Wildlife Ecology
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Lecture –02
A Historical Overview of Ecology

[FL]. In today's lecture we will have a look at their Historical Overview of Ecology. Now any discipline of science goes through several stages in which its theories are formed those postulates that are not correct, they get overturned and we gather all new forms of knowledge and we try to put them into a framework. Now in this lecture we will have a look at how ecology has come up through the years, now in this particular lecture we will not only see who did what, but will also pay a tribute to all the founders of this particular subject.

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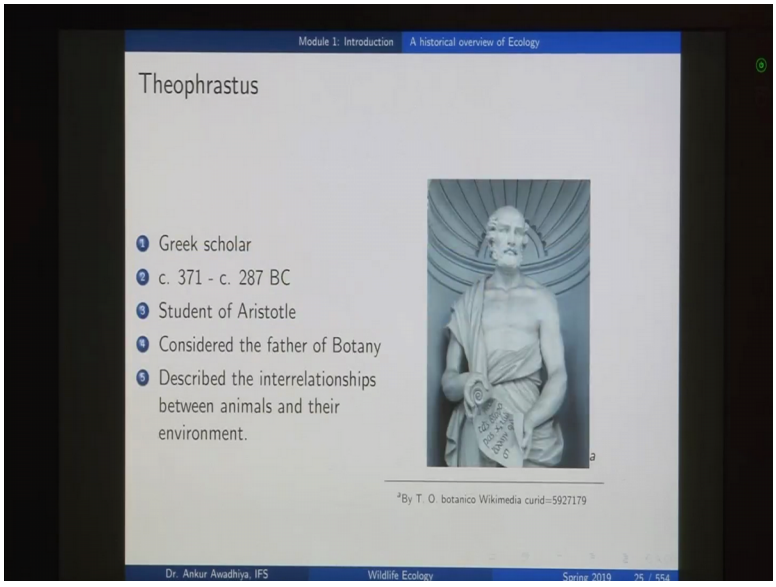

So, we begin with Theophrastus; now Theophrastus was a Greek scholar who lived from 371 BC to 287 BC. So, now, you can see that that our subject of ecology, its not just its not a new subject, it is as long as 23 and 2400 years old. Now Theophrastus was a student of Aristotle, he is considered the father of Botany and he described interrelationships between animals and their environments. Now a very basic tenet of ecology is that it tries to understand the distribution and abundance of different

organisms. So, in this case we asked this question that if you have a certain organism in a certain area why is it found in that area. So, first try to ask where are different organisms formed and then once you know that a certain organism is found in a particular area, you ask the question why is it found in that area.

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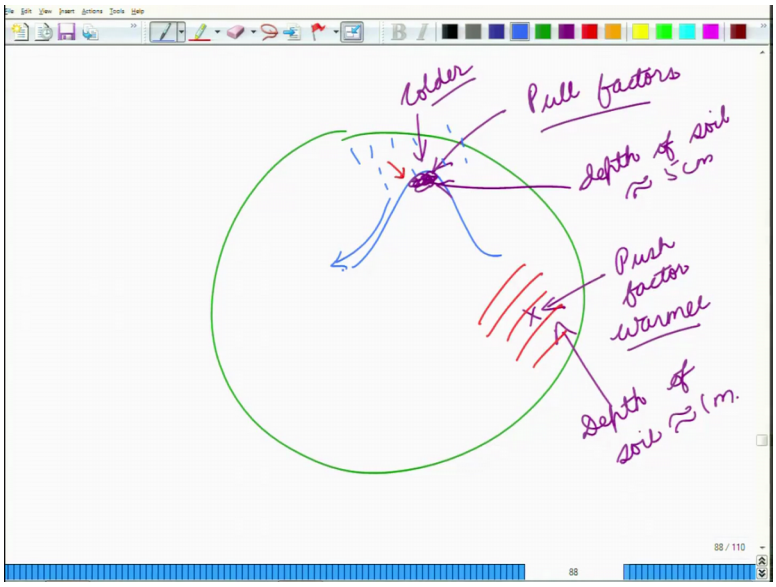

So, essentially for instance if you have this forest and in this forest you have saved some hills here and you have a certain species of plant that is growing in this area on the top of this particular hill.

So firstly, you will ask the question were are different species found in this forest? So, with that once you had you have documented things you find that this particular species resides on the top of this mountain. Next you asked the question why is it living in the top of that mountain, what are the conditions that it gets there that it is able to survive there? Probably this particular plant requires a very cold temperature which is not found in any other place and there is only found on the top of that particular mountain. So, we will call such factors as pull factors. So, these are the factors that are pulling this plant to this particular area.

And if we look at the other areas so, probably you will ask the question why is this plant not found here? So, probably you have a very high temperature in this area which becomes a push factor. Now while discerning the pull factors and the push factors you also understand the requirements of different organisms you also understand the

interactions that any organism has with members of its own species, with members of other species the kinds of interactions the organisms have with the environment. What are the levels of fluctuations in the environment that any organism is able to tolerate or not tolerate? So, all of these things when you study them together to understand the abundance and distribution of different organisms you are studying ecology. Now Theophrastus was one of the very first people who described the interrelationships between animals and their environment. So, which is why we say that, he was one of the very earliest ecologists.

Now, in those days we did not have a number of theories, we did not have scientific equipment, we did not have computers to take care of our data. So, how did people understand or how did people study ecology in those days, well most of it was seeing what is around you and documenting things.

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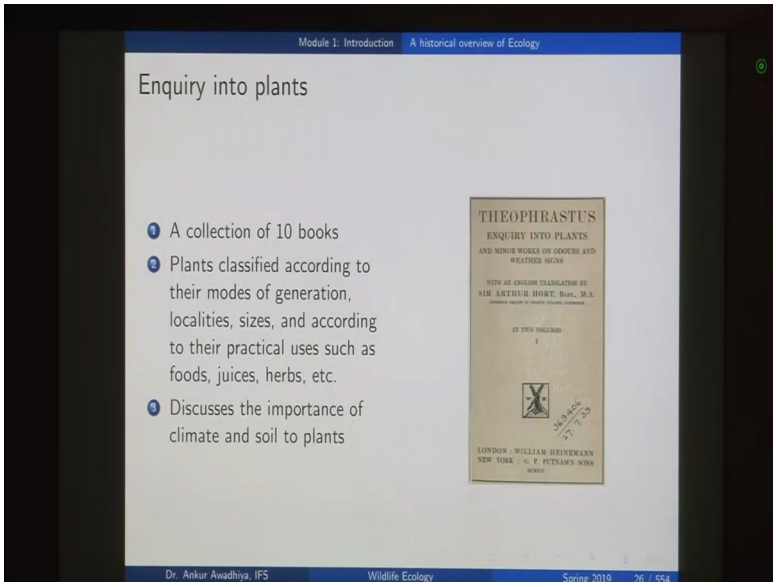

So, in the case of Theophrastus he came up with a collection of 10 books and in these books he classified plants according to their mood of generation whether they are coming out of seeds, whether they are coming out of birds, whether they are coming out from some other vegetative parts and so on.

He also classified plants on the basis of their localities what is found in which areas, he also classified plants on the basis of their sizes and he also classified plants on the basis of their practical uses such as food, juice, helps and so on. So, as you can see here he is

trying to gather information about as many plants as possible and he is then trying to classify these plants on the basis of their modes of generation, location, size, uses and so on. So, this is how ecology worked in the very early days, you tried to gather information you try to classify things. Then on the basis of these classifications he was able to discuss the importance of climate and soil to plants.

Now, here again when we are talking about this example of this plant that is living in this area we are talking about things like climate, because this area is colder, this area is warmer. So, even today when we are taking these concepts for granted Theophrastus was the first person to point out these points or differences in soil probably the soil cover in this area is very less. So, this has a say a depth of soil which is say around 5 centimeters, in this area you have a depth of soil which is safe around 1 meter.

Now, if you have a soil that is 1 meter deep. So, it can support a number of different plants, but the soil that is just 5 centimeters deep it will probably not serve the needs of a number of plants. So, because you have a very high density of plants that are found here so, your particular species is getting out competed. Whereas, in this area because other plants are not able to survive so, this plant is able to survive because, there is hardly any competition in this area or things like the amount of nutrients that are there in the soil. If you have a region that is on top of a mountain whenever there is a rain in this area so, the nutrients that are there in the soil along with the rain they get washed to the bottom areas.

So, typically we see that the soils in the mountains are not very nutrient rich and these are the factors that are governing the distribution and abundance of different organisms which is the science of ecology. And in this case Theophrastus was the first person to discuss these factors the importance of climate the importance of soils to different plants.

So, his book is known as Enquiry into Plants and Minor Works on Odours and Weather Signs. So, this is the first person who we are talking about, but then in the case of Theophrastus it was difficult to note all these different plants, it was difficult to classify these plants because, say even in the case of India, if I am talking in English I will say that this tree is a mango tree, but if I am talking in Hindi I will refer to it as [FL].

Now, if you have different names for any particular species it becomes difficult to communicate with other people. So, this was a problem that remained for a very long period of time.

