Evolution of the Earth and Life
Professor Doctor Devapriya Chattopadhyay
Department of Earth and Climate Science
Indian Institute of Science Education and Research, Pune
Dinosaurs

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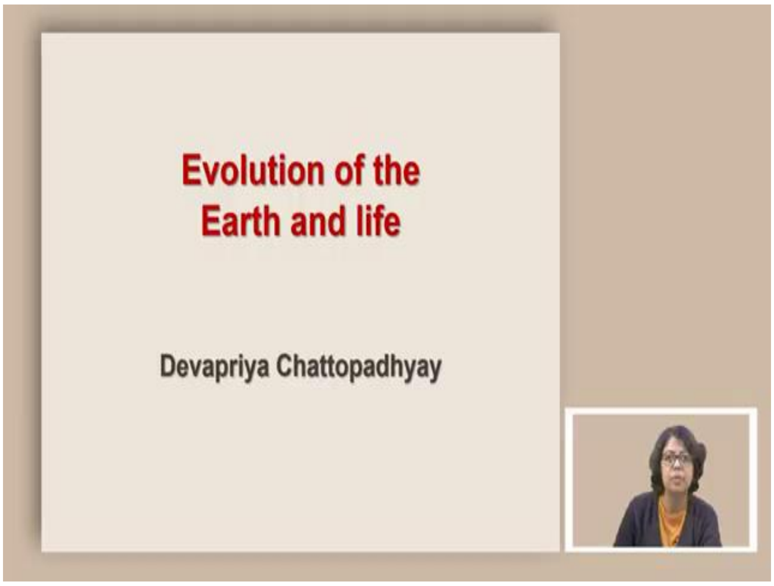

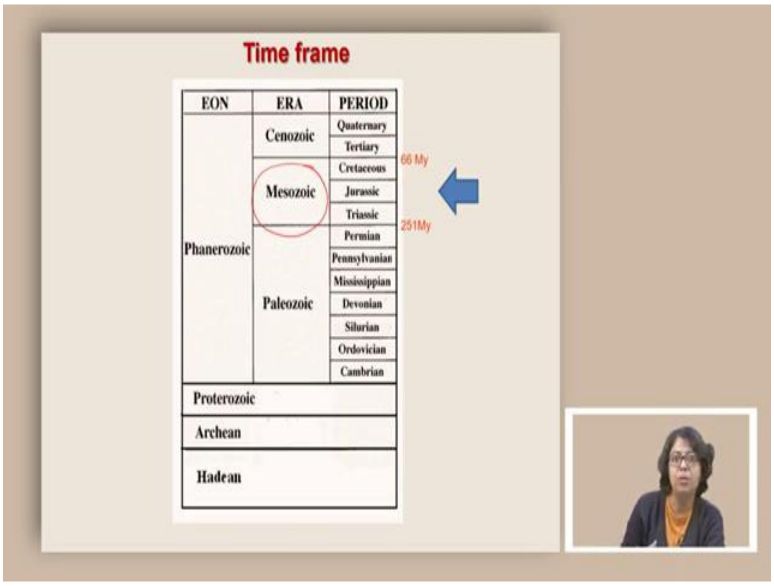

Welcome to the course evolution of the earth and life. Today we are going to talk about dinosaurs. So, the timeframe that I am going to be talking about is roughly called Mesozoic. And this spans from 251 million years to 66 million years, the events that took place during this time includes changes in ecology, and we will start seeing appearance of flying and that is what we are going to focus today.

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Flight appeared in multiple lineages independently, if we see today around us, we will find that there are different groups which can fly, insects can fly, the bats can fly, the birds can fly, but they are not really very connected groups.

Bats are mammals, the birds are the birds, they are not really mammals, they lay eggs, then we have insects, which are not at all closely related to these two groups, because they do not have a backbone. So, they are invertebrates. Now, how come these different groups start to fly at a different time so, flying and how it appeared is a big question.

We know that insects started to fly very early on, primarily in Paleozoic. And we know it because we have fossil record of things like dragon fly, and they had large wingspan. But flying for insects are quite easy, because they generally have a very light body weight.

So, therefore, any appendage which is large enough and which has a surface area, they can flap and they can fly. But things get complicated when we are talking about large animals, primarily vertebrate animals, because generally, they are larger than the invertebrates.

And in order for them to fly, they have to have wings, which are large enough to create something like a lift. And that is how the bats fly that is how these birds fly. But the problem is, it is very difficult to understand how come the groups started to develop their wings, because wings at the initial stage, if it is a small wing, it cannot contribute much to the flight.

And if they cannot contribute much to the flight, then what is the use of the wing and why would the groups with wings, even smaller wings will get selected and eventually increase their size where the wings can actually support the flight.

So, this is one of the major dilemma in understanding how the flight started to appear in vertebrate groups. Now, the groups that we are going to look at today will include birds. So, people try to answer this question by looking at one of the major groups which can fly and obviously that is bird and try to understand that which are the groups that are connected to birds and do we see any fossil record of flying in them and when we do that, we come across a very surprising pattern.

