Environmental Biotechnology
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Lecture – 04
Ecosystem: Basic Concepts of Structure and Function (Contd.,)

Welcome to next lecture on ecosystem and in this lecture 4 we are going to continue our discussion on the basic concept particularly emphasizing the major contributions by different components of the ecosystem.

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Including the concept of species, the population community, identifying the different components, concept of Biosphere and Gaia hypothesis, ecosystem definition, ecosystem function and energy and nutrient, closed Food Chain and tropical level.

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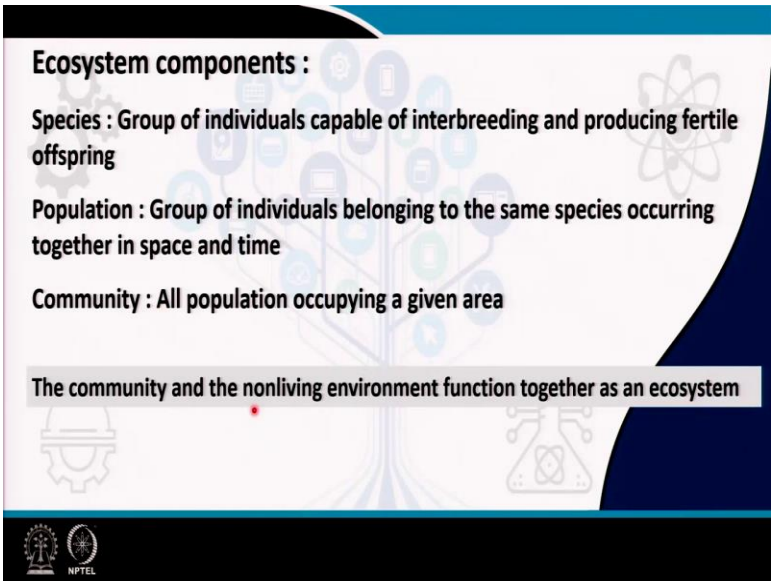

Ecosystem components: Ecosystem components are distributed into different categories in a sense with respect to macro ecology in particular. We can identify that the species represent the the fundamental component of the biotic part of the environment. And species refers to group of individuals organisms physically capable of interpreting and producing fertile offspring's. So, this definition is a valid for sexually reproducing organisms and of course that then it is not true for the prokaryotic organisms or the organisms who are incapable of sexual reproduction. So species is defined like this.

Group of organisms who are capable of integrating and producing the fertile offspring. Population refers to group of individuals belonging to the same species occuring together in a particular space and time. So I really population is represented by members of the same species. So as we are discussing about the macro ecology so this concept is more true for the macro ecology. So in case of macro equality in the species are very well defined and a group of organisms which belong to the same species are considered at the population.

Now community refers to all population occupying any given area that is in particular space and time all the populations and individually each of the populations are group of species order members of the species overall member of the same species. They are the populations all the populations together. They represent a community. Community and the nonliving environment that is the abiotic component of the environment function together as an ecosystem as we have

learnt in our earlier lecture.

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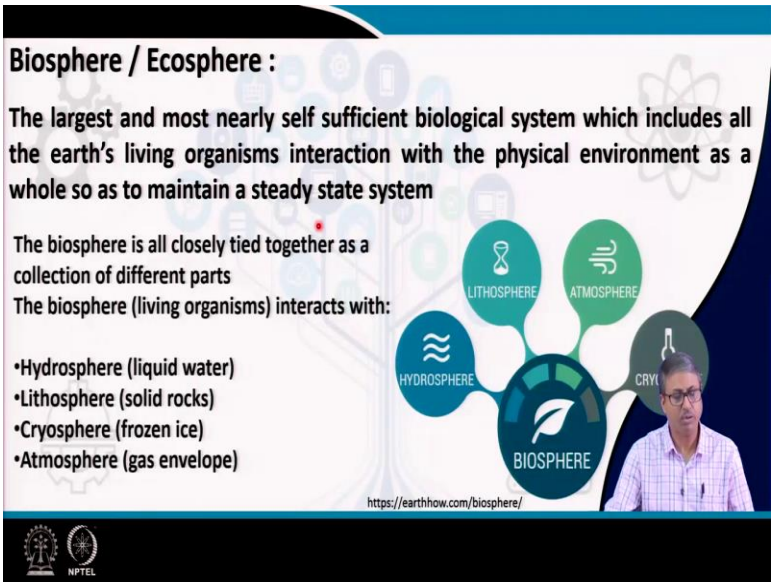

Now the definition of the or the concept of the biosphere and the ecosphere. Now the biosphere and the ecosphere is the largest and the most nearly self-sufficient biological system which includes all the earth's living organisms interaction with the physical components as a whole so as to maintain a steady state system. So it is the entire planet earth, it is considered as a biosphere where all the biological components are continuously interacting with the non biotic components of the planet.

And they are maintaining steady state within it. Now, the biosphere could be seen as interacting with many of its components including the Hydrosphere that is the liquid water based component. The lithosphere, hydrosphere atmosphere etcetera and all these components are closely tied together as a collection of different parts. So, the entire component is the biosphere where we can see the hydrosphere, lithosphere etcetera.

So, in any kind of environmental biotechnology study, wherever we need to consider the or adopt a kind of a holistic approach to address any kind of issues within that particular environment we have to keep in mind that all this interacting components which are actually part of these or could be the part of the hydrosphere, lithosphere, atmosphere and if applicable hydrosphere. They are all of the intricately in interrelated and there that going to have a very

strong influence and control over the function of that particular ecosystem.