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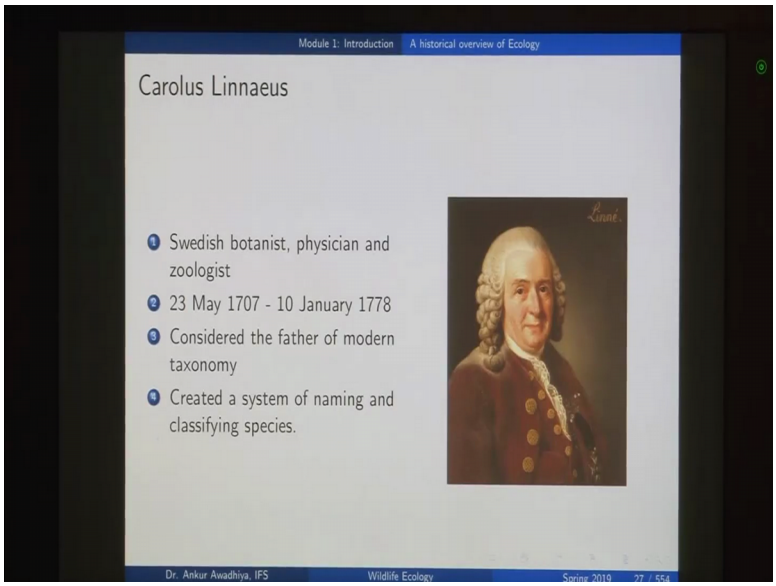

So, for instance in the case of Theophrastus in his book if he wrote the name of some particular plant and he was a Greek scholar and if this takes was taken to some other area say it was it was taken to Egypt and probably people in Egypt would be using some some very different terms. So, if you have different names for the same species in different areas you are not able to collate the information you are not able to collate it the information or the findings that are being taken up by different scholars. So, this problem was sorted out by the next fellow Welsh Carolus Linnaeus.

Now, from see around 300 BC we are now right we are jumping to the 18th century. So, that does not mean that we did not have any colleges in this period, but it is simply that because of want of time our list cannot be a very all encompassing list. And so, we are just picking on different people who in our opinion are great a very major ruling the science of ecology. Now Carolus Linnaeus or Carl von Linen he was a Swedish botanist, physician and zoologist.

Now here again you can see that there is one person who is a botanist, visa zoologist and he is also a doctor because, he is prescribing medicines he is a physician, because in those early days all these sciences had not matured enough in a way that we are seeing them now. So, now, even in the case of if there is a person who is studying botany, a person who is a botanist he has got so many things to study because there is.

So, vast amount of information that probably the people are able to devote very less amount of time to other fields, but in these early days we had people who had a grip on a number of subjects and so, in most cases we refer to them as naturalist.

So, a naturalist is a person who is studying nature, a person who is knowing about nature and a person who is observing nature, now that nature can be in the form of plants, it can be in the form of animals, it can be in the form of rocks or soil or anything. So, in these early people you will see that they had a command over a number of topics and they played a very important role in the development of a number of different fields of science. Now he left from 23 May 1707 to 10th of January 1778.

And he is called the father of modern tech taxonomy, now taxonomy is a process or it is a science in which you name different taxa. So, if you are seeing a plant if there is this mango tree somewhere what is the name that you give to this mango dream and what is the family to which this mango tree belongs. So, essentially in the case of our biological world we say that we have different kinds of taxa.

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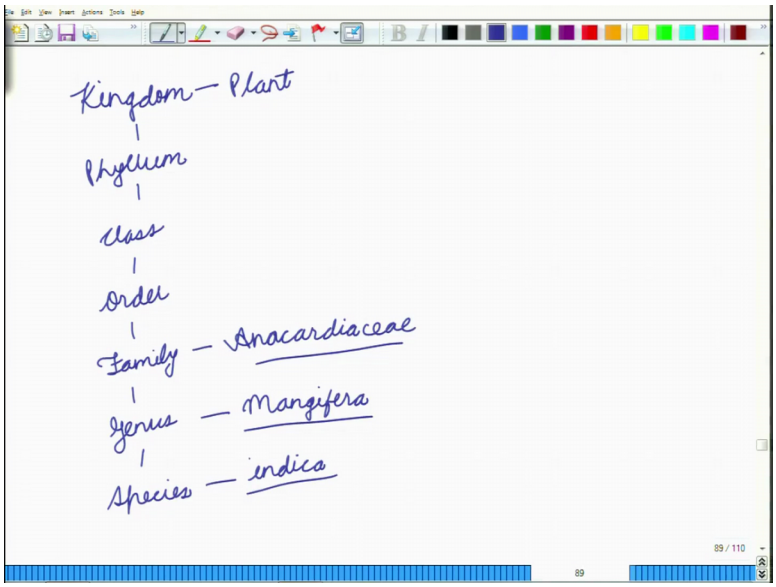

We start with kingdom. So, for instance a mango tree belongs to the plant kingdom, it is a plant it is not an animal. So, we have this hierarchy kingdom, phylum, class, order, family, genus and species.

Now in the case of mango he said that mango will be written as mangifera indica where mangifera is the genus indica is the species and it belongs to a family that is known as the Anacardiaceae family, now what he is doing here is that he is using these Latin words for different things.

So, in place of calling it a mango because different languages that are in used today they can change with time. So, for instance in the case of Hindi it could have chains from [FL] to [FL] and probably in some other places in India people would in place of calling it arm they would call it [FL]. So, in different dialects in different languages the names change and more so, if you are using a language that is currently in existence.

So, he made use of all these Latin terminologies and he developed this science of taxonomy which is a science of naming different species in different taxa and he is also called the father of systematics because, after naming all these different species you were able to classify different species. So, naming of different species naming of different taxa and classifying of all these taxa is the contribution of Carolus Linnaeus.

Now in the case of classification this also has a number of other consequences because once you have classified a particular species and if you find some other organism or some other species that is having very close connection, it looks similar probably it has similar attributes then probably you will put them together in the same genus similarly the organisms that are close together in the same genus they will be put in the same family.

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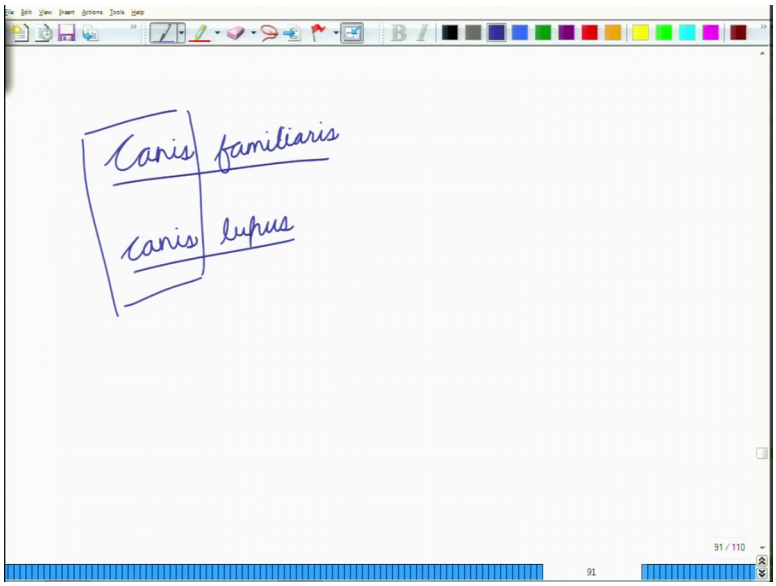

Now, for instance if we have an example, in the case of a dog we call it a Canis familiaris. So, it belongs to the Canis genus and the species is familiaris in the case of a wolf you call it Canis lupus. Now both of these belong to the same genera, which is Canis, now in this case it also tells you that those organisms that are placed together they probably evolved from a same common end system because of which they are having very common properties.

Now if we look at systematics we can discern a number of ideas about evolution and similarly evolution has been able to refine systematics and taxonomy over the ages. So, this is the contribution of Carolus Linnaeus once you were able to name each and every species. And each and every taxa once you were able to classify things together then you could observe patterns amongst different organisms amongst different taxa.

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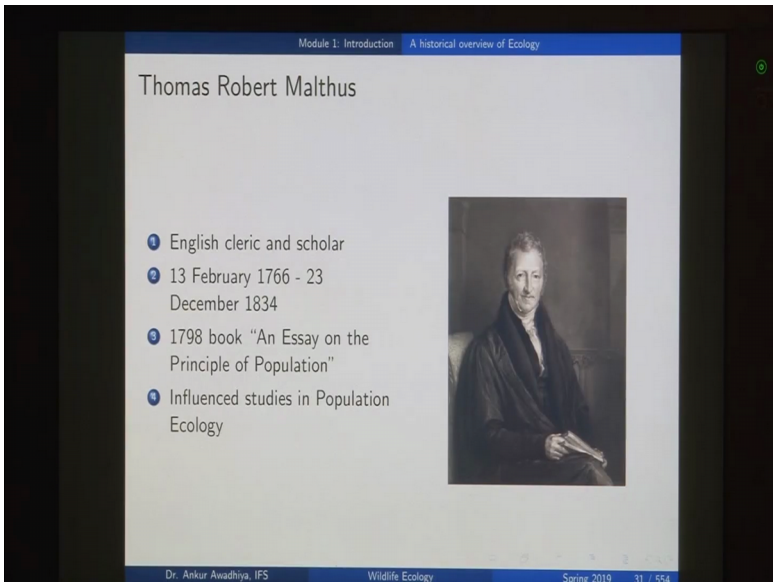

Next we will have a look at Thomas Robert Malthus and we will devote one complete lecture to what he said. So, he was an English cleric and a scholar, who lived from 13th February 1766 to 23 of December 1834 and in 1798 he wrote a book 'An Essay on the Principle of Population' and this person by writing this book has influenced a number of studies in population ecology.

Now put to put his ideas simply he said that if you consider any population so, it grows by a geometric progression. So, basically from two individuals you let us say you become four individuals from four to you become 8 8 to 16 16 to 32. So, essentially you are doubling at every point of time. So, let us say that if you have a population that was say 1000.

