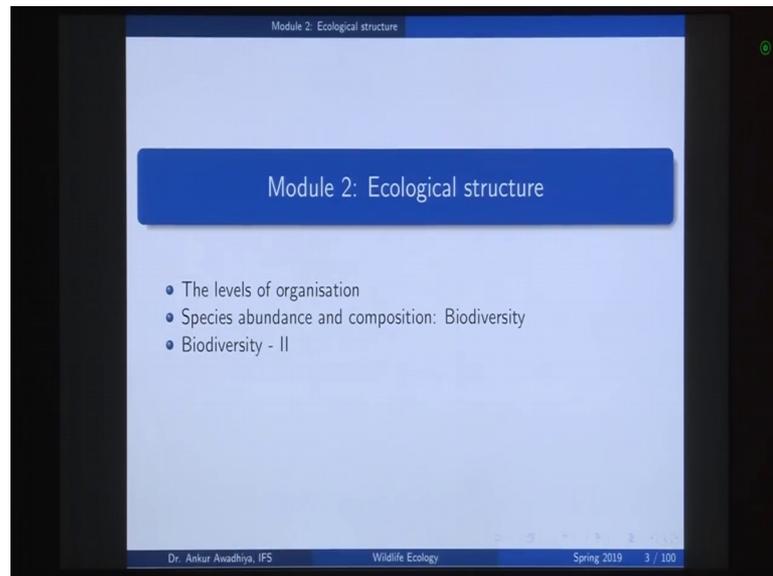


Wildlife Ecology
Dr. Ankur Awadhiya
Department of Indian Forest Services
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Lecture – 04
The levels of Organsation

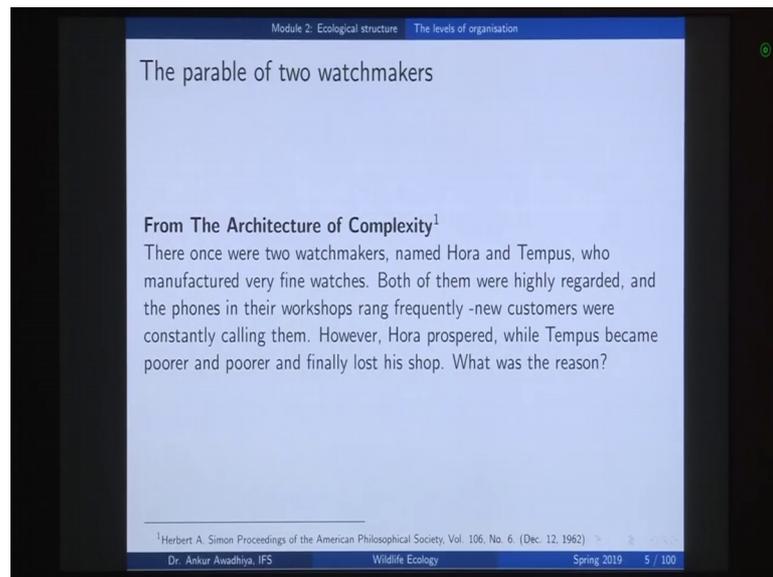
[FL] Today, we begin our second module which is ecological structures.

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In this module, we are going to have three lectures, the levels of organization, species abundance and composition which is biodiversity and also a closer look at biodiversity.

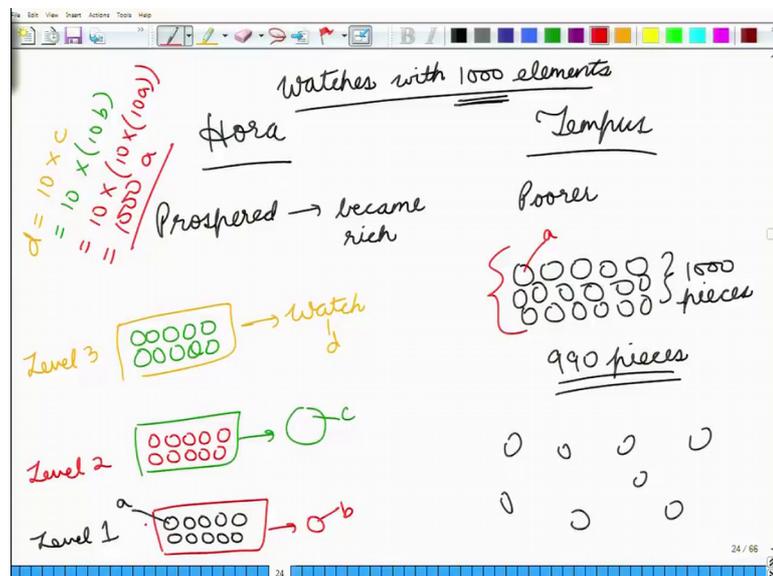
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So, let us begin with the levels of organization and as before, we will start with the story. Now, this is the story of two watchmakers; first written by Herbert Simon and it starts like this. There once were two watchmakers named Hora and Tempus who manufactured very fine watches. Both of them were very highly regarded and their phones in their workshops ran frequently. New customers were constantly calling them.

However, Hora prospered while Tempus became poorer and poorer and finally, lost his shop. What was the reason? So, this is a story of two watchmakers.

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One is called Hora and the second is called Tempus and both of them are very fine watchmakers. Both of them are highly in demand and both of them have their workshops in which the phones are ringing constantly because customers always want to know about them. Now, in this case, Hora is the one that prospered or say he became rich where is Tempus is the one who became progressively poorer and poorer. So, this is a story through which we will understand why organization is important.

Now, we move on. The watches, the men made consisted of about 1000 parts each. Tempus had so constructed his that if he had one partly assembled and had to put it down to answer the phone say, it immediately fell to pieces and had to be reassembled from the elements. The better the customers liked his watches, the more they phoned him, the more difficult it became for him to find enough uninterrupted time to finish a watch. Now, in both of these cases we have watches with 1000 elements or 1000 parts. Now, in the case of Tempus he constructed a watch in a manner that you had to bring all the parts together in one go to make the watch a functional watch.

So, all of these have to be together all the 1000 pieces have to come together at the same time so that the watch becomes a functional watch. However, the better the watches he made. So, with time as the quality of watches improved, the demand for the watches also improved and when demand increases, the customers call him again and again, they phone him in his workshop and Tempus has to leave his watch.

So, for instance if Tempus had prepared say 990 pieces he had put together, only 10 pieces remained and then he gets a phone call. So, he has to leave these 990 pieces and go ahead and attend the phone call. While he is attending the phone call, all of these pieces they just break down and so they come up as different pieces which have to be assembled again. So, this was the mode of operation of Tempus.

Now, because of this, whenever he got a phone call he was not able to complete his watch. And so, his rate of production of watches deteriorated like anything and there would even be days in which he would not be able to prepare a single watch. Because, you bring together 500 elements, you get a phone call it comes down to 0; you then again start making the watches, then again you get a phone call, again it goes down to 0 and so on.

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Module 2: Ecological structure The levels of organisation

The parable of two watchmakers

From The Architecture of Complexity³

The watches that Hora made were no less complex than those of Tempus. But he had designed them so that he could put together subassemblies of about ten elements each. Ten of these subassemblies, again, could be put together into a larger subassembly; and a system of ten of the latter subassemblies constituted the whole watch. Hence, when Hora had to put down a partly assembled watch in order to answer the phone, he lost only a small part of his work, and he assembled his watches in only a fraction of the man-hours it took Tempus.

³Herbert A. Simon Proceedings of the American Philosophical Society, Vol. 106, No. 6. (Dec. 12, 1962)

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Now, let us look at how Hora worked. The watches that Hora made were no less complex than those of Tempus. But he had designed them so that he could put together sub assemblies of about ten elements each. Ten of these sub assemblies again could be put together into a larger sub assembly and a system of ten of the latter sub assemblies constituted the whole watch.

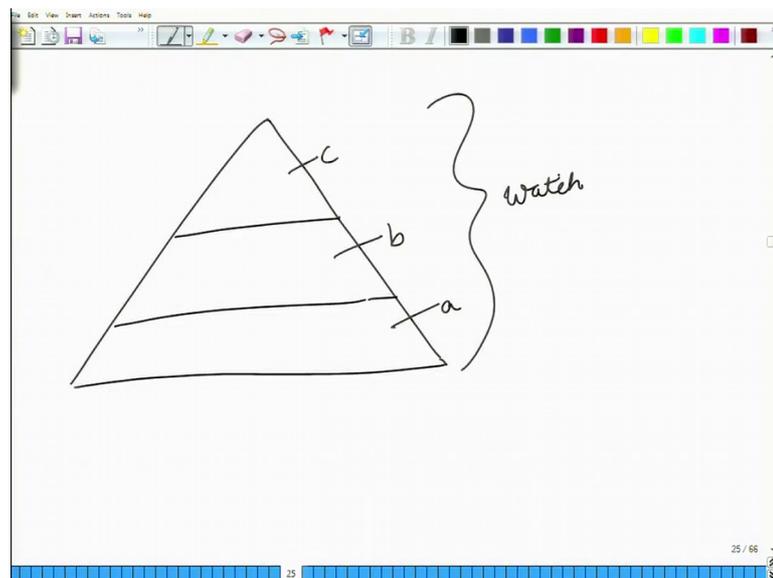
Hence when Hora had to put down a partly assembled watch in order to answer the phone, he lost only a small part of his work and he assembled his watches in only a fraction of the manners it took Tempus. So, how did Hora prepare his watches? When the case of Horas watches here again you have 1000 elements, but these 1000 elements work like this. So, you have level 1, now in the case of level 1, you bring together ten of the sub pieces. So, ten of these pieces will be put together and once they are put together, they become a big a bigger piece. So, now, you have this bigger piece in which you have ten of the original pieces that are together. So, now, this becomes a sub assembled part of the whole of the watch.

Now, in the case of level 2, you have ten of these sub assembled pieces and they come together and then they form another larger piece. And in the case of level 3, you had ten of these pieces together and all of these ten come together and then they make the watch. Now, in this case let us call these smaller pieces as let us say that this is a, this is b, this is c and then this is d. Now, in the watch d, d has ten elements of c. Now, each element of c

is ten elements of b and each element of b is ten elements of a. So, altogether we have 1000 pieces of a which is what we had in the case of Tempus as well. So, this is a and this also is a.

So, you have 1000 pieces together, but then because in the case of Hora, all of these pieces were sub assembled and made into an organization.

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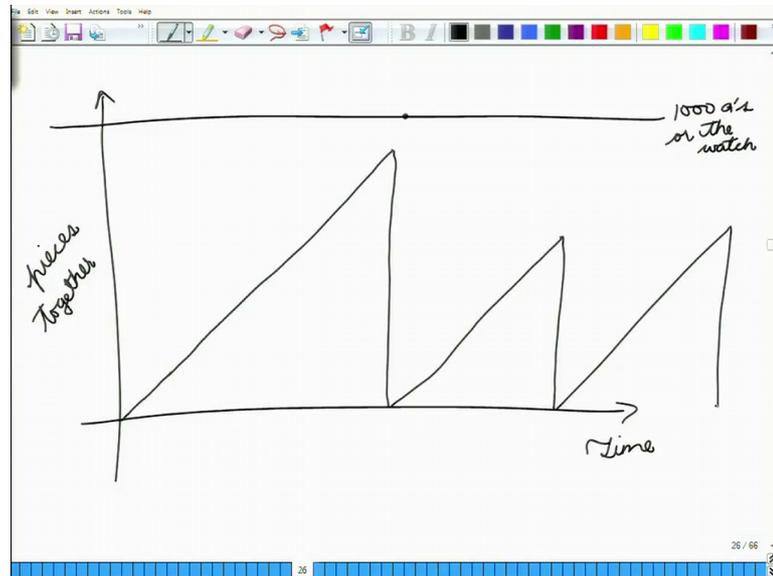


So, this was an organization in which you had a hierarchy. So, here you have all the a's, here you have all the b's, here you have all the c's. So, all the a's come together to form b's, all the b's come together to form c's and all the c's come together to make the whole watch.

