**Evolution of the Earth and life**
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**Diversity of Life**

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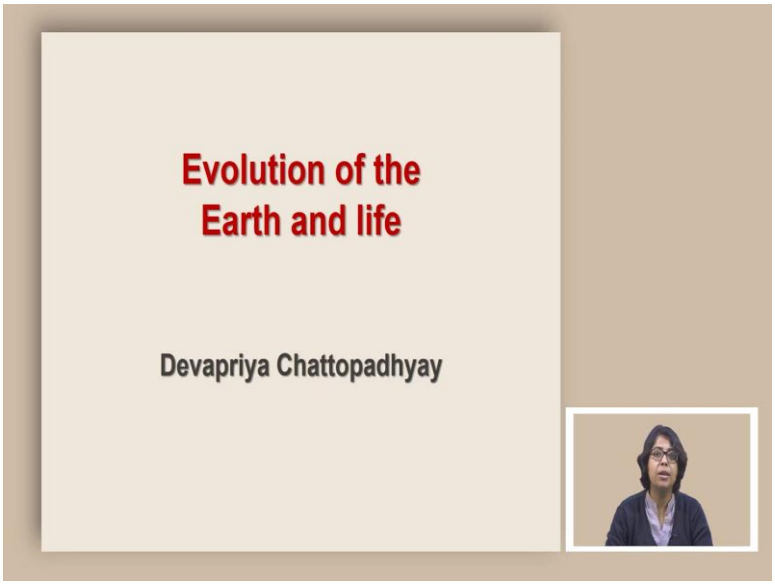