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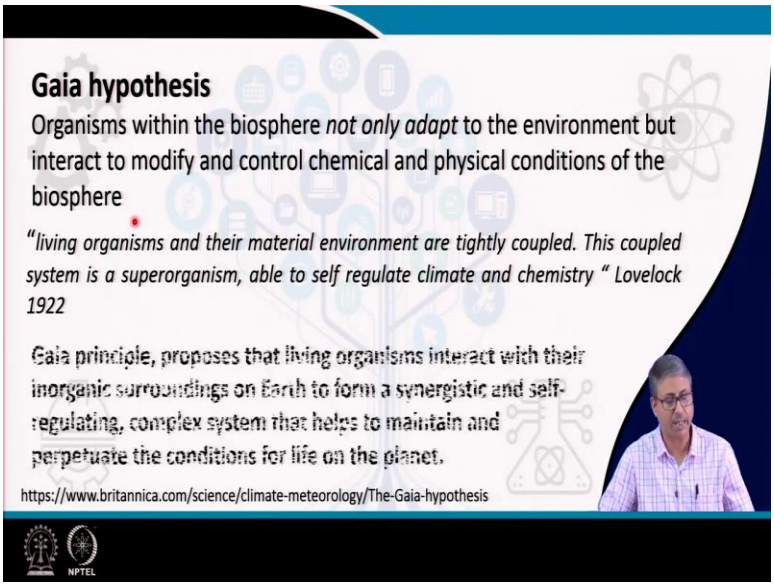

Now in this respect I would like to discuss briefly on very important hypothesis on this biosphere that is referred as the the Gaia hypothesis, meaning; now the Greek word Gaia refers to mother earth. It is proposed by a Lovelock's and in the name for earth, which is envisioned as a super organism. The entire planet earth is considered as a super organism engaged in all kind of bio, geo physiology.

So the all the functions all the biological on the biotic functions that we see within this planet earth considering its entirety is actually considered within this Gaia hypothesis. And it is actually considered to be at the planet earth is the biosphere is considered to be a super organism. And the goal of the super organism is to produce homeostatic or the balanced system. So the larger scale when we talk about the impact of the climate change or any kind of environmental biotechnology research which is aimed towards mitigating the challenges impost by the the climate change or other kind of pollution environmental pollution.

We need to understand that ultimately the planet earth has its own homeostatic mechanism and you need to understand at least part of that. And this Gaia hypothesis includes at all organisms within the biosphere. Eukaryotic, prokaryotic all kind of organisms they not only added to the environment but interact to modify and control chemical and physical conditions of the

biosphere that already we have discussed in our in the interactive space that the organism they interact and its right to modify.

And in his report he has mentioned the living organisms and their material environments are tightly coupled and this coupled nature at the super organism. According to this principle of the Gaia principal it proposes that the living organisms interact with the inorganic surroundings on earth to form a synergistic and self regulating complex system to help to maintain and perpetuate the conditions for life on this planet.

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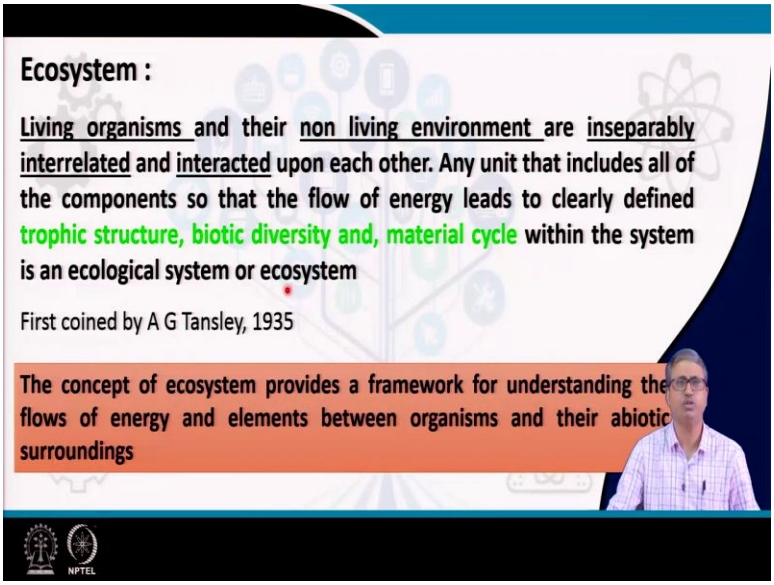

Now we are going to define the term Ecosystem. Living organisms and their non living environment are inseparable interrelated and interacted upon each other. This is a very important statement that living organisms all this species member present in an environment and they are not living or the abiotic components were which are present in that environment are inseparably interrelated and interactive upon each other that represents the interactive space.

Any unit that includes all the components so that the flow of energy needs to clearly define trophic structure biotic diversity and material cycles within the system is considered as an ecological system or ecosystem. And ecosystem is basically defined as a unit of any kind of environment where it includes all the components of the ecosystem that allows the flow of energy to the clearly defined trophic structure etcetera.

And these definitions we are going to have shown that the defining this each of these this terminologies. Now the concept of ecosystem provides a Framework for understanding the flows of energy and elements between the organisms and abiotic surroundings.

