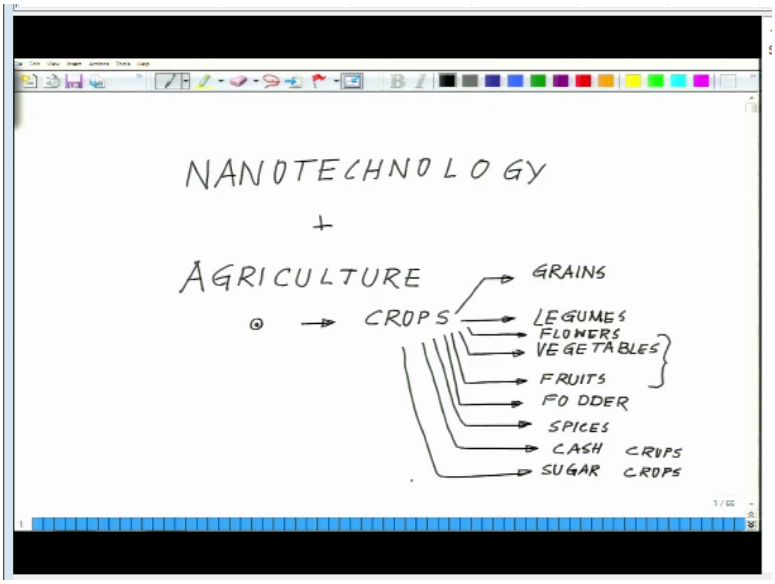
Nanotechnology in Agriculture
Prof. Mainak Das
Biological Sciences and Bioengineering and Design Programme
Indian Institute of Technology-Kanpur

Lecture-02
What is Nanotechnology

So, coming back to ancestors possibly through a trial and error they develop all these different techniques, different methodologies what we followed today and with the understanding of nanotechnology we are now appreciating some of those beautiful tools what had been developed by our ancestors. So with these 2 examples let me formally introduce the course.

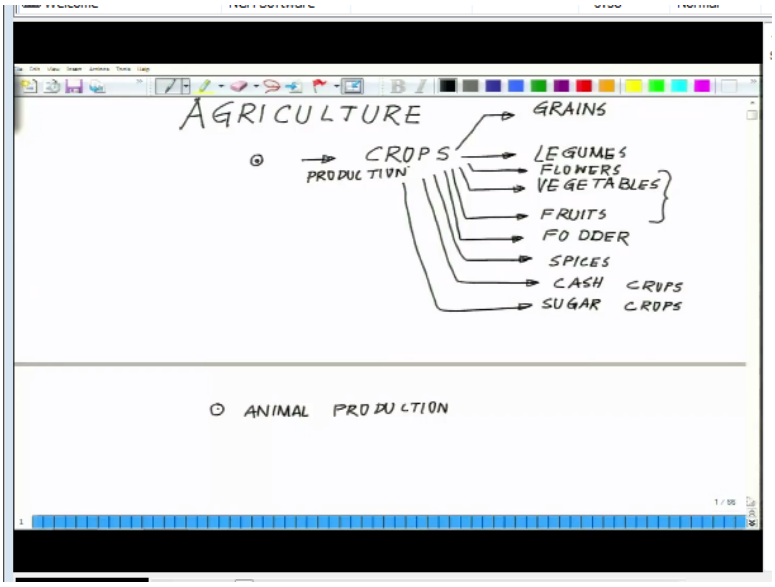
(Refer Slide Time: 00:55)



This is essentially what we will be doing is nanotechnology, these are all keywords and agriculture okay. So what essentially when you talk about agriculture, we talk about multiple areas of agriculture, one is the crop, within the crop you have multiple kind of crops which includes grains, which includes legumes or pulses, vegetables and they have different name like, then you have fruit, then you have fodder, spices, seeds of cash crops.

