Basics of Biology
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Module II – Origin of Life and Evolution
Lecture 9
Evolution (Part II)

Hello everyone, this is Doctor Vishal Trivedi, from Department of Biosciences and Bioengineering, IIT Guwahati. And what we were discussing, we were discussing about the origin of life on the earth. And in that context, we have discussed many aspects related to how the life was originated onto the earth, and how the different theories are being put forward.

Following that, we have also discussed about the how the simple organism like the primitive cell, which is formed into the primordial ocean, it could be developed into a very, very specialized animal or specialized organisms and these specialized organisms could be invertebrate organism or the vertebrate organisms.

Apart from that, if you talk about the plants, the plants are also being evolved from the very, very primitive plants like the single celled plants like the algae, and then it is being gone into the specialized forms like the pterophyta, bryophyte, gymnosperms or angiosperms and that all we have discussed in the previous module, when we were talking about the classifications and in the previous lecture also, we have also discussed about how the these forms could have been evolved.

And we have also understand the different types of experimental evidences what people have put forward and different theories which have explaining that how the evolution could have been happened onto the earth. So, that was sure that the evolution was happened these are, these complicated organisms or the advanced organisms are being evolved from the primitive organisms.

Now, in today's lecture, we are going to discuss about the mechanisms how this could have been done, and what are the different theories and mechanism which people have put forward to explain how a primitive cell which is formed into the primordial ocean could develop into very, very specialized organisms. So, with this, I think we will start our lecture.

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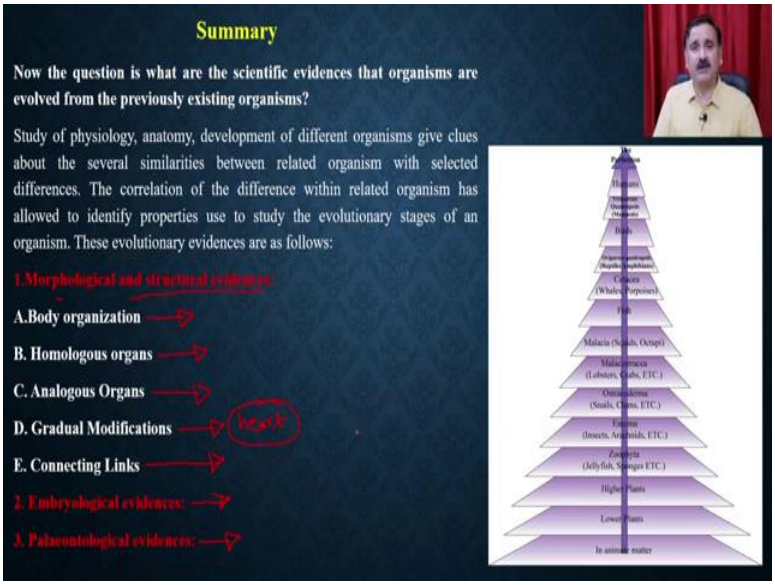

So, what we have seen, what we have discussed so far, what we have discussed is that the we have collected the scientific evidences that the organisms are evolved from to the previously existing organisms, we have discussed about the different types of, different types of evidences, we had discussed about the morphological evidences, we have discussed about the structural evidences.

And that we have discussed in terms of the body organizations, homologous organs, we have discussed about the analogous organs and we have also discussed about the gradual modification, where we have taken an example of the heart and this example, we have also discussed when we were discussing about the classifications, when we were talking about the classification of core data, we discussed how the heart is being evolved from two chamber heart to three chamber heart and the four chamber heart.

Apart from that, we have also discussed about the different types of connecting links. And then we also discuss about the embryological evidences as well as the paleontological evidences. Apart from that, we also discuss about the how the fossils are being formed and how you can be able to determine the age of a fossil using the carbon dating techniques or other dating techniques. And based on that the different eras are being discussed in the previous lecture as well.

So, one question is that how the evolution happened and the evolution and what could be the mechanism through which the evolution is would be taking place onto the earth? To understand this question and to undress these questions that people have put forward the different types of theories.