Now, if you have such an organization, what happens is that suppose Hora had come to this stage. So, he had prepared or he was in the process of making a c, so he had say nine elements of b that were together. Only one more element had to be put in and the phone rang. So, what would happen is that these nine pieces of b, but again shattered down and become nine individual pieces of b. But then, when Hora has attended the phone call when he comes back, he will just have to put these nine elements together, put one more and he has a c.

So, at every stage, here you can observe that the amount of work that is lost. If there is any error, is very little as compared to the case of Tempus in which the amount of work that would be lost because of any error would be tremendous.

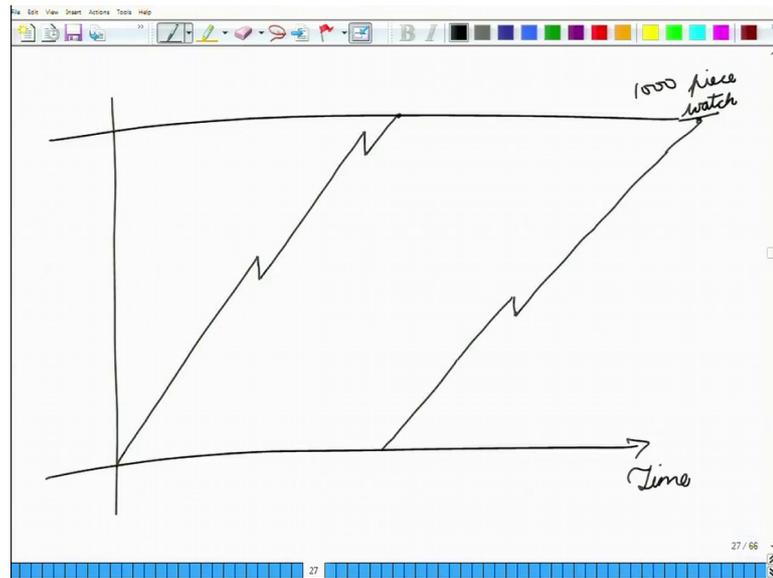
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So, if we had to put it graphically, in the case of Tempus, suppose he made and say this is the cut off. So, this is 1000 a's or the watch. Now, in this case, if you are able to reach this point, if you are able to reach this point, you have made a watch. But, what happened in the case of Hora was that he had re somewhere like here and then the phone rang and then he had to start from 0, then again he went till this point again the phone rang, he had to start from 0. So, here you have the pieces together versus the time.

Now, you would observe in this case that there could be situations in which the whole day passes and Hora is not able to make even a single watch because every time the phone rings, the number, the watch goes down to all it is sub elements and becomes nothing.

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Whereas, in the case of Tempus what happens is that, here also we have this 1000 piece watch, if we have the time. Now, what happens is that even if he has reached till this stage the phone rings, there is only a small amount of work that each to be retreated because only that level of organization will have to be remade and then he will progress like this, again a phone rings, then he will progress to this point and then he has made a watch.

Then, he will start making another watch and probably in this case, the phone rang only once and so, he was able to make two watches in a day. So, here is why organization becomes extremely important in the case of any system. So, from here, we come to Simon's hierarchical principle.

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Module 2: Ecological structure The levels of organisation

Simon's hierarchical principle

Hierarchy "emerges almost inevitably through a wide variety of evolutionary processes, for the simple reason that hierarchical structures are stable"⁴.

⁴Yin, H., Yao, X., Tino, P., Corchado, E. and Byrne, W. eds. 2007. Intelligent Data Engineering and Automated Learning-IDEAL 2007: 8th International Conference, Birmingham, UK, December 16-19, 2007, Proceedings (Vol. 4881) Springer.

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So, using this story, Simon came up with a principle that hierarchy emerges almost inevitably through a wide variety of evolutionary processes for the simple reason that hierarchical structures are stable. Now, in the case of evolution, we have a series of changes that go on to make an organism, a species or the whole system more and more fit for survival and in that process, hierarchy would emerge almost inevitably. So, hierarchy becomes a sanguine and it becomes a very important parameter. If you want to have evolution that is taking the system towards a bit of fitness and for the simple reason that hierarchical structures are stable.

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Module 2: Ecological structure The levels of organisation

Simon's hierarchical principle in centipede

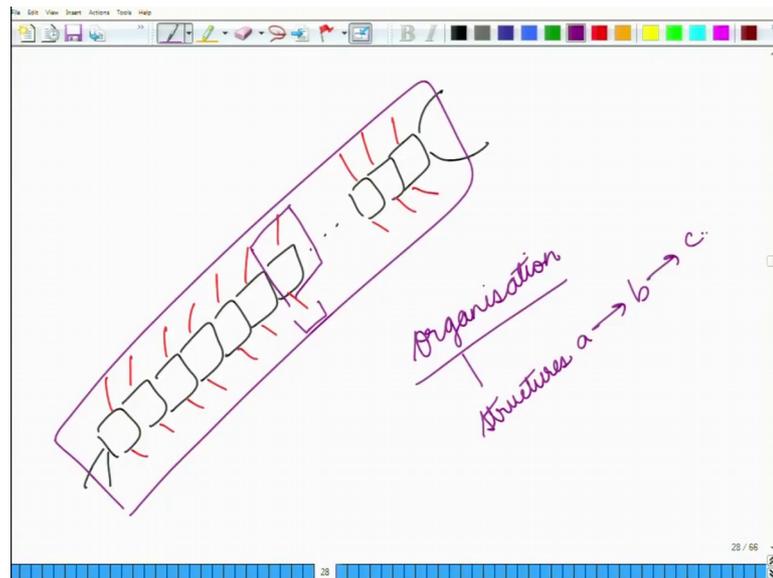


⁵Ankur Awadhya, Kruger National Park 2018

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Now, where do we see hierarchy in nature? Well, you look at anything and you might find some amount of hierarchy. So, here we have a picture of a Roller that is eating a Centipede. Now, in the case of a centipede, if you look here closely, you have a number of segments and all of these segments have two legs.

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So, if we drew a centipede, it would be something like this. So, you have different segments, then you have the mouth parts and maybe you will have the n region. Now, all of these segments have two legs. So, what nature has done in this case is that we have this small structure that was made and a number of copies of this structure were made and then they were put together. So, this is a very similar case as that of the watches of Hora. So, you have this small piece that is constructed from its sub elements.

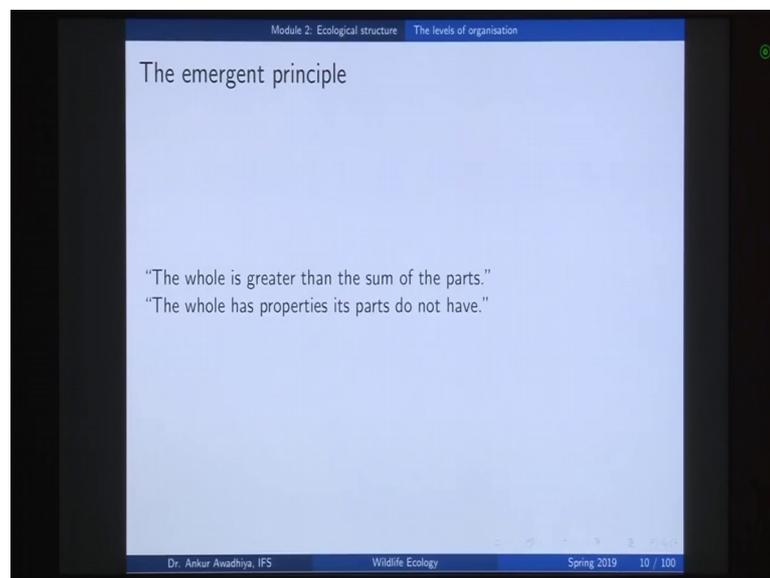
And then, a number of these pieces are then put together to create the next level of organization. Now similarly, if you look at your hands, now all these fingers, all the fingers have these three structures. So, why these three structures, here we also we are seeing the same thing.

We are observing segmentation as we had observed in the case and these segments are also very similar to what we had observed in the case of this Centipede. And you will observe the same thing everywhere when you look around. You will find it this in centipede, she will find this in Millipedes, you will find this in Caterpillars, you will find this in Earthworms, you will find it even in our bodies.

So, for instance, if you have a look at your hands, so, the fin the fingers are having these three segments everywhere. You have a look at the vertebral column that holds our spinal cords and there also we have a number of bones that are very similar in shapes and then once these bones are constructed, they are put together.

So, essentially we are observing these levels of organization when we look around in nature and in the case of this organization, what we observe is that we have one level of structures that is call them a, that up are combined together to make a structure called b, that are combined together to make a structure called c and so on. And whenever we have such an organization, we also observe the emergent principle.

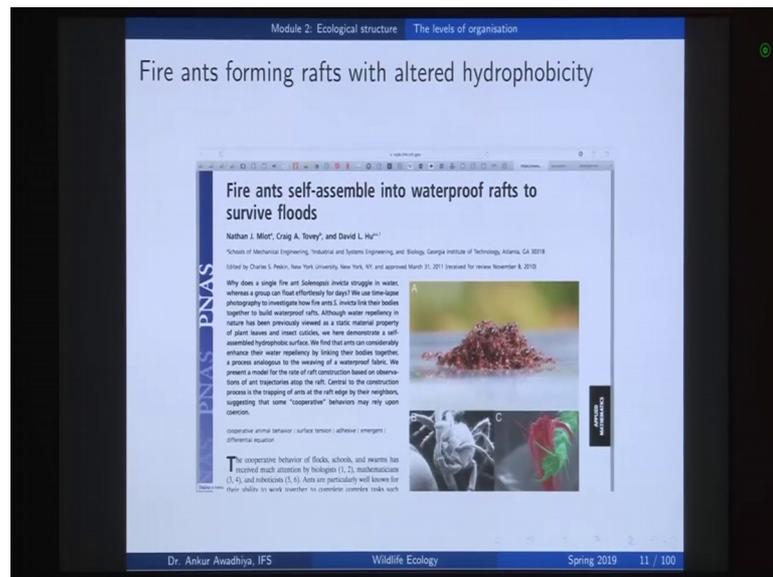
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Now, the emergent principle says that the whole is greater than the sum of the parts or the whole has properties that it is parts do not have.