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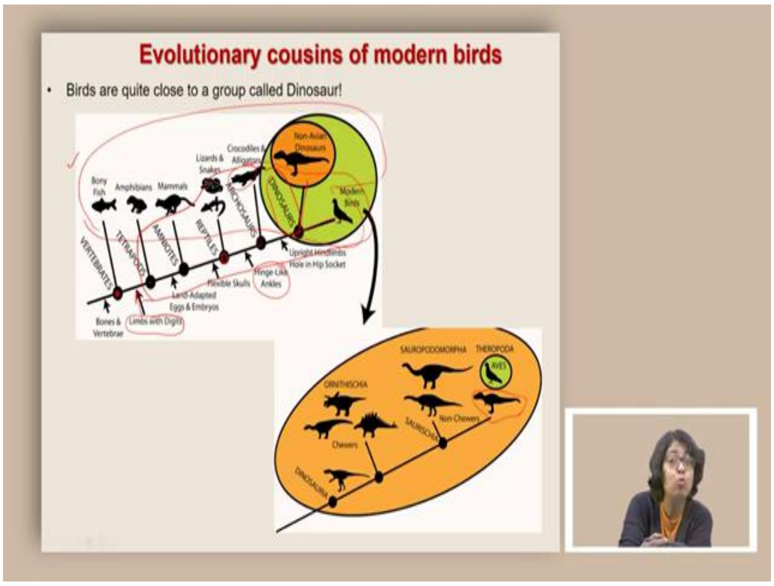

So, this is a classification pattern, we are going to call it a credogram where different groups are positioned in places based on their similarity. So, if we look at this particular one, we will find that if we are talking about vertebrates that includes everything at the right side of this plot. Everything will be called a vertebrate and that is why this node is there. Now, within vertebrates there is bony fish. Then we are adding a character limbs with digits.

So, when we are adding a character here that means everything after this will have this character. So, everything beyond this point all these nodes all the animals corresponding to it will have limbs as well as digits.

Now, when we keep on doing it, we will find fish, we will find amphibians, we will find mammals, we will find reptiles and then we hit a roadblock because we also find things which do not present in the modern ecosystem which are not present which are extinct and they are.

So, when we move from reptiles, then there is a node which is called an Archosaurs. Basically, what it means it includes all groups, which has a hinge like ankle, it includes crocodiles, it also includes birds.

But then when we look deeper into it, we will also find another group, which you do not find today, and they are dinosaurs and as it turns out the dinosaurs and the birds are very, very closely related.

So, if we actually look at all kinds of dinosaurs, and try to look at their relationship, that how close they are among themselves, what we will find that there are these dinosaurs, which are almost indistinguishable from the birds in terms of many of their bone character. So, it is quite clear that the birds and the dinosaurs share some level of commonality. And can that tell us something about the evolution of flight, it is important to recognize that to fly it is not necessary to have feathers.

There are different kinds of animals which have different ways of flying. For example, as I say that the dragon fly, it does not have any feather, it simply flies because of the wings, which are made up of other material, very light material, but not feathers. If you look at the bats, they also do not have feathers, they basically have a skin, which goes between their digits. And that thin layer of skin actually helps them to create enough force, which basically takes them up. It is only the birds, which have feathers as a way of flying.

Now, the question is, when we are looking at these birds, and we are also looking at the dinosaurs, we find that they are very similar in many ways. Now, the question is that, do they also share other similarities like flight? So, we are going to talk about that. Now, what are these dinosaurs?

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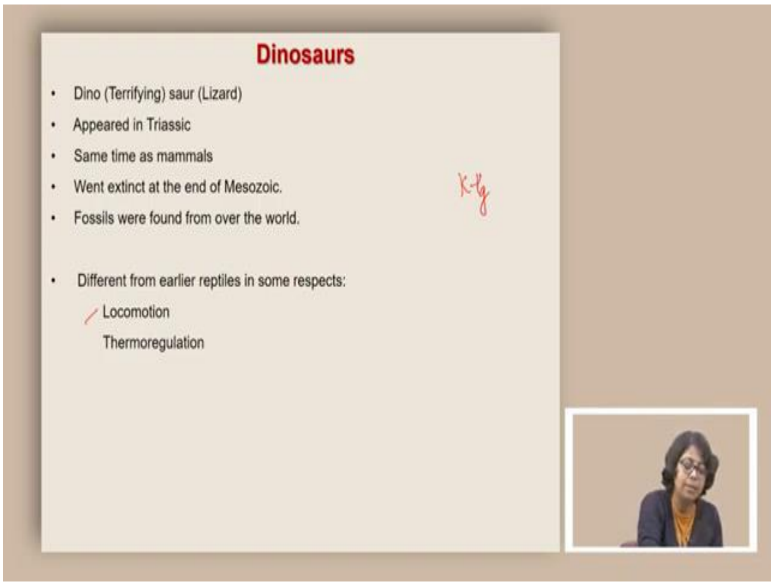