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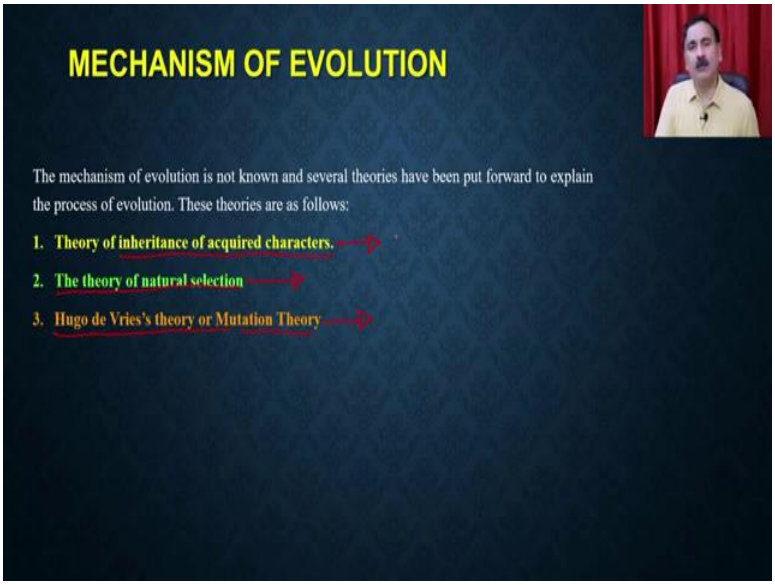

So, what are these theories? These theories are there are mainly three theories which are people have put forward, one is called as the theory of inheritance of the acquired characters, which has been proposed by the Lamarck. Then we have the theory of the natural selection which is proposed by the Charles Darwin. And then we have the Hugo de Vries's or the mutation theories.

So, let us start discussing about the each theory and how these theories were explaining the evolution, the mechanism of evolution and what are the their drawbacks and what they could not be able to explain. So, let us start with the first theory and the first theory is the theory of inheritance of the acquired character.

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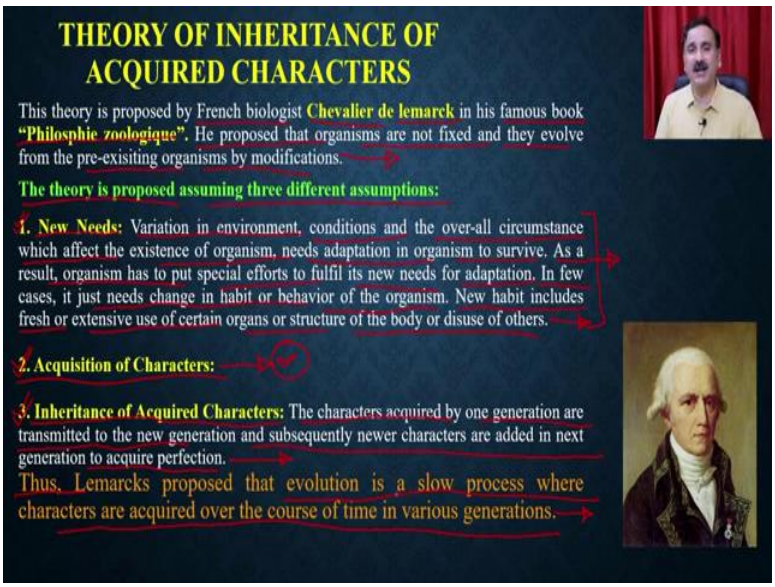

The theory of the inheritance of the acquired character is proposed by the French biologist Chevalier de Lamarck in his famous book “Philosophie zoologique”. He proposed that the organisms are not fixed and they evolved from the preexisting organism by the modification and they have, he has assumed several types of modifications or the several types of assumptions, the theory is proposed assuming that three different assumptions, so, what are the three assumptions?

The three assumption is there is a need, new need, then we have the acquisition of the characters and the third is the inheritance of the acquired characters. So, what is the new need, the new need is the variation in the environment, conditions and the overall circumstances, which affects the existence of the organisms need adaptations in the organism to survive.

So, what they and as a result, the organism has to put special efforts to fulfill its new need for the adaptations. In the, in few case, it just needs change in the habit or the behavior of the organisms. New habit includes fresh or extensive use of certain organs or the structure of the body or disuse of the other. So, what the assumption of the new need says that there are challenges what the people, organisms are going to face from time to time.

