**INDIAN INSTITUTE OF TECHNOLOGY ROORKEE**

**NPTEL**

**NPTEL ONLINE CERTIFICATION COURSE**

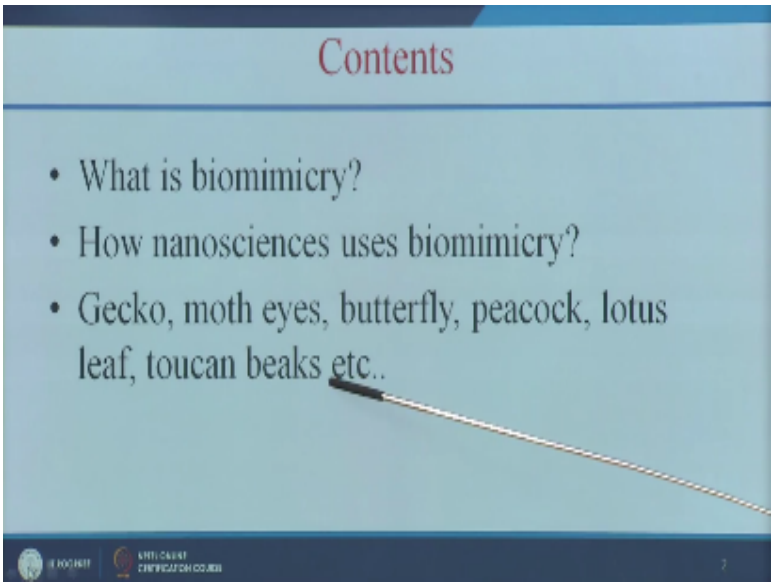
**Biomedical Nanotechnology**

**Lec-02**
**Nano-Biomimicry**

**Dr. P. Gopinath**
**Department of Biotechnology**
**Indian Institute of technology Roorkee**

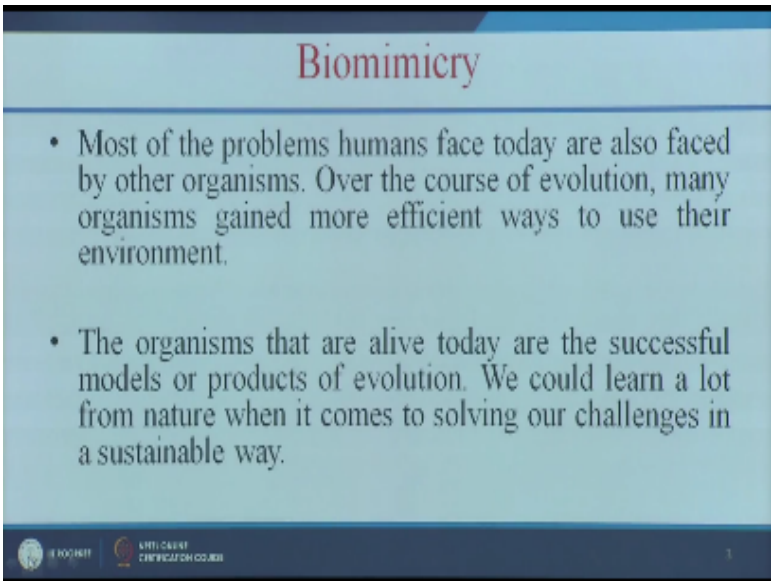
Hello friends I welcome all to the second lecture of this course. Today we are going to see an interesting lecture that is nano-biomimicry.

(Refer Slide Time: 00:31)




So in this lecture we are going to learn what is biomimicry and how nanosciences users biomimicry by using this examples like Gecko butterfly and toucan beaks etc.

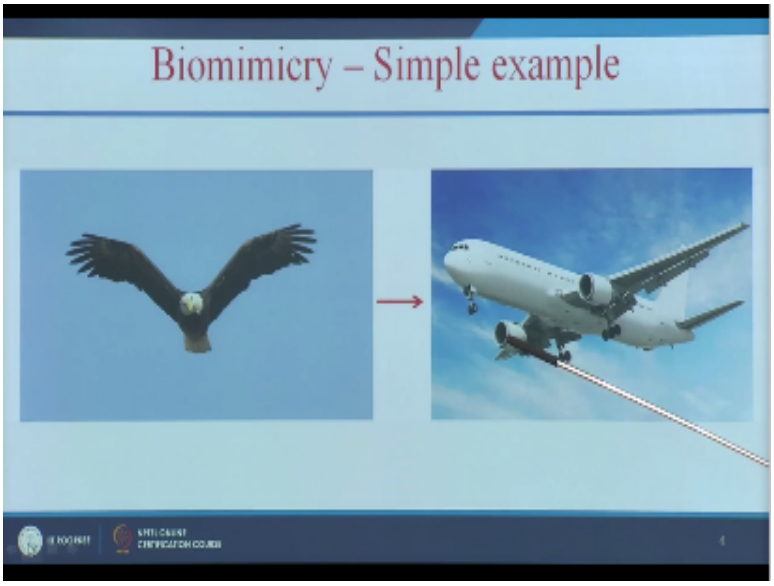
(Refer Slide Time: 00:41)




So let us see what is biomimicry, so what is the meaning for the word mimicry, mimicry means copying or mutating. So what is biomimicry, we are going to copy some idea from nature and we are going to develop some product which will be useful for human. So why we have to select idea from nature, because most of the problems human face today are also faced by other organisms. So over the course of evolution many organisms gain more efficient way to use their environment.

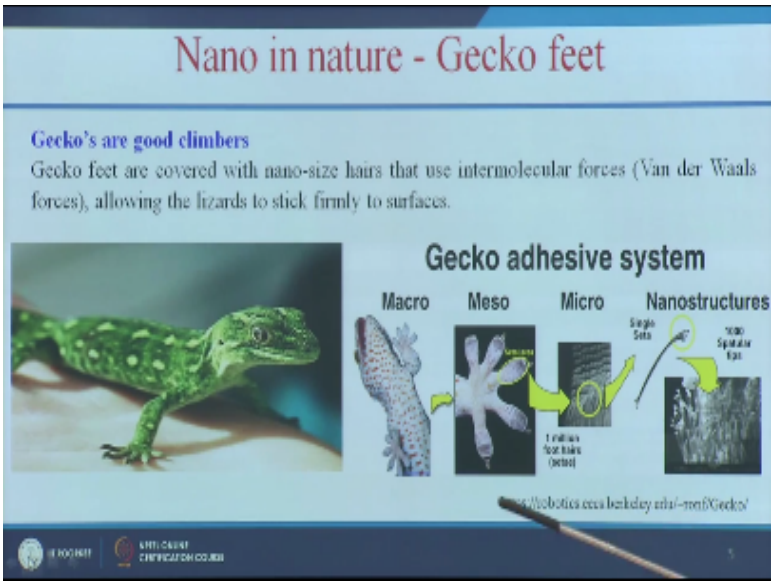
So that is why we are selecting the idea from the nature, because the organism that are alive today are the successful model or products of evolution. So we could learn a lot from nature when it comes to solving our challenge in a sustainable way. So we can take a idea from nature and we can mimic that and we can make a usual product for the human beings okay. So let us see a simple example for biomimicry.

(Refer Slide Time: 01:36)




So we got the idea of aeroplane from the bird. So this is a simple idea of biomimicry, so we can understand what is biomimicry from this simple example. So in this lecture we are not going to focus this kind of applications, so let us focus more on nano in nature.

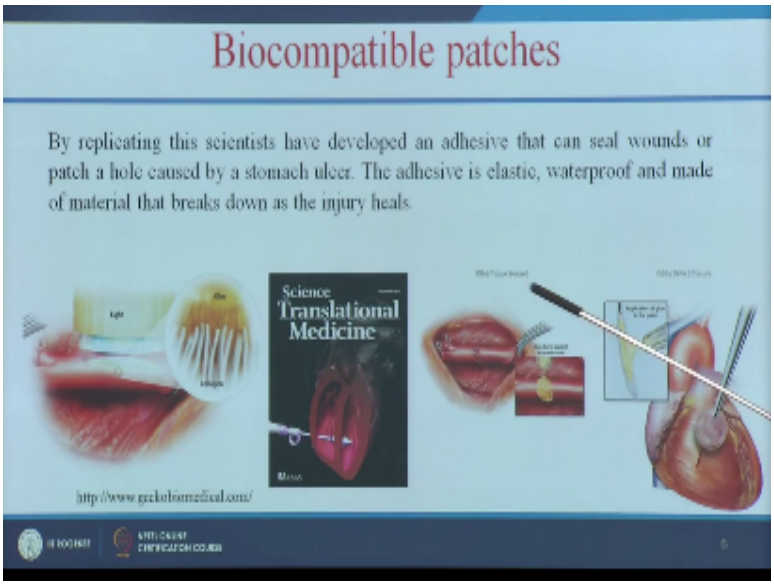
(Refer Slide Time: 01:51)




So what are the nanostructures available in nature and how we can use the nano-size and nanotechnology to replicate those structures and how we can make useful product for the human applications. The first example is Gecko, so this Gecko it is one of the very good climber, it can climb any kind of surface, it can be soft surface or it can be slippery surface. It can easily climb, so how is this possible, so the Gecko feets are covered with nano-size hairs, this nano-size hairs will use the intermolecular forces that is Van der Waals force. So that allow the lizards to stick it to the surface very strongly.

So let us look into the nano-structures available in this Gecko feet okay. So if we see that Gecko lizard feet and you can see here there are lot of nano hair like structures in the feet, so this is going to stick it strongly to the surface through Van der Waals force.