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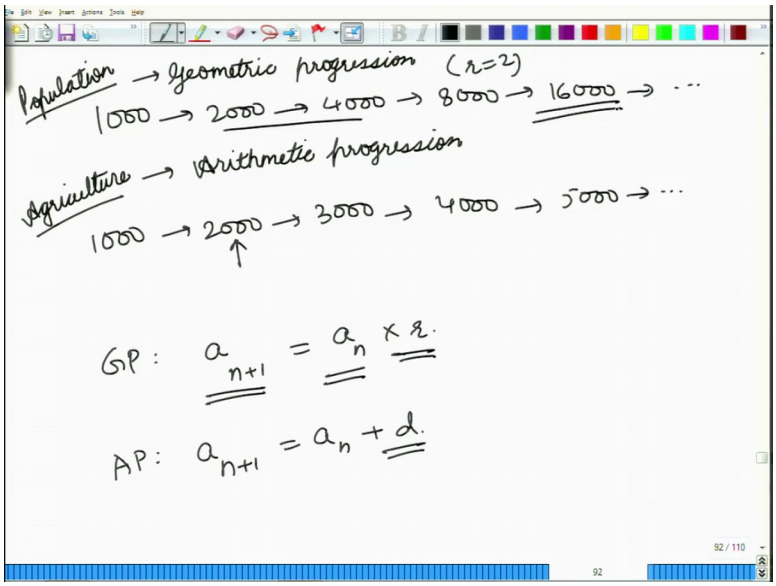

So, from 1000 from 2000 from 2000 it becomes 4000 then it becomes 8000 then it becomes 16000 and so on now that is about the population. And in this case we are talking about the population of human beings, but then if you look at the resources in terms of say agriculture. So, probably when you had 1000 bush 1000 population you probably had 1000 bushels of wheat that were being grown. Now agriculture grows via arithmetic progression in which case in the time it became from 1000 people to 2000 people it grew from 1000 to 2000 bushels of wheat.

Now, when this population was able to grow from 2000 to 4000 this was a geometric progression. Now in the case of a geometric progression you have this situation that a n plus 1 is given by a n multiplied by a factor of r. So, which means that you can get to the next term of the geometric progression by taking the previous term and multiplying it with a common factor, in this case we are taking r is equal to 2. So, from 1000 into 2 is 2000 into 2 is 4000 into 2 is 8000 and so on.

In the case of an arithmetic progression you say that a n plus 1 is equal to a n plus a common difference which is d. So, you add something that is common. So, in 1000 if you add 1000 you get 2000, but then this d remains constant. So, then to your 2000 you add 1000 you get 3000, then you get 4000 then you get 5000 and then so on. Now it is very easy to observe here that in a very short period of time the population would have grown to such a large extent that the agriculture will not be able to compensate for that

particular for that amount of growth. So, essentially your population will grow much faster than agriculture will grow.

So, you will have a dearth of resources and once you have a dearth of resources there will be intense amount of competition and probably some individuals in the population will have to die. So, he talked about preventive measures and he also talked about positive measures through which you can keep your population in check, now these were the very early ideas that influenced a lot of thinking of population ecology.

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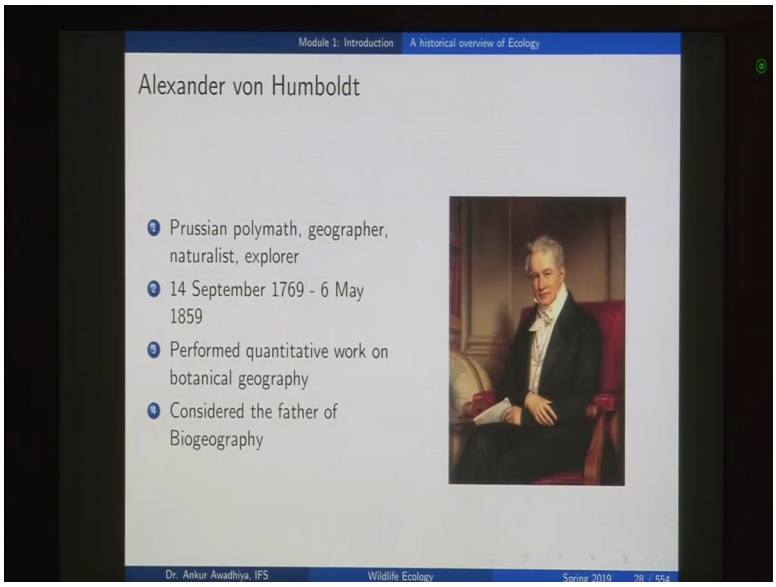

So, he was also a person who played a very important role in a sub discipline of ecology which is population ecology. Now the next person will consider is a Alexander von Humboldt, he was a Prussian fellow now Prussian is a person who is who belongs to the erstwhile empire of pressure, which is now Germany. So, he was essentially a German person.

So, this guy was a polymath, he was a geographer, he was a naturalist, he was an explorer, again we are seeing that he had a command over a number of languages and a number of fields. And he lived from 14th of September 1769 to 6th of May 1859 and he performed quantitative work on barnacle geography and he is considered the father of biogeography. Now this guy was in explorer so, he took a contract from the Spanish empire and then he went to South America, in South America he went to Peru him into Venezuela he went to Cuba and a number of other places.

And when he went to all these areas he kept a lookout for what different organisms are found in what different areas. So, in this case you see that there are certain organisms that are found in the lower slopes of a mountain.

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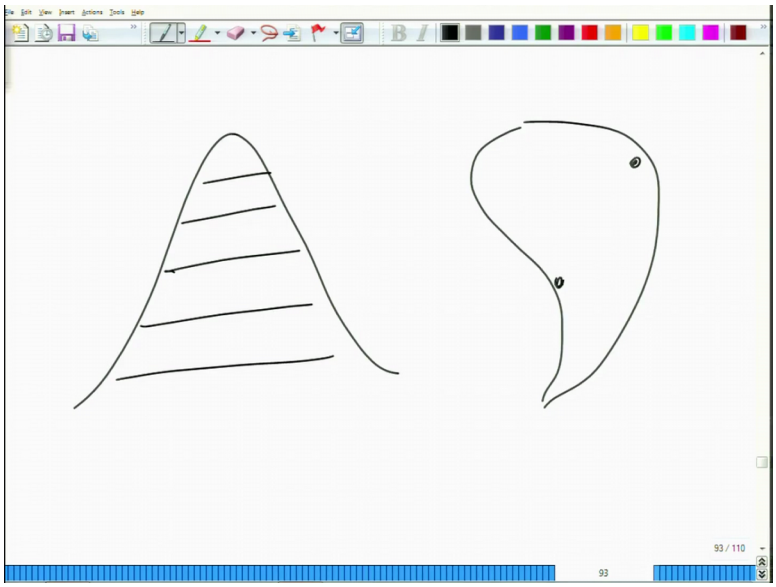

So, there are certain organisms that are found here certain others that are found here certain others that are found here and so on or probably in the South American continent you had certain organisms that were say found in this area there were certain organisms that were found in this other area. So, essentially he studied the distribution of different organisms and heap of he looked at it in a quantitative manner. So, he put everything down to numbers and he is considered the father of this field of biogeography.

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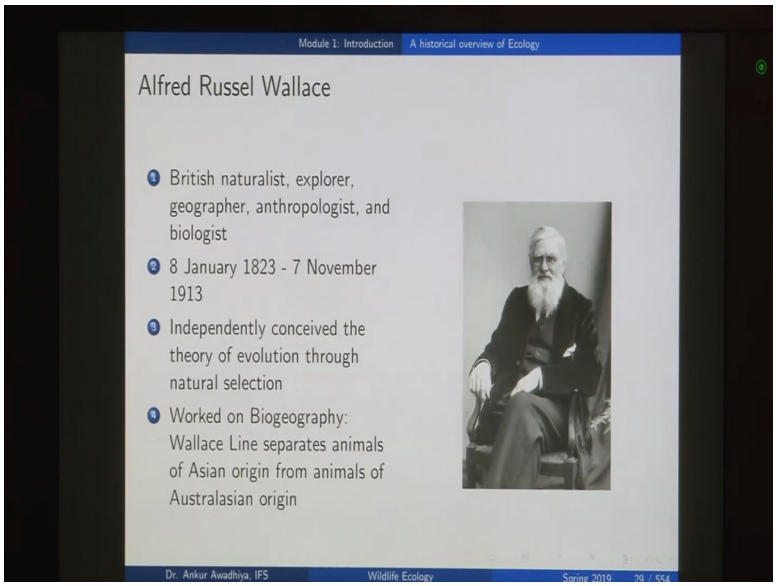

Next we will have a look at Alfred Russel Wallace, now he was a British naturalist an explorer, a geographer and anthropologist and a biologist who lived from 1823 to 1913 and his contributions were that he independently conceived the theory of evolution through natural selection and also worked on biogeography. So, Wallace line separates animals of Asian origin from animals of Australasian origin his main contribution was about the theory of evolution. Now we generally attribute the theory of evolution also to another fellow which is Charles Darwin.

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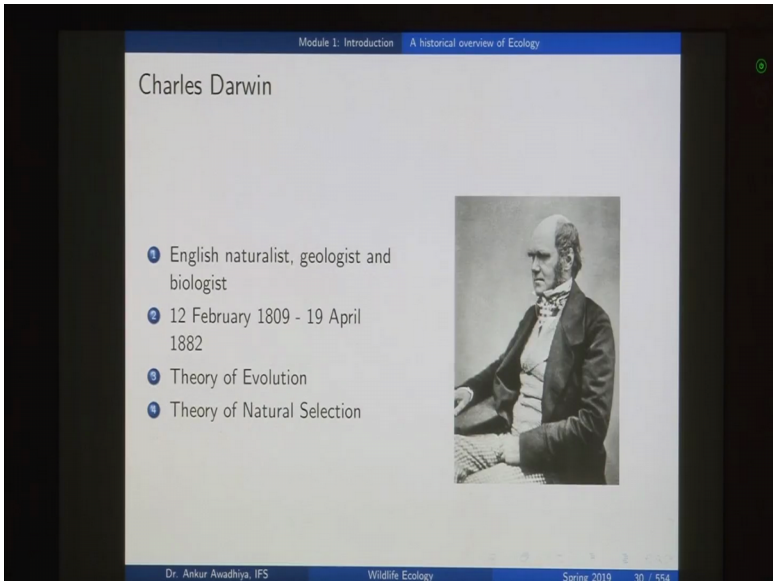

Charles Darwin was an English naturalist, geologist and biologist he lived from 1809 to 1882 it is he is famous for the theory of evolution and the theory of natural selection.