And then according to those challenges, whether these challenges could be environmental or whether the challenges could be because of the change in the availability of the food or other kinds of things, there could be adaptation, there will be an adaptation in the organisms to survive. And as a result organism is going to do the modifications in his body, either he is going to start using some organs or it will stop using some of the organs and because of that, there will be there will be changes, then it is going to acquire the characters.

So, there will be an acquisition of the characters that we have going to discuss in detail, what are the different types of acquisition of the character, what could be the mechanism, who wished there will be an acquisition of the characters, and once there will be an acquisition of the character that acquisition of the character are going to be inherited.

So, the character acquired by the one generation are transmitted to the other generation and subsequently new changes or new characters are being added in the next generation to acquire the perfection which means, when the generation one is going to face these kinds of environmental conditions, and they will be going to change, they will be going to face any kind of challenge, they will going to use the some organs or they will be going to stop using

some of the organs and because of that, they will be going to acquire the some of the characters.

And these acquired characters are then going to be inherited and that will go automatically or spontaneously to the second generation. And then because of that, the second generation is not going to face those problems and because of that, it will going to survive. Thus Lamarck proposes that the evolution is a slow process, where characters are acquired over the course of time in the variation generations.

So, that is a whole soul process that whole soul message that the Lamarck has said that the evolution is a very slow process and it is not being done in a single generation it will be done in a multiple generation and because of that, it is going to acquire different types of characters. Now the question comes how you can be able to acquire or how you can be able to acquire the different types of characters?

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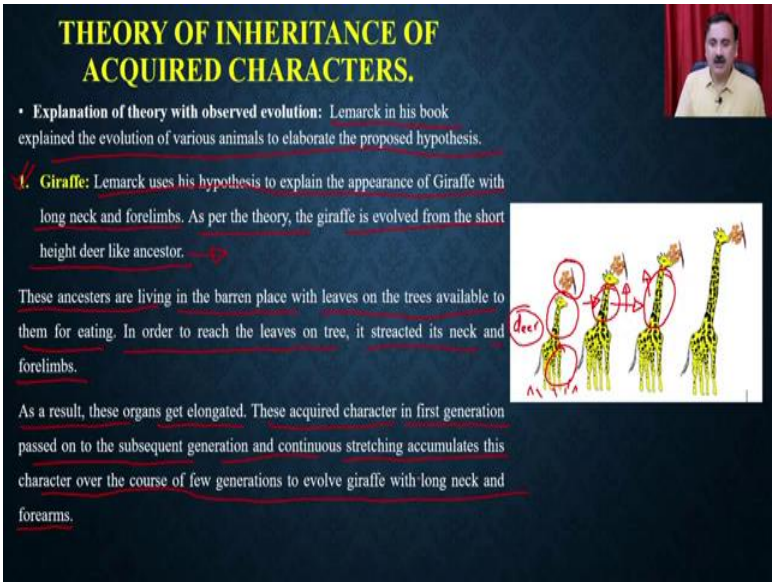

There are three ways in to acquire the character required to adopt into the change conditions, these change conditions could be environmental, you can have change in the temperature or there could be a scarcity of water, there could be a scarcity of food, like for example, there will be a scarcity of grass and so on. So what is the three ways in which you can be able to acquire the characters, one is innate tendency.

There is an innate tendency, innate means, there is a spontaneous tendency in each organism to acquire the greater complexity and perfection to perform the function, in this process of achieving perfection the organism is better and better adapted to the change environment, you

remember that the example of the heart. So, I have discussed when we were discussing about how the modifications into the existing organs could be, could be a way to explain that the evolution is happening and that is a very classical example of the heart.

Heart was two chambered in the beginning and then it was converted into three chambered and then it got converted into four chambered and why it is so, because, if you have two chambered heart, there will be a mixing of blood. If it is a three chambered heart the mixing of the blood is going to be less, but it is still be there, because the auricle and ventricle are still be able to mix the liquid, mix the blood.

And the efficiency of the heart is also going to be less because you have two chambered heart it is going to give you the mixing of the blood and as well as the efficiency. As soon as you acquire the final thing that which is the fourth chambered heart, it is going to be very precise, you are going to receive the deoxygenated blood in one chamber, you are going to supply the oxygenated blood from the other chamber and so on.