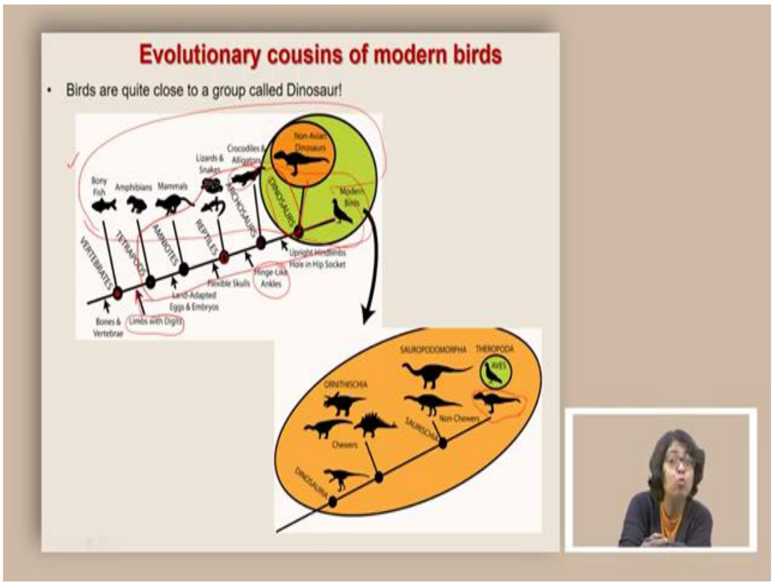

So, dinosaurs are type of a reptile. And if we go back, we will see that this reptiles actually has lots of groups. One is lizards and snakes then there are crocodiles and alligators. And then there are dinosaurs. So, dinosaurs are kind of different from crocodiles and alligators and lizards and snakes, which we find today. But they are more related to birds. But we do not really see them today. And therefore, the classical view has been that the groups which have certain characters, we are calling them dinosaurs, and they are completely extinct.

The name comes from these two words, sore means lizard. So, anytime you come across any scientific name, which has a later part, which says sore, it basically means it is a type of reptile or lizard, and dino means terrifying. So, dinosaur means terrifying lizard. They appeared in Triassic. Interestingly, that is the same time when the mammals also appeared.

And then what we know about the forms, we think that they went extinct at the end of Mesozoic so, end of Mesozoic at the K-Pg extinction, the dinosaurs went extinct.

More specifically, we are going to call it non avian dinosaur. Avian means something which can fly so non avian dinosaur means the dinosaurs which could not fly went extinct. They sort of brings this question that where there are dinosaurs, which could fly. Another important point that there are different kinds of reptiles during this time, but not all of them were dinosaurs.

So, there were reptiles at that point of time, which are called Mesosaurs and Icthyosaur, these were reptiles, but they lived in the water. Then there were reptiles, which are called pterosaurs, which could fly. But they did not have any feathers. They simply had skin extensions, just like bats. And that is what helped them to fly. But again, those are not dinosaurs. Dinosaurs were land living organisms.

Now, the dinosaurs are very interesting because they differ from many of these modern day lizards and reptiles of that we find around us. Let us start try to look at some of these aspects that make them very unique. And they are very different from the modern day reptiles. So, we are going to look at two things. One is locomotion how they move, and the second one is thermoregulation which means that how did they control their body temperature.

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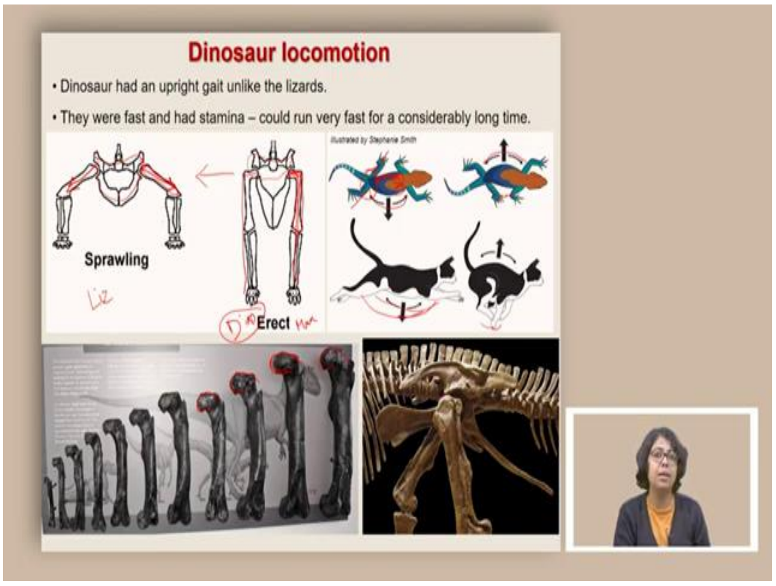

So, dinosaur locomotion is very interesting. Couple of things how do we know that anything about dinosaur locomotion. Well, as it turns out, that there are two sources of information.