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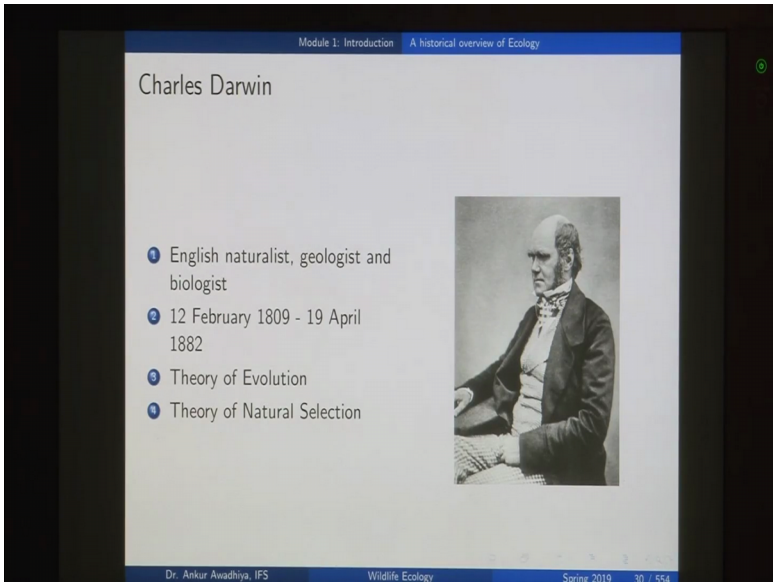

So, essentially this was a contribution of both of these fellows Charles Darwin and Alfred Russel Wallace.

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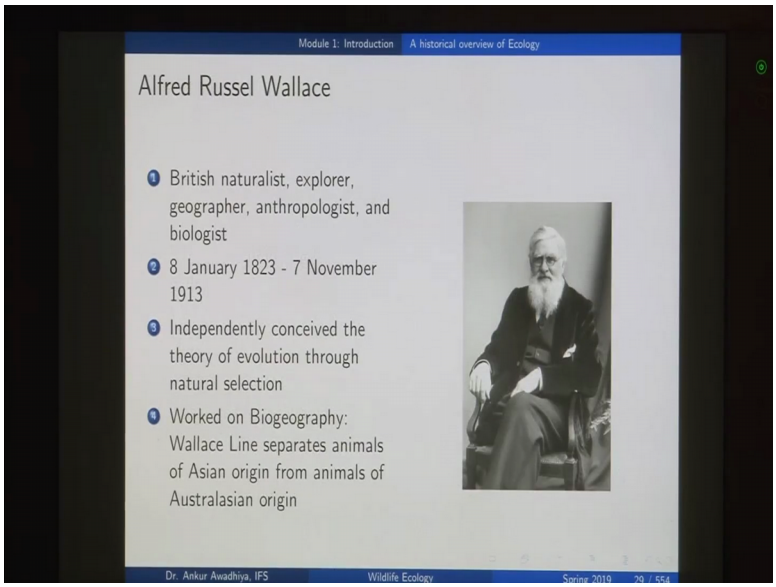

Now, what do you mean by evolution?

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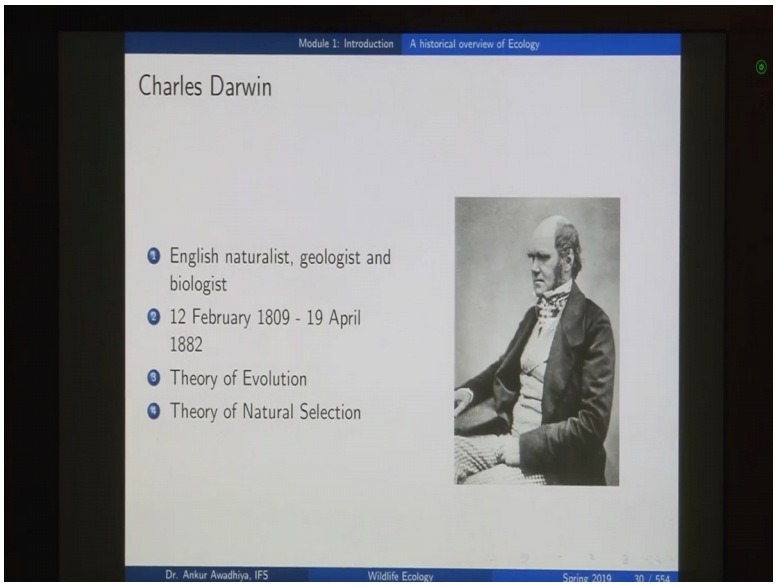

Evolution refers to changes that happen with time in different species they may lead to differences that prop up in a species and they may also lead to the formation of a new species. So, you can understand evolution very easily if you look at the sub steps of evolution.

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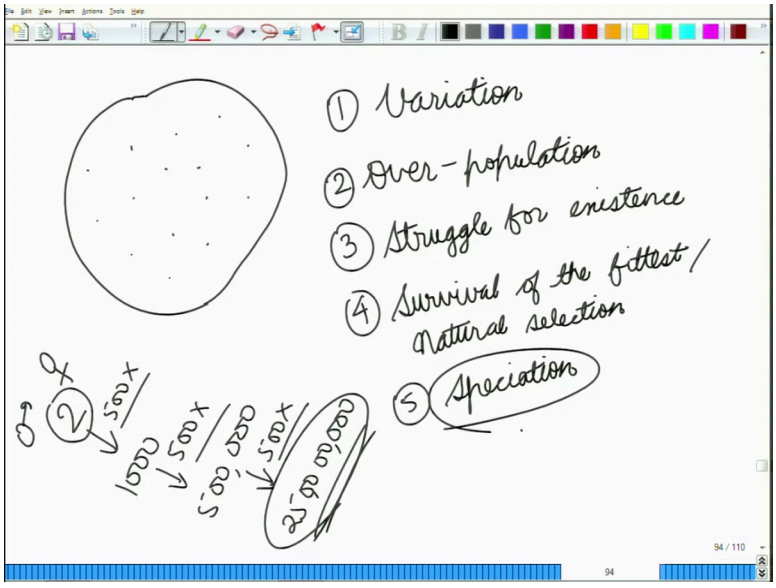

So, if you consider any population. So, let us consider the population of human beings. So, in the population of human beings you will have different individuals who have different characteristics.

So, there will be somebody who is tall there will be somebody who is short, there is somebody whose dark, somebody whose fair, there will be somebody with a black hair, somebody with a brown hair, somebody with black colored eyes, somebody with a blue colored eyes. So, you see n number of variations and these variations are not only in the external traits, but these variations are also found in a number of internal traits such as metabolic processes, there are some people who can drink milk very easily there are some other people who have a lactose intolerance.

So, we have variations in a number of these different traits and similar to human beings we have variations in all different species. So, if you take any species and if you consider the individuals of that species every individual will have some differences from the other individuals maybe less so, in the case of homozygote ik twins, but more so, in the case of people who are theses relatives or maybe not related to each other. Now if you have these variations now what can be these variations?

Let us say in the case of mosquitoes. So, you spray your insecticides on a population of mosquitoes there will be some mosquitoes that will die off preferentially because they are completely not able to tolerate at the insecticide, but then there will be some individuals that will be able to tolerate the insecticide and they live, all there will be some mosquitoes that fly very fast or there will be some mosquitoes that are.

So, in flying now those mosquitoes that are flying very fast are probably using immense amount of energy and those mosquitoes that are. So, are probably using less amount of energy, but then you will find variations everywhere. So, the first tenet in evolution is variation. So, every species handles has individuals and every individual is different from every other individual.

So, there are some variations that are there in different populations, but then the second tenet is about overpopulation. Now in this case what we are saying is that every species the organisms of every species have this innate ability to produce n number of springs, may be much greater than what the nature can sustain. So, for instance if you look at a single female mosquito it may lay as many as 500 to 1000 eggs.

So, from 2 mosquitoes that are there in the parental generation. So, you have a male mosquito and a female mosquito and then you have 1000 individuals in the next population, in the next generation. So, from 2 to 1000 you have a 500 times excess, now

if this thing continues for a while in the next generation you again have a 500 times xs and you have 500000 individuals.

And then in the next generation you again multiply it by 500 and you have 250 million individuals. Now what is happening in this case is that if you have two individuals and suppose nature can support for say 100 individuals or say let us let us say that nature them suppose and support for 1000 individuals, but then you can see that in just first generation second generation third generation you have exceeded the capacity of nature by a very huge amount. So, every species has got this trait that it can over populate even in the case of human beings people can produce as many as say 6 or 10 offspring's. So, in just one generation you can increase your population by as much as 5 fold 6 fold 7 fold.

And then in a few generations you will have so many human beings that you do not have ample resources for them. So, which brings us to the 3rd point which is your struggle for existence, now in the case of these mosquitoes you have these 250 million mosquitoes and the nature can provide for say 1000 mosquitoes so, what will happen? At every stage there will be some number of individuals that will die off because those individuals that are better able to get food, that are better able to find a mate, that are better able to say fend off from the predators they will survive and the others they will either die of starvation or maybe they would not find a mate.

So, they are not able to pass on their traits to the next generation or maybe they are killed off by the predators and so on. So, there is a constant struggle for existence if you see the nature

And because of this struggle for existence the 4th step is that of the survival of the fittest or the process of natural selection. So, just because there is a huge struggle for existence you have less amount of resources more number of individuals. So, there will be some individuals that will be lost and when you have these processes that are going on for a very long period of time, then you will have certain plates that will preferentially start showing up in this particular population. And probably this would even lead to something that we call as speciation in which the population becomes so; different from the previous generations that it now, becomes a new species in itself.