So, because this why the organism have evolved into this because they want to acquire the better perfection The same is true for many other things, many other examples and why and then the second point is the use or the disuse of the organ. The use and the diffuse of organ affect their structure, shape and the efficiency of the functioning. More usage of a particular organ brings additional strength, size and the more efficiencies

In contrast, the disuse or the under usage of the organ gradually make them weaker and smaller and finally, they may disappear as well. Thus, differential usage of organ allowed the additional character in the body during the lifespan of organism, so that if what it says is that if you utilize the organ, it is going to be more strong and it is going to be more and more stable more and more efficient.

This you can imagine that many of the body builders they are still using their organs, they are they are using the different types of exercises and because of that, they are going to build up their muscles. So, that is a classical example to say that if you use the particular organ like for example, if you do a weightlifting, you are going to strengthened your muscles like biceps and all those kinds of things. So, that is a classical example of the use and disuse of the organ.

Then we have the environmental factors. So, variation in the environmental factors such as temperature, light, humidity, wind, enemies affecting the living things and bring changes in the lifestyle and the habits. The combined effect of the use and disuse of the organ and the

influence of environmental factor results into the change in the body of the organ organism and these characters are known as the acquired character.

So, what is mean by the acquired character is that the character which you are going to acquire, which you are not going to get your from your parents, acquired character means the character which you are going to acquire during your lifespan and then these acquired characters are going to be inherited into the, into the offspring. And that is how that was the proposal from the Lamarck's.

Now, Lamarck has cited many examples, many observations and many theory, many hypotheses to explain these three phenomena through which the organisms are acquiring the characters and how that how the acquisition of the additional characters are helping them in terms of the adopting into the change conditions and that is how they are succeeding into the fulfilling or finish completing their lifespans and that is how they are surviving.

So, there he has cited many examples, one of the classical example is where he has cited the example of giraffe. So, he has taken many examples. So Lamarck in his books explained the evolution of various animals to elaborate the proposed hypothesis. One of the classical example is the giraffe. So you know that the giraffe has a very long neck and because of that, it can take the food from the even from the very long trees and high trees.

So Lamarck uses his hypothesis to explain the appearance of giraffe with the long neck and the forelimb. As the theory that giraffe is evolved from the short height deer like ancestors. So, initially the giraffe was (())(15:19) as a very short deer like thing and because of that it is taking the food from the grass which was there at the bottom.

But at the same time it was also trying to take the additional nutrition by the taking the nutrition from the, so he was using more and more his forelimbs and as well as its neck and because of that it started developing the neck muscles and as well as the height health of the length of these muscles and because of that it started developing these organs.

So, these ancestors, the deer like ancestors are living in the barren place with the leaves on the tree available to them for eating in order to reach the leaf on the tree it is stretched necks and the forelimbs. As a result, these organs get elongated these acquired character in its first generation passed on to the subsequent generation and continued stretching accumulate this character over the course of new generation to evolve the giraffe with a long neck and the forelimb.

So, what happened is that the giraffe as the as the Lamarck has proposed, the giraffe is being evolved from a deer like situation, but these organisms do not have or these animals do not have adequate food on to the earth or on to the grass. So and they were having the leaves on to the higher end, higher trees. So, because to get the nutrition they started utilize using the neck and as well as they started using the more and more and because of the stretching of the neck as well as the forelimb it started developing its neck.

So in the first generation it started developing the neck to some extent and then that thing continued because every in every generation, the giraffe has to survive in that particular environment. And because of that, it has started developing its neck length, and as well as the forelimbs and because of that, it developed into a giraffe with a long neck and the forelimbs.