One is how the bones are arranged, and dinosaur bones have been found from various parts of the world.

The second part is that sometimes when they walked on soft ground, muddy ground, they left footprints, and using the footprints, you can reconstruct the speed of motion. And what we find is, they were quite fast. Not only that, they were quite fast, and they could continue to move fast for a very long time. And that is not something very usual for various reptiles.

Now, let us try to understand it a little bit more. When we look at a reptile, let us say a house lizard, the way it moves is very different from any other organism, let us say mammals. What we will find that when the reptile moves, the house lizard moves it basically moves, where one part of it gets extended, one side of it gets extended, it squeezes the other part and then right after this, this part gets extended, and this part gets squeezed up. So, they are moving sideways and their movement, if you did not know which kind of animal you are looking at, they mimic the way fishers move.

So, fishers often move by squeezing one part of their body sideways, and then flexing on the other side. So, this movement is very typical to the lizard. So, if I have to use my hands, I will squeeze it in one side and then move on the other side. So, that is the movement of the fishes, as well as the reptiles. But when we think about the mammals, it is a very different thing, because the legs or the limbs are underneath the body.

So, instead of moving sideways, they basically squeeze on the bottom of their body. And what happens if I move it like this, it squeezes by making the arms coming closer to each other and then extending it.

So, let us take a look at how cat runs. So, you will see the extension of it and then squeezing of it. Now, the thing interesting thing is it is not doing it sidewise, it is actually going back and forth on from the top and from the bottom. And this is happening because the limbs are underneath the body, for the mammals and for birds.

But when you look at the reptiles, such as house lizard, the limbs are actually coming out of the body. And now if we look at their bone structure, we will also find a difference. We will find that for these lizards, if you look at this part of the body, there is this bone structure and from which the limbs are coming out the legs are coming out and the legs have multiple bones. But this bone is basically coming out of the body and because they are coming out of the body they have this awkward posture where they are moving sidewise.

Now, let us take a look at how the mammal bones look like. And what we are finding that the mammal bones are basically coming out and then getting down and making an angle. As a result, the limbs are not really going away from the body, it is underneath the body. And therefore, the limbs which are underneath the body can come closer to each other and move away.

Now, the question is, what is the difference be in terms of the movement because of this arms or limbs below the body versus away from the body it actually has a very important function in terms of controlling the speed and tenacity.

So, when these house lizards run, every time they are squeezing one part of the body, the lung that is situated somewhere here also gets squeezed. And therefore, when they are running, when they are moving, effectively, they are on one lung which has been extended. On the other hand, because these movements are underneath the body, they do not have any effect on squeezing the lung. And therefore, they can perform with the strength of two lungs at a time.

The reflection of it is in their stamina. So, stamina means how long a particular animal can run at a stretch. So, what we will find that most of these lizards, they can run quite fast sometimes, but they cannot continue it for very long, because they get exhausted, so their stamina is very low. Whereas if we look at the mammals, or even birds which can run, we will see that because they are not squeezing their lungs, they can keep on going for quite some time at high speed, and they have higher stamina.

Now, when we look at the dinosaurs, we find an interesting pattern. When we look at the dinosaurs, this is a dinosaur femur bone. So, this is kind of the bone that we are going to talk about this is the bone that we are going to talk about this is called a femur bone. What we find that the top of the femur bone actually has this extended part. And these this is basically different sized femur bones of the same dinosaur species and because the individuals can be of different sizes, you can also find different femur bones from different individuals.

But all these things are showing you this kind of top part, which has an extension. And this extension once you fit it within this pelvic part, which you will see that it actually has an upright posture or erect posture.

So, the sprawling posture or sprawling gait is true for most of the lizards. This one is true for most of the mammals, but the dinosaur actually false here. So, the dinosaurs do not look like the other lizards, they have the limbs underneath the body so that means that probably they did not face the situation of squeezing the lung sidewise and therefore being sluggish and not being able to run for a very long time.

This is also supported by their footprint evidence, the footprints show that they can they ran for a very, very long time. And they could continue this run for even longer time. And that makes dinosaurs very different from any other reptile that we see around us today.