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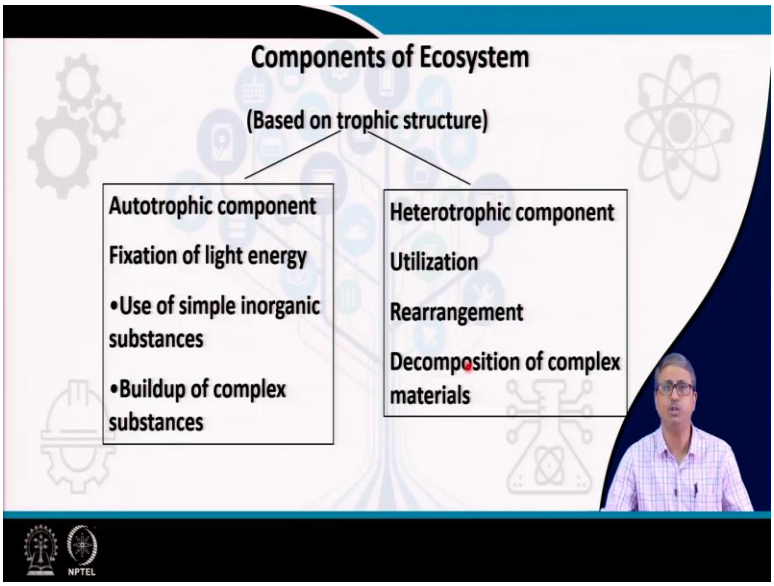

Now the components of ecosystems are highlighted. Now based on the trophic strucutre actually what trophic means in this case is nourishment that is who is nursing whom that is the nutrients. How the nutrients are obtained by any organism based on that the components of ecosystems are also divided. So autotrophic component and heterotrophic these are the two components which are very well defined in almost all the ecosystem.

Both in case of the macro ecological context as well as micro ecological context; that is the only a focusing only on the microorganism. They are also we see that autotrophic and heterotrophic as well as in macro ecology context also we see this autotrophic and heterotrophic system. So this autotrophic components are capable of fixing the solar light that the photosynthetic organisms. So most of the cases in case of microbiology these are the plants and the the photosynthetic green algae etcetera whereas in case of the micro ecology there are many autotrophic organisms who are some of them are photoautotrophic some of them are kemoautotrophic.

They may not rely on sunlight always in case of a micro ecological context. So, we will talk

about them during our later class when we talk about the specific group of organism. However, autotrophic component of any ecosystem they use this simple inorganic substances. They acquire these nutrients from the soil of the water or from their surrounding environment and through a series of metabolic reaction they weed out the complex substances within them.

Heterotrophic component is capable of utilisation, rearrangement and decomposition. These are the three important properties of the heterotrophic component of any ecosystem. The utilisation of what? Utlisation of the complex substances which are already produced by heterotrophic components, autotrophic components are utilised by the heterotrophic members. So, they not only utilise actually they rearrange because in the early steps of the oxidation of those substrate like organic carbon in the cellulose, it may be some other organic components or organic compounds which are produced by the autotrophic organisms.

They are oxidized and their following oxidation is the precursor molecules are produced and they are again assimilated or they are process to different type of anabolic reaction which are called rearrangement. As per the organisms requirement they rearrange the precursor molecules and produce the own type of molecules which are required by that particular species. So utilisation and rearrangement these processes are interconnected to the metabolism of the heterotrophic mode of nutrition.

It also allows the decomposition of the complex materials which often we see that many of the heterotrophic organisms they just produce a number of hydrolyzing enzymes which are capable of the polymerizing and decomposing the different type of complex materials and the monomers are oligomers which are produced from the decomposition reactions are transported inside heterotrophic organisms and they are capable of utilising it.

So maybe for particular for the organisms as belonging to the the fungus or different fungal species or many of the heterotrophic bacteria can do the same thing.

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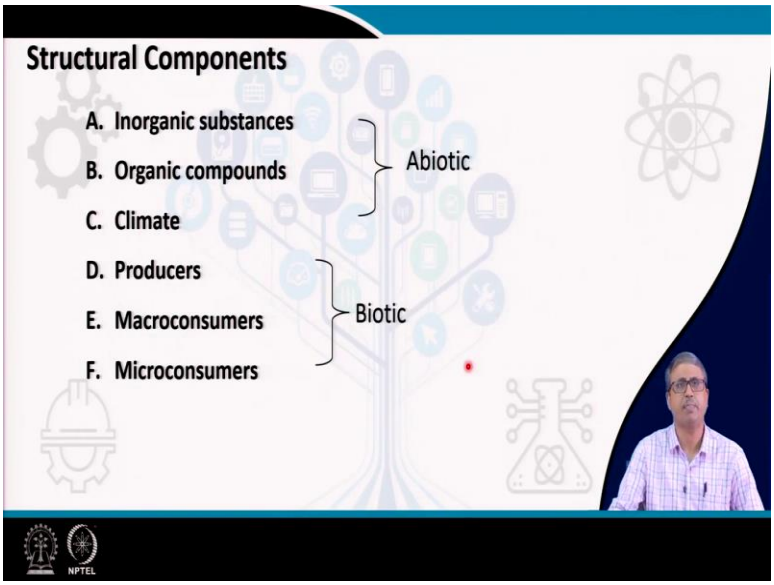

Now with respect to structural components we can identify that there are very well defined structural components conventionally the abiotic and the physical, chemical components and the biotic components. The inorganic substances, organic compounds and different type of parameters which are included during the climatic conditions are all the members of the abiotic components of the ecosystem.

Whereas the different the autotrophic members which are considered as a producers because they produced complex organic material. So, it may be autotrophic microorganisms autotrophic plants, it may be photoautotroph in macro ecological system, or it may be the chemoautotrophs in case of a micro ecological context and then there are macro consumers and micro consumers. This macro and micro consumers are more relevant or more of scene in case of microbiology. In case of microbial ecological system we may not identify always these macro consumers and micro consumers.