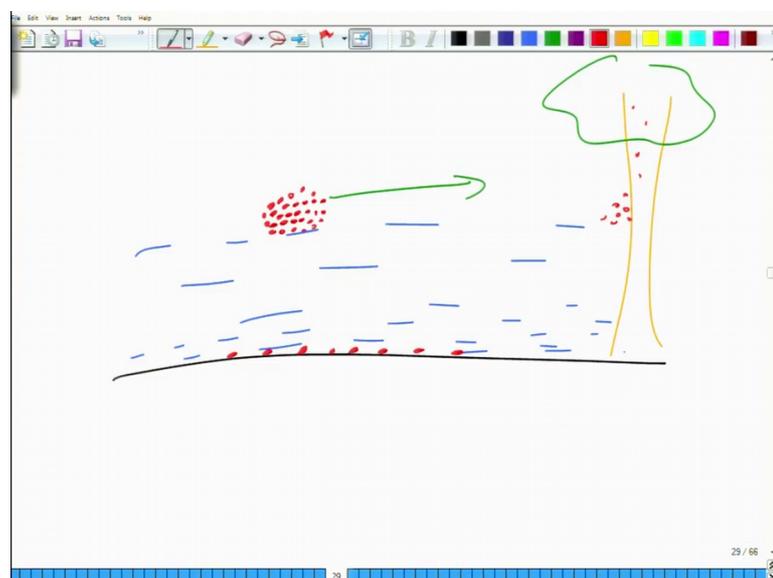
So, coming together, coming back to our example of the Centipede, we will observe that this portion, this is small segment of a Centipede. It has got some properties, it has a particular weight, it has a particular size and shape, it has these two legs. But once you have put all these small parts together to construct the Centipede, the Centipede has properties that are very different from those of these smaller segments. So, it incorporates the properties of the segments, but by coming together as a larger organization, it also gets some new properties. So, the whole is greater than the sum of it is parts and the whole has properties that it is parts do not have.

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Now, we look at some more examples of the emergent principal. Here is an example of fire ants. Now, fire ants are ants that are found in South America and these ants are called fire ants because they are extremely prone to attacking other organisms and also because if they bite you, it will feel as if your body parts are on fire. It is it has got a very pungent, a very irritating bite. Now, in the case of these ants, we observe that these are small insects, but then when they come together, when they form an organization that will give out some new properties. So, like in this paper, we see fire ants self-assemble into waterproof rafts to survive floods.

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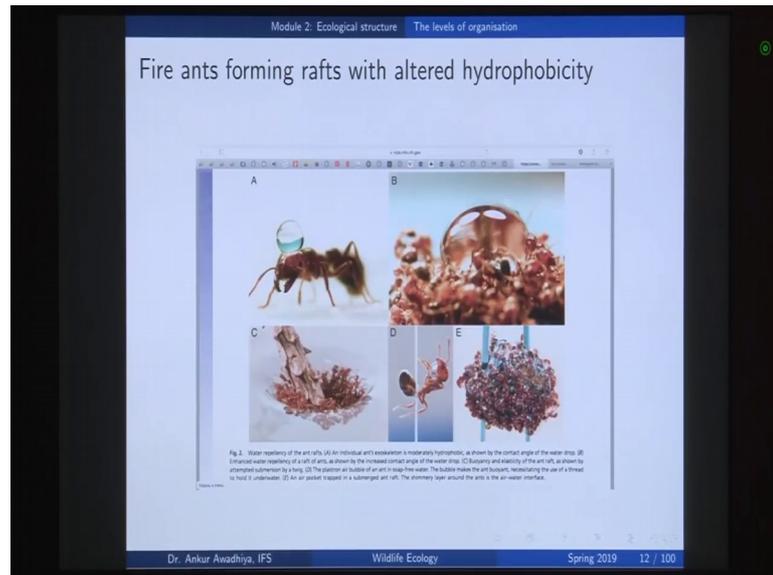
Now, what happens in this case is that if you have a low lying area and you have an ant and in this area, suppose you have a lot of rain and so, now, you have some amount of inundation. Now, if you had ants that were separate from each other; all of these ants would die off because they are not submerged with water. They would not have access to air. So, to avoid such a situation, to avoid death and to avoid the extermination of deadness, what these ants do is that they come together.

So, all of these ants will come together, they will attach themselves to each other and they will form a new structure. Now, in this structure, you will even have air that is trapped inside this structure to make the whole of this structure point. So, as we can observe in this image here, you have a group of these ants that are together and inside this structure, inside this organization will be having a number of air pockets that will make this whole structure point and if you put this structure onto the surface of water, this structure will float.

Now, once you have a structure like this, what happens is that, all these ants that are on the top are outside of water. So, they have an axis of free access to air; whereas, even these ants that are touching the water, their body is not completely submerged. So, in this case, they also get some access to air and the whole colony is able to survive and if you look at the electron micrographs of these ants that are together, we will find that they are mandibles or their mouthparts are attached together in a manner that they are not biting the other individual, but they are together in the form of this organization.

And what happens when you have this organization is that, this organization even if you have lots of water, this organization will float and when it floats, it will move with the water and once it finds a tree somewhere, then this organization will then slowly disperse and then they will climb the trees. So, now, this is one property, this is one emergent property an individual ant might drown in water, but because of this property, because of this emergent property, they are able to survive. So, again here the whole is greater than the sum of it is parts.

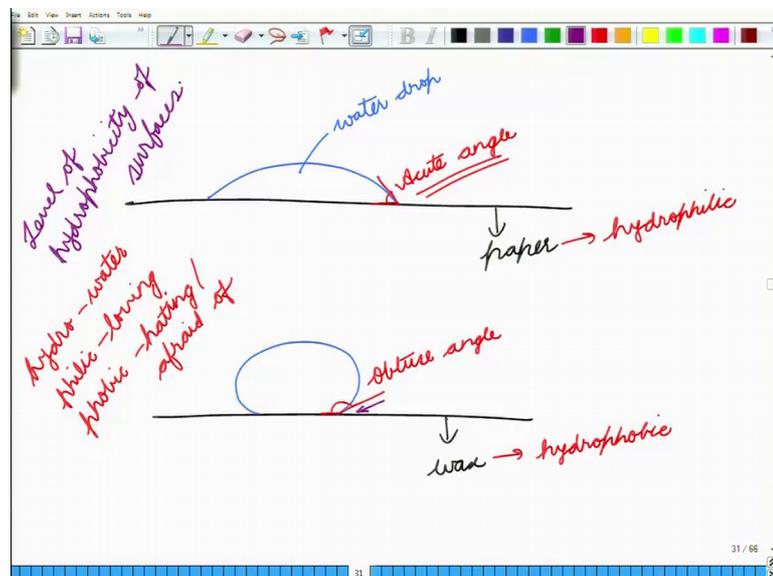
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Here is another example when they are forming these rafts you can study their properties and how the properties change?

So, if you look at this image, here we see an ant and on this end, we have a drop of water that is put on the top put on the top. And here we have a raft and here also we see a drop of water that is put on top of the raft. Now, we can study the properties of the surfaces of the end and that of the raft using this drop of water and by having a look at the contact angles that are being made here.

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Now, for any surface, if you put a drop of water and if the surface wets because of the water, so it is considered a surface such as paper. Now, if you put a drop of water on the paper, this is what a drop. So, once you put a drop of water on the paper, it will subtend an angle that is an acute angle which would show that the paper is hydrophilic. Now, if you put a drop of water on another surface such as the surface of wax, here water will subtend an angle that is an obtuse angle which would give us the information that wax is hydrophobic.

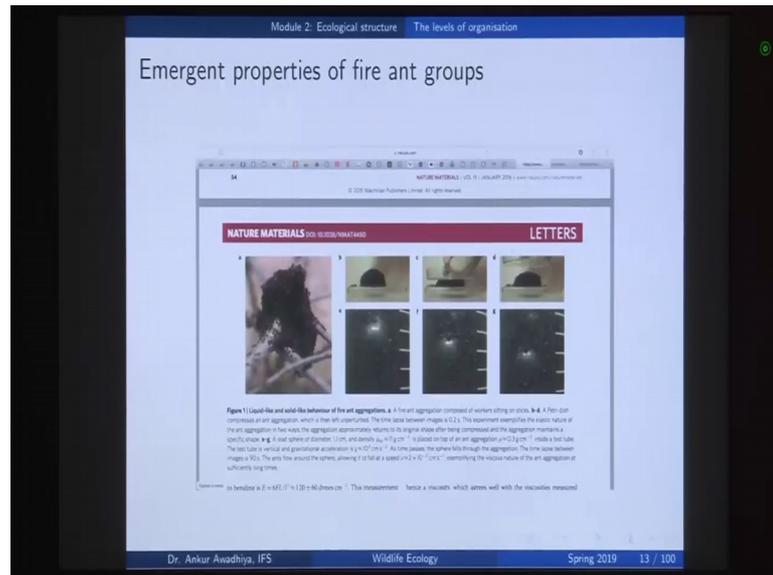
Now, hydro is water, philic is loving and phobic is hating or someone who is afraid of. Now, in the case of paper because paper is hydrophilic so, it is in love with water, it wants to have as much water as is possible. So, it attracts water to its surface because of which we get an acute angle whereas, in the case of wax, because it is hydrophobic it is afraid of water, it wants to repel water as much as possible. So, it tries to clear off these surfaces. So, this surface is now cleared off and it wants to have as little contact with water as possible because of which it forms an obtuse angle. Now, by looking at these angles, we can understand the level of hydrophobicity of surfaces.

Now, if we come back to the images, here we are observing that there is a drop of water on top of the ant and this outer surface is called the cuticle. Now, this cuticle is mildly hydrophobic because it is subtending an obtuse angle, but if you put this drop of water on a raft of ants, the angle that is subtended it becomes even more obtuse.

So, the level of hydrophobicity increases, so that the amount of water repelling nature of the ants also increases. And at the same time, we can also observe that if you put a single ant inside water it will try to grab a small pocket of air, but if you have this whole raft that is that is drowned using a stick, it will have so much amount of air that it will be much more buoyant as compared to a single ant.

So, the whole will have properties that are derived from the components, but are also there will be some emergent properties that are different from all the components that are combined together.

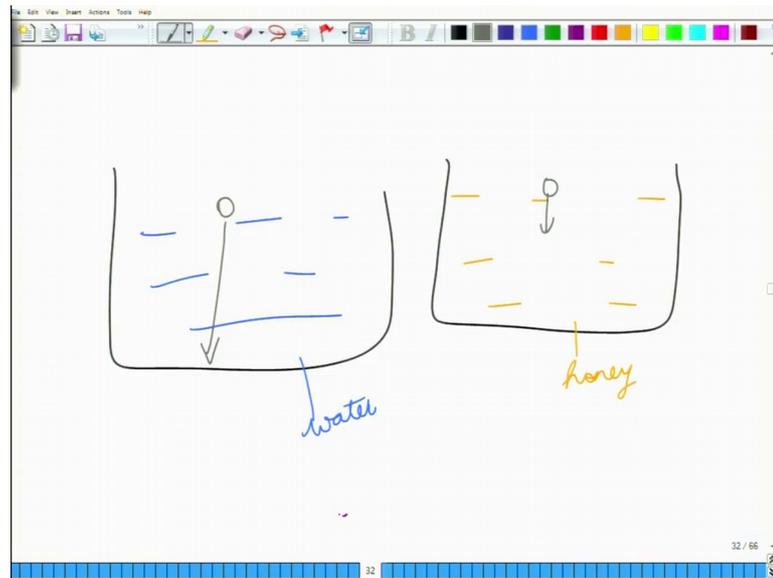
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Now, with this, we can also observe number of a liquid like properties of these ant rafts. So, for instance, here we have one such raft that is put on top of a Petridish, now if you put another petridish on top and if you press this and then if you release it, it will come back to the original shape.