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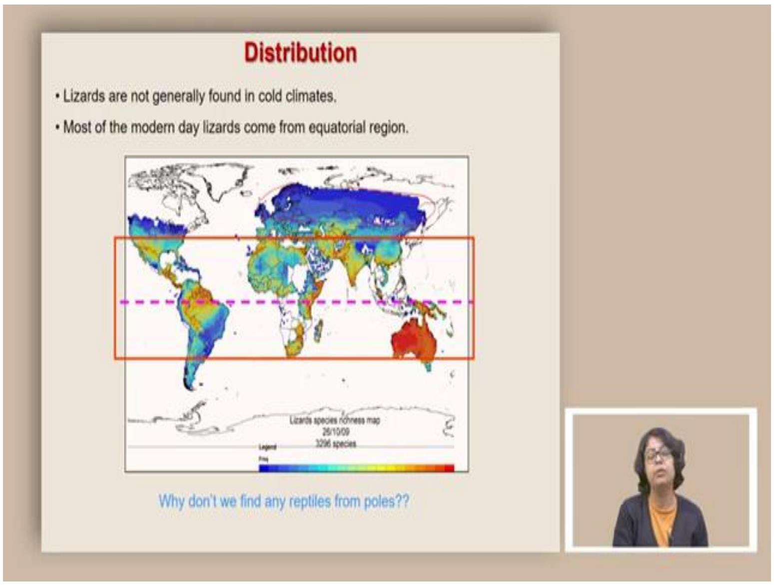

The second important point that is very curious about dinosaurs are their distribution. So, if we look at the reptiles or the lizards today, and where they are distributed, what we are going to find is that they are mostly situated around the equatorial region.

So, this is a plot where lizard species richness is plotted. So, the warmer the color, it means that it has a lot of lizard and if you get to the blue color, it means that there are no I am or there are very low number of lizards. So, if we look at it, in this map, we will find that all the colder places virtually do not have any lizards.

And the reason for this is basically, that lizards cannot live in cold climate because they cannot maintain their body heat, they become very cold and they die. And this is important to recognize, because we have the distribution pattern of the dinosaur also, when we plot the distribution pattern of dinosaurs, we basically find things very interesting.

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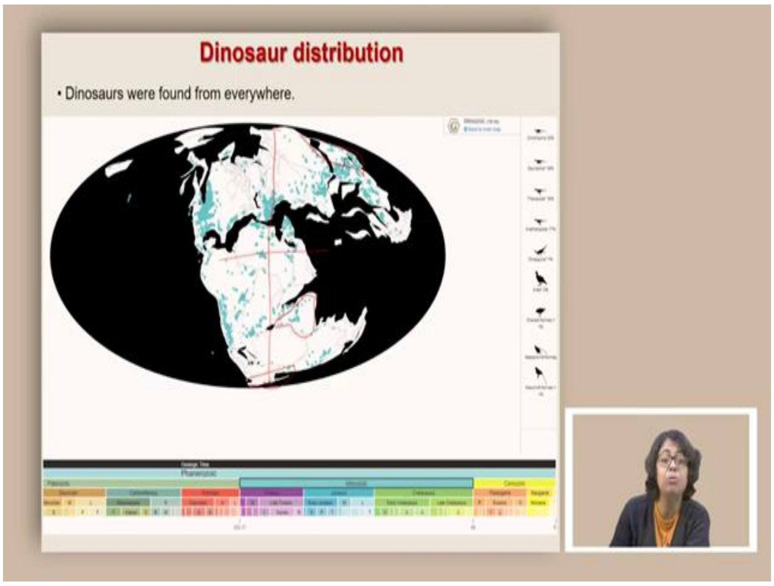

So, this is the distribution of dinosaurs. But dinosaurs lived during Mesozoic where the continental plates were differently organized. So, once you have organized the continental plates, it will look something like this, where you will find Africa somewhere here and then you will also find India right around here.

And these continental pieces have been put together by using many other data points. And on top of it, we have plotted the blue dots, which show where dinosaurs were, and what we find is that we are actually finding dinosaurs in the pole very close to the pole and throughout.

So, their distribution is not really like the reptiles that we see today. They were there in the warm places they were there in very cold places in both the poles. The question is, how could they maintain their body heat, and this leads to a really large question, which is, how do one organism or many organisms, how do the organisms control their body temperature.

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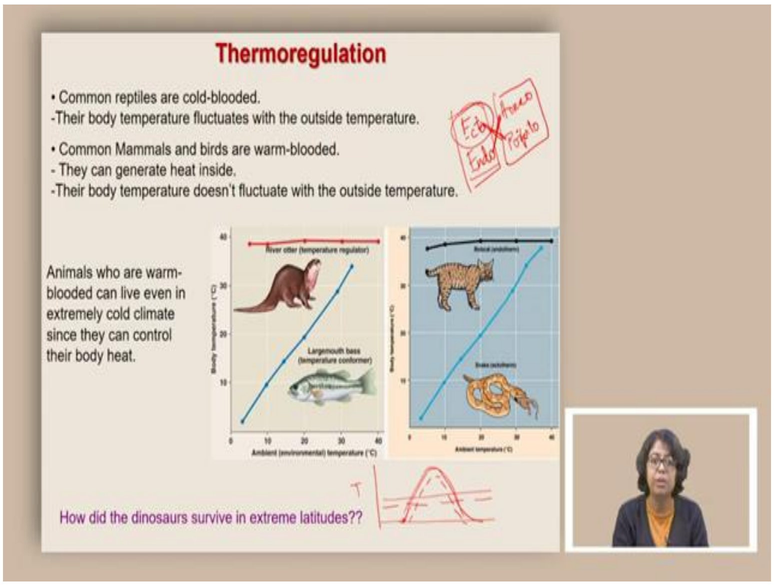

So, that brings us to this idea of thermoregulation. So, thermoregulation means how an organism is controlling their body temperature. So, there are different kinds of organisms, one type of organism, they can create their body heat, and these are generally called the warm blooded organisms. But important thing to remember is does not matter how they are controlling their body heat, these are organisms which can maintain their body heat.