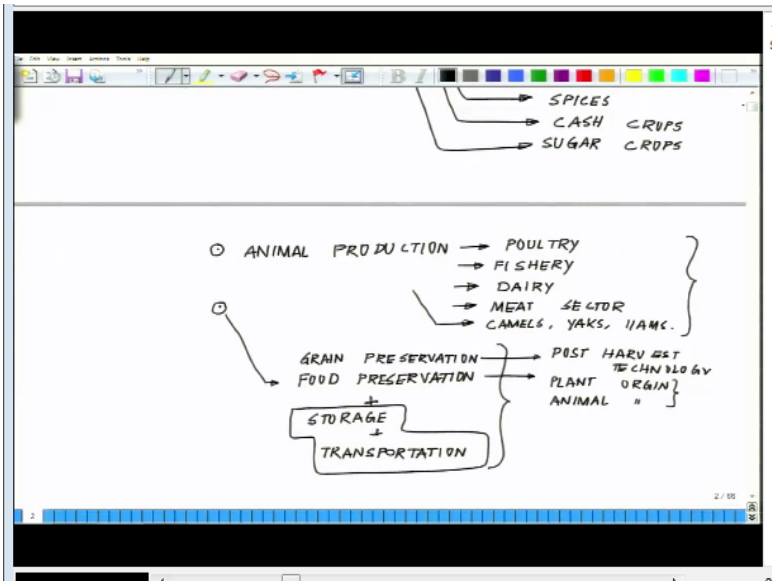
And this let us can go on then you have this is of course a cash crop, sugar crops and these different crops, say for example this area and of course you have and this you have flowers, this is the different area called floriculture, vegetables (()) (03:07). They all falls under the horticultural section, so not only agriculture encompasses the crops, this is one aspect.

(Refer Slide Time: 03:21)



Second aspect of agriculture is animal production, this is the second part of agriculture, crop production, we have already mentioned here, so the crop production, animal production, second aspect, third aspect sorry of is.

(Refer Slide Time: 03:50)



So within animal production before I here you have poultry, fishery, dairy and of course the meat sector and apart from it you have several animals which are being grown or which are being followed for different other applications like you know camels, then you have llamas, then you have yaks, so the series of them, so this is where you have different food products coming out of it, third aspect of agriculture is your food preservation.

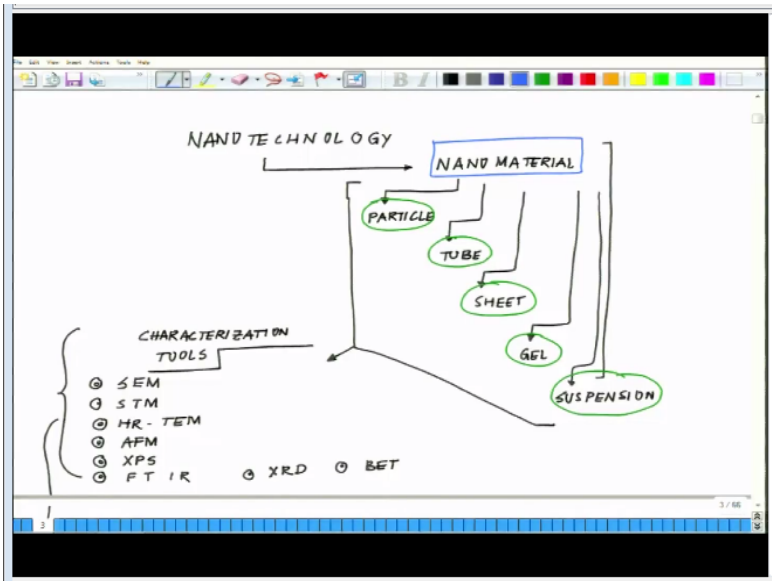
Because and storage food preservation, grain preservation and storage and transportation, this is another area which is a prime importance which falls under a big heading which is called

for of course for the grain and the food ok. If it is not for an animal origin, so this is false and in case of grains is falls under post harvest technology where as for food preservation if it is of plant origin or any kind of vegetative origin.

Then of course a normal plant origin or animal origin which includes including from preservation of milk, called that to preservation of meet in all other products okay. And then comes one of the most challenging area of a storage and transportation and in this journey of agriculture where which includes all the production practices what we do from crop, animal and preservation.

These are the 3 basic area and here I should include this also includes when you talk about flowers how to preserve the flowers. And they have lot of usage in terms of cosmetics in the industry, perfume industry, several other industries which has branched out from the world of flowers. Now having say this, so this is the whole range of agriculture what we deal with and in terms of nanotechnology to talk about certain things.