So, essentially this group is now getting some properties of elasticity. Then, if you put one such group into say a pipette and then you put a drop of or a ball of lead inside this pipette, so you will observe that this ball of lead it slowly moves down. It will behave very much like a very viscous liquid something like honey.

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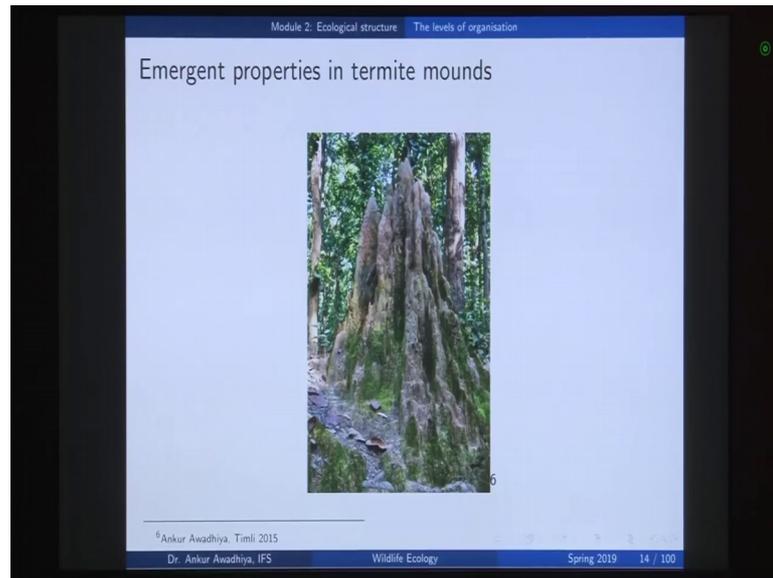


So, if you put, so, suppose you have two containers and one container has water and the second container has honey, now you are taking a ball of lead and you are dropping it in both of these containers. Now, in the case of water because the level of viscosity is this, this lead will fall down very fast whereas, in the case of honey, it will have a slower speed. Now, in the case of ants when you are putting them together because they are combining themselves with each other.

So, they are also getting the properties of viscosity which is an emergent property. So, if you talk about a single ant, you would not have a property of viscosity because it is a single element, but you put all of these together and they get an emergent property which is viscosity and also emergent properties such as elasticity.

So, elasticity viscosity are things that we are getting as emergent properties.

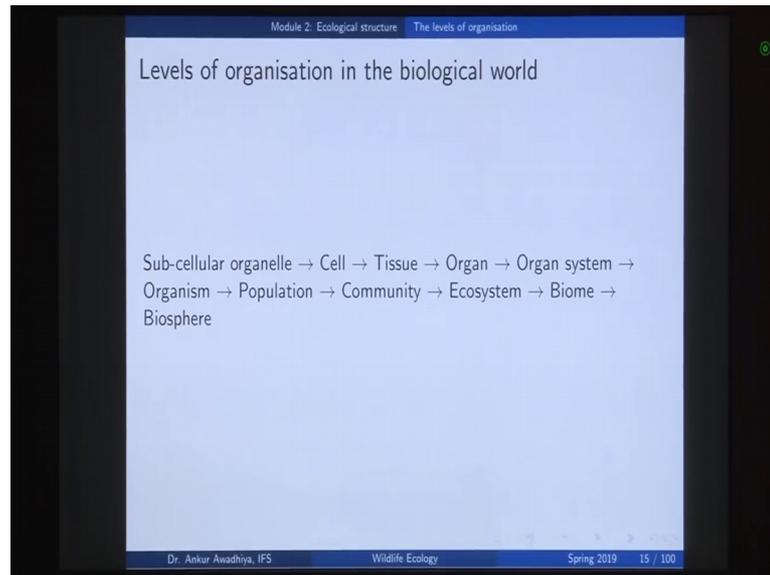
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Now, emergent properties are found nearly everywhere in nature. So, for instance, if you look at a termite mound, so, a termite again is a small insect and such as such a small insect and only do n number of items in it is life. But you put a whole colony of termites together and they will form of these structures, these mounds like structures which again have their own properties. Now, these structures are made in a manner that you have ample amount of air circulation, you have thermal regulation and so on.

Now, if we talk about the construction of any building, there would be a supervisor that would be coordinating the actions of all of these of all the people who are making the building whereas, in this case there is no such supervisor. All these termites are just doing their own jobs and by doing their own jobs they construct this structure. So, this again is an emergent property, you just use a single termite and it will not be able to make a mound. But because of the collective actions, they get this property that they are able to construct among of this particular shape.

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Now, if you look at the level of organization in the biological world. So now, whenever we are talking about organization, you need to remember two things; one is that in this organization. So, when we say that we have a sub cellular organelles, cells, tissues, organs. So, if you look at any particular linkage say cell to tissue. So, tissue will be comprised of a number of cells. So, here we will observe a hierarchical principle or Simon's principle that will operate. So, you will have cells as independent units, you put these cells together and they form the next level of structure which is a tissue. So, we will observe hierarchical structures everywhere. And second, we will observe emergent properties everywhere. So, a cell has certain properties.

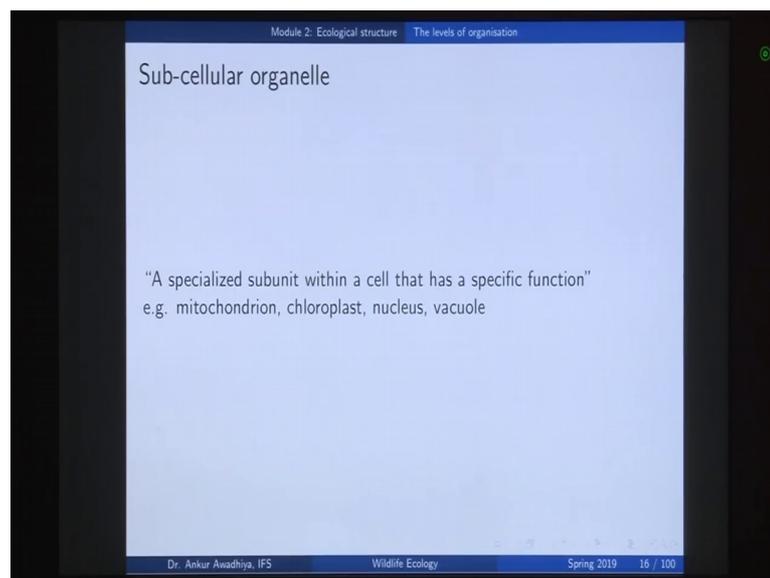
But when you put all these cells together they form the tissue. So, tissue will be comprised of cells, but we will also have a number of properties that are not found in cells. So, it will also have a number of emergent properties. So, when we look at organization, these are two things to keep in mind. Now, what are the levels of organization in the biological world? So, we begin with the sub cellular organelles. A number of these sub cellular organelles will come together and form the cell. Now, a sub cellular organelle does not have any characteristics of life, but a cell is a living entity. So, just by putting these organelles together, you get a new emergent property which is life in the form of a cell.

Then, you put cells together and they form a tissue. Tissues come together to form organs. Organs come together to form an organ system followed by an organism. Now, an organism is the basic entity from which we can start our analysis, especially in the case of ecology. So, you put organisms together and these organisms are of the same type.

So, they form a population. You put a number of populations together, they form a community. Now, till community we have all the biological elements. Now, you put community which is a biological element together with the a biotech elements and you get the ecosystem, a number of ecosystems together will form a biome and a number of biomes together will form the biosphere or the life sphere that is formed on our planet.

So, now we will have a look at all of these levels of organization in more detail.

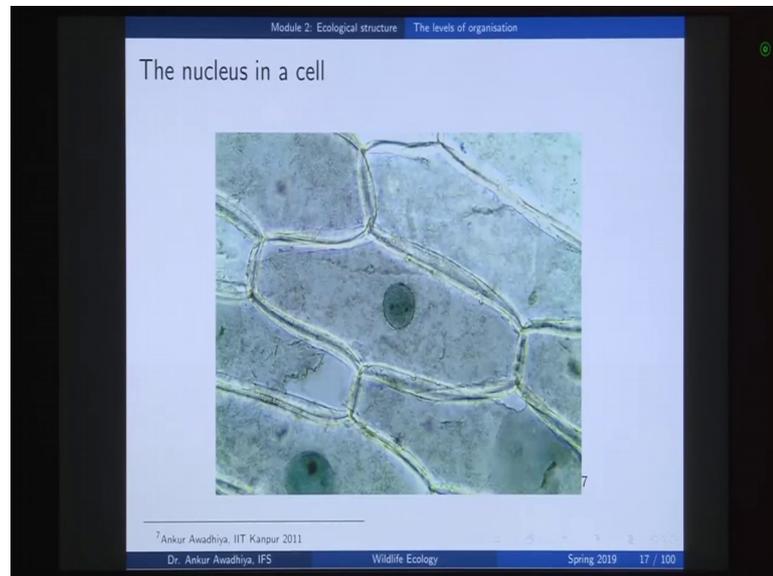
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A sub cellular organelle is a specialized subunit within a cell that has a specific function. So, you might remember these from your school days, we have mitochondria which are organelles that are responsible for the generation of energy inside cells. We have chloroplasts that are found in the plant cells and are responsible for photosynthesis. We have nucleus which is an organelle that stores DNA and all the hair editorial in formation together inside. We have vacoules which are like waste bags or specialized containers inside the cells to store something.

So, all of these are specialized subunits within the cell and all of them have a specific function.

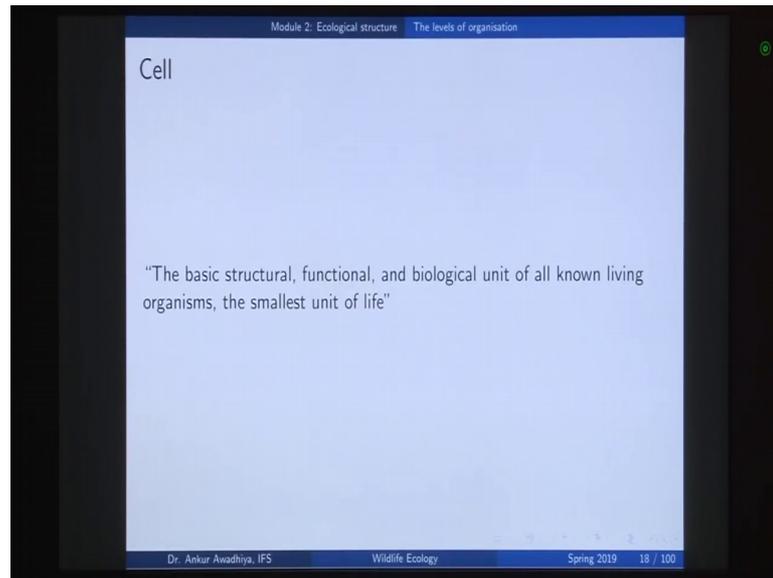
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Now, if we have a look at the epidermis of an onion. So, you take an onion, you separate out its outer layer, then you stain it with stains and then you have a look. So, here we will observe that there are cells. So, this is a plant cell and here we observe a nucleus. So, nucleus is a sub cellular organelle, sub cellular because this is at a level that is below that of the cell.