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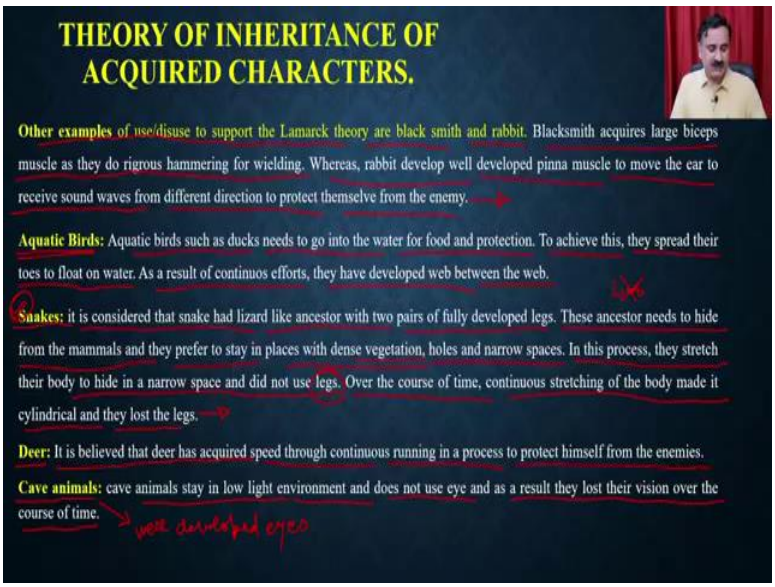

Then the second is the aquatic birds. So, other examples of the use and disuse to support the Lamarck theory are black smith and the rabbits. So, black smith acquired large bicep muscles as they do rigorous hammering for the welding. This is like I just cited as body builder like the body builders are also doing the same but black smith is also acquiring a very strong biceps because they have to do the hammering for the welding.

Whereas the rabbit develops a well-developed pinna muscles to move the ear to receive the sound wave from the different direction to protect themselves from the enemies, you might have noticed when the, when you are or you might have seen the rabbits in zoo or in your home that when you they can be able to rotate their pinna muscles or they can be able to rotate their ears to such an extent that they can be able to hear the sound from each and every direction.

And why that is so because the rabbit has to hear the entry of the enemy and that is how it can be protect themselves from the enemy. Then we have another example of the aquatic birds, the aquatic birds such as ducks need to go into the water for food and protection. To achieve this, they spread their toes to float onto the water, as a result of continuous effort they have developed the web between the fingers.

So then we have the snakes, so snake you know that snake does not have the limb and why the snake lost the limb? The Lamarck has explained that because the snake is considered to be originated from the lizard like ancestor with the two pairs of fully developed legs. These ancestors need to hide from the mammals and they prefer to stay in places with the dense vegetation which means they are or holes or the narrow spaces.

And because the dense vegetation and holes as well as the narrow is obstructing the limbs, so they have stopped using the limbs for and they started stretching their body to hide in the narrow places and did not use the leg. Because of they do not use the leg for a very, very long time, like the several generations over the course of time, continuous stretching of the body made it cylindrical, and they lost the legs. So that is a classical example of how the disuse of a particular organ is going to turn into the disappearance of that particular organ from the subsequent generations.

Then we have the deer, it is believed that a deer has acquired a speed through continuous running in a process to protect himself from the enemy. So deer has because deer has to protect themselves from the tigers and all other carnivorous animals, it has developed strong muscles and that is how it could be able to run very fast.

Then we have the cave animals. So cave animals do not have a well-developed eyes. And why they do not have the well-developed eyes because the cave animal stays in a low light environment and does not use the lights and as a result, they lost their vision over the course of time.

So, these are the evidences the what the Lamarck has put forward, but if you have a theory, there are also contradictions, there are criticisms. So Lamarck has also, the people have put those kind of evidences to criticize that particular Lamarck theories of the acquired characters.

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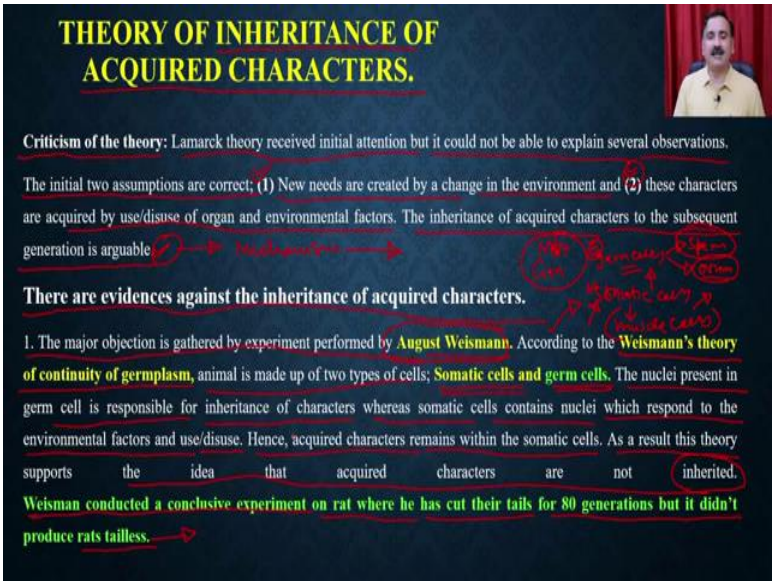