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So, there are also different types of components in terms of the function of the different type of processes going on. So we are now discussing the last type of categorisation. One was the topic level the second one the structural and the last one is the functional. Within the functional components we can see there are energy circuits, there are food chains, there are diversity patterns in the time and space because of the change in the nutrients and the type of other stresses present within environment.

We can have the change in pattern nutrient cycle, development and evaluation and control by which the homeostasis is actively maintained within a given ecosystem.

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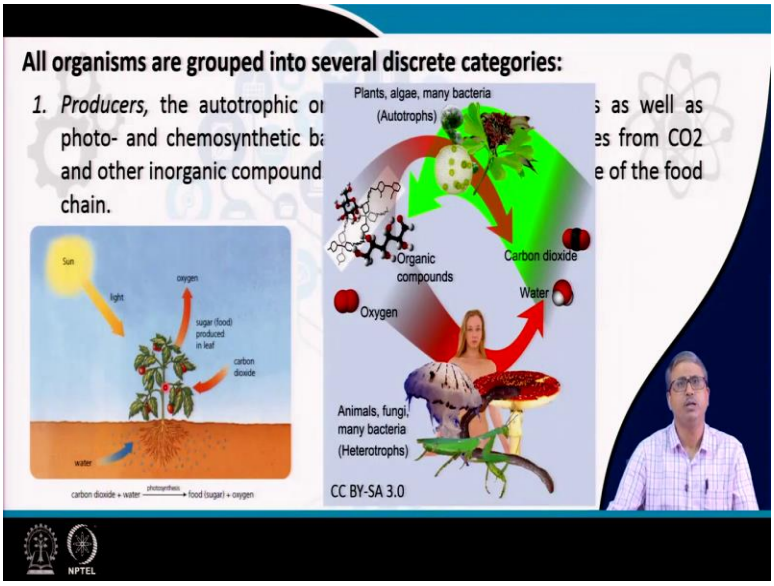

Now all organisms which are present in an ecosystem particularly in context of the; if we refer to the micro ecology it will be more relevant. All organisms could be grouped into several distinct categories. The first one is the producer that is the autotrophic organisms who are the photosynthetic plant as well as the photo and chemosynthetic bacteria, as I mentioned earlier. There constructing their bodies and they are their depositing the organic materials, organic compounds, organic substances which are which are synthesized from the inorganic carbon that is the carbon dioxide.

And other inorganic compounds generated obtained from their surrounding environment. These organisms form the basis of food chain in any kind of; there are two types of food chain that we are going to discuss briefly. And any kind of food chain that we found that this producers are the basic level of organism. They provide the food that is the required nutrient for the all the other type of organisms.

It could be the green plants who are able to fix the carbon dioxide with the help of the solar energy, the moisture and nutrients which are assimilated or acquired from the root system. They produce the organic material and which is eventually consumed by all the heterotrophic organisms dependent on them. Now in micro ecological context we can see there are numerous microorganisms, which are also capable of utilising the carbon dioxide, utilising the moisture on the water present and they are capable of converting or transforming these gaseous carbon dioxide and the water vapour into organic compounds.

And these organic compounds can be utilised by different heterotrophic members, including the hetrotrophic fungus, heterotrophic different type of insects the Eukaryotic organisms and even the higher animals as well.

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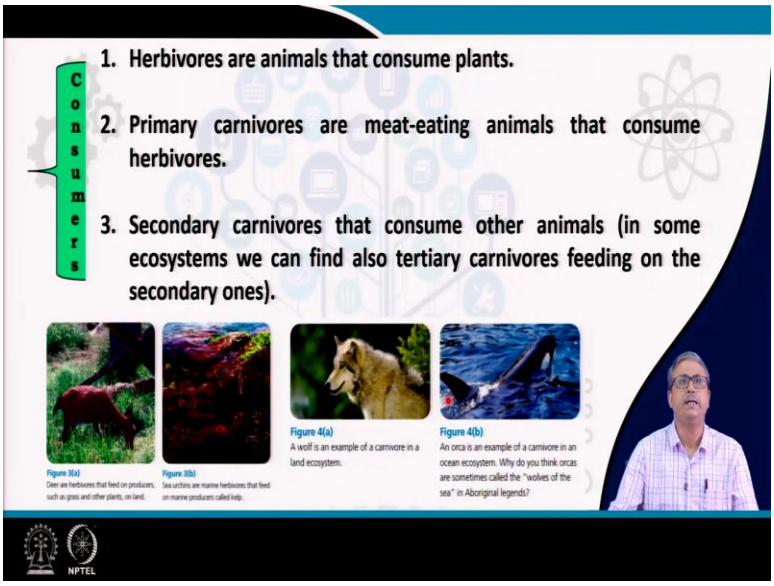

On the consumer category we have the herbivores which are again predominant or as a member of the macro ecology herbivores which are the animals that consume the plants. Then the primary carnivores which are the meat eating animals that consume the herbivores and then the secondary carnivores that consume other animals. In some ecosystem we can find also the tertiary carnivores feeding on the secondary one.

So whether you have the primary carnivores or secondary or tertiary carnivores it depends on the different types of ecosystem. Some of the eco system might have only primary and secondary and some might have all three or maybe something like that.