So, this is a sub cell organelle; organelle because an organ is, we will come to it in a short while, but an organ is an organization that is performing the specific function. So, here also these organelles are performing some specific functions but because they are very small in size we do not call them organs, we call them organelles when they are sub cellular in size. So, here we observe sub cellular organelles within a cell.

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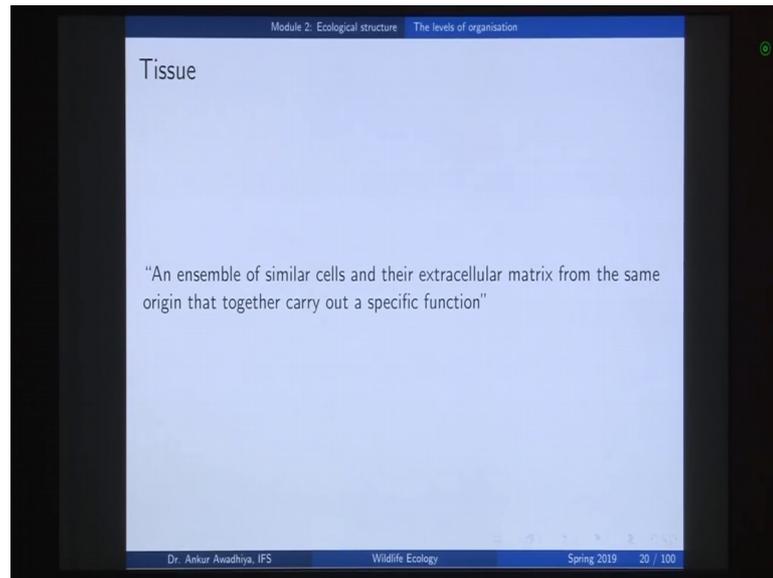


Now, a number of these sub cellular organelles will come together to form the cell and the cell is the basic structural, functional and biological unit of all known living organisms or the smallest unit of life. It is the basic structural functional and biological unit. So, all the organisms have are made up of cells, a cell or a number of cells.

One cell in the case of a unicellular organisms such as bacteria and multiple cells in the case of multi cellular organisms such as human beings. Now, this is the basic structural unit. So, the structure of the body will be made by cells. These are the basic functional units because they will be performing all the functions and they are responsible for all the emergent functions that are there in the body and they are the basic biological units.

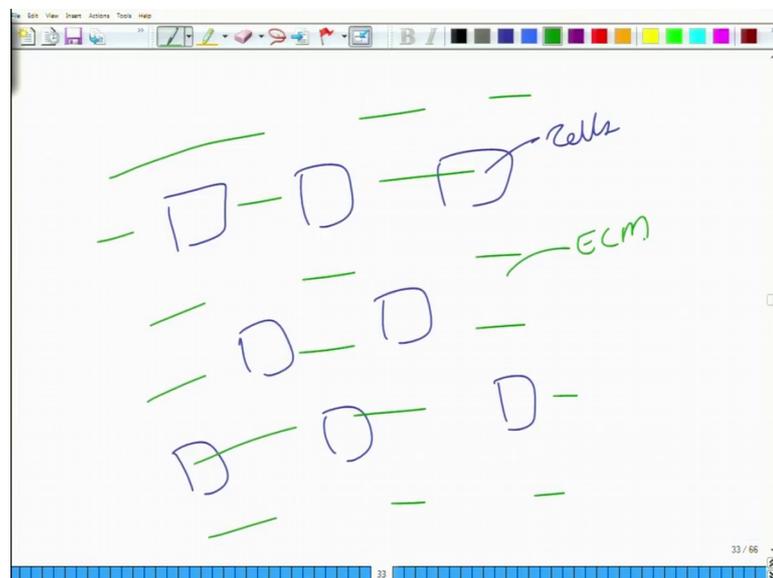
Because all the processes like respiration or say, cell division they all happen at the level of the cells. So, they are the basic structural, function and biological units of all known living organisms or the smallest unit of life and we can observe cells very easily in the case of onion or in the case of animals if you make a smear of blood, you will be able to see the red blood cells. If you make a smear of your cheek cells, you will be able to see a number of epithelial cells and so on.

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Now, from cells we move on to tissues. An ensemble of similar cells or assembly of similar cells if you go with the French pronunciation; an assembly of similar cells and their extracellular matrix from the same origin that together carry out a specific function.

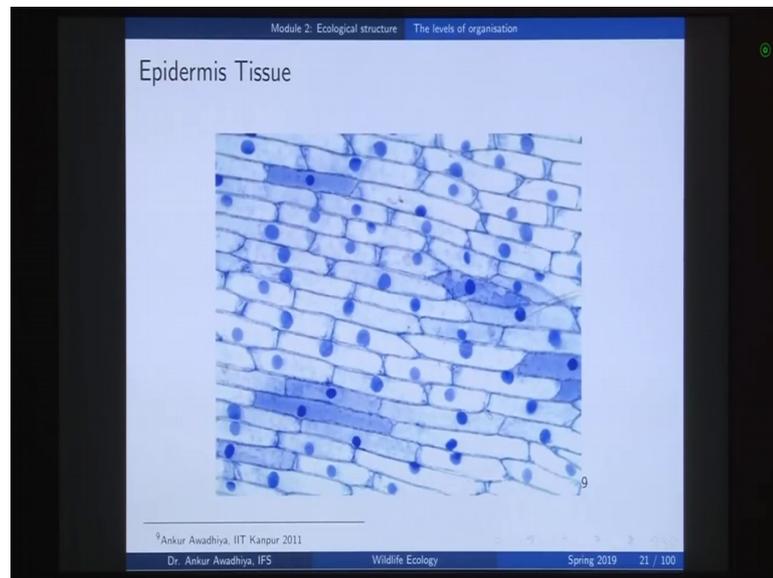
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Now, in the case of a tissue, you will have a number of cells together. So, you have cells and these cells are embedded in an extracellular matrix. So, these cells together with the extracellular matrix will form a tissue. So, it is an assembly of similar cells. Now, these cells have to be similar, if they are coming from different origins, if they are different

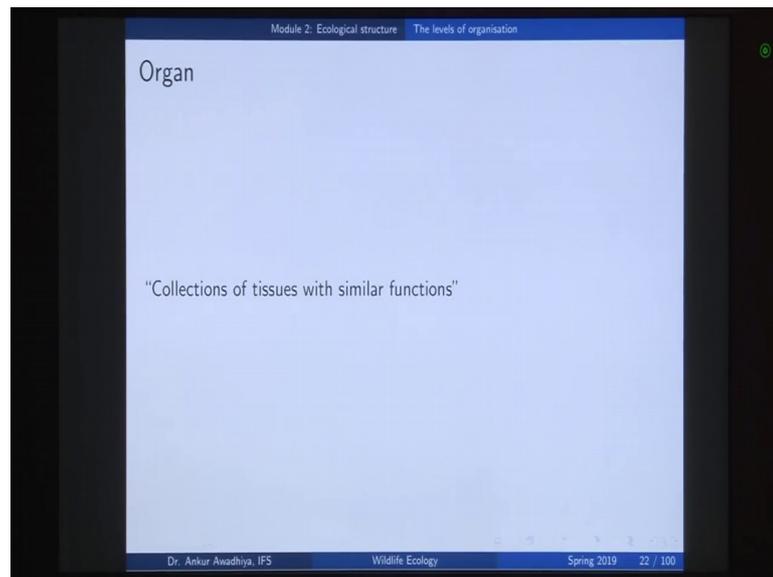
cells, then probably we are looking at multiple tissues together. But, an assembly way of similar cells and their extracellular matrix from the same origin that together carry out a specific function.

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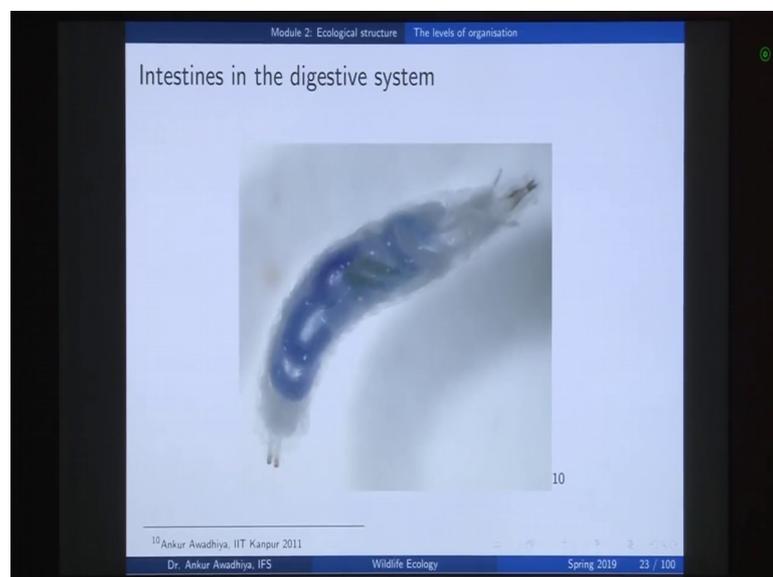
Now, what could this function be? So, when we look at the onion cells, when we are looking at the epidermis tissue of the onion cells, they are performing a very specific function and that function is to keep water inside that function is to protect the onion bulk from outside environment. And so, this is specific function that is being done by this tissue which is the epidermis tissue and this tissue will comprise of a number of epidermal cells together with the extracellular matrix that is binding these cells together and the and this is the matrix in which these cells are embedded inside.

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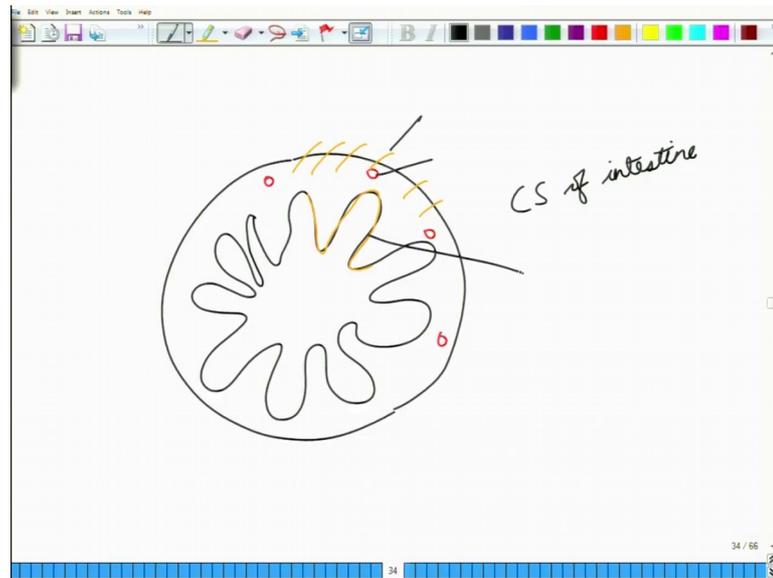
Now you put a number of tissues together, so, tissues from different origins together and you get an organ. Now, organs are collections of tissues with similar functions. So, for instance, intestines are organs.