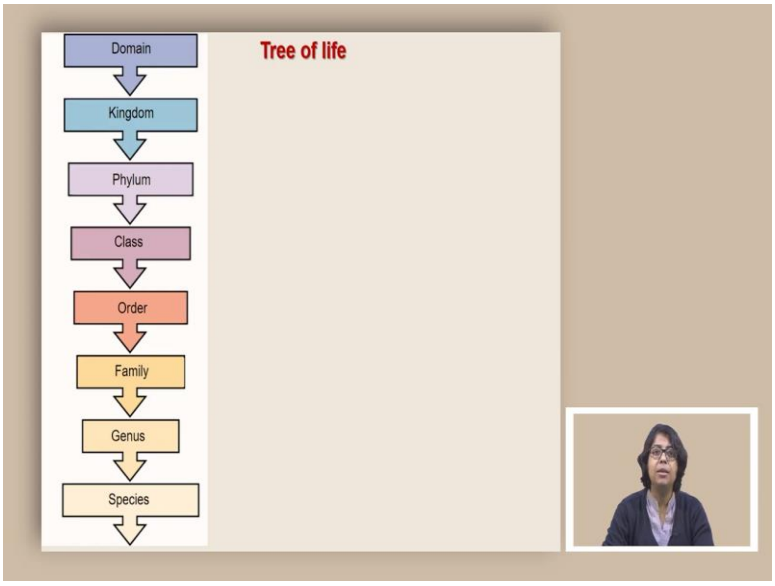

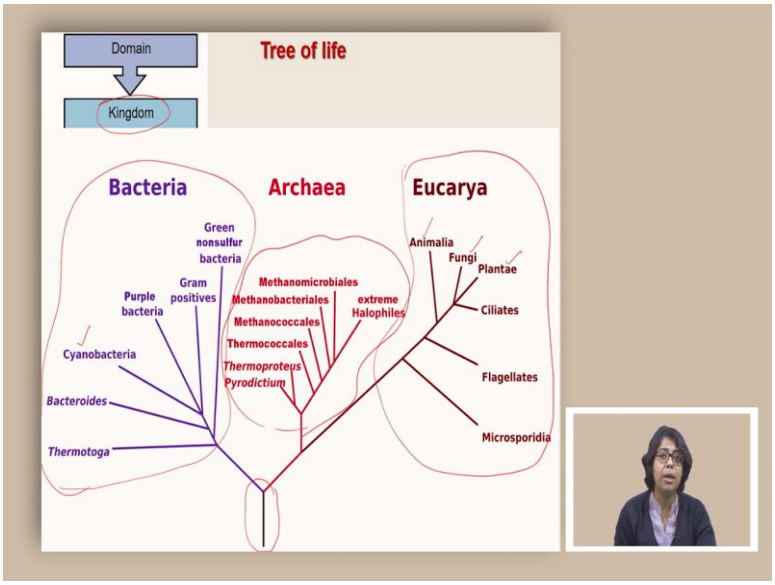


Welcome to the course evolution of the earth and life. Today we are going to talk about the diversity of life. So, when we think about life on Earth, and how different they are, among each other, we need to understand some hierarchical level of the organization of life. And in today's lecture, we are going to focus on that. So, when we think about the diversity of life, it can be classified into different groups, and those groups have an hierarchic order to them.

So, what I mean by that is, if we look at all kinds of living organisms on the earth, they can be subdivided into 3 major domains, what it means is, any living animal will belong to one of these 3 domains. And these domains are bacteria, archaea, and eucarya. And this is like a 3 domain classification, what it also tells us that, all these domains, these 3 domains, they are also connected, that means, all of us at some point of time had a common ancestor from which all life emerged and diversified.

Now, if we look detail into these 3 domains, we will find that this eucarya contains quite a number of groups that we are familiar with, for example, there are animals, there are fungi, there are planned and things like that. On the other hand, if we look at the bacteria, this contains all kinds of bacteria that we are familiar with, and we will come across some more bacteria, which are important in terms of the creating the geologic record. And then there are these relatively ancient group of archaea, which includes extremophiles groups that live in extreme conditions.

Now, if we zoom in to this domain of 3 domains of life, we will find ourselves in a place where we can further subdivided when we subdivided further that level is called the kingdom.

Now, we are going to talk about major kingdoms and for simplicity's sake, I am going to use common names for these kingdoms.

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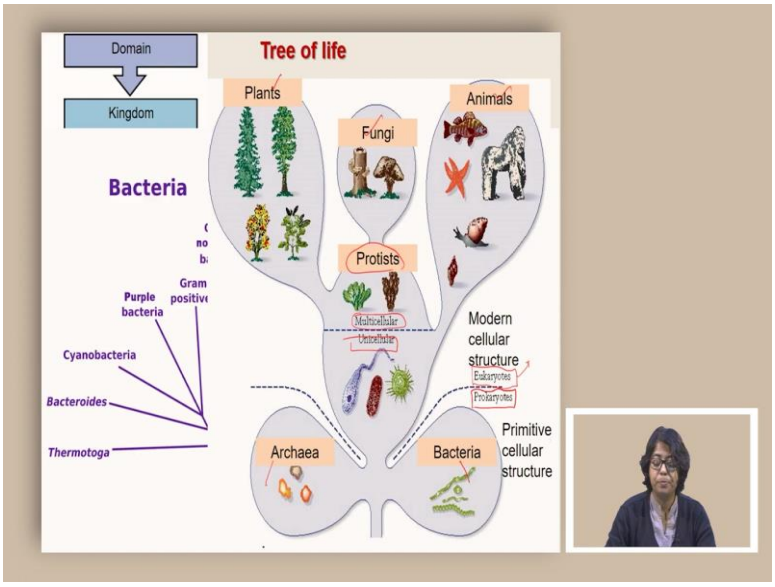


So, if we look at these kingdoms, we are going to find that there are major kingdoms and these major kingdoms have some of them have complicated structure complicated cellular structures, others, on the other hand, have relatively primitive cellular structure. So, if we look at the primitive cellular structure, what we will find that that is what contains archaea and bacteria and in terms of domain classification, they also belong to different domains. And these are all prokaryotic.