(Refer Slide Time: 07:40)

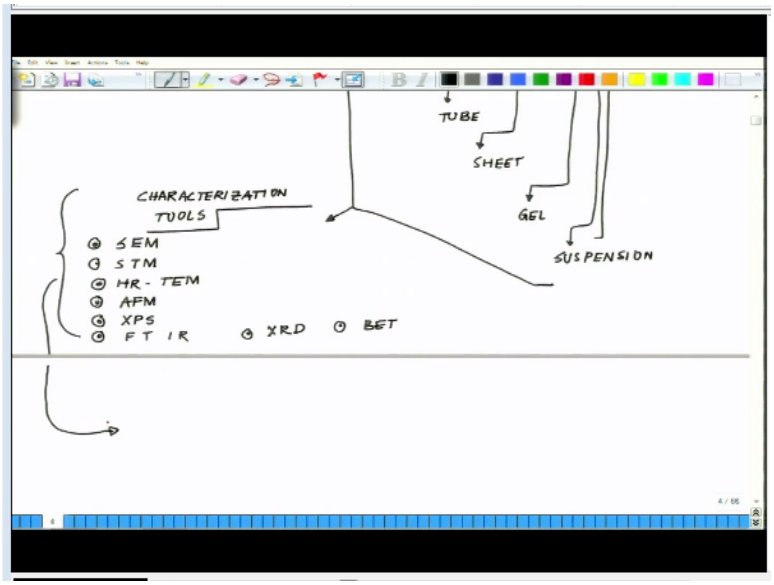


In the very beginning that will include our the first thing the basic nanomaterial, this nanomaterial could be several kind, it could be a particle, it could be a tube, it could be a sheet, it could be a gel or it could be a suspension, some kind of a mesoporous suspension okay. Now when we talked about this wide area of nanoparticles then you have to realize we have to have different characterization tools to appreciate them.

And this is what I was telling you in the beginning, so we have to use see the characterization tools which includes your SEM scanning electron microscopy, STM scanning tunnelling microscopy, high resolution transmission electron microscopy, AFM atomic force microscopy, XPS x-ray photoelectron spectroscopy, FTIR Fourier transform infrared spectroscopy likewise then x-ray diffraction for different kind of surface analysis you have BET.

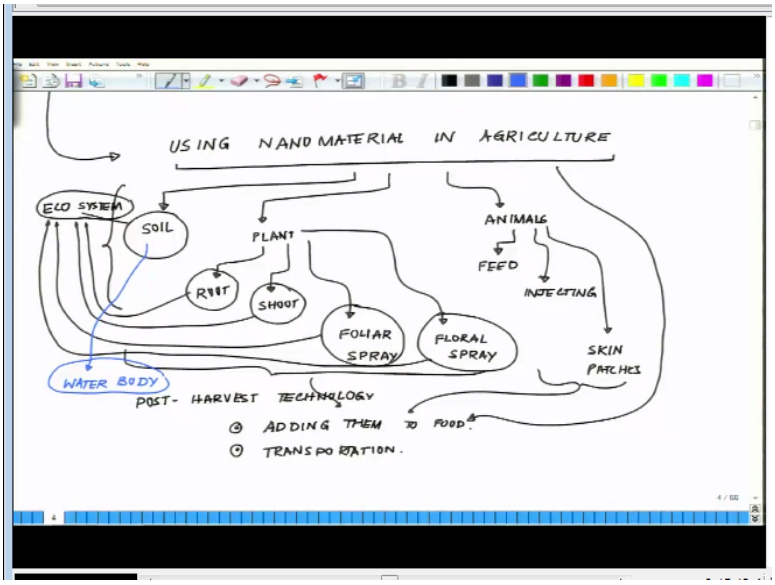
So other several techniques are there and many more techniques are there which I have not used here or which are needed to characterizing this particles.

(Refer Slide Time: 10:25)



So, next when we are applying these particles for some application, then we have to realize at what level we are trying to use them, say for example when we talk about using nanomaterials in agriculture okay.

(Refer Slide Time: 10:38)



When we are using the material in agriculture we have to understand it what water level or we applying this to the soil or we applying this to the plant. We are applying this to the plant or we applying it to the root or we applying this to the shoot or we are doing foliar spray or a floral spray. In case of animals when you talk about because are we giving this as a feed to them or we injecting them or we are using them as skin patches, how we are offering them.