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So, in an intestine, you will have a number of different tissues.

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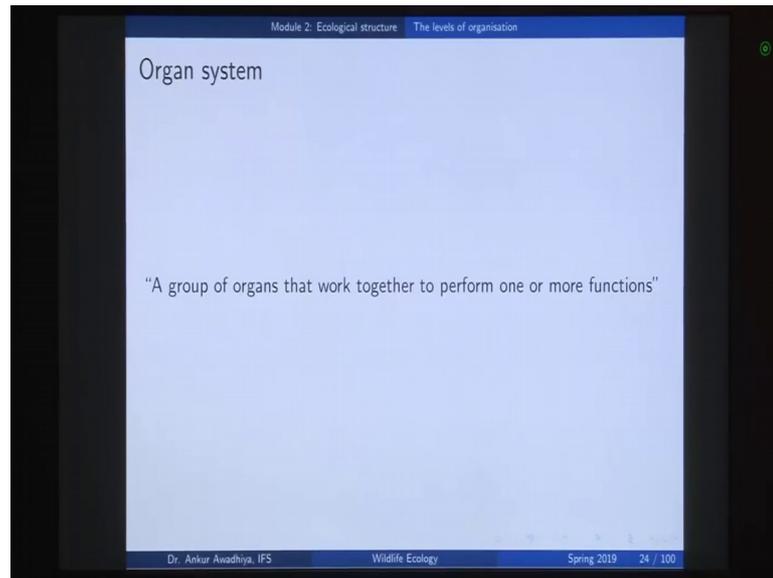


So, if we look at a cross section of intestine, we will be having these tissues which are the endothelial tissues. We will also be having some blood vessels which are vascular tissues; we will also be having some muscular tissues. So, we have blood vessels, we have the muscular tissues, we have the endothelial tissues and so on.

So, all of these different tissues from different origins, they are coming together to perform a specific function. And in this case, the function is to absorb nutrients that we are getting from food. Now, in this case, we are looking at the larvae of a drosophila and we have stained the intestines using a blue coloured stain and here you can observe one organ. Another organ, say can be the mouth of the organism.

So, mouth is also comprised of a number of tissues from different sources. Even in the case of our mouth, we will be having epithelial cells on the inside, we will also be having blood vessels, we have muscular tissues, we also have the skeletal tissues inside and so on.

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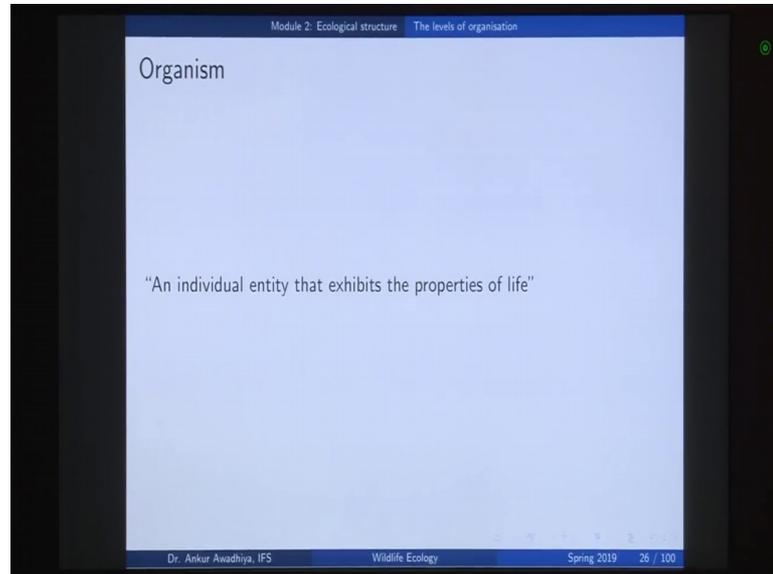
The next level of organization is an organ system, a group of organs that work together to perform one or more functions. So, it is a group of organs that are working together to perform some function. So, for instance, an organ system is the digestive system. Now, digestive system will comprise of a number of organs. It will comprise of the mouth parts, it will comprise of the intestines, it will comprise of the stomach, in our keel also comprised of the liver, it will comprise of pancreas, small intestines, large intestines, a rectum and is all these different organs together will form an organ system which is the digestive system. Now, all these organs are performing some specialized functions and they are put together to perform a next higher level of function.

So, for instance, in the case of our mouth, the mouth is only chewing the food, but then you after chewing it goes through the oesophagus which is a conduit medium then it goes into the stomach which performs the function of a reservoir in which the food items are put into an acidic medium and then a number of enzymes are added there.

Then it moves into the small intestines which provides a basic medium and then it moves to the large intestine which will absorb quite a lot of water from the food materials that we have ingested. Then, it will move to rectum and anus through which those portions of the food that are not absorbed by the body and then get gotten rid off. Now, all of these different organs are performing just one function together which is the consumption,

digestion and ejection of the food. So, all of these will together form the digestive system.

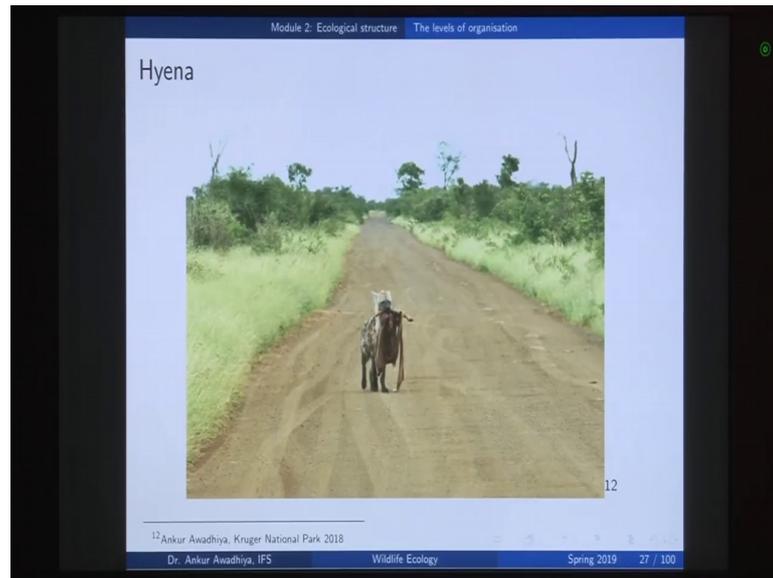
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The next level of organization is an organism. An organism is an individual entity that exhibits the properties of life. Now, when we see properties of life what are those this organism should be able to get its own food. It should be able to digest the food it should be able to assimilate the nutrients inside. Then, probably another function of life would be movement.

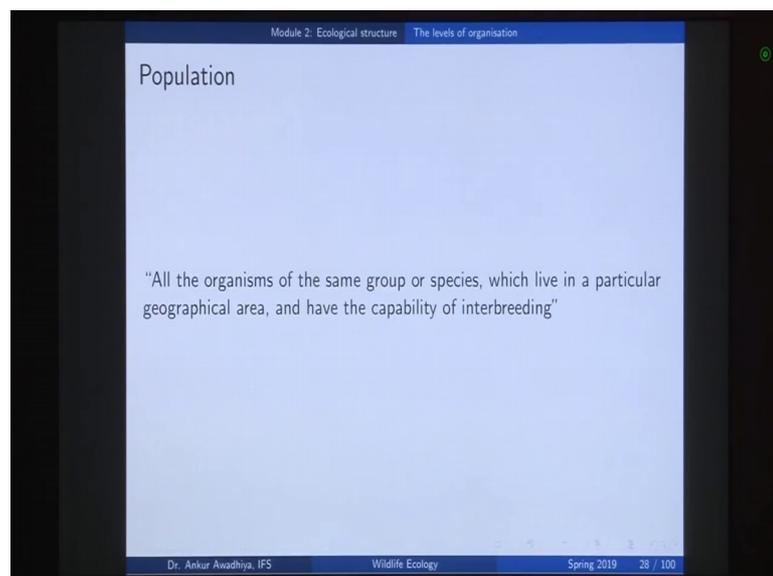
So, a number of organisms there are a number of organisms that do not move like plants, but, but movement is also another function of life. So, like all the animals move. Then, another basic function of life is procreation. So, they give rise to their offspring. So, all these functions of life that are together performed are performed in an entity that is called the organism.

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So, here we can observe an organism which is Hyena. So, this Hyena is carrying a food that it has gotten from somewhere and so it is able to get it is food, it is able to eat it is food, it is able to digest it, it is able to assimilate it, then Hyena will also give rise to it is own progeny, it will live in a social structure. So, it will it will be able to get air, it will be using oxygen, it will give out give out carbon dioxide. So, it is performing the processes of respiration which is another basic function of life. So, it is performing everything that a living entity should and this is the level of an organism.

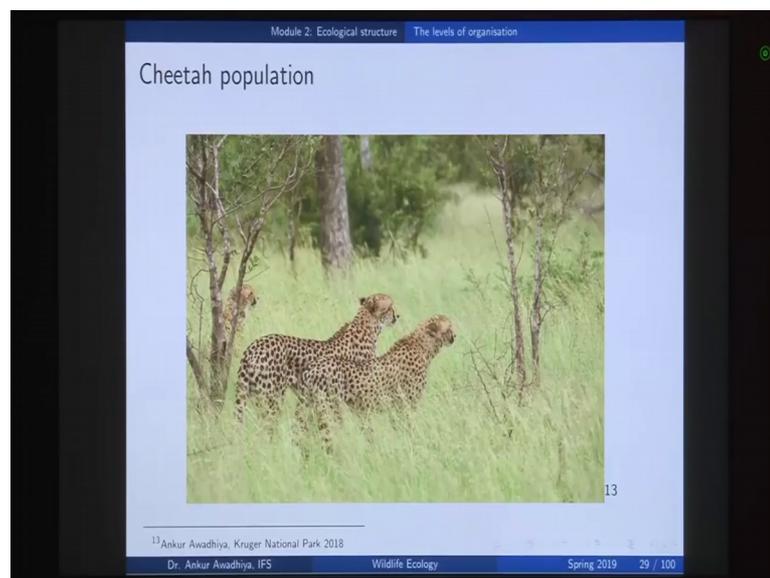
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Now, the next level of organization is a population. Now, population comprises all the organisms of the same group or species which live in a particular geographical area and have the capability of interbreeding. So, a population comprises organisms of the same group or species. Now, species refers to those organisms that can breathe together to give rise to fertile off springs. Now, population will comprise of organisms of the same species. So, if we consider a population of tigers, will only have Tigers there we would not have a Lion inside that population and these groups live in particular geographical area.