So, that is the contribution of Charles Darwin and Alfred Russel Wallace. So, once you have this idea. So, in the case of Carolus Linnaeus he talked about different individuals different organisms he was able to classify these organisms, but then Charles Darwin and Wallace were able to show how these new organisms get formed how these different these different classes how these different genera they get formed. So, this was a very big contribution because it was able to collect all the information that had been given off on given out by the previous generations.

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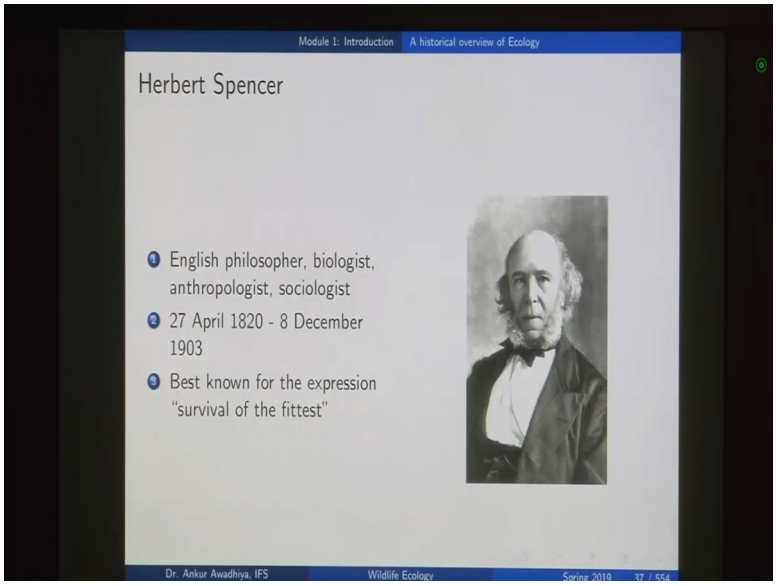

Next we will have a look at Herbert Spencer, he was an English philosopher, biologist, anthropologist and a sociologist who lived from 1820 to 1903 and he actually gave this term survival of the fittest. So, he also worked on the ideas of evolution.

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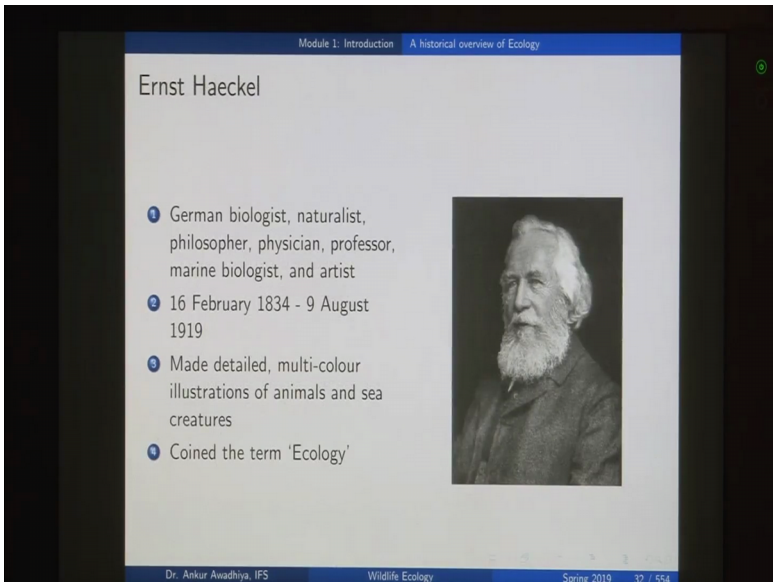

Next we will have a look at Ernest; Ernst Haeckel, now Ernst Haeckel was a German biologist, naturalist, philosopher, physician, professor, marine biologists an artist who lived from 1834 to 1919, he made detailed multicolored illustrations of animals and sea creatures. So, here we can see that our request with naming different things, classifying different things has continued even till the 20th century because, Ernst Haeckel was also involved in making a collection of what different organisms are how do they look and so on and he also talked coined the term ecology.

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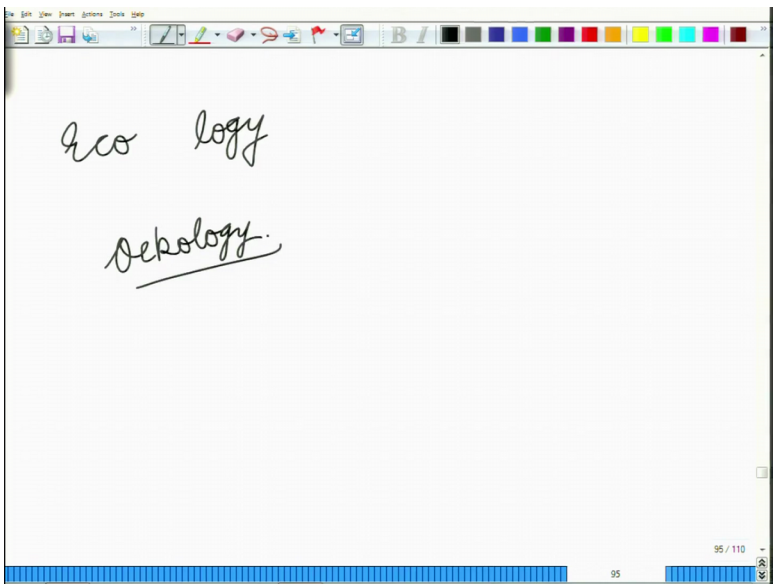

So, ecology in this case eco is home logo's is steady so, it is the study of the home. And in the case of unshackle he actually called it as Oecology. So, this was the person who was who played an important role not only in making all these different illustrations which then also guided the succeeding generations, but he also coined the term ecology.

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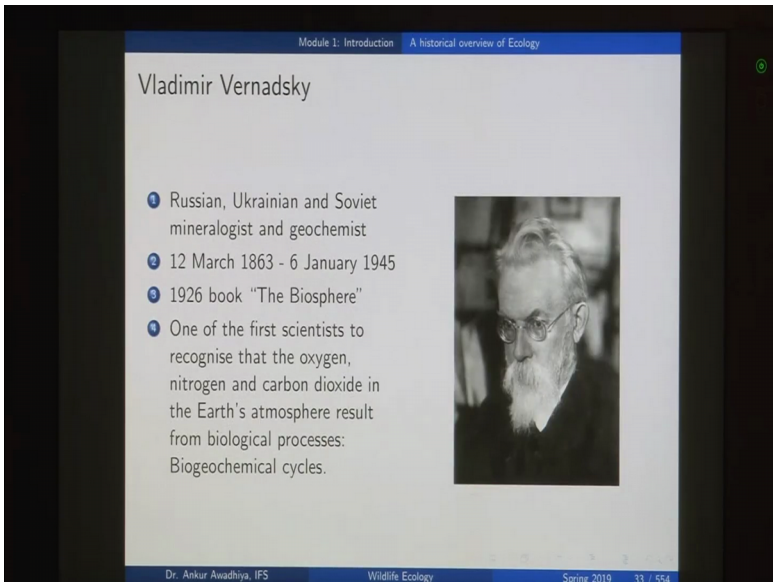

Next we locate Vladimir Vernadsky, now Vladimir was a Russian scholar, he was he belonged to Ukrainian or autocrine and he was a mineral eulogist and a geochemist. Now here we can see that that this is a fellow who is not very much related to biology, but then because of his command over minerals and over geochemistry he was able to give vital inputs to the science of ecology. He lived from 1833 to 1945 and in 1926 he wrote the book the Biosphere, now biosphere refers to that portion of the earth that is able to serve to support life.

So, on the earth we talk about lithosphere. So, lithosphere is the rocky portion we talk about atmosphere which is the air that is surrounding us we talk about the hydrosphere which is all the water bodies that we have together and there is life on land there is life in the air there is life in the water bodies. So, a combination of all of these that the supporting life is called the biosphere, now Latimer also played an important role in being the one of the first scientists to recognize that oxygen, nitrogen and carbon dioxide in the earth's atmosphere result from biological processes.

And he also gave rise to the biogeochemical cycles, now what do we mean by biogeochemical cycles? If you consider any organism if you consider yourself so, you are taking in a number of nutrients. So, you are taking carbohydrates, proteins, fats different mineral salts and so on, now how are you getting all of these you are getting it from your food whether you are on a vegetarian or a non vegetarian we are consumers we are not able to produce our own food, we are not able to perform photosynthesis.

So, we get it from something else, now that something else can be a plant if you are a vegetarian or that can be an animal if you are a non vegetarian. Now, where does that any will get its food from? Ultimately it will get its food from a plant source. So, plants are ultimately supporting the whole of the biosphere.

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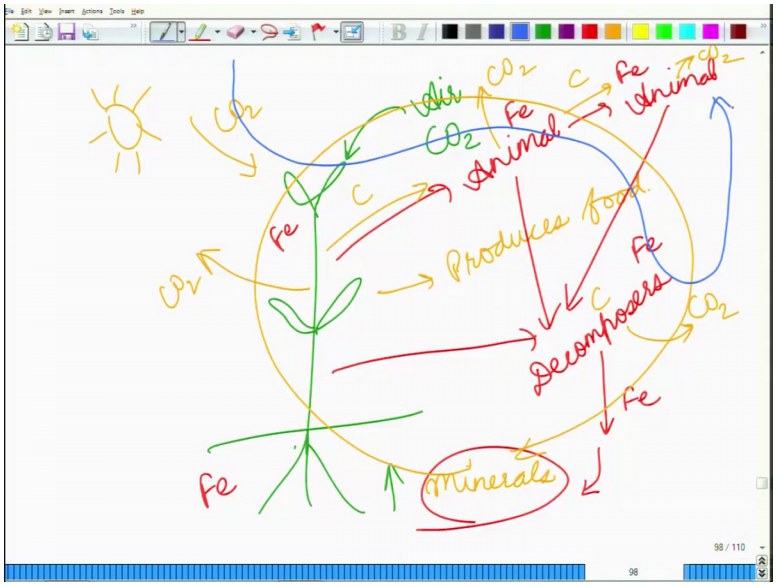

Now if you consider any plant so, the plant by lettuce is growing it requires water. So, it draws up water from the soil through its roots, it requires air especially it requires carbon dioxide which it takes from the air, it requires energy from the sunlight and it also requires a number of minerals that it gets from the soil when they are dissolved in water. So, through the process of transpiration this water is taken up from the soil and then it is released into that atmosphere with the water, it takes up the mineral salts, it takes carbon dioxide from the air, it takes energy from the sunlight and then it produces the food.