And therefore, they are able to survive even in cold climate, because they can maintain their body heat. On the other hand, there are other organisms which could not control their body heat, they are basically their body heat or body temperature fluctuates along with the fluctuation of the temperature outside.

So, if the day gets very cold, then they basically get colder, and then they can either go to hibernation, and they reduce their body activity. But mammals are very good in terms of maintaining their body heat, they generate the body heat, and therefore, if the climate gets colder around them, they basically increase the intake of food, convert that to heat and maintain their body temperature.

The problem with this is that means they have to eat a lot just to keep their body heat. On the other hand, if you look at the ectothermic organism, which means they are not generating the body heat, they are simply using the heat available outside to keep their body warm and therefore, if the outside temperature fluctuates, then they also have to change sometimes the outside temperature if it gets too cold, they cannot even survive, and therefore they will survive or they will live only in places which does not get too cold.

That explains why we do not find the lizards today in the very cold climates in the near the polar region. But that does not explain how come we are getting the dinosaurs in the north pole as well as close to the south pole. How did they manage to create the temperature and kept the temperature constant inside their body? Now this is one point where we are going to look at two different concepts. We already talked about exothermic and endothermic.

So, ectothermic means that the groups which cannot really generate body heat, whereas endothermic means it is the groups which can create their body heat inside and therefore, control the temperature. Then there is another concept, which is called homeo thermic versus poikilo thermic, homeo thermic means, they can maintain their body temperature very close to one level poikilo thermic means the body temperature fluctuates a lot. So, this is how they do it, and this is what they do.

Now, when we look at these two classifications, we find that generally what we find is groups which are endothermic are also homeo thermic they can maintain their core body temperature and ecto thermics are generally poikilo thermics.

So, that means, if the body temperature, they cannot create heat inside, and therefore, their body temperature fluctuates, if they are going to a colder region, not only that, if we look at their body temperature core body temperature, not the surficial part, but inside their body, if we take the temperature that fluctuates during the day, because at the day as the days goes by, we will see a cold temperature at the morning, then the temperature increases and at night it again goes down.

So, for mammals and other endothermic organisms, what we are going to find that the body temperature kind of remains the same. This is our temperature graph. And for the ectothermic organisms, often, it basically follows the same pattern of the daily temperature, and therefore, it mimics what is outside.

But it is not always true that we are going to find this combination, there can be other combinations too. For example, there can be some of the very large turtles, which are definitely ectothermic.

But if we look at their body temperature fluctuation over the time over the day, we will see that they basically show something very similar to what we would expect for mammals, they are keeping the temperature constant. The question is how come they are keeping their temperature constant.

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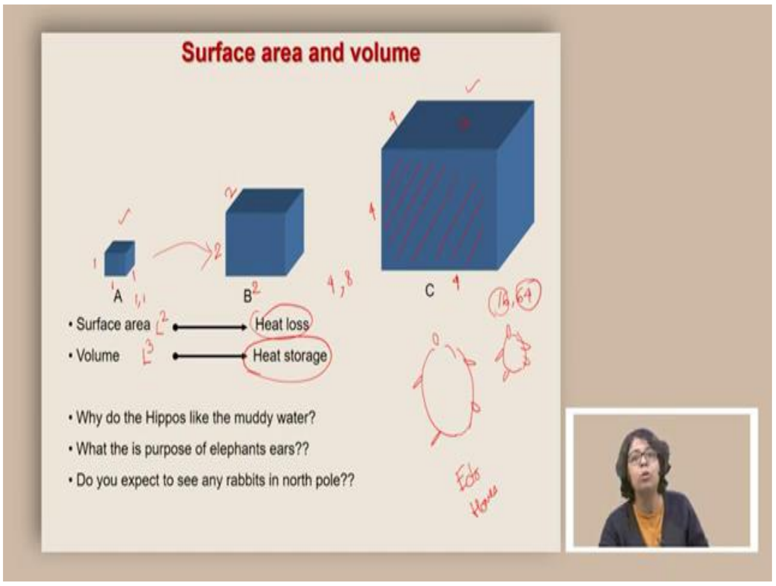

To understand how groups can modulate the temperature, we also have to understand a little bit about surface area and volume. So, surface area as we know that is basically if I have to draw and paint the outside of this box, that is what is going to tell me about the surface area.