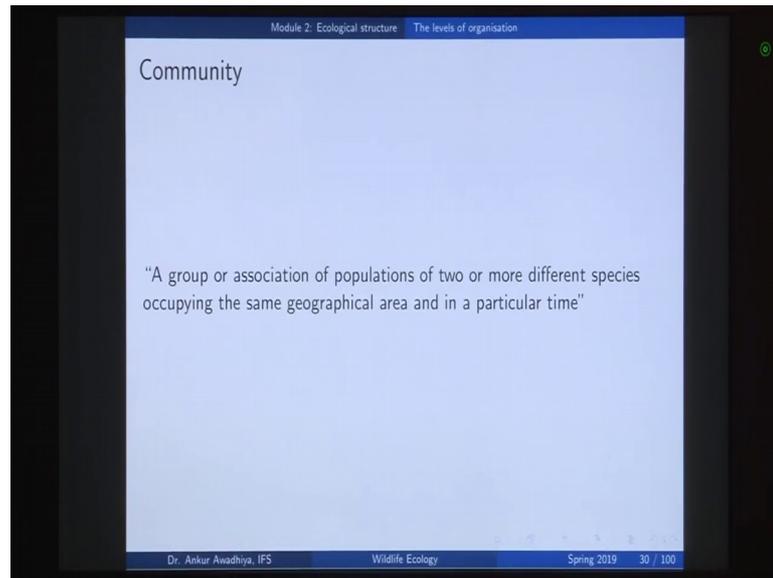
So, we can talk about a population of Tigers in Sundarbans. We can talk about a population of Tigers in Kana tiger reserve. We can talk of a population of tigers in Mudumalai tiger reserve and all of these are different population because they are living in different geographical areas. And these have the capability of interbreeding. So, for instance this is a population of Cheetah.

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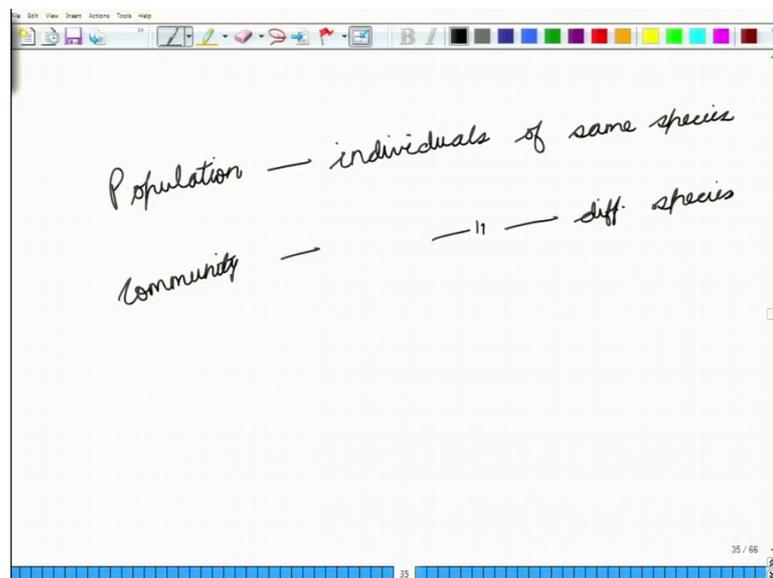
So, it comprises of a number of cheetahs that are together and they live in a system and they are living in the same area and they are capable of interbreeding amongst each other. So, this is a population.

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Now, from population, the next higher level of organization is a community a community is a group or association of populations of two or more different species occupying the same geographical area and in a particular time.

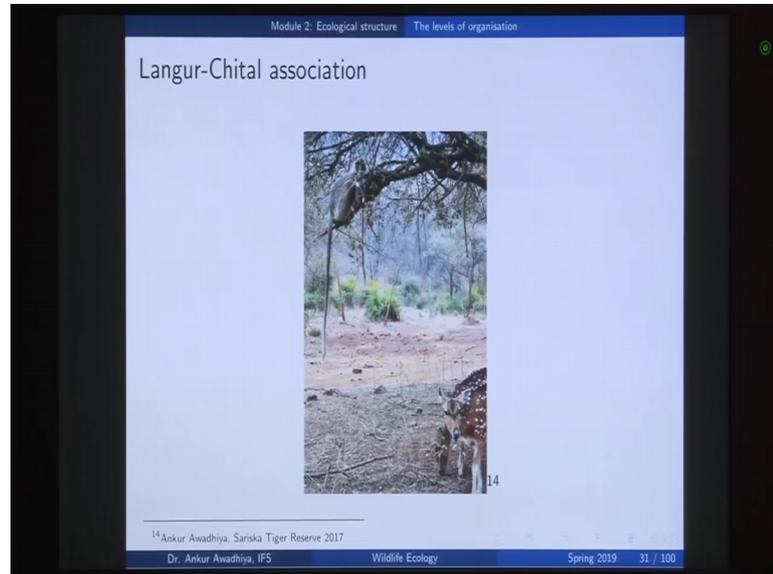
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So, population comprised of, population comprises of individual of same species and community comprises of individuals of different species and the rest of the things are similar. So, they are the groups or associations of populations of two or more different species that occupy the same geographical area and in a particular time. And of course,

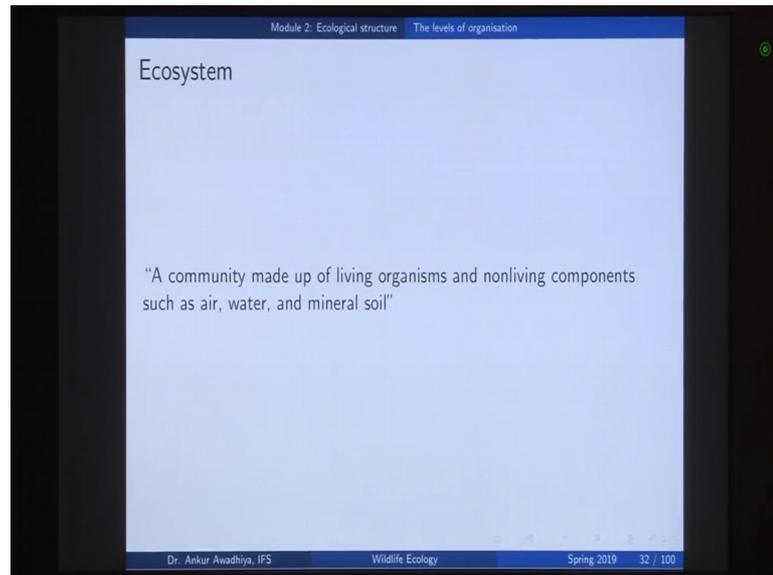
because these are different species, so they are not interbreeding with each other, but each population is able to interbreed with each other.

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So, for instance here, we are observing Langur Chital association which we also dealt with in an earlier lecture. And this is an example of a community, now in this community will have populations of Chitals, populations of Langurs, populations of a number of different tree species that are living together and this level of organization is called a community. Now, it is important to note here that in a community, we only have biotic elements. Biotic elements are living elements. So, Chital is a living entity, Langur is a living entity, all these trees are living entities. So, a community only comprises of a number of populations and all of these are living entities.

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If you add the abiotic components together with it, you will get to the next level of organization which is an ecosystem. An ecosystem is a community made up of living organisms and non-living components such as air, water and mineral soil.

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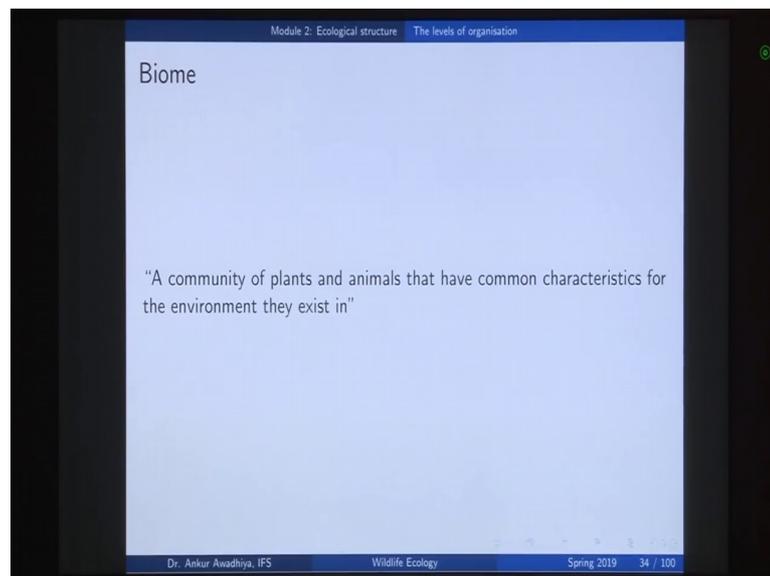


Now, if you look at any ecosystem like, here we are observing an ecosystem which is that of a pond in a Forest. Now, this point or this forest. So, we have a pond ecosystem here, we also have a forest ecosystem. Now, in this ecosystem, we have a number of communities, a number of populations that are living together, but we can also observe a

number of non-living entities such as the earth that is seen here or the water that is found here or the air that is here or the amount of sunshine that this area is getting. So, a community is able to exist only because of these abiotic factors that are also present in the same ecosystem.

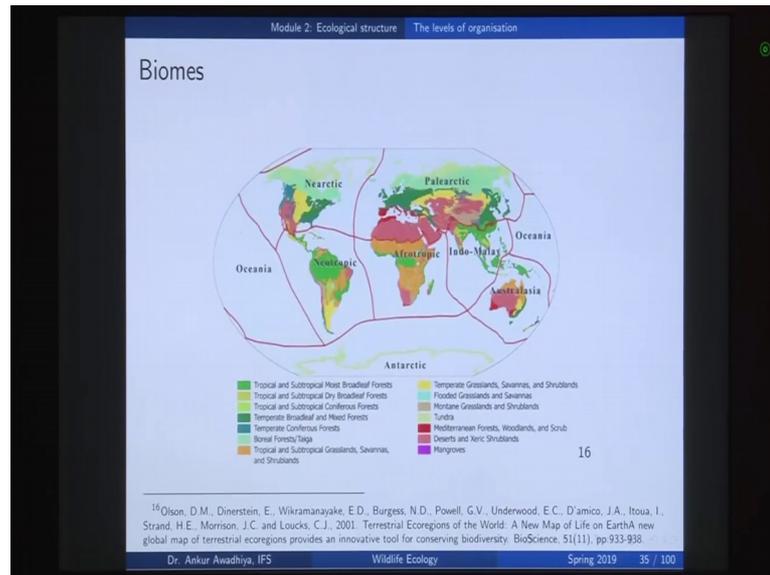
If you remove water from this ecosystem, now, what is an abiotic elements. But if you remove it, the whole community will collapse. Similarly, you remove air from this ecosystem, the whole community will collapse. You remove soil from this system and you would not have any plants and if you do not have any plants, you would not have any animals. So, this level of organization in which you have living and non-living things together with the non-living items supporting the living entities forms an ecosystem.

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The next level of organization is a biome a community of plants in an animals that have common characteristics for the environment they existent is called a biome. So, it is a collection of ecosystems from different areas even different geographies that have some common characteristics.

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So, for instance if we talk about the Tundra biome, now Tundra refers to these areas. So, here you have this light green colour that is Tundra and here are these areas on the very top and on the very bottom. Now, Tundra comprises of those areas that are permanently covered with snow. So, these are very cold environments.

So, you can have an ecosystem that is here in this Tundra and you can have an ecosystem that is here in this Tundra and both of these are not connected with each other. But still, these ecosystems will have some similar properties. Because they are very cold, so the animals that are found there will be having lots of fur for example, or they will be having a layer of fats because they would not be having an access to quite a lot of food most of the times or let us look at the next level, another one Tiger.

Now, Tiger is this area. So, this is comprised of forest and these forests have trees that are practically untouched till this date. Now, in these areas whether you consider a Taiga forest in Canada or you consider a Taiga forest in say Russia, both of these will have very similar characteristics because they again are very cold. They do not have quite a lot of access to sunlight, the level of primary productivity is very less and so, the organisms that are found in this area will also tend to be larger in body size, so that they are able to store a lot of nutrients inside their body because the level of primary productivity is less.