Now, this food is in the form of carbohydrates, proteins or fats which are then stored in its body and then from this plant when a herbivore eats it. So, it gets into the animal

kingdom then from one animal it moves to another animal and then so on till till it reaches the top predator or the apex predator. Now when a plant dies when an animal dies or any of these animals die or when they are giving out some base products say the animal is not giving out feces or the plant is shedding its leaves. So, all of these will be then acted upon by the decomposers.

So, the minerals that were taken up by the plant. So, let us consider any one metal let us say the plant took up iron, now this iron when the animal ate this plant the handle got the iron from this animal it moved to another animal and so on. And when the plant died or the animal died or with their waste products the decomposers got this iron and then they were able to break down these organic molecules. So, that the island got released into the environment and it was again able to reach the mineral pool that is there in the soil.

So, in this way we can see that there is a continuous cycle that is going on from the minerals that are there in the soil they are taken up through all of the biosphere and then they are released back into the soil. Now similarly if we look at another when another element such as carbon now carbon is a component of carbohydrates, its therein proteins, which there in fat so, its there in most of the organic molecules that we have.

Now, where do the plants get carbon from they take it from the air in the form of carbon dioxide then they make food from there when the animals eat it the animals are getting the carbon from one animal its moving to another animal which are again getting carbon, all of these organisms are releasing carbon dioxide through the process of respiration. So, if there is any animal it is responding it is releasing a carbon dioxide and when this and organisms die or when they shed their parts or will they release feces all of these come to the decomposers so these decomposes are also getting carbon and then these decomposes break down this carbon into carbon dioxide and release it into the atmosphere.

So, here we are seeing another cycle which is moving from the atmosphere through the plants through animals and then back into the atmosphere. So, these processes are known as biogeochemical cycles because, they are involving biological beings the living beings in the form of plants and animals they are also involving in the earth. So, which is why you have the geo component and these are chemical cycles because you are seeing a movement of chemicals through all of these.

So, Vladimir Vernadsky was the first person was able to recognize that oxygen, nitrogen, carbon dioxide, everything in the earth all these chemicals that are there in the earth they are resulting from biological processes and they are a part of bio geochemical cycles which was a big contribution.

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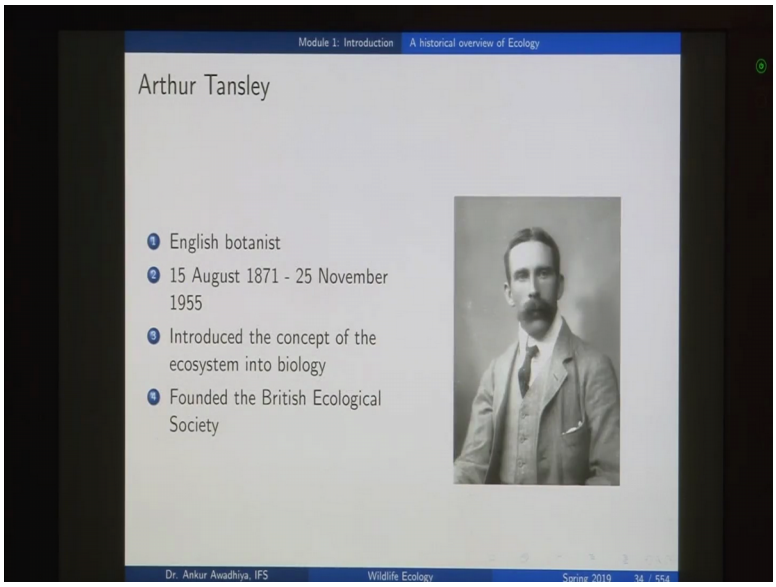

Next we have a look at Arthur Tansley, Arthur Tansley was an English botanist he lived from 1871 to 1955 and he introduced the concept of ecosystem into biology. So, till this peak point of time we were only talking about different species. So, we were talking about see a plant species or an animal species or we were these groups of organisms, now ecosystem is a combination of different communities together with the a biotic components that are there in the surroundings. So, essentially if we talk about say a lake.

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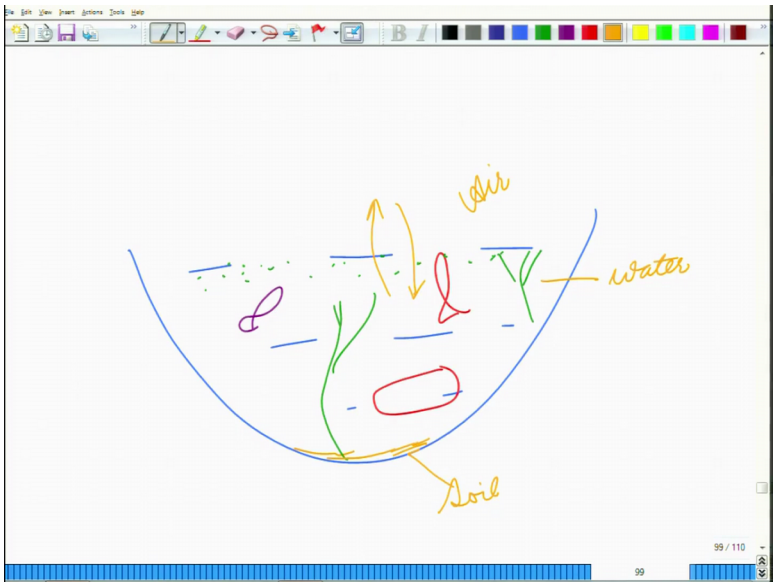

So, in this lake you have different organisms you may be having some fishes that are there in this water, you may be having some plants that are growing in the water, you may be having some planktons or some algae that are growing in this water, maybe some other animals that live in this water say a frog.

And you also have a number of a biotic components, what are those a biotic components? Consider the air, if you do not have air then oxygen will not get dissolved into the water carbon dioxide will not be released and ultimately all these life forms will die off. So, you require air for the survival of all of these, you require water for the survival of all of these organisms you require this soil that is then in the bottom. So, all the biotic components together with the a biotic components they form the ecosystem and whence you study the ecosystems you get very different properties from what you can get from a study of only the biotic components.

Now Tansley is very important because, he introduced this concept of ecosystem into biology. So, the biologists do not have to study just the living forms, but they also have to study the nonliving portions the a biotic components and he also played a big role in consolidation of the science of ecology by founding the British ecological society. So, that was one of the very first societies that were formed for the promotion of ecology.

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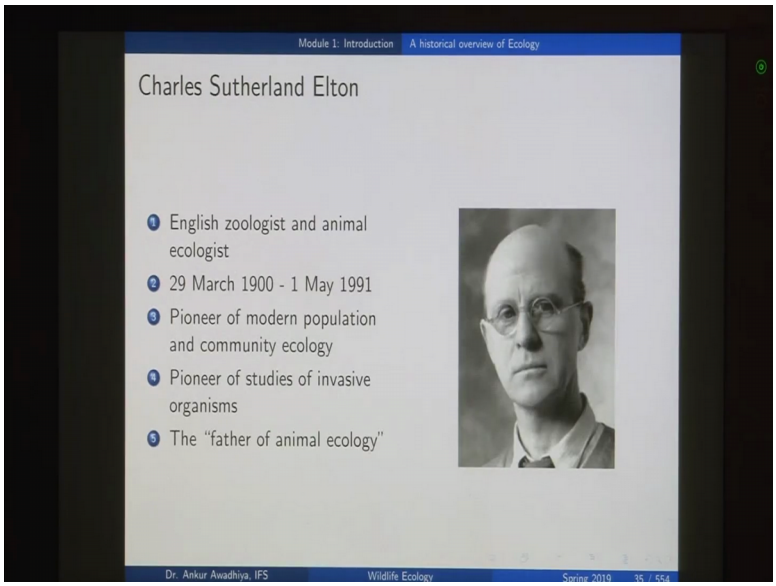

Next we will have a look at Charles Sutherland Elton, he was an English zoologist and animal ecologist, he lived from 1900 to 1991, he was a pioneer of modern population and community ecology and a pioneer of the study of invasive organisms and he is also known as the father of animal ecology. Now what do you mean by a father of population ecology? Now when we say population ecology a population is a group of animals that belong to the same species that I live in together in one area. So, let us say consider all the monkeys that are living in a forest.

So, they are forming a population, now what are the interactions between the members of a population how does the population size grow or reduce do, these members cooperate with each other or do they fight with each other. So, is there competition or is there cooperation when do we have a competition, when do we have a cooperation, all these things are studied in population ecology. When we talk about community ecology a community is a group of different populations so, when we are talking about a population. So, a population has only one species a community has several species.