(Refer Slide Time: 02:48)

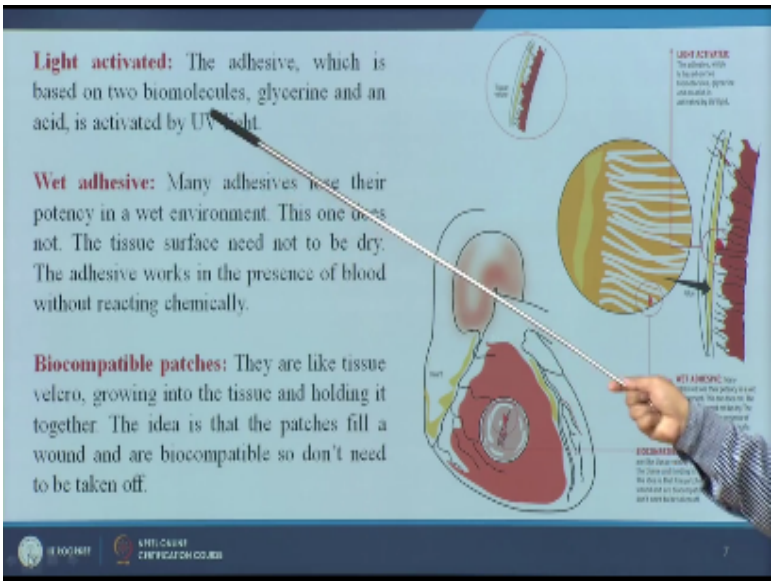



So the company Gecko biomedical so they got the idea from this Gecko feet and so they have developed a new technology called bio glue or adhesive method is they made a very good biocompatible adhesive that is called as biocompatible patches. So what is the meaning for biocompatible, that means the material which is compatible with your biological system that is called as biocompatible material.

So this biocompatible adhesive it can seal your wounds or it can patch a hole caused by stomach ulcer or any other, and this adhesive is elastic and it is water proof and it is made of material that breaks down as a injury heals, that is the material is biodegradable that means the material will degrade inside the biology system and it would not cause any immune response or toxic effect that is called as biodegradable material.

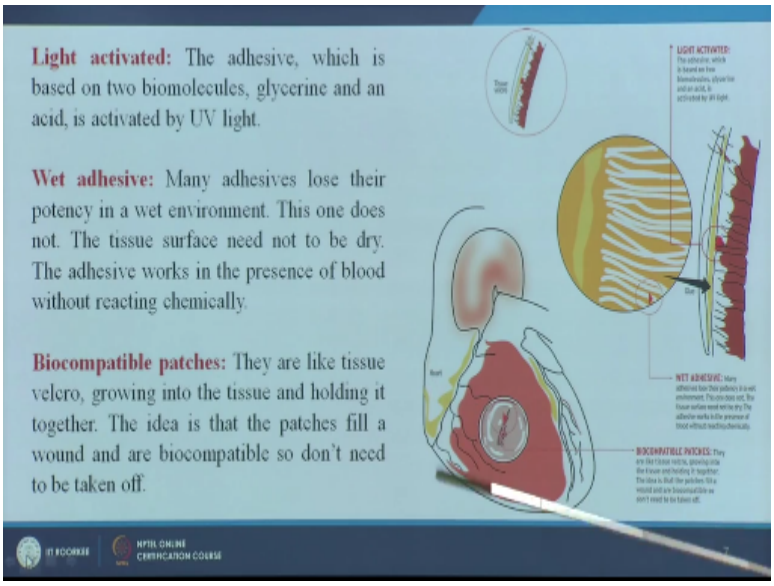
So this material is biocompatible as well as it is biodegradable material. So what was the idea, so if there is a wound or anything so we can apply this glue and apply the UV light and this will seal the wounds.

(Refer Slide Time: 03:58)




So how this biocompatible patch work let us see.

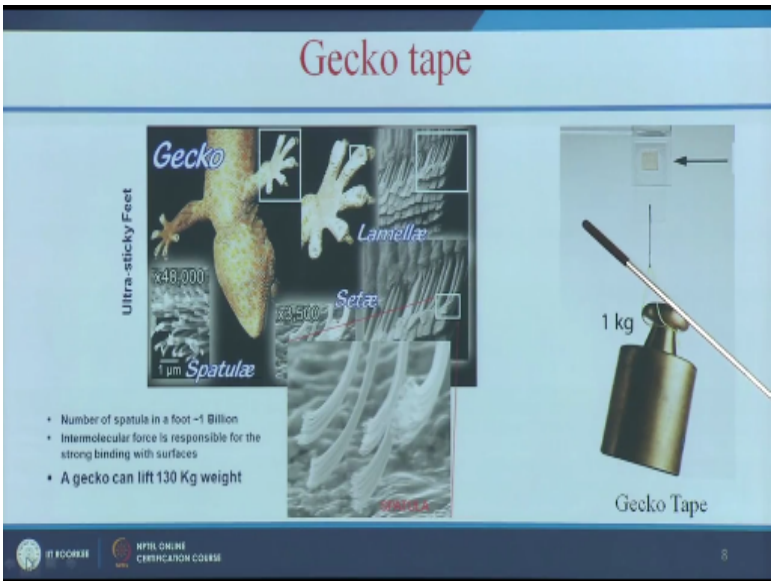
(Refer Slide Time: 03:59)




So this is a adhesive this adhesive is made up of two bio molecules one is glycerin and other one is an acid so this will be activated by a UV light. So this acid is pattern produced and this one this we can use this wet adhesive for sealing the wholes who this wet adhesive works because most of the adhesives lose their potency in a wet environment, but this does not needed dry surface so this can work on in presence of blood without reacting chemically.

So that is the advantage of this wet adhesive and this biocompatible patches work like your Velcro like a tissue Velcro it grow into the tissue and holding it together so this idea is that the patches fill the worn and biocompatible and it do not need to be take out of so that is the advantage of this biocompatible I guess there is a lot of cynical times going on this and soon it will be available in the commission for human use.

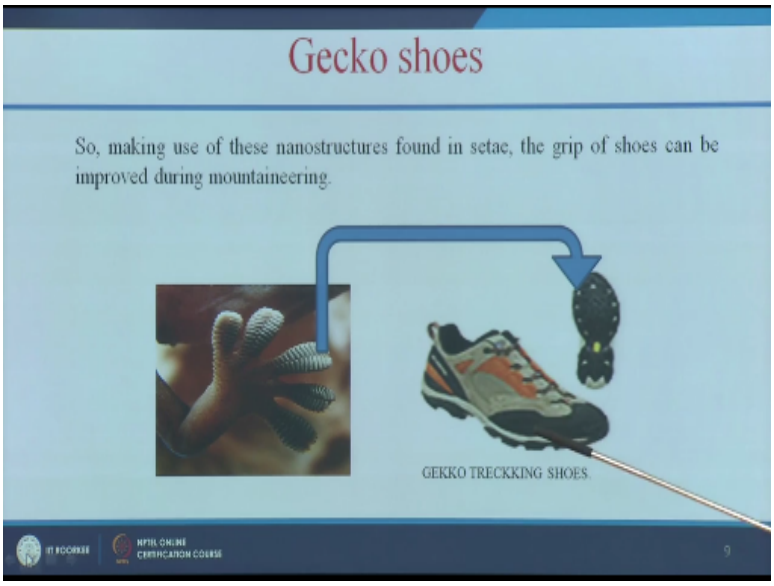
(Refer Slide Time: 04:57)




So let us see the another example not only biomedical application we can also take the idea of gecko and we can make a adhesive tape so we can when compare to the normal tape we can see here this tap is very strong and it is reusable we can row it n number of time because this is striking based on the wander wall force and you can see the capacity it can carry even 1 kilo gram weight and a maximum weight it can lift is 130 kg and if you see that what is the reason iron it as a nano kind of has arrangement on the Gecko feed and for seeing this nano arrangement you need as specialist Microscope called electron microscope.

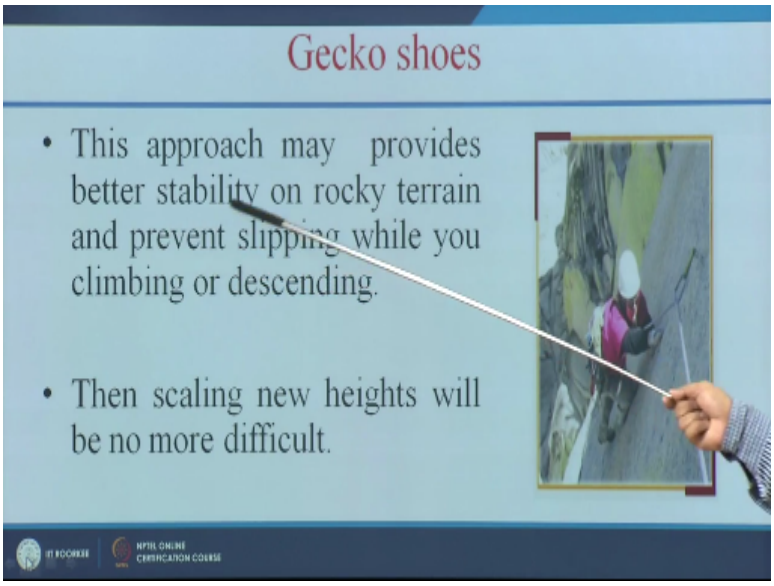
So for normal objects you have to use the light microscope but when you want to see something in the nano structure microscope but when you want to see something in the nano structure, nano level you have to use electron microscope like transmission electron microscope or scanning electron microscope to the nano scale structures.

(Refer Slide Time: 05:50)



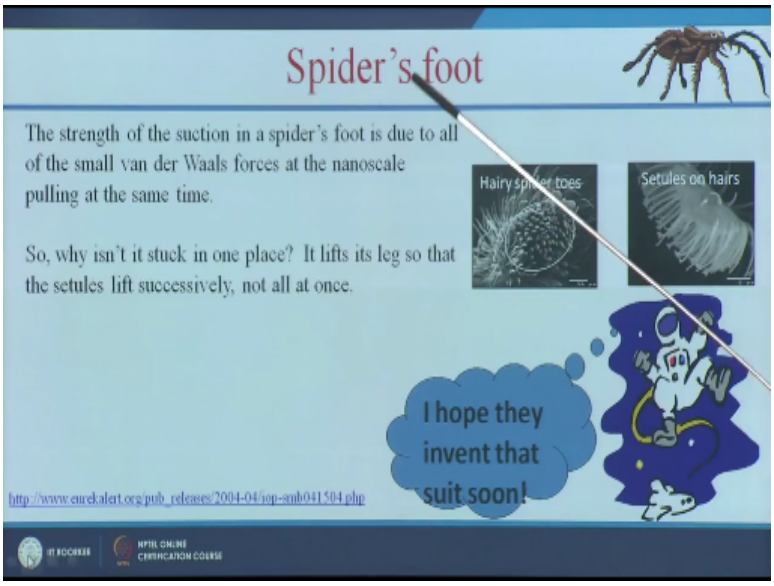

So from the gecko freed we can make a gecko shoes so that will be useful for the people those who are going mountaineering and also it will be useful for the people, those who have disability in walking or some old age people those may need this kind of gecko based shoes which will have strong grip on the surface.