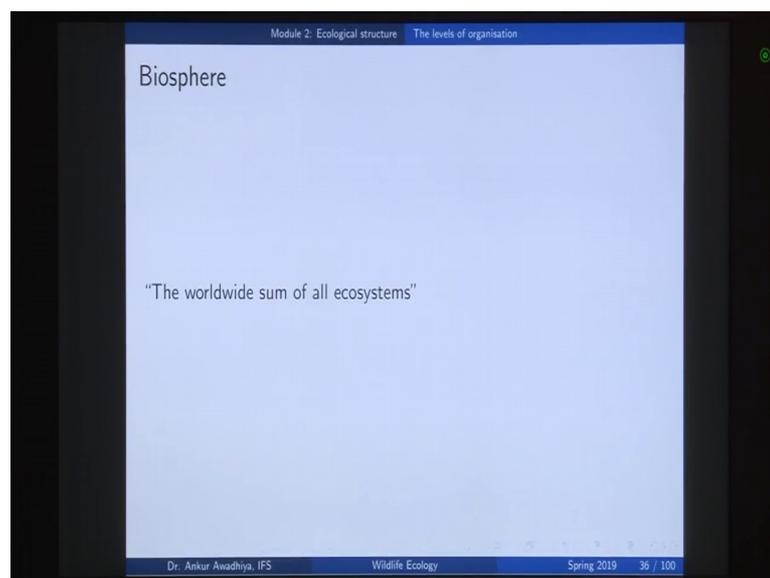
So, an ecosystem that is there in the Taiga Biome in Canada and an ecosystem that is there in the Taiga Biome of Russia, even though they are very different from each other,

even though they are highly separated from each other geographically, they will be having some common properties and which is why we group all these ecosystems in similar environments into a biome. So, this is the next level of organization.

Similarly, you can have a Desert Biome. Now, if you consider a desert in India or you consider a desert in Australia or you consider a desert in Africa or a desert in North America, all the ecosystems that are found in these deserts will be having similar properties. They have less amount of water, they have extreme temperatures, may be a lot of sand.

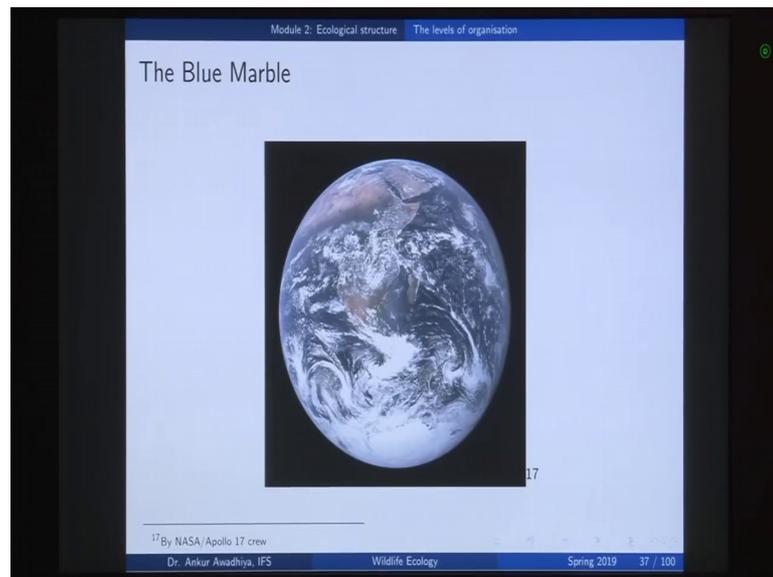
And because of these common properties, they will be having ecosystems that will also be having very common properties and the communities and the populations that will live in these areas will also have a number of common properties. So, which is why we organize them as biomes.

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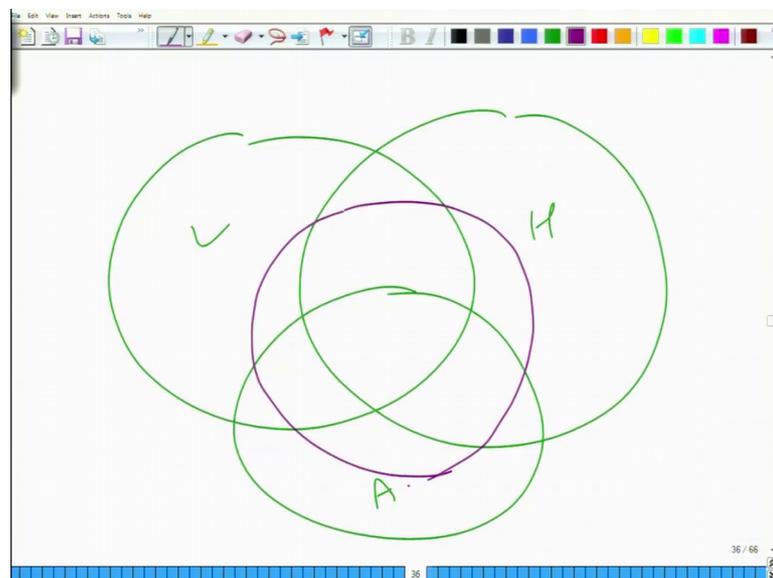
Now, you put all the biomes together or all the ecosystems of all the biomes together and you get to the biosphere. Now, biosphere is that portion of earth that supports life.

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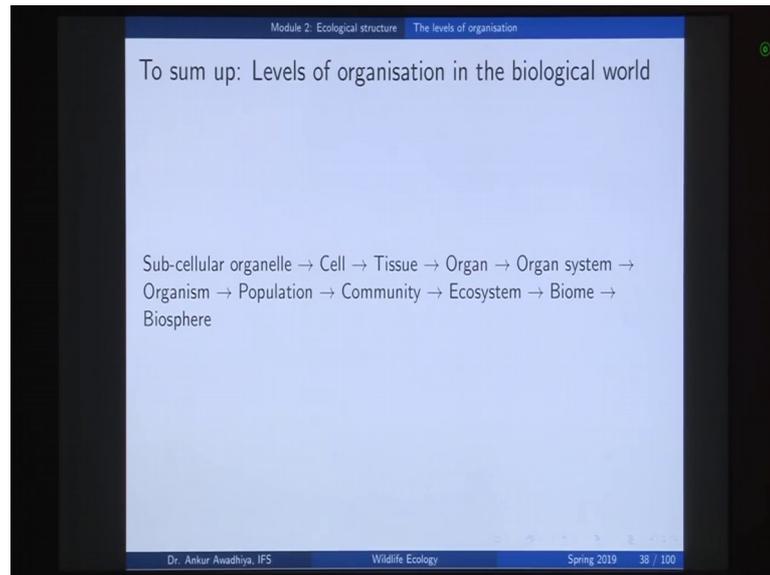
Now, biosphere will comprise of some elements of hydrosphere which is water, some elements of lithosphere which is land and some elements of atmosphere which is the air around us and there is a particular confluence of all three of these.

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So, you have the lithosphere you have the hydrosphere and you have the atmosphere and there will be some portion of all of these that will support life and that will be called the Biosphere.

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Now, we sum up by looking at the levels of organization in the biological world once again. So, we can begin with the organism. So, organism is a living entity that is performing all the biological functions and an organism is comprised of a number of organ systems, the organ systems such as the digestive system or the respiratory system. The respiratory system will comprise of your airways, your nose, your lungs, the diaphragm or say the circulatory system which comprises of the heart and all the blood vessels.

So, you have a number of different organ systems that comprise an organism and each organ system is comprised of a number of organs. So, for instance as we look before, the respiratory system the respiratory organ system is comprised of a number of organs such as the nose, the trachea or the windpipe, the bronchi, the bronchioles, the alveoli, the lungs the diaphragm and so on. Now, each of these organs will be comprised of a number of tissues. So, for instance if you look at the diaphragm which is an organ. So, this diaphragm will be comprised of muscular tissues, it will have nervous tissues and it will also have circulatory tissues or vascular tissues.

Now, these tissues will comprise of cells that are similar of similar origin and they also comprise of the extracellular matrix that is surrounding these cells and in which the cells are embedded. So, for instance, if we talk about the muscular tissue in the diaphragm that

will be comprised of a number of muscular cells and a number of and a large amount of extracellular matrix that is surrounding these muscular cells.

Now, these cells will be those are the smallest structural functional and biological subunits of life and these cells are able to perform most of the functions of life. So, these cells are also able to respire, they are able to get nutrients from the blood, these cells are able to get oxygen from the blood, they are able to perform respiration, they will generate energy they will generate ATPs, they throw out waste into the blood vessels to be taken off and disposed and so on. So, you will have a number of muscular cells in the muscular tissue of diaphragm and all these cells are comprised of the sub cellular organelles.

Now, sub cellular organelles would be things like the nucleus, the nucleoli, the golgi apparatus, the mitochondria in these cells, the vacuole in these cells and so on. So, this is the level of organization moving from organism downwards. Now, if you move upwards, we will have from organism will move to a population. So, for instance, an organism is say an elephant. So, you consider a single elephant and then you consider a group of elephants that are living together in a same geographical area they are capable of interbreeding together and they will form a population.

Now, this population of elephants together with a population of say Chital or Sambar or Tigers in that area will form a community. So, that is the next higher level of organization. So, from population, we move on to communities. Now, communities will have some emergent properties that are very different from that of a population. So, for instance, a relationship will be that of a predator-prey relationship. If you consider a population of Chitals, there is no predator-prey relationship in a population of Chitals, but you consider a population of Chitals together with a population of tigers and you have predator prey relationships that are acting at this level of organization.

So, this is a community a community is comprised of a number of populations that are living together in the same place in the same time. So, that is the community. Now, to this community, you add all the non-living elements that are formed in that area. So, you add air, you add water, you add soil, you add sunshine, you add at wind speed and they will form a particular ecosystem. Now, these non-living components of the ecosystem are also supporting the biotic component and together they form this level of

organization which is called the ecosystem. Now, you take an ecosystem. So, let us consider a small Oasis that is found in our desert of Rajasthan.

So, that is an ecosystem and that ecosystem is supporting a number of communities and a number of populations. But then, you consider another oasis that is found in the desert of Sahara or another oasis that is found in the deserts of Kalahari and all of these ecosystems will have some common properties. When you will take all of these ecosystems together they form a biome that is and a desert biome.

And so, desert biome will comprise of all this asses, it will also comprise of the sand dunes, it will also comprise of rock formations that are found in these areas, they will also comprise of pliers that are found in these areas, they will also comprised of a number of salt deposits that are found in these areas and you put all of these together and you get to the desert biome.

So, here we are talking of the next higher level of organization which is all the deserts of the world. And you put different biomes together, you put all the cold biomes that is the tundra biome, you put all the taiga biomes together, you put all the equatorial rainforests together, you put all the deserts together and you make and you reach next higher level of organization which is called the biosphere.

The biosphere is that sphere of the earth that is supporting life. So, here are the levels of organization and at each level of organization, you will be observing hierarchy, you will be observing Simon's principle and you will also be observing emergent properties that arise at each and every level. So, that is all for today.

Thank you for your attention [FL].