What are these theories? The criticism of the Lamarck theory is that Lamarck theory received initial attention, but it could not be able to explain several observations, the initial two assumptions are correct, there is a new need to create by a change in the environment. So, the people were agreed that okay, there is a new need, because you will have to adopt into the change environment and the whatever the changes you do, they are going to be acquired by the use and disuse of the organ as well as environmental factors.

The inheritance of the acquired character to the subsequent generation is arguable because there was no mechanism through which the Lamarck has proposed or Lamarck has explained how the acquired character because we said acquired characters are the character which you are going to acquire into your lifespan, but they do not, you do not get those acquired character from your parents.

So, because you cannot get the acquired character from your parents, how the acquired character can go into the next generation? So, that a mechanism Lamarck could not be able to explain or Lamarck could not be able to verify. Then there are additional evidences which are against the inheritance of the acquired characters. The major objection is gathered by the experiment performed by the August Weismann.

So, August Weismann is a, is proposed that the Weismann's theory of the continuity of the germplasm that the animal is made up of two types of cells. Animal is made up of two types of cells, one is called as somatic cells and the other is called as the germ cells. The germ cells, the nuclei present in the germ cell is responsible for the inheritance of the character, whereas

the somatic cells contain nuclei, which responds to the environmental factor or the use and as well as the disuse.

Which means according to the theory of Weismann of the continuity of germplasm, you have the germ cells and you have the somatic cells. So somatic cells are the, one of the classical examples is the muscle cells. Somatic cells are the, all the other cells except the germ cells. Germ cells, in the case of humans, you have the two different types of germ cells, one is called as the sperm, the other one is called as ovum.

And these germ cells, they are the nuclei present in the germ cells are responsible for carrying the genetic information, sperm you are going to get from the father; the ovum, you are going to get from the mother. So that is why, when they will be going to fuse to each other, they are going to give you the zygote and as well as the offsprings.

So, these or germ cells are going to carry the genetic information from the one generation to next generation, whereas the somatic cells which are like classical example is the muscle cells are going to respond to your habits. If you are using the muscles, they will be going to be stronger and stronger, because you are going to use them every day.

So they will be going to acquire the mass and that is how they will become more and more stronger. But they that information, will not get into the germ cells because germ cells are very, very far away from the somatic cells. So, the acquired character, so these somatic cells are going to be responding to the acquired character.

Whatever you acquired like for example, when we study into the our classes, that information goes into our somatic cell that goes into our brain that does not mean that if I have done the PhD, and I have acquired that much information, I can be able to pass on that information to my next generation and that is not possible, because it is not been transcribed or it will not going to be gone into my germ cells and because of that, every generation have to study, every generation has to learn how to make the alphabets, when you born you are go through that learning experiences.

So, the acquired characters remain within the somatic cell. As a result, this theory supports the idea that the acquired characters are not inheritable, which means the basic idea of the Lamarck is that Lamarck theory is mostly been dependent on the inheritance of the acquired character.

So, people were not having any objection, people were not having any problem with the that there is a new need for an organism to survive into the change environment. And it is going to use or disuse the different types of organs and that is also going to develop that particular organ.

The only problem was the third assumption that there will be inheritance of these acquired character and that is how it has been criticized and performed the even the Weismann has done several types of experiments to prove that, that you are actually, if you make the changes into the somatic cells, those cells are only going to be modified, but the germ cells are not going to be modified in the second generations.

In fact, what he has done is he has conducted a conclusive experiment on rat where he has cut their tails for 80 generations and that did not produce the rats without the tailless, which means the Weismann has cut the tails of the rats. So, once you could the tale of the rat, the rat cannot use that particular tail because there is no tail available.

So, that is mimicking the condition that you are forcing the organism to disuse that particular organ. But even then, when the new-borns are being produced, they were not being produced without a tail, they will be produced with the tail only. So, that has conclusively proved that there is a no inheritance of the acquired characters.