Now in terms of using nanomaterials in agriculture when you talk about the post-harvest technology which if you follow me, this will so this part. So, we talked about where you are using, so this is where I was trying to explain at what level you are using it in terms of animal production how you are introducing it. And now coming to the post harvest technology which is very critical because this is where the process the food which is getting processed out of it from all these different sources are combining or we so this is for the post harvest technology okay or we adding them to food or they are just being used for transportations purpose like you know.

While we have to transport food from one place to another, we coat the boxes or coat the bags with certain material or something or is it just that. So you realise the very moment we talked about that we are introducing something into the soil that means you are infringing into the ecosystem or when we say we are introducing something to the roots of the plant or shoot of the plant or we are doing a foliar spray or we are doing a floral spray.

So that one become the biomass is actually getting into the ecosystem, all gets into the ecosystem. And eventually this part of the soil what we are talking about is actually allowing

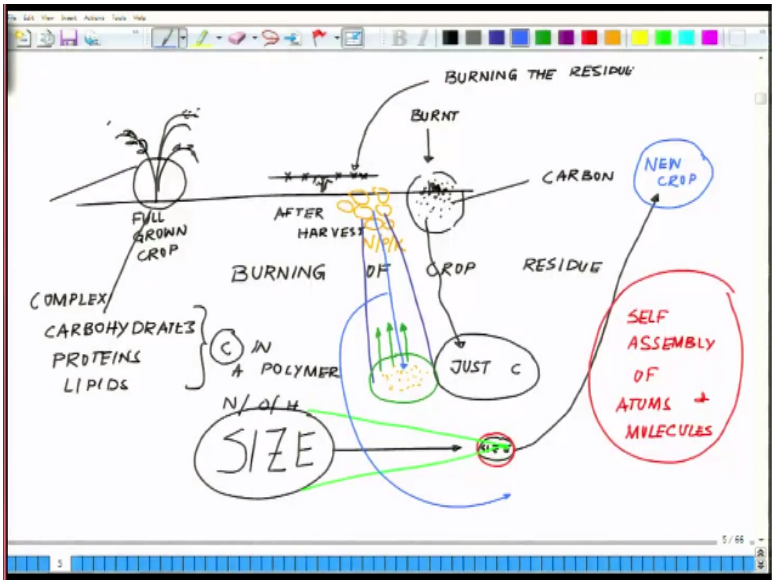
these things become part of the water body. So in other world the very moment we are introducing newly synthesize nanomaterial into the agricultural sector. We are talking about introducing newer stuff into our ecosystem.

And what will be the impact of it over the years is something which has to be looked upon very carefully. Now with this chart in front of you, you must be now realising that why this subject is of so much prime importance for us that as we are marching. This is for sure the nanotechnology is the future, there is no looking back and nanotechnology and the different nanomaterials what we have talked about out here whether it is a particle, whether it is a tube, whether it is a sheet, whether it is a gel, whether it is suspension.

They will all in some of form of other will be used in agriculture application. They are already in use, now this is inevitable what is important for us to understand is how we or how fast we appreciate that we are moving ahead yet we deal with a degree of caution that there are limits, there are thresholds which biological system can withstand, otherwise it will become, it will those a newer set of go challenges for us. What will be those notes sooner we realise, faster we realize will be we make a difference, now you might wonder that what is and why we are going in the nanomaterial domain.

The reason to go to the nanomaterial domain is I told you in the beginning something and I will again pull that example what I told you.

(Refer Slide Time: 18:01)



So, this is what you see, you have these crops growing and once the season is over the stems are left which are being burnt okay. So what is left behind is a small carbons, so this is burning of crop residue. So this is the full grown crop, these are after harvest, now burning this burning the residue. And then what you are left behind is a mass of carbon, now in this process essentially in the biomass was there it was a carbon in a polymeric chain in the form of polysaccharides, pectin, all series of carbohydrates.

Now what you see here, so these were all we are having complex carbohydrates, proteins, lipids, all containing carbon, carbon in a polymer or of course there are other atoms with it including nitrogen, oxygen, hydrogen and all, but since we are talking about carbon, so it is a just stress upon carbon here. So once you burn what you are having is just carbon. So what is happen in terms of size here carbon was at a much more bigger moiety in the form of a polymer, here size has gone down.