(Refer Slide Time: 06:07)



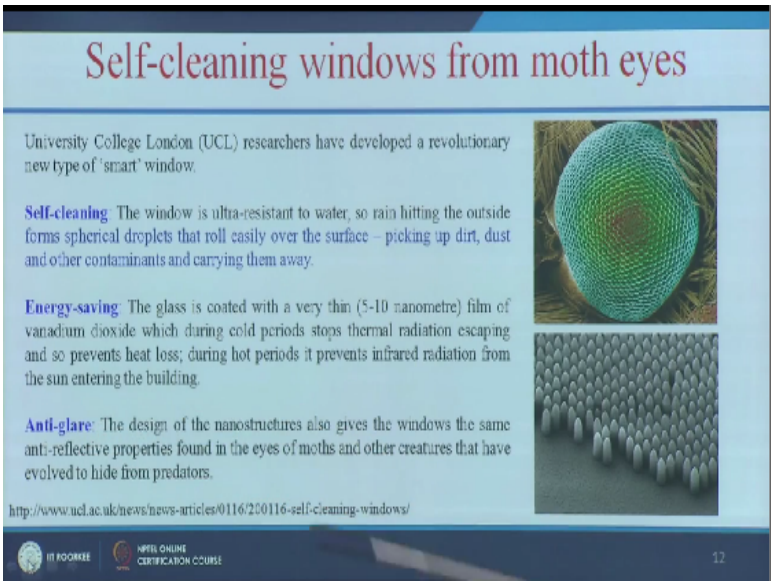

And it will also have a stability and prevent slipping when you are climbing or descending so we can have this gecko shoes and it could be have very good applications and useful for terrain and let us see another examples that is spider foots.

(Refer Slide Time: 06:24)




And the spider foot is also based on this nano structures so if we see that the spider foot also have that nano scale pulling at the same time and it lifts a leg so the setules are lifts successfully not all once if you see that how the spider walks it lift the leg slowly and it will walk that means it lifts it's leg so that all the setules lifts successfully so based on that we can have a space shoes for astronauts so that will help them to stick to the walls our space craft like a spider.

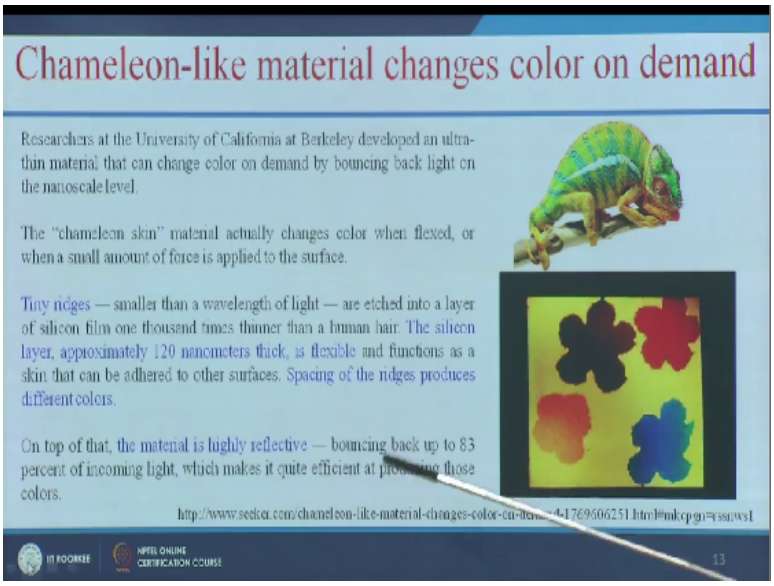
(Refer Slide Time: 06:58)




So let us see another example moth eyes so if you see this moth eyes we can develop similar kind of nano materials so university college London researchers they have developed a smart window based on the moth eyes so they imitate this moth eyes and they have made a nano structure similar to that and this nano structure is having all this property like self cleaning energy saving and glare property so what is self cleaning property.

So when the water falls on this structure it will easily role of and it pick up all the dust and dust particles and it is emery saving how it is energy saving this glass is coated with very thin 5 to 10 nano meter of vanadium dioxide and this material is low cost as well as it is very abundant material so we can easily use it and during the cold periods it stops the thermal radiation and it prevents the heat loss and during the hard periods it prevents the infrared radiation from the sun entering the building and it also work like a Anti-glare and Anti-reflective properties.

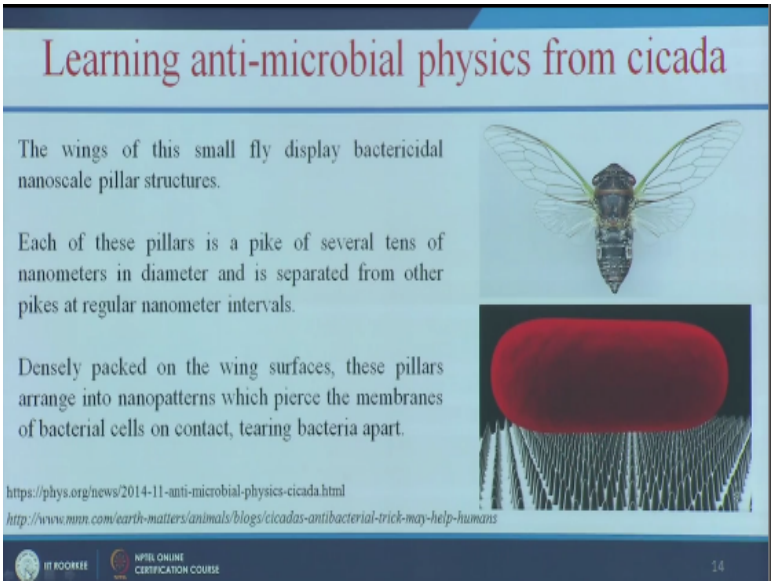
(Refer Slide Time: 08:07)




So let us see another example chameleon so we must seen that chameleon changes the color according to the environment so we can take the idea from that we can make such kind of material which can change color when you apply a pressure or very applies small amount of force so researches from University California so they develop a ultra thin material so that can change color on demand by bouncing back light on the nano scale- level. So this chameleon skill material actually change the color.

When you apply some force to this material, so this material is made of small tiny ridges and this is made up of silicon layer approximately one 120 nanometers thickness and again it is flexible so the spacing of the ridges producers different colors and also another important property of this material is so it can bounds back up to 83% of incoming light which makes it quite efficient at producing those different kind of colors.

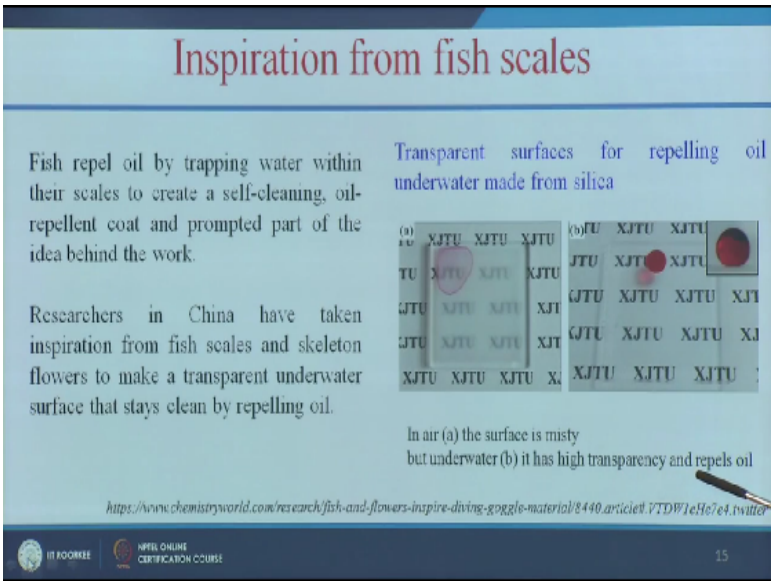
(Refer Slide Time: 09:11)




And one of the major problem now-a-days what we are facing is the micros like bacteria getting resistant to the antibiotics so we have to develop new antibiotics to kill all those bacteria so it is day by day it is getting increase so what we can do is we can take the idea from nature so one of the important example is cicada light so the wings or this small fly have a nano scale pillar structures you can see here this wings have this kind of nano scale pillar structures and this pillar is nanometers in diameter and it is separated at a nanometer interval.

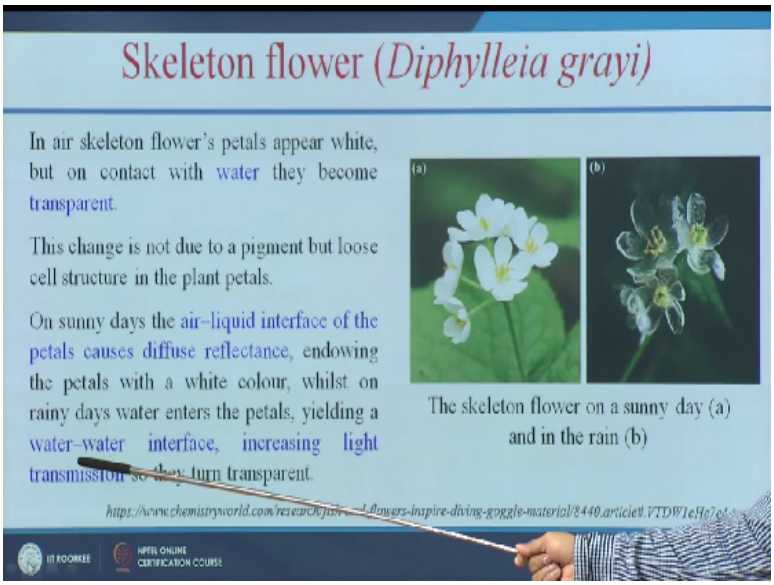
So when the and you know the size of bacteria the size of bacteria in the range of micrometer and this picture you can see this red color is the bacteria and this is the nano pillars so when the bacteria stick on the surface of nano pillars and this nano pillars can pierce the membranes of bacteria cells and it can tear the bacteria and it can destroy the bacteria so what idea we can get from this we can make similar kind of nano pillars coatings okay so that can prevent the bacterial infection so this kind of coating can be applied in the public places or a public toilets so this can prevent the bacterial infection.