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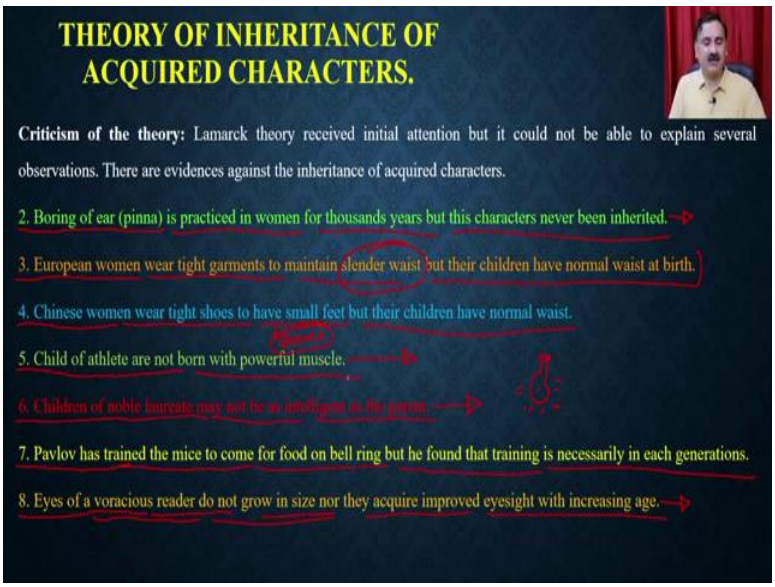

Then there are other evidences. So, there are many evidences from the human civilization, there are many evidences from the what people have observed during the, in other animals as

well. So, for example, the boring of the ear is practiced in women for 1000s of years, but this character never been inherited.

You know that in every civilization, the women as well as the men for some times are piercing their ear pinna, so that they can be able to wear the different types of ornaments. But these piercing which is be a kind of a practice from happening from generation to generation, but even then, you will not see a new born, born with the pierce our new born is born with the hole actually.

Then we have the European women, so, European women they wear tight garments to maintain the slender waist, but their children have normal waist at the birth. So, that is another example where the women are wearing the tight garment so that they could be able to look slim and smart, but that information that is acquired corrected does not go into their children.

Then we have the Chinese women, so the Chinese women wear the tight shoes to have the small feet. So that is a disuse of that particular organ. So they will be trying to constrict that particular use. And because so that they want to develop small feet, but their children have the normal feet.

Then we have the child of the athletes are not born with the powerful muscles, same is true for the black smith or the weight lifters. Weight lifters are acquiring the huge power into their muscles. But that muscles power is not getting collect or transcribed into the their offspring. Then we have the child of the Nobel laureates or child of the professors are not intelligent as the parents, because, as I said, when you are studying you are collecting the information into the brain and brain is nothing but a somatic cell, brain is a somatic cell.

So, if you are acquiring and making changes into the somatic cell, that changes are not going to be go into the subsequent generations. Then the Pavlov also has done, so Pavlov was a scientist he trained the mice to come for the food on bell ring. So, when he was ringing the bell, when he is ringing a bell, the mice are coming. So, they will be getting they are being trained that okay when they will be a bell ringing, there will be a food.

But, what he found is that that training is necessary even for the subsequent generation you are not going to get the kids automatically been trained because training is also a part of the brain activity or spinal cord activity. And both of these organs are the somatic cells. Then we

have the eyes of a voracious reader do not grow in size, nor they acquire improved eyesight with the increasing age.

So what Lamarck says? Lamarck says if you use a particular organ, that organ is going to be more and more efficient, it will be more and more strong. But that is not the case, when you are say going to see that many people are reading novels after novels or they are going to read the novels in the night, but that does not allow their eyesight to be improved or that does not allow their eyes to grow in size and that character is also not being transmitted to the new generations.

So to address these criticisms, the Lamarck has taken a help of the, to the latest information and that is how he came up with an idea of the revised hypothesis or revised theory of inheritance of the acquired character.