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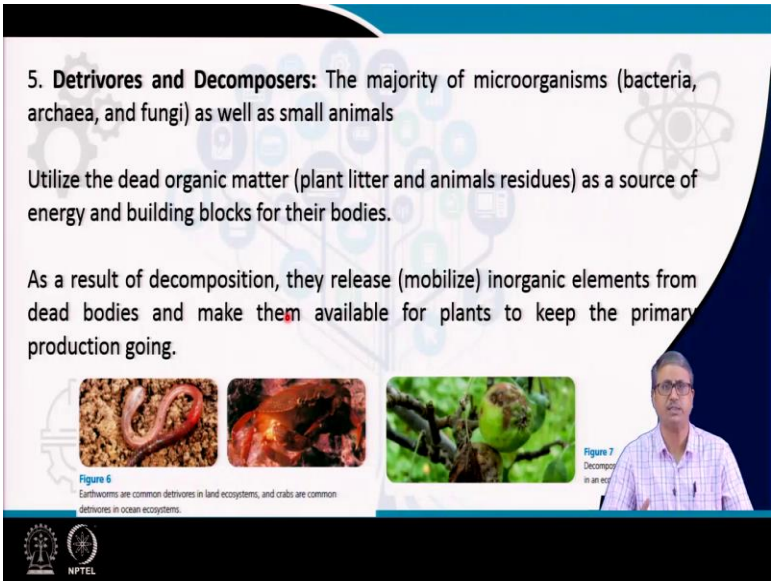

And the fifth one; fifth component is the detrivores. The detrivores and the decomposers: So these are the organism mostly the microorganisms which are represented by bacteria and archaea and fungi. As well as some of the small protozones that are produced animals they are capable of utilising the dead organic matter that is the plant litter and animal residues as the source of their energy and building blocks for their body.

So that these organisms decomposers and detrivores that they do not rely on any green plants directly, but they indirectly rely on them because they utilise the dead plant tissues that is a plant litter and enable the decomposition and the degradation of those plant material that is the cellulose hemicellulose kind of components and also the animal tissues that the dead animal tissues and there they are capable of releasing organic or inorganic materials and nutrients.

And acquire the energy by the oxidation of those compounds that is present in the plant litter and animal residues. As a result of the decomposition they release or rather mobilize inorganic elements from the dead bodies of the dead tissues and make them available for the plants to keep the primary production going on. So it basically helps into the recycling of the nutrients because plants acquire nutrients and inorganic nutrients from the soil or from the soil system to their roots.

Now, where from these nutrients are coming into soil? Because soil may not be having this kind of perpetual access to these nutrients, it is the detrivores and the decomposers who are recycling or who are supplying back the nutrients or the inorganic nutrients particularly. All the inorganic nutrients which are accumulated deposited in the plant and animal tissues following the death or the decay of those plant tissues.

These inorganic materials are released and they are made available to the plants thereby helping into the recycling of the nutrients within the plants or to the plant system.

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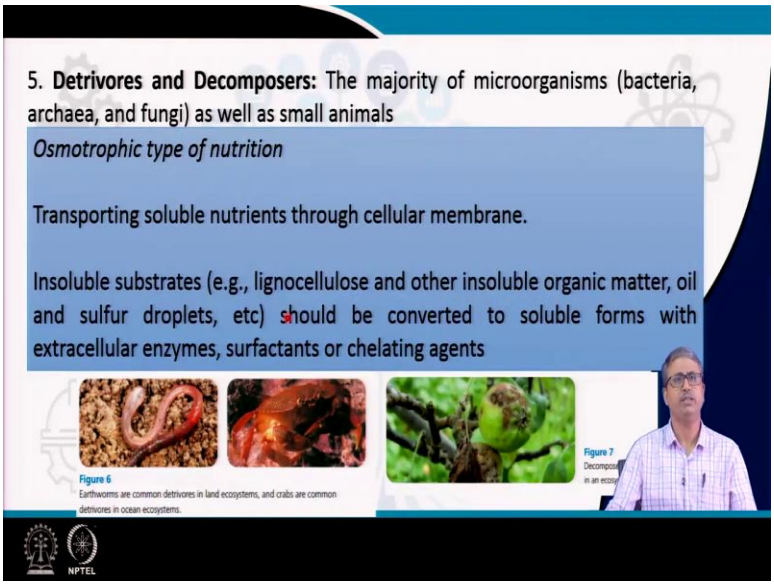

There is also another very interesting type of metabolism called nutrition which is called osmotrophic type of nutrition. In osmotrophic type of nutrition transport in are they actually allowed the transporting soluble nutrients to the cellular membrane, mostly microorganisms particularly the fungal species they are capable of doing this. So, insoluble substance for example the lignocelluloses and other insoluble organic matters, the oil and sulphur droplets etcetra they are converted to different type of soluble forms with extracellular enzymes released by the these microbes of the fungal species.

And often the surfactants or different cheleting agents are also involved and they transport these nutrients through their cell membrane for their further processing to the metabolism.

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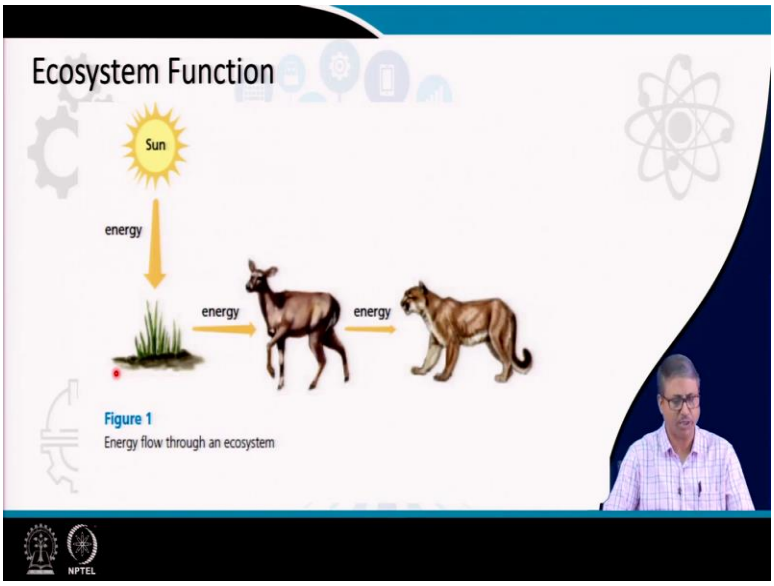

Now the ecosystem functions.