(Refer Slide Time: 10:26)



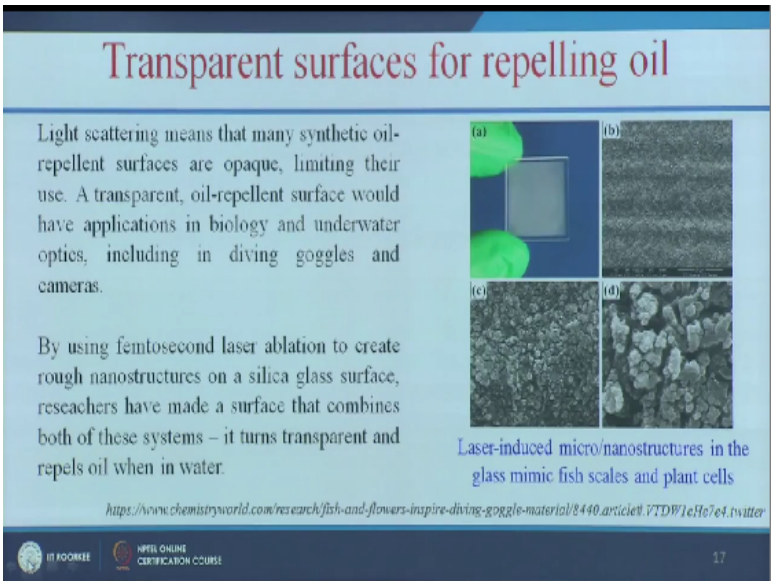

So another idea is a Chinese researchers they got the idea from the fish so kind of idea they got usually the fish repel oil by trapping water within that scales to create a self-cleaning and oil repellent coat so they got the idea from the fish and skeleton flowers to make such kind of transparent under water surface that stays clean by repelling oil so you can see this sphere so this is silica it made by the groups and what is this like a remain a nano scale arrangement on this silica surface. In the air the surface is misty but under water you can see here it has the high transparency and it repels oil.

(Refer Slide Time: 11:13)



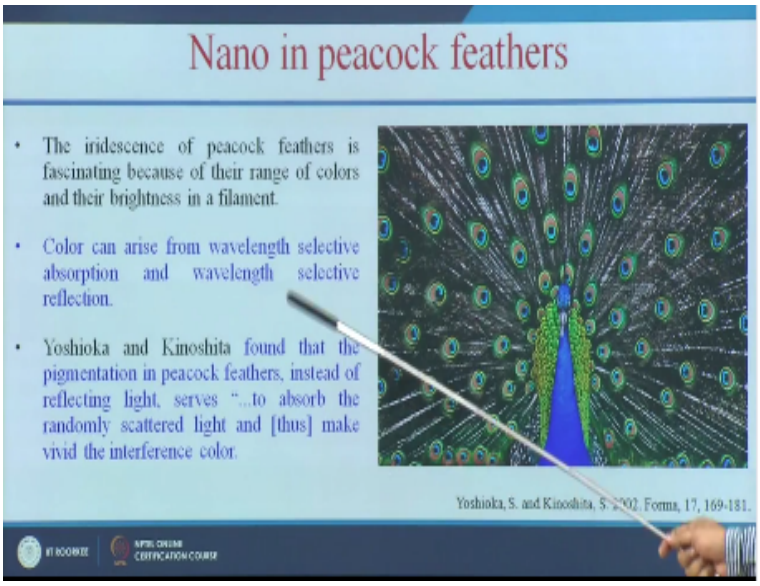

They can take the idea from this skeleton flower we can see here this skeleton flowers petals appears white but when it is contact with water it became transparent it is not due to the pigment but lose of cell structure in the plant petals okay so on sunny days during summer season what happens is air –liquid interface or the petals causes diffuse reflectance but in case of rainy season what happens is water, water interface will happen and it increasing the light transmission so that they became transparent.

(Refer Slide Time: 11:44)



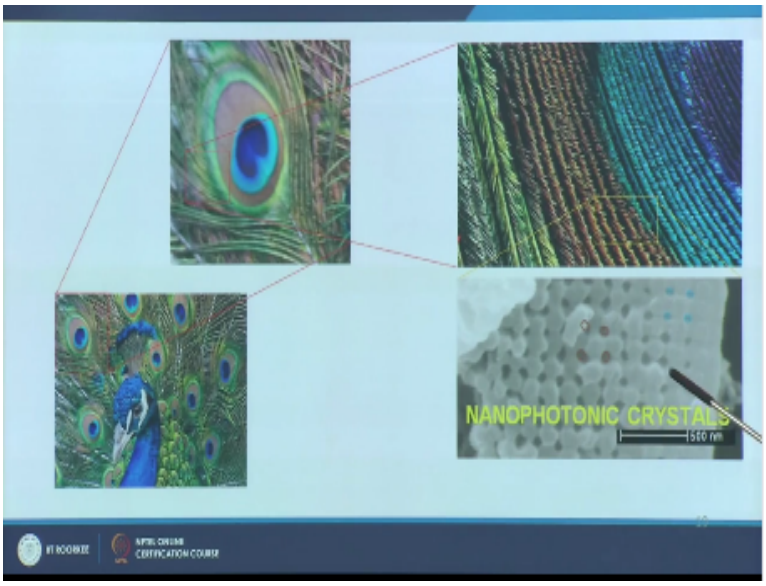

So this researchers they use this idea and they made a transparent oil repellent surface so which will have lot of application biology as well as underwater optics so the result have used a femto second laser ablation to create rough nanostructures on a silica glass surfaces and they made a surface that combines both of the systems and it turns transparent and it repels oil when in water. So they got the idea from the fish and scare an flower and they made a transparent and oil repelling surface.

(Refer Slide Time: 12:18)



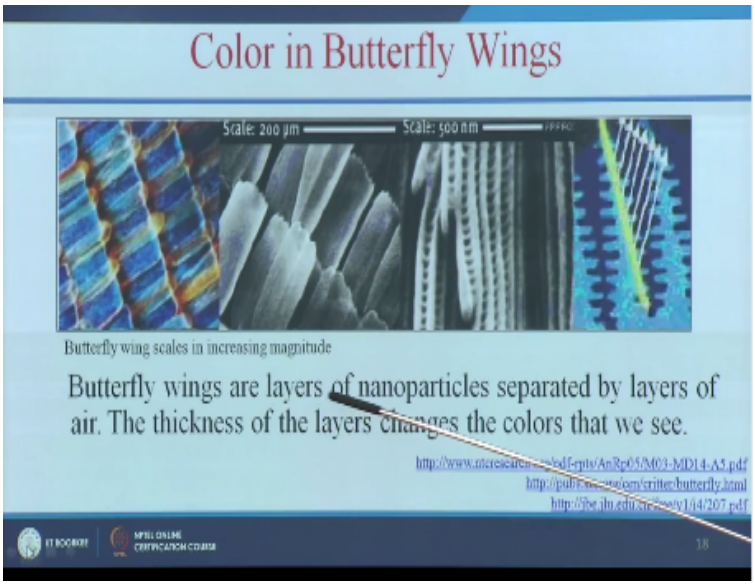

So let us see another example peacock feathers so the beautiful colors of peacock feathers is also due to Nano scale management usually that color arise from wavelength selective absorption and wavelength selective reflection but in case of peacock this side is found that, the pigmentation in peacock feathers instead of reflecting light it serves to absorb the randomly scattered light and that makes the beautiful color of peacock feathers.

(Refer Slide Time: 12:45)



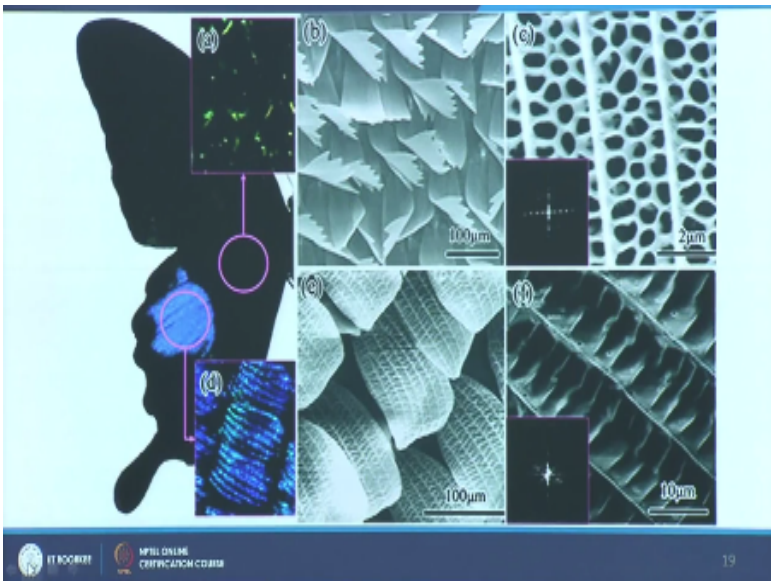

Let us see the peacock feathers in zoom, so here you can see here the beautiful color of peacock feathers that is due to this Nano scale arrangement of photonic crystals.