If there is a hole here, and I have to pour water and fill the inside part with water, that is what is going to tell me something about the volume so, surface area and volume are not the same. And they are very different when it comes to heat loss and heat storage. The larger the surface area is it loses heat very quickly.

On the other hand, if the volume is very large, it basically stores heat. Now, the question is how surface area and volume changes. Now, let us see, start with a small box. I have taken this box A which is a cube and what I have taken is every dimension of it is let us say 1 centimeter. So, every dimension that I can think of is 1 centimeter.

Now, I am doubling it. So, every linear dimension gets doubled. So, what happens to the surface area? Now, what we see is if I am making 1, to double, so basically I am making it 2 and this one becomes 2, and this one becomes 2. So, then my surface area for this box becomes 4.

So it is going to be 4. On the other hand, when we are calculating the volume, it is going to be 8, so now let us say we are trying to double this even farther for C, so I am going to make it 4, so I am going to make it 4, make going to make it 4, this one also gets 4. So, now, the surface area becomes 16 and the volume becomes.

Now, let us try to double it once more, so then it will become 4 centimeters of this length, and then height becomes 4 centimeters and then this width also gets 4 centimeters. So, now, if I have to calculate the surface area, it will become 16. And then, if I get have to calculate the volume, it will become 64.

Now, what I am trying to show is here, I started with a surface area and volume, which is the same, because here the surface area was 1 and volume was also 1. But the moment I doubled it in all direction, the surface area grew but the volume grew faster, because the surface area is basically the linear dimension square and the volume is basically the linear dimension cubed.

So, if I have to compare this one with this one, what I am finding is just because I have multiplied this linear dimension, I am finding more volume compared to the surface area. And this general principle works for majority of the shapes, that if we are increasing the linear dimension, we are going to see that the volume is growing faster compared to the surface area.

As a result, as groups are becoming larger in size, they will retain more heat, they are going to keep heat storage because the volume is really large. On the other hand, if groups are small, then they do not have enough volume, their surface area is large, and therefore they are going to lose the heat and they will have trouble maintaining the temperature inside their body.

So, now when we think about these turtles, and the observation that the large turtles actually kept their body temperature constant, is because of this reason that the large turtles basically had enough volume, so that they can maintain their body temperature.

On the other hand, if there are small turtles, which do not have enough surface area, do not have enough volume, they are losing the heat faster. Please remember that both of these organisms are not really creating heat inside their body. It is simply the heat which is available outside they are utilizing it.

But the large ones can keep the heat stored inside their body for longer. This one could not. And this that just by being large, they can control their body temperature for longer is a pattern that people have tried to understand and utilize for many groups, which are ectothermic, but also show homeo thermic. That means they can control their temperature, although they are not generating heat inside their body. And the turtles, the sea turtles actually show this pattern.

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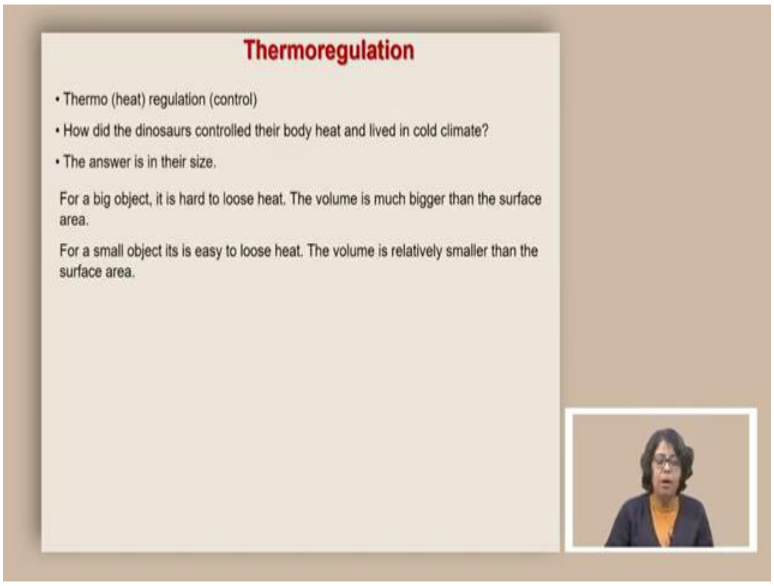

