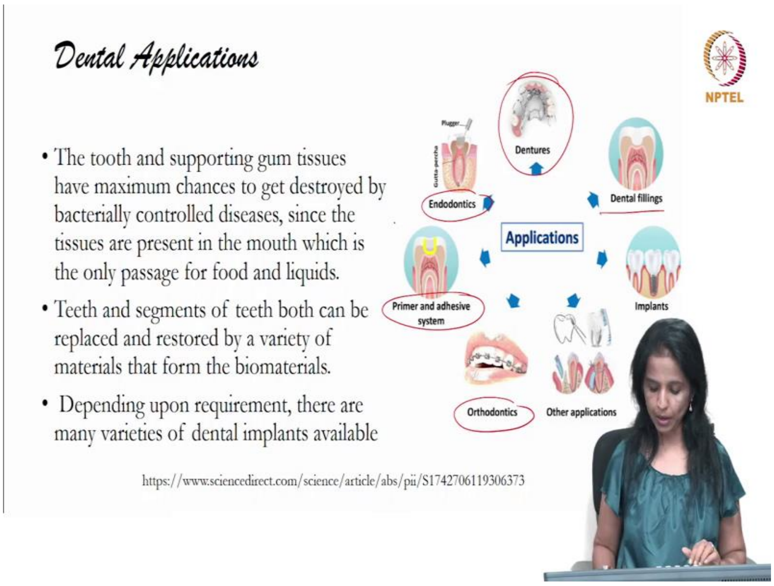

And now we move on to a very interesting area which we are very keenly looking forward the dental applications of biomaterials is very very huge. No biomaterial lab in the world stops without doing a dental application, every bio material scientist has a research work related to dentistry. So, that is the scope of biomaterial science in dentistry, even though they have other applications there would at least be a related work related to dentistry because, dentistry is hugely dependent on material science.

And because, the teeth and it is surrounding structures needs to be replaced by very good, very highly efficient bio materials. And the options which are available are enormous and so the curiosity with the engineering graduates and the interest with the problem solving, healthcare workers that is the dentist, a conglomerate would really make the field even better and better and we can think and plan out very interesting biomaterial applications related to dentistry.

So, the one which is what we commonly know is your dentures. So, till now dentures are all acrylic polymer based and there are numerous disadvantages of acrylic polymers. So, if we can derive a very nice biomaterial strong enough. At the same time biocompatible, at the same time which does not allow any antimicrobial agents, colonizing to it would be of a great use.

There are a lot of research which are in progress, but till now in the market we do not have a material which is exactly fitting into the ideal requisites of a denture based material. We have materials, but there is a compromise it at least in one or the other properties.

And then we have dental fillings, again dental fillings that is the same story till date there is no material which exactly fits into what enamel can offer or what dentin can offer. They are closer, they are closer there are materials which are very close, but till they have not come into exact match of what nature has already given to us.

So, again there is huge prospects of giving a very ideal restorative material, again in the field of implantology, titanium based implants are the order of the day and there are numerous opportunities to create multiple surface modifications, create numerous, new novel, coating materials to make the implant survival better all that has very high applications and then, we have other periodontal regeneration.

Periodontal regeneration periodontitis and dental caries are the most common prevalent diseases of mankind. So, please be assured that oral diseases that is dental caries and periodontitis are the most commonest disease of mankind himself. So, other diseases come after that. So, the prevalence of dental caries and your periodontitis is ranges anywhere between 60 to 80 percent.

So, the prevalence is very high. The amount more the prevalence you need to given multiple therapeutic opportunities and there is a world of opportunities over there in the field of dentistry. Then we have orthodontics, we know that we need orthodontics to make a smile more beautiful, make a smile more aligned and orthodontists are the ones who align all the malposed tooth.

So, biomaterials have a very big role to play because, as we as the orthodontist goes into aligning the teeth, the force which is generated, there is a lot of friction which is generated and these biomaterials play a really great role in reducing the friction mechanics which actually slows down the orthodontic forces. So, in that way they are really helpful and there are materials which actually reduce the antibacterial colonization around the bracket and reduce the white enamel lesions which happen during wearing of your braces or your orthodontic appliances.

And then we have the primer or adhesive systems, these are also part of the restorative dentistry and endodontics where the entire chamber is filled up with an artificial material. So, we are again in constant search for ideal biomaterial which is not only inert, but which is bioactive which is able to really mimic what was lost in the form of pulp.

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And having read through what is biomaterials about; having read through what biomimetics is about. To conclude about biomaterials application, what we need to understand as a healthcare worker or as a technological graduate. We have to understand, the need is huge, the applications are very wide ranged and the requirement is very very huge and it is up to us to full fill in all those gaps and make better services to the mankind and be a better human being in serving your societal or your next neighbor.

So, it is of very great importance service to mankind is service to God. So, it is very important. So, all that you need to understand is biomaterials allows you to do a great service by providing very high-quality health care, by doing a very giving a very high-quality health care, you are helping your fellow being, you are reviving your fellow being, making him better, giving him better function and giving him better quality of life.

Thank you.