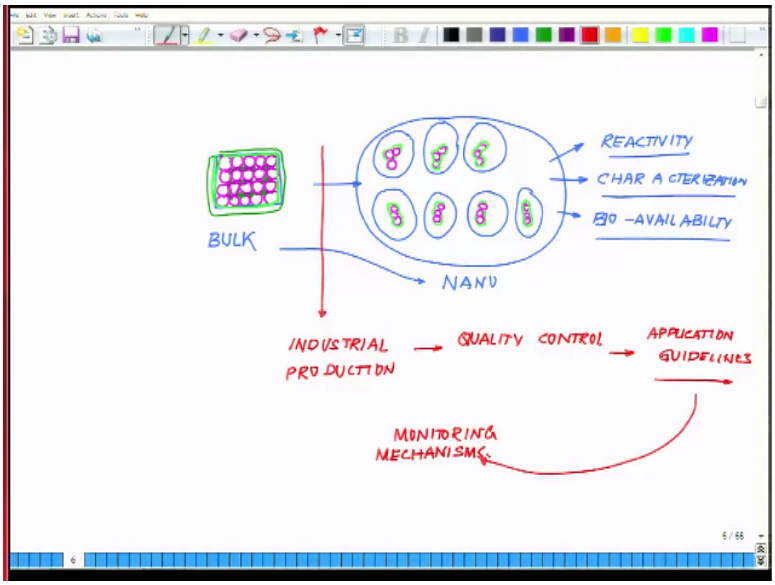
Now this small size is now could be made available to the new crop, so in other word the whole fundamental around which our life is revolving, it is essentially is 1 word which can define it very clearly is called self-assembly of atoms and molecules. So of course the self-assembly is driven by series of enzymatic forces, several templates. Now when you talk about this small size these are the one which self-assemble to form those complex structures.

So when you talk about nanoparticle essentially what we are talking out here we gave the scheme of it we are bringing down the size to make it more available. So this is what essentially is the reason why we are heading for more nanotechnology application to give you another angle to this, so say for example I have to apply fertilizer here okay.

So I am using this big chunks of salt say in the form of NPK nitrogen, phosphorus and potash. Now think of it in the light what I just now told you if this size goes down to this, this smaller size has much more availability to the plant. So in other word the final we go chances are it will be made more available to the plants instead of having something which is much more bigger.

So now from here the journey from here to here is changing many things, you are changing the surface areas to the volume ratio. In other word now we are talking about something which has much more expose surface area, say for example let us think of this situation.

(Refer Slide Time: 24:22)



I have a box like this in front of you and this box has these atoms like this, so the pink ones are the atoms okay, I am not doing it 3 dimension I just showing in 2 dimension okay. So, your expose surface area is all over this, but now think of it this whole part what I am drawing now is completely unexposed right. There is no exposes, this is not at all exposed, only exposed area is the 1 which is shown in out here lightly, this is the only exposed area.

So there is a huge area which remain unexposed, now if I reduce it down to the units of trees, say for example I say I have something like this and something like this, so how many we have 1, 2, 3, 4, 5, 5x4 25. So 15 I am just increasing 1 atom, now think of the surface area we were talking about. Now this is the surface we were talking about even without doing any arithmetic, you can see the amount of surface area increase what is happening.

Now if you add this and you add all of this you will see the difference, but now when you talk about this small particles their properties, their reactivity, their interaction drastically alters. There is a drastic alteration in their activity, now how to handle this, these nature equipped to handle it possibly yes but then nature has a limit our understanding will be. So this is what we called as bulk and this is what we called as nano, this journey.

And then of course we talked about their characterisation, their reactivity, characterisation and several other aspects to it and their bioavailability likewise okay. So another question arises what will be those industrial techniques, so how we can make them. This is another

aspect of nanotechnology, industrial production. Because has to go through a whole series of quality control.

And then what will be the application guidelines and what will be the monitoring mechanisms okay. So, now you realise that when we are assuring into new era of applying nanoparticles into agriculture domain. Then we have to take all these things into account that how we are going to balance out all these things.