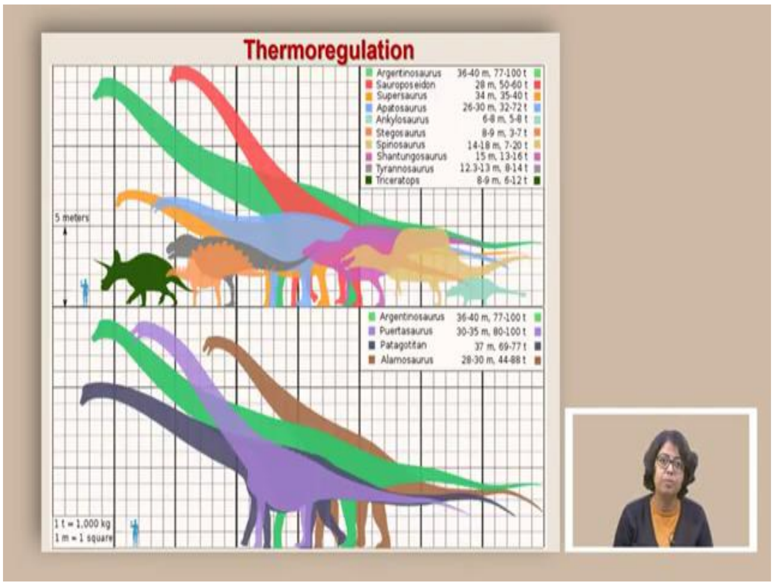

Now, what we find is our size range of the dinosaurs. So, when we look at the size range of the dinosaurs, especially some of the large dinosaurs, what we find is in comparison to a human which is who is 6 feet tall these dinosaurs were really, really large.

And one idea is that they could control their body temperature simply by being big, because they are being big. They had enough volume to store the heat and therefore their body temperature were not fluctuating enough because they were not fluctuating they can survive in temperatures which are sub polar, which are very cold.

So, this sort of explains how we can get all the dinosaurs, these large dinosaurs in the polar region, where today we do not find the lizards in the polar region, the lizards that we are going, we are talking about of modern day they are primarily small, and it is not possible for them to survive in cold climate.

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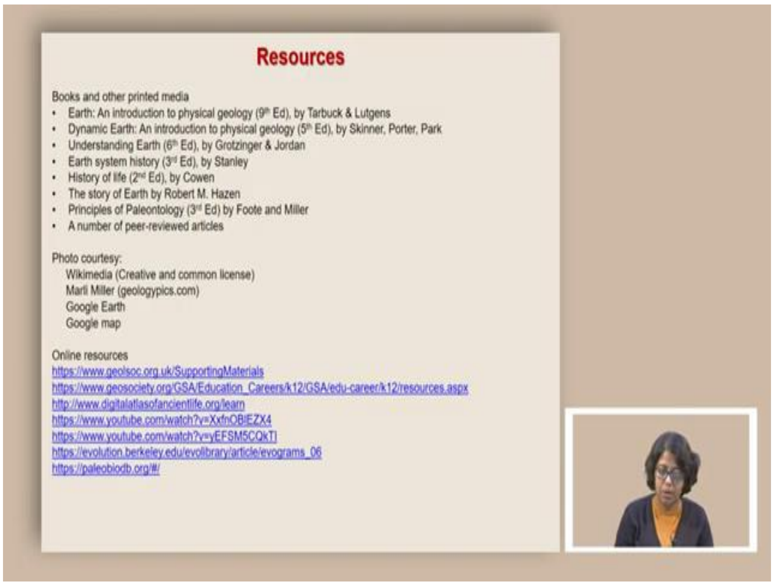

In summary, today, we learned how the group called dinosaur is related to other groups that we see today. We also learned that dinosaurs were quite unique in terms of their locomotion, and thermoregulation.

When we compare them to the lizards that we find today, they had something called an erect gait or upright gait, their limbs were underneath the body, and they could run for longer and at high speed. They also could control their body temperature probably being just big. Here are some of the resources that I used for making the slides.

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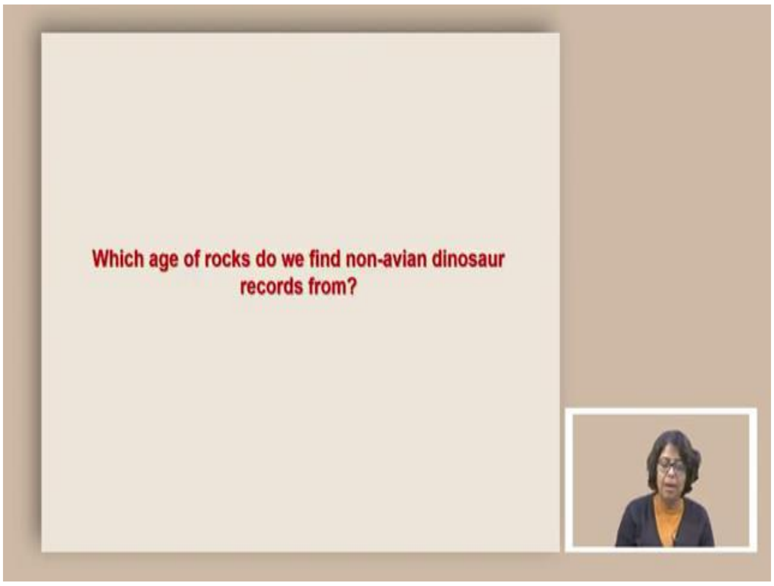

And here is a question for you to think about. Thank you.