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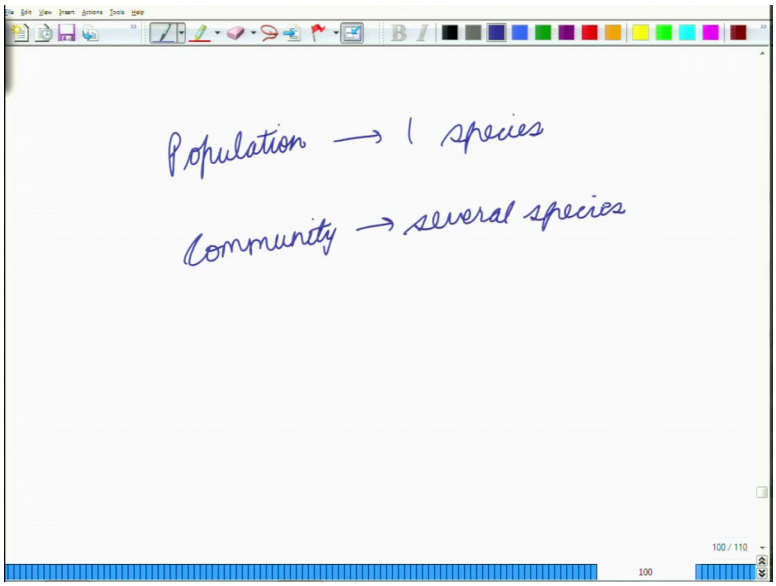

So, when we are talking about community ecology we asked the question how do these different populations are the members of different populations which belong to different species how do they interact with each other. So, for instance we might ask the question what are the relationships of predation in this area? So, in this forest there are monkeys and probably there are some mosquitoes what is the relationship between the monkeys?

And the mosquitoes probably you can ask the question what is the relationship between a monkey and a plant? There is a mango tree that is growing in the forest as the monkey helping the mango tree or is it destroying the mango tree because we may see on the first glance that the monkey is eating up the mangoes and so, the monkey is harming the plant,

But on the other hand will find that by this process of eating of the mango fruit the monkey is also transporting the seeds of the mango tree to other areas. So, it is playing the big role for the mango tree if it were not for the monkeys the all the all these mango fruits would just drop down below the tree.

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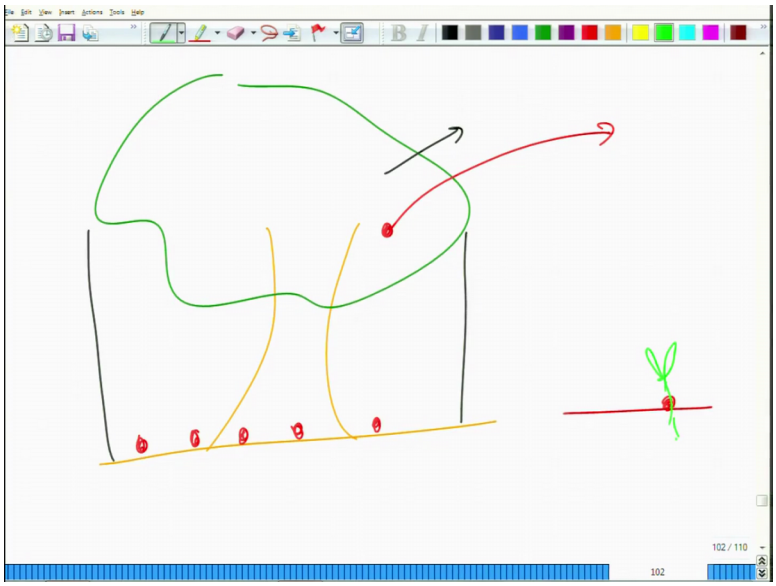

And once you have a situation where you have a tree and all the fruits are coming down here only. So, in this case the seedlings that come out the seedlings that germinate they will not have access to enough resources because this plant is taking up all of the sunlight. So, probably all this area is dark, it does not have sufficient light for these seedlings to grow or probably because this tree has a very large network of roots.

So, these seedlings will not be able to compete for water or for minerals. So, because you have monkeys in this system so, they are taking this fruit and they are throwing it somewhere else. So, probably you have a fruit that is thrown here. So, from this seed you will get a mango plant that is coming up in this region. So, a monkey's playing a very big role for the for the mango tree.

And such kinds of interactions are studied in the field of community ecology and Elton happened to be one of the very first people who studied these topics the differences between population ecology and community ecology. He was also one of the pioneers of the study of invasive organisms, now what is an invasive organism? An invasive organism is an organism which if it enters into a system is able to out compete everything else or a number of other native species consider lantana. So, lantana is a shrub like species that is some woody species that is formed and it is not native to India it comes from Africa, but then it is now invading into all of our forests.

So, what it does is that, it has a it has a number of flowers it produces a very large amount of fruits, those fruits are sweet it produces very small sides seeds and those seeds are very hardy. So, those seeds are able to tolerate a very wide range of conditions. So, you will have birds that feed on these fruits they have these seeds they gulp it down into their intestines into their stomachs and intestines and after these seeds have come out they will after these seeds have been eaten they will come out along with the bird droppings.

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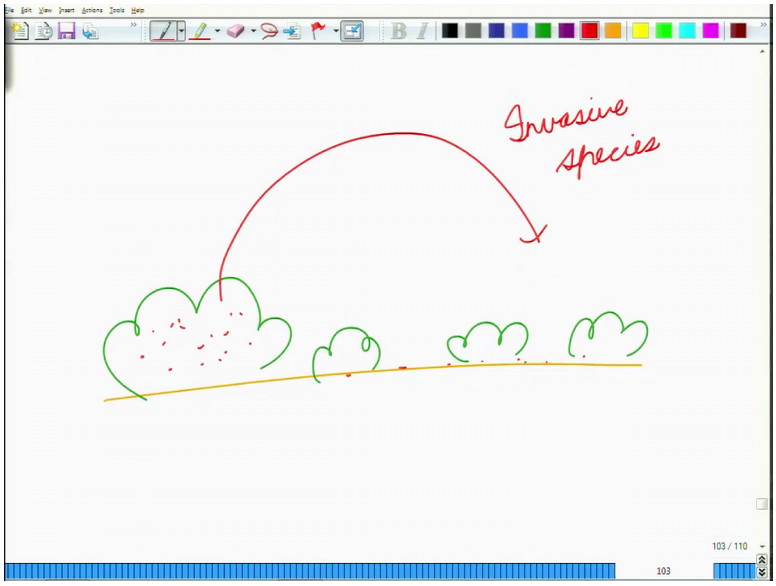

So, if you have a forest and you have see a patch of lantana here, you have n number of fruits and seeds you have you will have a bird that will transport these seeds and because these seeds are very hardy they will then start growing up in a number of other areas. So, you will start having these small lantana patches everywhere.

And lantana is so, good at getting nutrients from the environment that it is able to out compete most of the native species. So, you will have a forest that after a while will be full of lanthanum, now such species are known as invasive species and Elton was one of the first people who studied these invasive organisms he is he is the pioneer of the study of invasive organisms.

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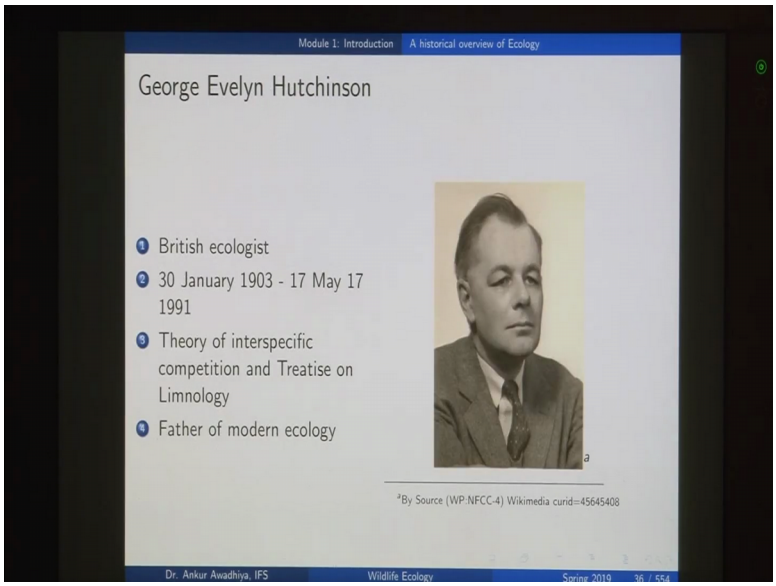

Next we will look at George Evelyn Hutchinson, he was a British ecologist who lived from 1903 to 1191 and he gave this the theory of interspecific competition and also wrote a treatise on limnology.

Now limnology is the study of lakes now in the case of a lake ecosystem what is happening is what you will be studying in the case of limnology he is called the father of modern ecology. And he wrote a lot on interspecific competition, now interspecific competition is when an organism of one species is competing against an organism of another species. So, for instance in a forest you have kittles which are deer species you have some bears and chital are also feeding on grasses and say numbers are also feeding on grasses and they also browse a bit.

Now if you have different species that are feeding on the same resources there would be some sort of competition it is possible that you will have some sort of competition. Now there are mechanisms through which organisms tend to come out of this problem of competition so, they will go for specific resources. So, for instance some bird will prefer to live in areas that are more hilly and chitin will prefer to live in those areas that have more grasslands, but then what are the relationships between these organisms that are using the same resources or for instance there is also a classic case in which you have these two organisms.