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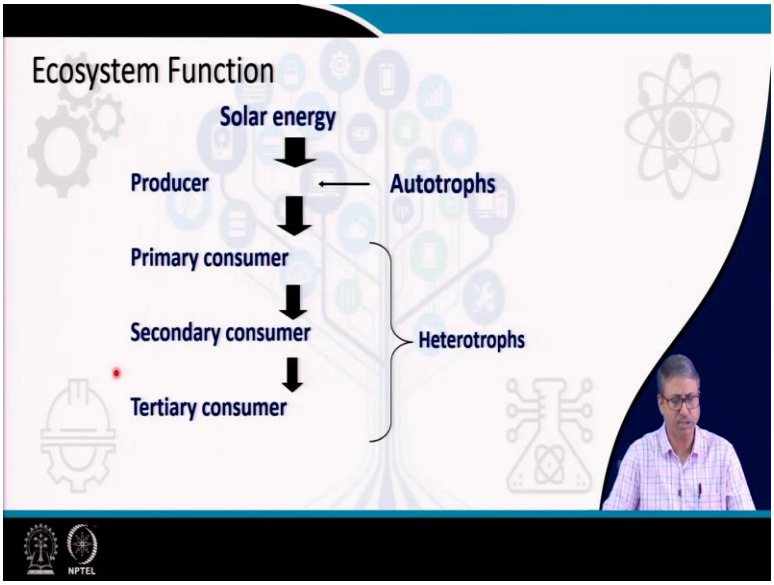

We can see that within the ecosystem function that is a very distinct flow of energy. As you can understand that the solar energy for micro ecological context or to some extent in the micro ecology also where photoautotrophs are involved. The producer organisms are the autotrophic organisms were capable of converting the carbon dioxide, high organic carbon into the organic carbon and capture the solar energy.

Energy gained from the Sun is used to reduce the carbon dioxide and produce the organic matter, which is eventually used by all the heterotrophic numbers. So the autotrophic members they are

capable of performing a very important function that is they are utilising the solar energy and they are converting the gaseous carbon dioxide into the organic carbon which is then utilised to buy all the other members of the community that is the primary consumer to the tertiary consumer.

So, essentially none of these members included under the head of consumers are capable of accessing the energy available through the sunlight. So it is only the autotrophic organisms who are capable of utilising the energy available through the solar light that is the photo energy and then those energy which are available there they are able to convert into the reduced organic matter.

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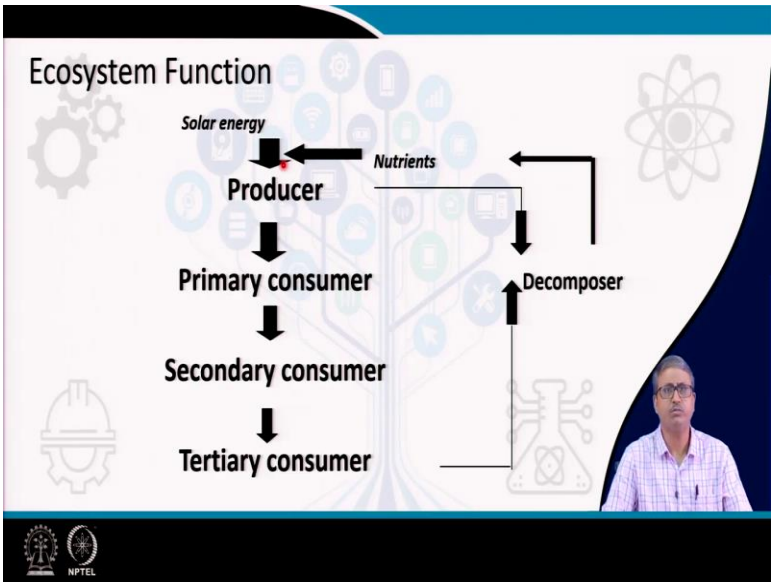

Now the energy flows with the direction that from the producer to the consumer the energy flows and we also know that at each level that is a substantial amount of energy loss.And eventually when the tertiary consumer is a dead the decomposers and detrivores they utilise the organic materials and other materials available into that and they get to oxidize most of it but a large chunk of energy is eventually lost.

But unlike that the nutrients which are assimilated the elements which are assimilated by the producer organism, like the green plants because other than the energy which is captured and energy which is utilised to store and the chemical bonds and the chemicals which are eventually

being oxidised by this consumer. Huge amount of inorganic nutrients are assimilated by the green plants.

These assimilated nutrients are eventually trance offered to the consumer organisms and consumer organisms they utilise that and following their death and decay of any kind of tissue decomposer and detrivores organisms that they allow release of those nutrients and then the nutrients are essentially coming back. So one important message in this particular slide is that the flow of energy is unidirectional whereas the flow of the nutrients are cyclic because the energy is eventually going to be lost after the death of the organisms at each level huge amount of energy is lost.

And finally after the death of this secondary or tertiary consumer all the energy, which is captured, is essentially lost most of it is lost. But the composite organisms they are trying to utilise those organic materials and particular the nutrients are returned back into the system. And those returned nutrients can be again assimilated by the autotrophic organisms but the energy cannot be captured wherever the decomposers are there decomposers are going to grow utilising those energy, but they are not going to help us to return the energy into the system.