(Refer Slide Time: 12:55)



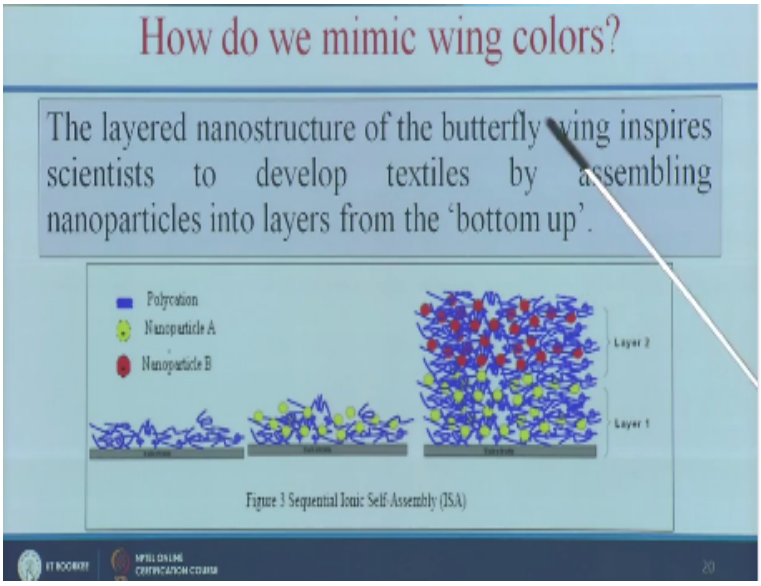

So let us see some of the simple examples so you might have seen the butterfly wings it have lot of beautiful colors, so what is the reason for this beautiful colors if you see that again Nano scale arrangement so what are the Nano scale arrangement, the butterfly wings are layers of Nano particles and it is separated by the layers of air, so the thickness of the layers changes the colors that we see.

(Refer Slide Time: 13:20)



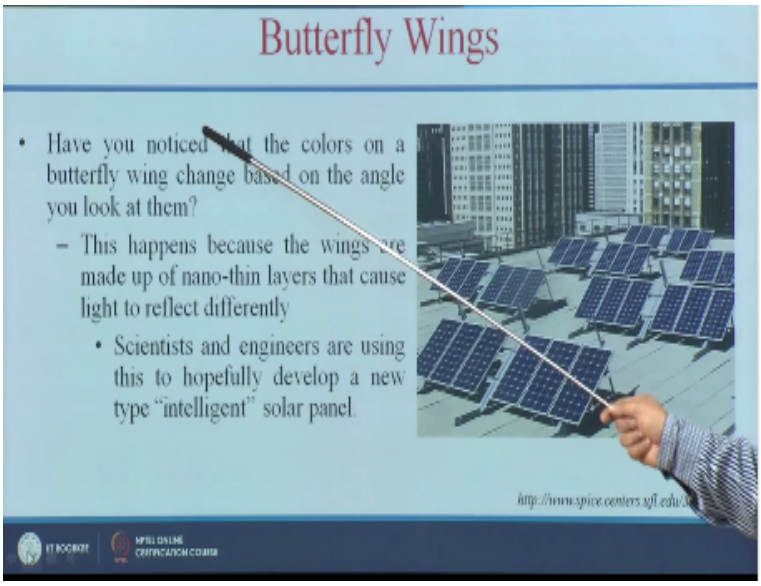

When you see that butterfly wings under the ultra microscope you will get this kind of Nano scale arrangement, so how do you mimic wing colors?

(Refer Slide Time: 13:32)



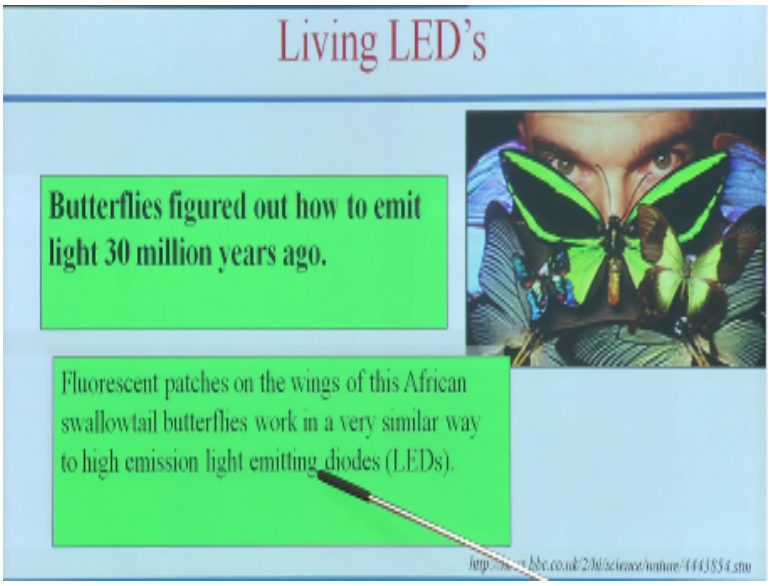

So the layer Nano structure of butterfly wings inspire scientist to develop textiles by assembling Nano particles into layers from the bottom up, so you can do the layer by layer assembly and you can make such kind of textile material so this kind of textile material will give a different kind of color in the indoor light and it can give a different kind of color in the outdoor light.

(Refer Slide Time: 13:54)



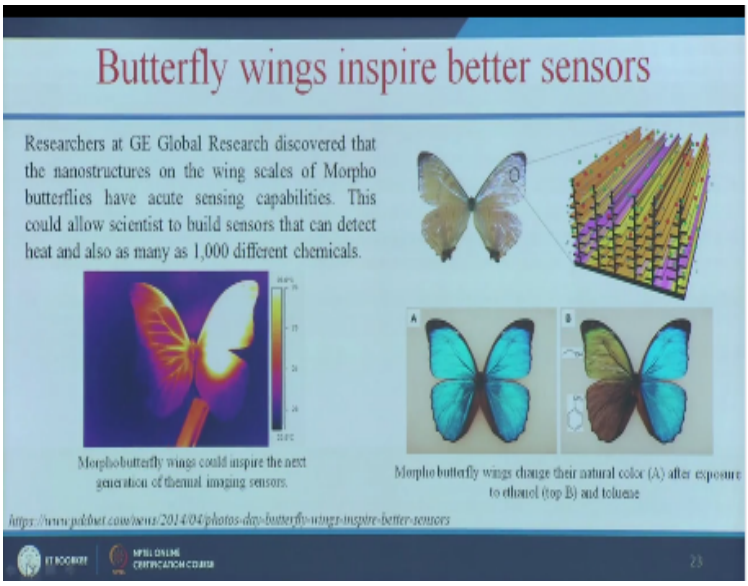

And again another example is for the same butterfly like you can notice that the color of butterfly wing change based on the angle you look at them, okay. So why it is happening, this happened because the wings are made up of Nano thin layers that cause the light to reflect differently. So scientist brought the idea to develop such kind of intelligence solar panel so that it can harvest more amount of solar light.

(Refer Slide Time: 14:20)




And again the butterflies emit light and they know how to emit light 30 million years ago and this African butterfly is a very good example for developing such kind of high emission light emitting diodes so scientist are trying to medicate and they are trying to develop high emission LED's.

(Refer Slide Time: 14:43)

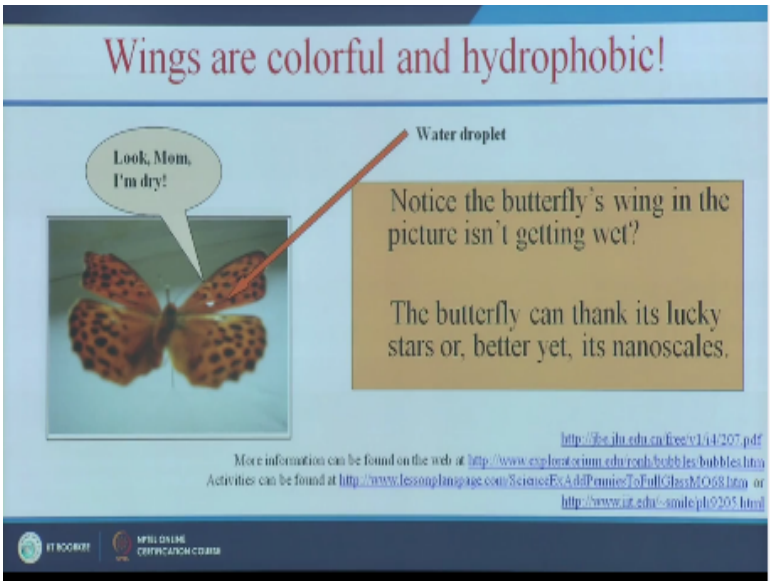



So and again not only that the butterfly wings can also be a very good sensor for heat as well as various chemicals, so researchers from GE global research they discovered that the Nano structures on the wings case of morph butterflies have very good sensing capability, so this will allow the scientist to bill very good sensitive sensors which can detect the heat as well as it can detect more than 1000 different kind of chemicals.

So if you see the Morpho butterfly wings it have a very good Nano scale arrangement and here you can see here how they use this butterfly wings for checking the chemical sensitivity and when you apply the alcohol the color of butterfly wings is different when you apply the toluene the color of butterfly wings get changed. So based on that we can make a chemical sensor simple chemical sensor.

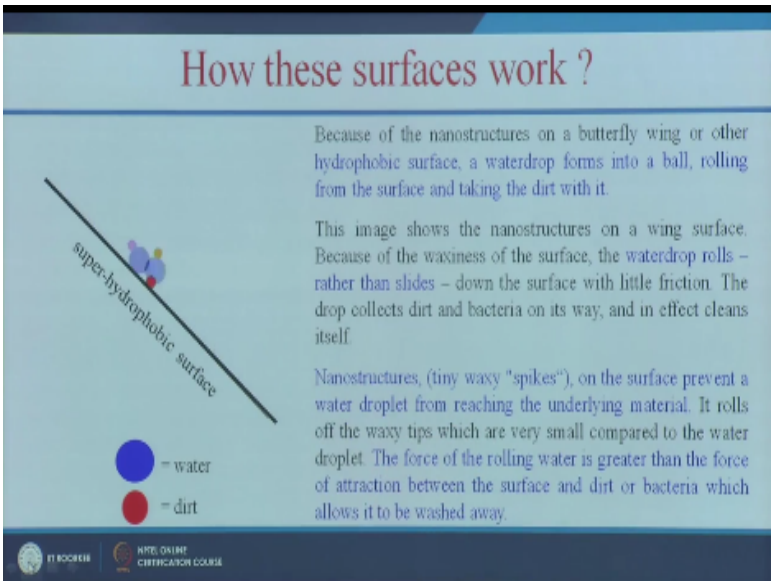
And again here you can see here when you apply the heat the butterfly wings color get changed, so based on the principle we can make a similar kind of material and that can be a very good heat sensor as well as chemical sensor.