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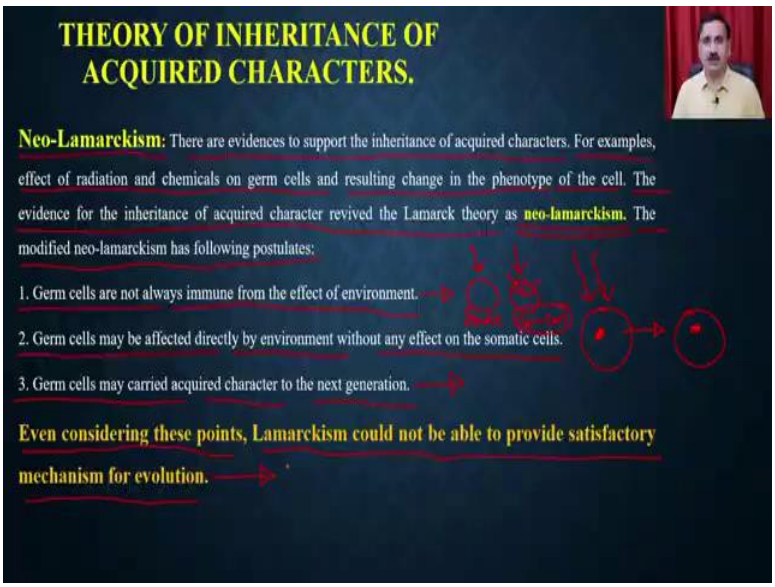

What is this new theory? This new theory was called as the Neo-Lamarckism. So there are evidences to support the inheritance of the acquired character. For example, effect of radiation and chemical on the germ cells and resulting change in the phenotype of the cell. The evident for the inheritance of the acquired character revived the Lamarck theory as the Neo-Lamarckism. The modified Neo-Lamarckism has following postulates.

So what people have observed that if you are going to get exposed to any kind of the radiations, which is going to make the changes into the germ cells, then those changes will go into the subsequent generations and that has given the clue of, to the people who are supporting the Lamarck theory, that this could be the reason, this could be the way in which

the acquired character can be able to transmitted to the next generation and that is how they have proposed a new theory which is called as the Neo-Lamarckism or the new theory of Lamarckism.

This new theory of Lamarckism or Neo-Lamarckism have the following postulates; the germs cells are not always immune from the effect of the environment. So what it says is that when there is a change in the environment, it is going to change both. It is going to change the somatic cells, it is also going to change the germ cells and so if there is a radiation, it is going to affect the germ cells, it is also going to effect the somatic cells or if there is any change in the environment, that is going to effect the somatic as well the germ cells.

The germ cells may be affected directly by the environment without any effect on the somatic cells. So whatever the effects are happening on to the germ cells may or may not affect the somatic cells. The germ cells may carry acquired character to the next generation. So that is how they have explained the many, how the inheritance of the acquired character could be possible.

But even considering these points, Lamarckism could not be able to provide the satisfactory mechanism for the evolution. They were still having the questions; they were having still the objections which they could not be able to explain and that is how the people have dropped the idea of the inheritance of the acquired character as a best solution to explain the mechanism of the evolutions.

So what we have discussed? We have discussed about the theory of inheritance of the acquired characters, where the Lamarck has said that first is that the organism is getting forced to change its needs, it has trying to evolve, trying to make the system more and more efficient and because of this tendency or because of this habit, the organism has to evolve.

Why it is so and how it is doing so is because it is using or disusing its organs. If it is using the organs, it making the organs more and more strong and developed. If it is does not use that particular organ, then it is going to shrink that particular organ or it is going to disappear. With the classical example what data has cited is the snake example, where the snake has to go through the bushes and when it was having the legs, it legs were interfering while going through those bushes.

So what it has done is, it started sliding onto these bushes without using the limbs. And because of that during the course of few generations, there was disappearance of the legs.

And the third is inheritance of the acquired characters, so if you can be able to make the changes into the body, that will be get inherited, that character is going to be inherited to the next generations and that is how you can be able to develop a new species and you can be able to develop the new organism which is going to be more and more advanced compared to its (pre), compared to the previous organisms.

And that is how if you keep going with that particular modification, you can be able to develop a new organism. So these are the few points what Lamarck has put forward and that is how he explained has the theory of the mechanisms of evolutions. So with this I would like to conclude my lecture here and in the subsequent lecture we are going to discuss about the few more theories were the people have put their efforts to explain the mechanism of evolutions.

Thank you.