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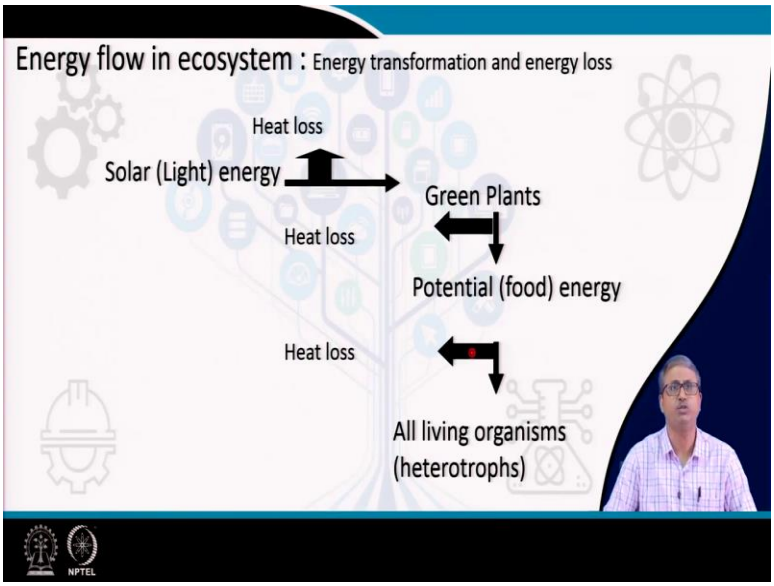

So, the energy flow basically depicts that that this particular slide depicts the loss of energy in each stage and at finally when it goes to the heterotrophic organisms, there the most of the

energy is eventually lost.

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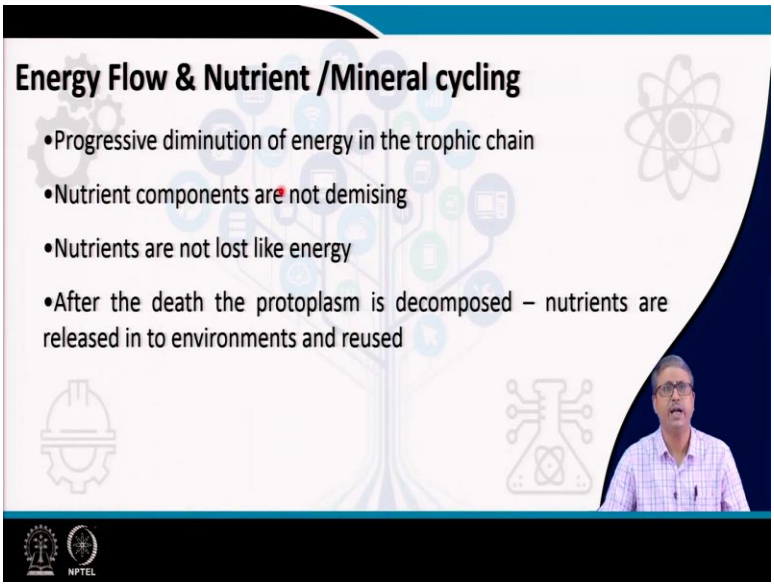

Now in a sense that the energy flow and nutrient mineral cycling, there is a progressive diminution of energy in the topic that you have understood that at each level some amount of energy is lost as heat energy. And also the oxidation of the materials which are processed at each step leads to some amount of energy wastage and eventually all the energy which is assimilated by the plants are lost.

The nutrient components on the contrary are not diminishing. Nutrients are not lost like energy and after the death of the Protoplasm which is decomposed and nutrients are released into the environment for their subsequent utilisation by the plant again.

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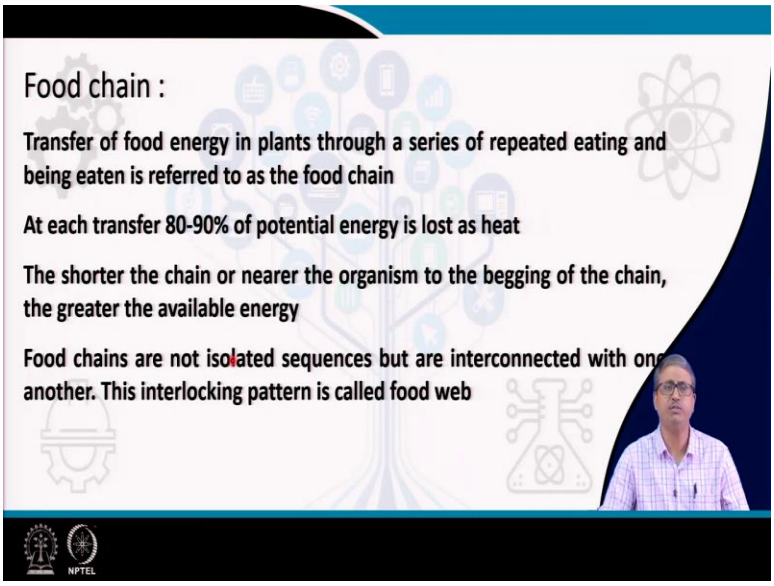

Now the food chain: Now the transfer of the food energy that is the energy which is gained by the autotroph the producer organism and subsequently transferred to the consumer organism that process is called the transfer of energy. So the transfer of food energy in plants through a series of repeated eating and being eaten because who is eating that is the herbivores that will be eaten by the carnivores. So through a series of repeated eating and being eaten is referred as a food chain.