(Refer Slide Time: 15:44)




And you might have observed that butterflies fly more here and there during the rainy season but it would not get any wet, how is it possible because the butterfly wings not only colorful it will have very good hydrophobic property. So let us see how we can use this hydrophobic property.

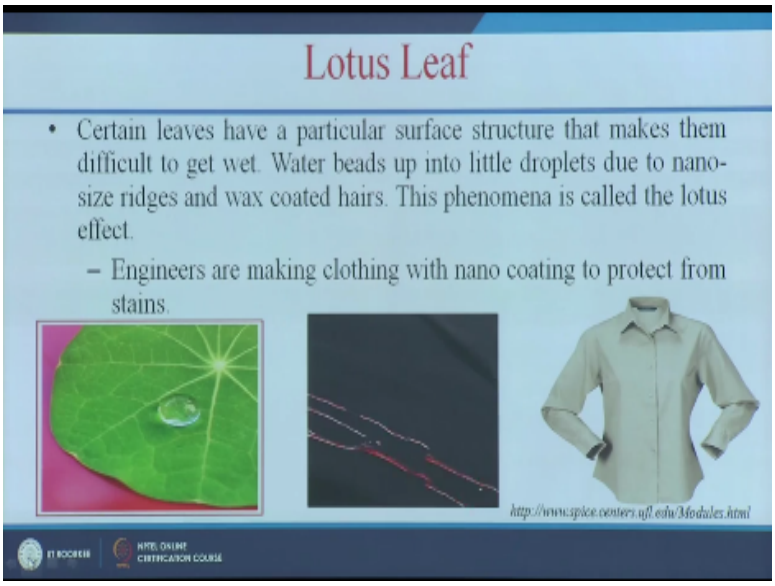
(Refer Slide Time: 16:07)




And what is the mechanism how it is having self cleaning property so if you see the butterfly wings it has a very good super hydrophobic surface, okay so this hydrophobic surface makes a water like a ball and it will roll from the surface and taking all the dirt you can see here the red color is a dirt and the blue color is a water, so the water drops rolls rather than slides and it has a nano structures like a tiny waxy spikes okay, so it will prevent the water droplet to reach the underlying material.

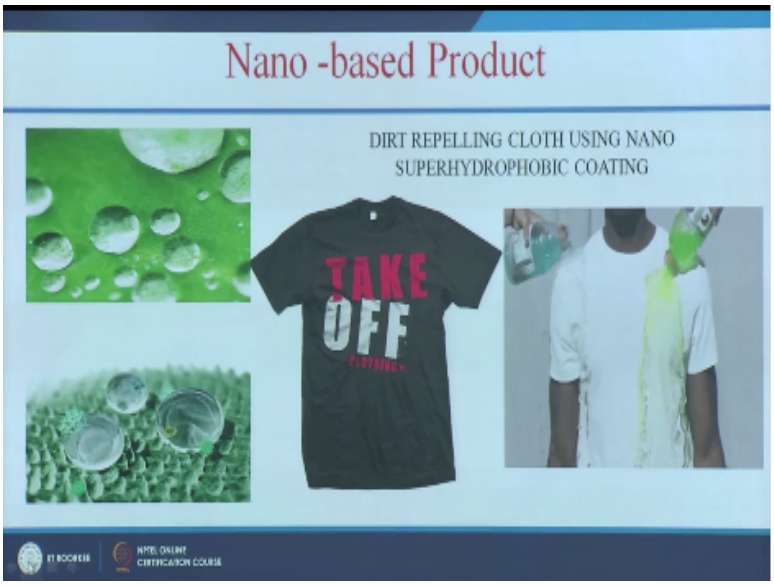
And the force of the rolling water is greater than the force of attraction between this surface and dirt so that it can easily wash away all the material so the butterfly wings have very good cleaning property because of its super hydrophobic nature as well as it has the tiny waxy spikes.

(Refer Slide Time: 16:59)




Similarly lotus leaf also have such kind of nano size ridges and wax coated hairs, so this phenomenon is called as lotus effect so based on this principle based on this idea we can make similar kind of hydrophobic textile materials.

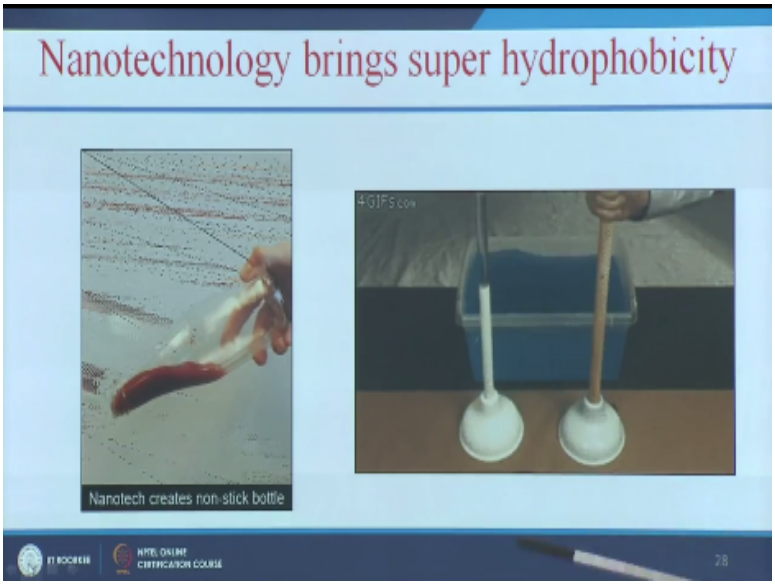
(Refer Slide Time: 17:13)




So you can see here this is the scanning outer microscope picture of your lotus leaf it has the tiny nano ridges and this is super hydrophobic, I mean in the water droplet at falls on that is it rolls on the surface and it remove all the dirt particles or bacteria. So we can make a super hydrophobic t-shirts or shirts which will have a very good hydrophobic and we do not have to wash the shirts using detergents, you just simply dip in the water it will clean your shirts.

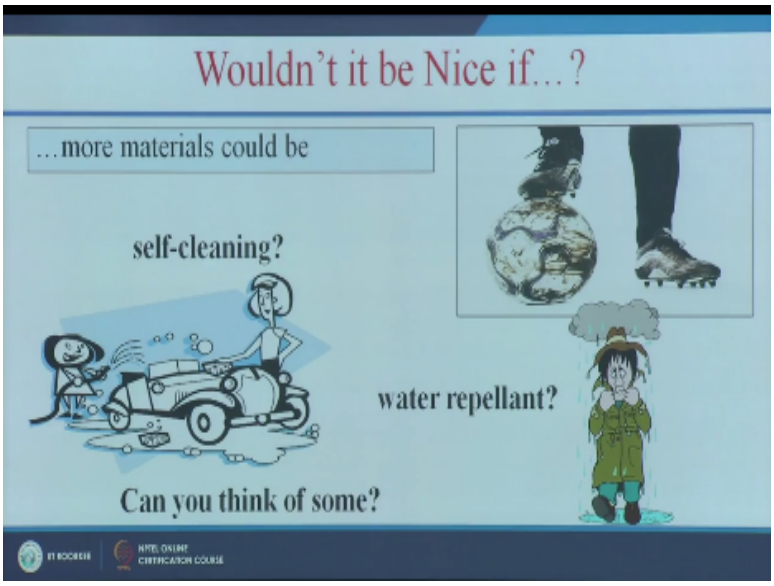
So this kind of t-shirts or shirts it will be useful for the students those are staying in hostels you do not have to wash the t-shirts or shirts using detergents just dip this t-shirts in the water that will clean all your dirt and strains.

(Refer Slide Time: 17:58)



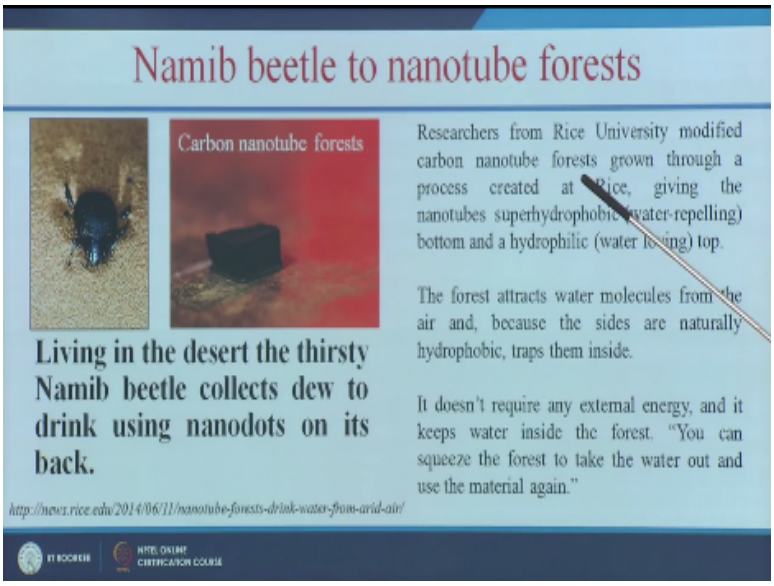

Not only that we can also make a non-sticky bottle we do not want to waste even a single of ketchup so and also we can make like a super hydrophobic coating based plastics which laws have a lot of applications.

(Refer Slide Time: 18:08)




So you can also think some other any new ideas for example, it can have such kind of coatings on the car so that you do not have to take your car to service center for cleaning your car it will have the self cleaning property and also self cleaning shoes are football and again you can have a water repellant clothing materials okay, so we can think of something like that.