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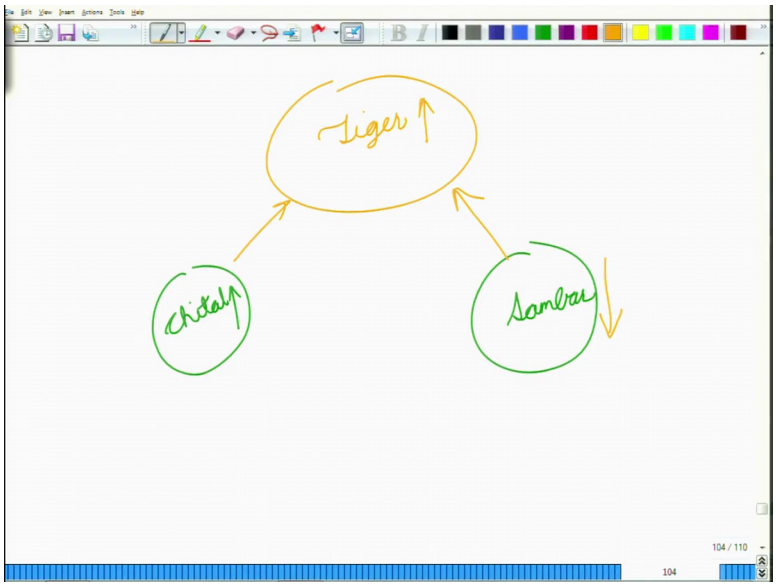

So, let us say you have this chital and you have the sambar and you also have a tiger in the system, now if a chital is able to increase its population. So, in that case the tiger will be getting both food, because a tiger feeds on the. So, the tiger population will increase, now if the tiger population increases a tiger also feeds on a sambar. So, if just your chital population is increasing and the sambar population is not increasing then because of the impact of the tiger you will have a decrease in the sambar population because more number of tigers will be feeding on more number of sambars.

So, there are also a number of interactions in which organisms are not interacting directly, but at the same time they are competing with others they are giving a negative interest influence on other organisms. Now all such things come under the domain of interspecific competition and George Evelyn Hutchinson was one of the first people to study these.

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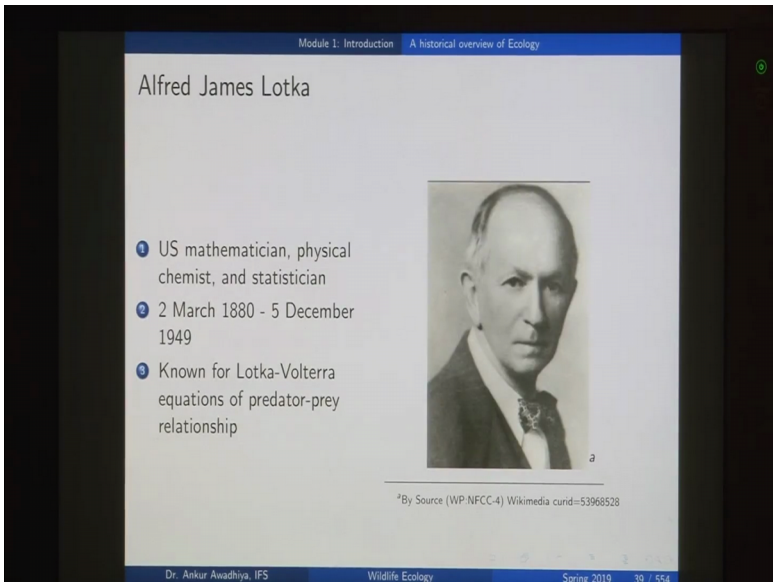

Next we will have a look at Lotka. So, Lotka and Volterra there were two people Alfred James Lotka was US mathematician physical chemist and a statistician. So, you can see that he was quite away from biology he was more inclined towards mathematics and the physical sciences and he is known for Lotka Volterra equations of predator prey relationship.

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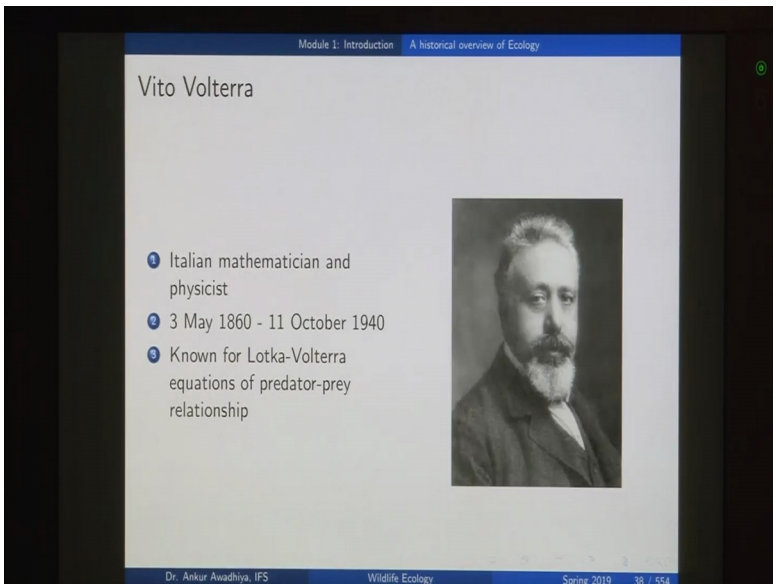

Together with Vito Volterra who was an Italian mathematician and physicist who lived from 1860 to 1940 and both of these people Lotka and Volterra are known for the Lotka

Volterra equations of predator prey relationship. Now, what is this relationship? So, let us suppose we are considering a system where you have a predator and a prey.

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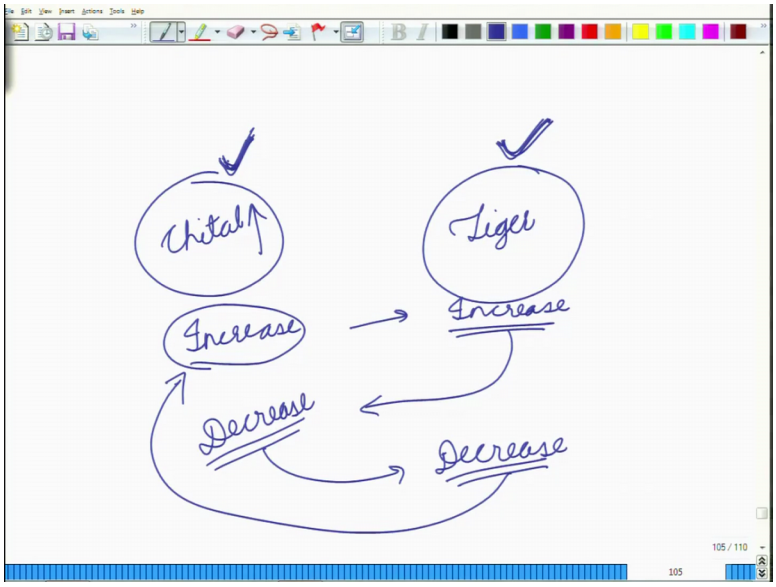

Let us say we are only considering two species one is a and the second one is a tiger. Now if this population if it increases; so, let us say we have an increase in the population that would result in an increase in the tiger population because now the tiger has more amount of food. And so, it does not have to wander off to larger areas it does not have to defend a larger territory, but can reproduce much more easily, but then if you have an increase in the tiger population that would in effect start predating on the cheetals.

So, you started with an increased population, but then an increase in the tiger population will result in a decrease in the population, now if your chital population decreases. So, in that case you will have less amount of food that is available for the tigers, now if you have less amount of food that is available for the tigers then in effect the tiger population will decrease because they are having less amount of food. Now if the tiger population decreases so, the now have less amount of predatory pressure.

So, in that case the chital population will increase further. So, this is a sort of cyclical relationships that we observe in nature that if you have two species that have these relationships of predator and prey dynamics. So, the increase in the predator population will depend on its own population plus it will depend on the population of the prey and similarly the population of the prey will the increase or decrease in the population of the

prey will not only depend on its own population, but it will also depend on the population of the predator, now these dynamics and these equations are known as Lotka Volterra equations for predator prey relationship. So, now we are moving towards the field of mathematical ecology.

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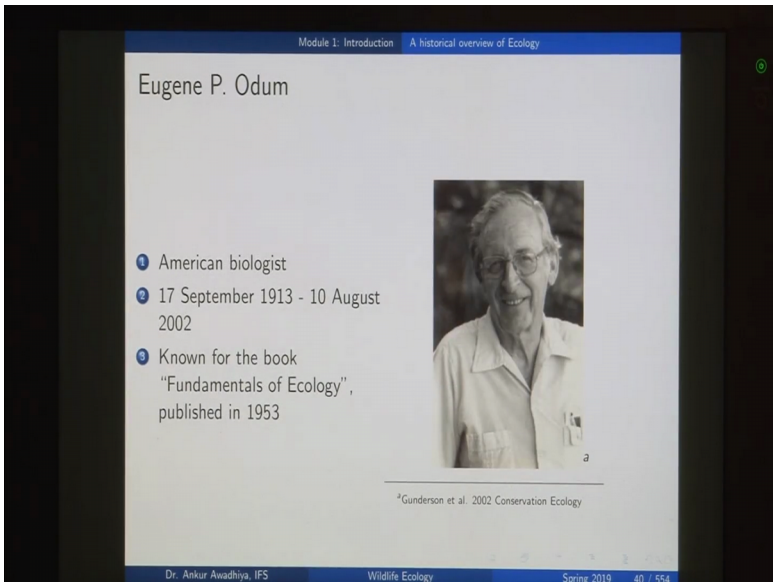

Lastly we will have a look at Eugene P Odum he was an American biologist who lived from 1913to 2002 and he is known for the book 'Fundamentals of Ecology' that was published in 1953. And he was one of the stalwarts of the field of ecology because he was able to collate all these different informations from different fields and he was able to bring it out in the form of a book which gives us an access to all of this different information. So, the book fundamentals of ecology is one of the very first text books that was published in the field of ecology and this also cemented the role of ecology as the science in itself plus he also did a lot of research in different technological phenomena.

So, we can see that ecology is a very old science even people who lived in the in the pre Christian era, but also looking at distributions, abundances of different organisms and using the resources that they had at their disposal, they did not have computers, they did not have access to all these different theories, but then because of their inquisitiveness this started this field of understanding the abundance and distribution of different organisms and with time we have dealt delve more deeper and deeper into the subject we

have started looking at how members of one population interact with members of the same population.

How do members of one species interact another with other species we have moved into mathematical ecology, we have tried to describe different relationships and forms of equations and so on. So, we can see that the science of ecology has its own long history and now it has come up in the form of a separate field and itself. So, that is all we had to discuss today.

Thank you for your attention [FL].