So this transfer of energy food energy within the autotrophic organisms is eventually transfer to all the other members of the food chain. At each transfer 80 to 90% of the potential energy is lost as heat. Now eventually the shorter the chain or nearer the organism to the to the beginning of the chain the greater the available energy. Of course because the more the number of steps are there in between the transfer from the autotrophs to particular consumer more amount of energy is going to be lost.

Food chains are not isolated sequence interestingly but are interconnected with one another this interlocking pattern of food chain is called food web because there are multiple food chains expected in any kind of environment. And all this or many of these members like the consumers, primary consumer and the secondary consumers are often having different kind of their nutritional types.

So you can find out that a large number of food chains are operating in any kind of ecosystem particularly in a macro ecological context if you think of it. So it is going to be a food web.

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Now the trophic level: In complex natural community organisms whose food is obtained from plants by the same number of steps are said to be belong to the same trophic level. As I mentioned earlier the trophic word means nourishment. So, how the organisms are nourished? Are they all in the same level when they are acquiring the nutrients or they are being nourished? So, like the green plants their first trophic level because they producers.

They are converting the solar energy and they are reducing the carbon dioxide into the complex organic matter. So they are the producer organism. Whereas the herbivores are the primary consumers and all the herbivores represent the secondary trophic level. The organism to are categorized at the first card level of carnivore that is they are consuming or dependent on the herbivores. They are the secondary consumer and then the tertiary consumers who are the secondary carnivores or the second level of carnivores who are dependent on the first level carnivores that represent the fourth trophic level.

So, we have the first trophic levels which are the producers. Second trophic level, which are the primary consumers, the third trophic level the secondary consumer and the fourth trophic level is the tertiary consumer.

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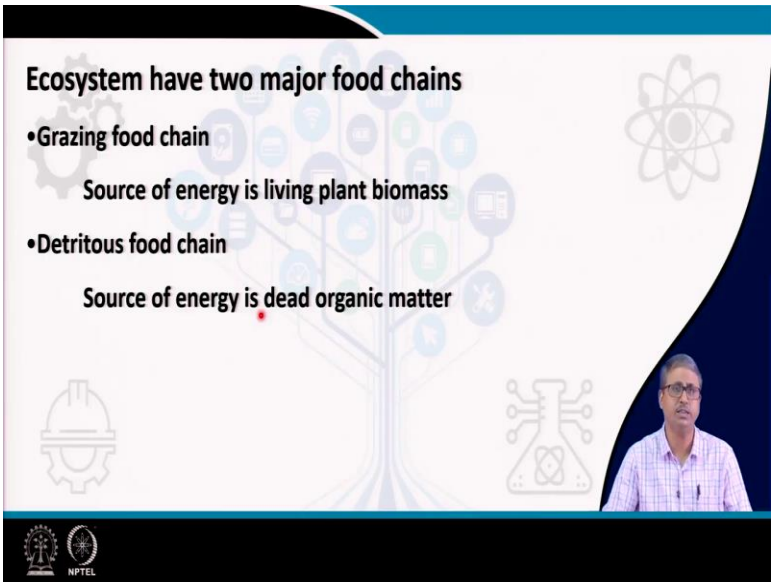

Now ecosystem also has two major types of food chains. One is the grazing food chain that is more prevalent where the green plants are producing the complex organic matter and the herbivores are dependent on them and the carnivores of different levels are represented the consumers who are all dependent or they are utilising the nutrients obtained from the plants to the herbivores.

The other one is the detriviores food chain: Where the source of energy is the dead organic matter. Basically all the detrivores and the decomposers they are responsible for the detrivores food chain where the solar light is no more the source of energy rather the source of energy is the organic matter rather the dead organic matter and these organic matter which is rich in organic carbon as well as different type of nutrients.

So essentially we can see that certain characteristic feature of the detrivores food chain are that the loss of energy is or rather the loss of nutrients are not there because in this case the nutrients are all recycled back or all they are provided into the environment and these organisms are mostly relying on the oxidation process of the organic matter rather than that reducing the carbon dioxide and utilising the solar light present in our atmosphere.

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So, for this part of this lecture I would recommend these references.

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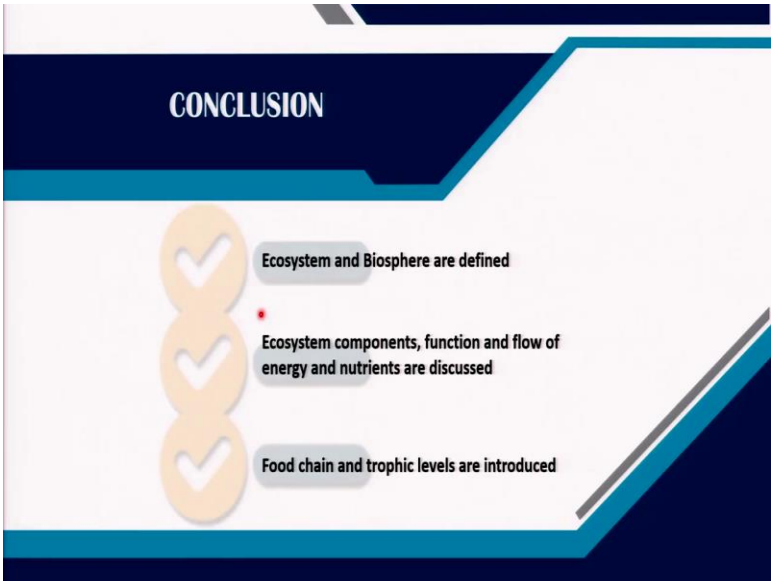

And the concluding remarks that the ecosystem and the biosphere are defined. The ecosystem components function and flow of energy and nutrients are discussed. Food chain and trophic levels are also introduced.