(Refer Slide Time: 18:31)

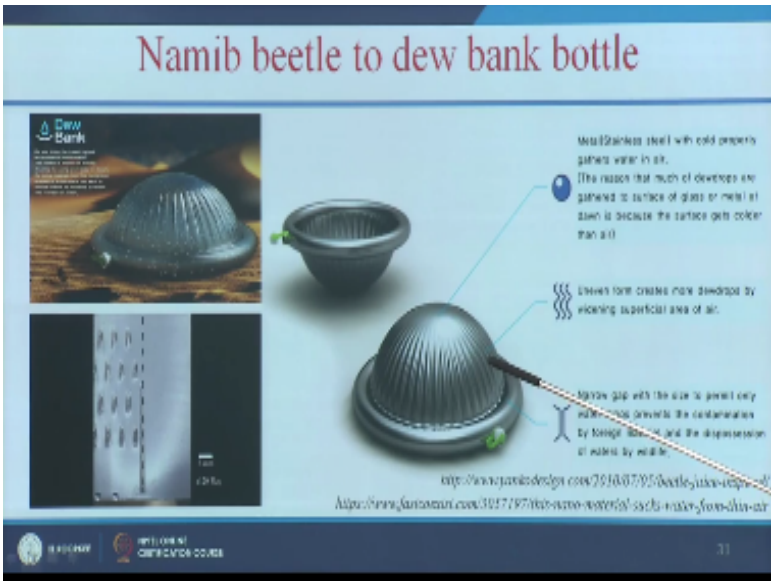



So next idea is carbon nano tube forest okay, so from the namib beetle how we can make the nano tube forest, so this namib beetle lives in the desert and it collects the dew to drink using nanodots on its back so this namib beetle has a nanodots on the surface it will collects the dew and it will drink the water from there so based on that researchers from Rice University they have modified the carbon nano tube.

So what is carbon nano tube the carbon nano tube is like a simple graph and sheet rolled in to tuber form so they use the carbon nano tube and they have slightly modified the carbon nano tubes what that it is the nano tubes are super hydrophobic that means water repelling bottom and it has the hydrophilic that is water loving top I mean the top is water loving and bottom is water repelling.

So this carbon nano tube based for us it can attracts the water molecules from the air because the size are naturally hydrophobic so that it can traps them inside, and again it does not require any extent energy and it keeps the water inside the forest so whenever we want the water you can squeeze the forest and take the water and again the another important property of the carbon nano tubes we can re use it there is the one of the important property of this carbon nanotubes forest.

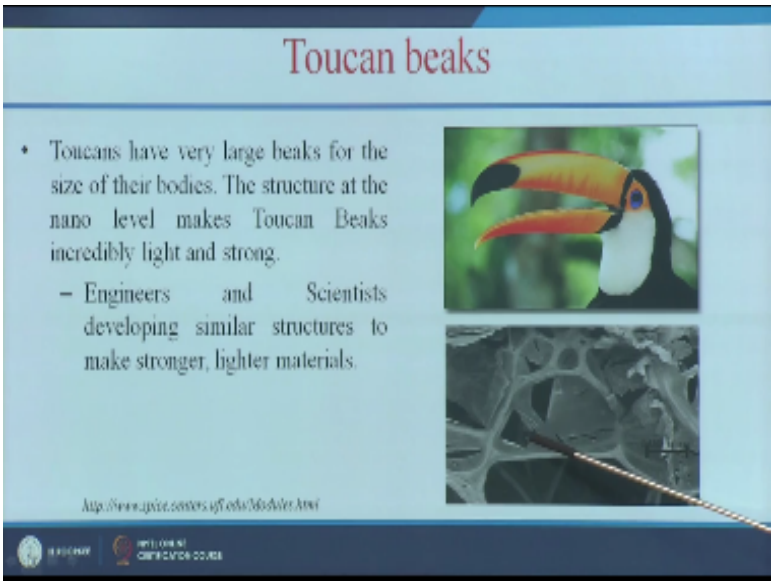
(Refer Slide Time: 19:53)




So based on the Namib beetle a company due bank they made the water bottle, so from Namib bottle they made a dew bank bottle okay. So let us see how the bottle works so this is made up of mettle so which has the cold property it gathers water in air and it has the uneven forms surface okay. So this uneven form creates more dew drops by widening the superficial area of air, and it has the narrow gap so it allow the \water to enter to this and it will prevent the condemnation of foreign material.

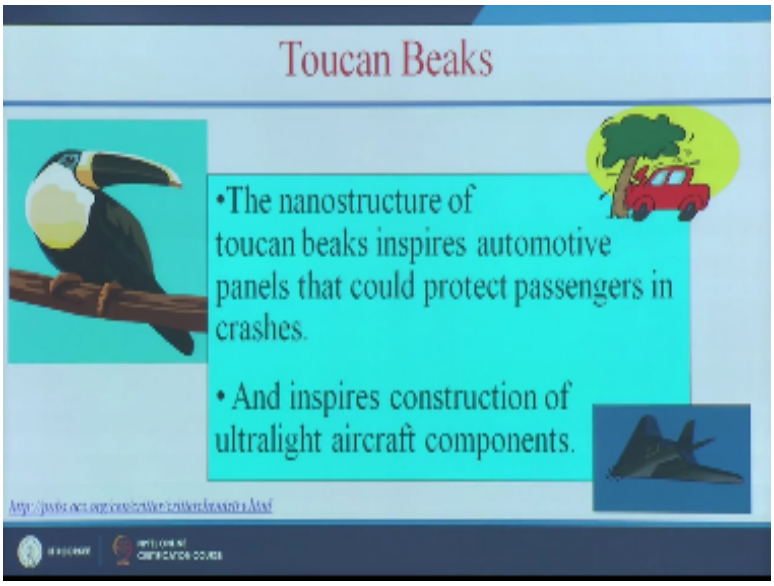
You can see here the water droplet falls and rolls in to the bottom so you keep this water bottle in the night time and morning the water is ready for drinking.

(Refer Slide Time: 20:38)



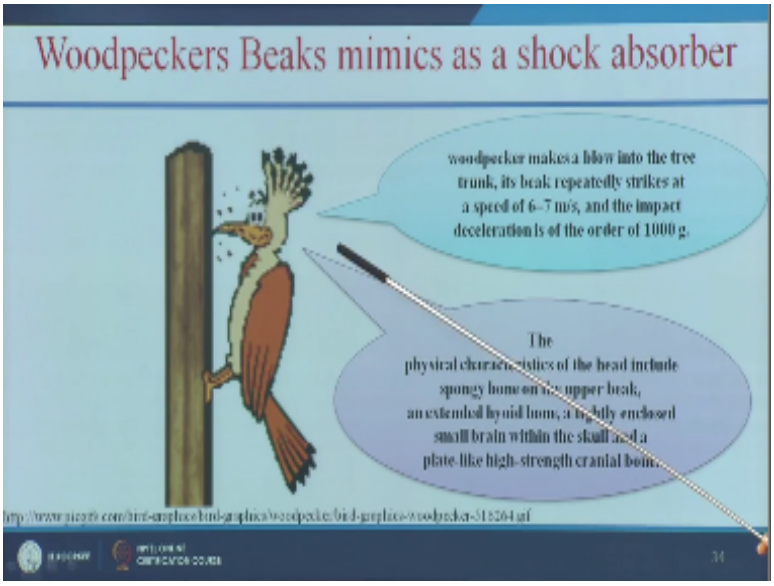

So let us see another example Toucan beaks so if we see the bird the beak is very big size when compare to its body size but still it is able to manage it and it is able to fly and it is able to break, break the food materials so how it is possible. So when you see that beaks under the electron micro scope it have a very good nanostructure it is a strong material as well as it is the lighter material so it can carry it at the same time it is the very strong material.

(Refer Slide Time: 21:09)



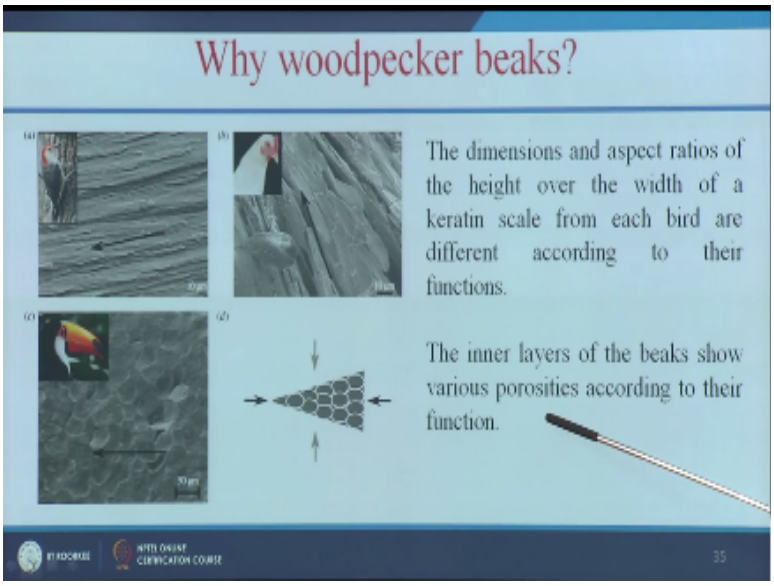

So we can make something similar to that so what we can do is we can take the idea from the Toucan beaks and we can make such kind of automotive panels, so that will protect the passengers and also we can make some construction of ultra light aircraft components which will also useful in aerospace industries.

(Refer Slide Time: 21:34)




So let us see another example woodpeckers beaks, so the woodpecker beaks, so you can see here the woodpecker makes blow in to tree trunk and it beak repeatedly strikes there a speed of six to seven meter per second and the impact of deceleration the order of 1000g and still it is able to maintain its proper structure, it is not the bone is not getting damaged or the head is not getting injured and it is able to protect the brain. So what kind of idea we can get from this we can make similar kind of

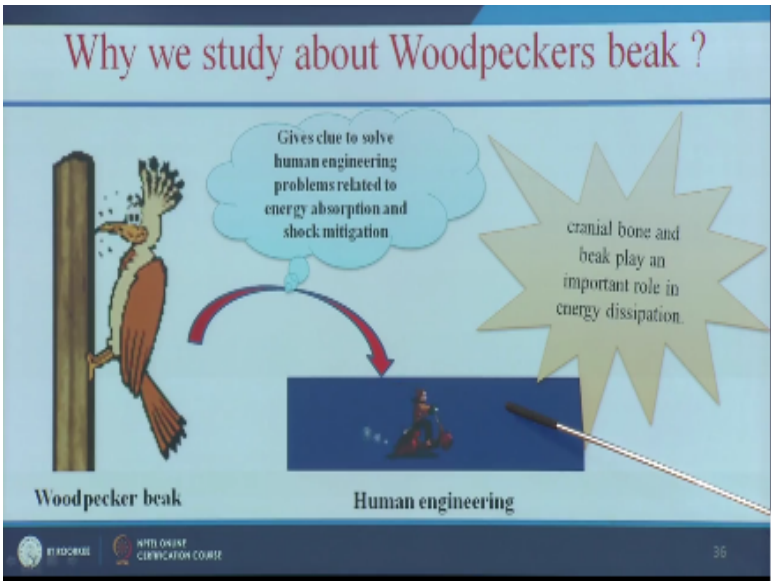
(Refer Slide Time: 22:05)




We can get shock observer or helmets so they have made a detailed study and comparing the beaks from different birds like hen and beaks and they studied the dimension and aspect ratio of height over the width of a keratin scale from each bird are different according to their functions and again the inner layers of the beaks show  various prosperities according to their function.

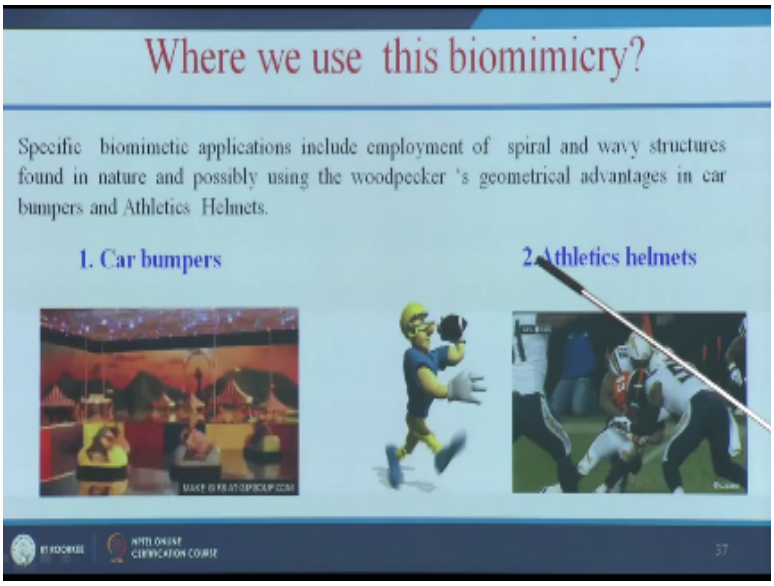
That means this when you compared this with several birds they are telling that this woodpecker beak has very good keratin proposition as well as porosities, so that act like a very good shock observer.

(Refer Slide Time: 22:42)



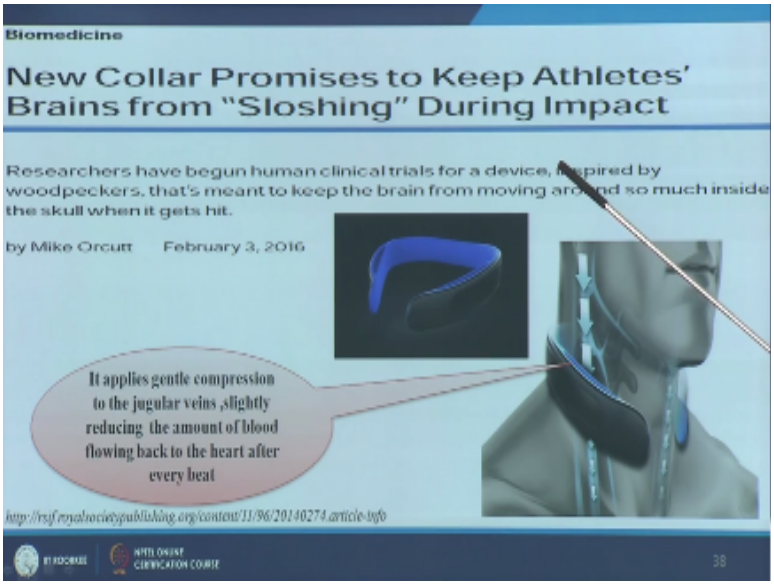

So what idea we can get from wood pecker beak we can mimic that idea and we can make a shock observer which can protect the person.

(Refer Slide Time: 22:51)




And we can also make a car bumper and athletic helmets.

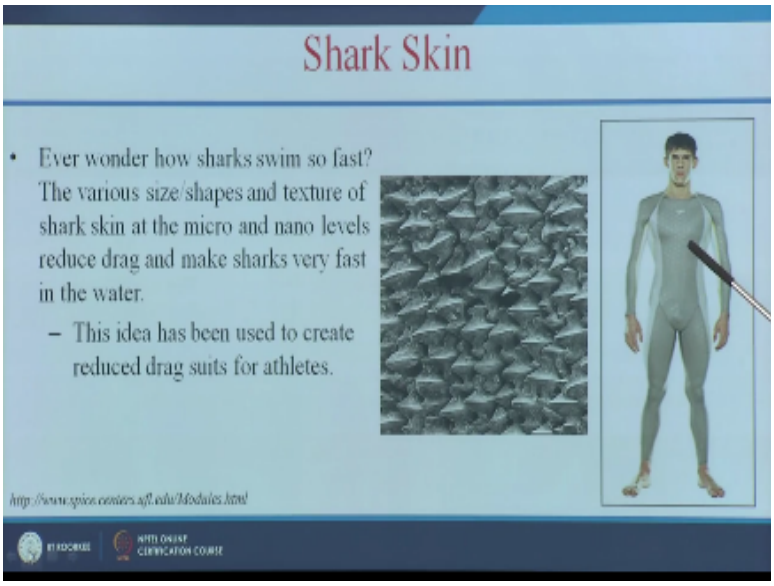
(Refer Slide Time: 22:58)




So last your there was research publication and in this they have shown that they have made smart collar what they did is they got the idea from the wood pecker and they made smart collar it applies this collar applies gentle compression to the to the juggler veins and it is slightly the amount of blood flowing back to the heart after very beat.

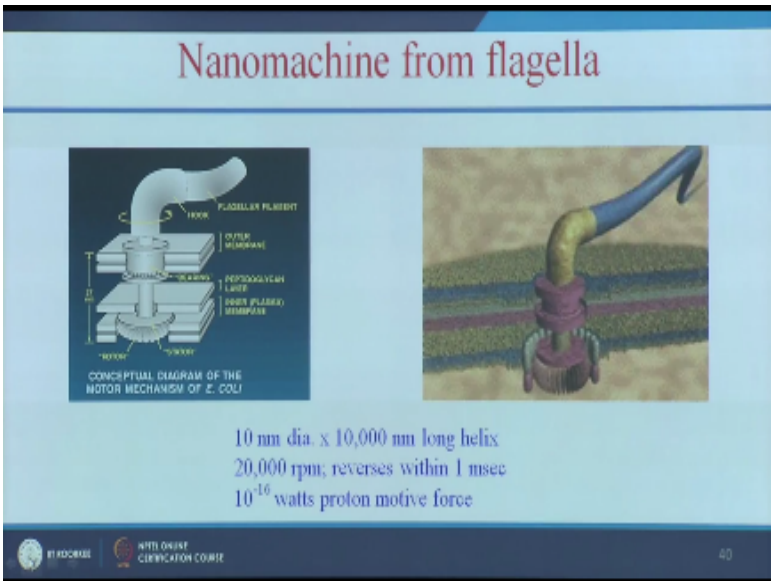
So this smart collar will protect your brain moving around so much inside and the skulls gets hit, so it will protect the brain when there is a head injury or when there is some kind of accident and another example is

(Refer Slide Time: 23:37)




Shark skin so you might have seen that the shark seem very fast so how is it possible if you see the shark skin it has a very good nano skin arrangement and this micro nano skin levels will reduce the drags and it makes the shark swim very faster in the water. So the scientist got the idea and they made similar kind of drag suits for the athletes, so this will be useful for the swimmers.

(Refer Slide Time: 24:05)




So let us see other simple example bacteria flagella you might have seen that bacteria move from one location to another location using the fklagella. If you closely observe these flagella it look like a nano machine or nano motor you can see here the size of the flagella is 10diameter and 10000 nano meter long helis.

And it goes like 200000 rpm what is rpm revolution per minute or rotation per minute okay. So again it reverse with in 1 milisec so which is not possible by any human made machines so it route at the speed of 20000rpm and it reverse is direction with in one msec and so we can take the from this idea flagella and we can make similar kind of nano motors and nano machine which also have very good applications.

We can make a nano robots or nano machines which can swim very fast and it can deliver it in your body. So similarly we have plenty of examples okay and from this lectures we have understood bino Greek and we have understood the nano sciences uses bino Greek for making useful products for the human applications. So I end my lecture here thank you for listening I will see you in another interesting lecture.

**For Further Details Contact**

**Coordinator, Educational Technology Cell**
**Indian Institute of Technology Roorkee**
**Roorkee-247 667**
**E Mail: etcell.iitrke@gmail.com, etcell@iitr.ernet.in**
**Website: www.iitr.ac.in/centers/ETC, www.nptel.ac.in**

**Production Team**
**Sarath. K. V**
**Jithin. K**
**Pankaj Saini**
**Arun. S**
**Mohan Raj. S**

**Camera, Graphics, Online Editing & Post Production**
**Binoy. V. P**

**NPTEL Coordinator**
**Prof. B. K. Gandhi**

**An Eductaional Technology Cell**
**IIT Roorkee Production**