So, that means, we are talking about a relatively primitive cell structure cellular structure, where there are no organelles. On the other hand, the ones which are relatively complex cellular structure, they are eukaryotes, where there are organelles, the general size of the cell is bigger. And often we find not only unicellular, so, that means, it is not just made up of one cells, but it can also be made up of multiple cells and some of these cells behave differently and look differently and so, they are basically classified into higher order.

So, within the eukaryotes, there can be unicellular organism but there can be multicellular organisms too. Among protists, we find both unicellular as well as multicellular organisms. And then there are other groups such as plants, fungi, and animals. These are the major kingdoms that we are going to talk about.

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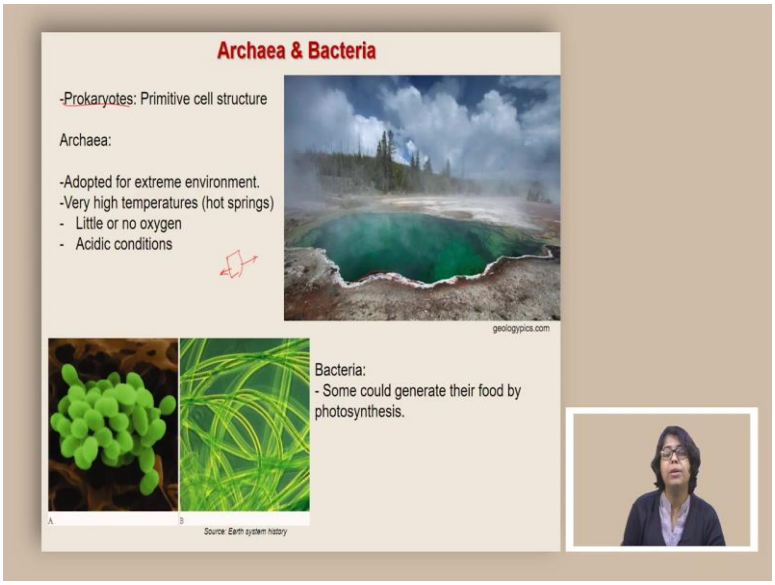


Now let us take a look at some of the most primitive domains, archaea and bacteria. They are also representing kingdom. So both of them are representing prokaryotic cell. It has a primitive cell structure. Now, archaea is even more interesting, because they are adapted to extreme conditions. So what are these extreme conditions, for example, we often find them living in very high temperature conditions sometimes are very acidic conditions, sometimes very alkaline conditions, so they can actually live in very broad range of pH. Often they live in little or no oxygen condition.

So, let us take an example of this hot spring. These hot springs are places where, because of our plate tectonic divergence, the lithosphere is quite thin, and therefore, the ground water gets heated up. And once it heats up, and it also has quite a bit of metal mixed in it, it can create these kinds of hot springs. Yellowstone National Park in the US is a very good example of such hot springs.

Now, in these hot springs, because of the high temperature of the water, the metal can get mixed. So these are areas where the pH is extreme, the temperature is very hot, yet, we find there are Archaea colonies around it. The other place where we can get archaea and a good amount of archaea would be again, other extreme conditions such as hydrothermal vents, and so on. And they do not really require oxygen to survive. And that is why one of the ideas for what might have been the nature of the very origin of life and the first organisms, many people think that Archaea closely resemble those very primitive organisms.

Bacteria, on the other hand, although they also have prokaryotic cells, they could generate their food by photosynthesis, many of them that basically means that even though with a prokaryotic cell, they have some complexity in the cell, some of them are able to generate their own food.

Archaea on the other hand, and many extremophiles for that matter, are using the natural change in the metal, sometimes other elements to survive. So they can use the chemistry they can use the rock to basically survive. So these are often called as chemosynthesis. So basically, they use the chemicals to survive and to create food. Some of them are methanogenic. So basically, they use the methane production in the natural condition, to basically use it for their own gain.

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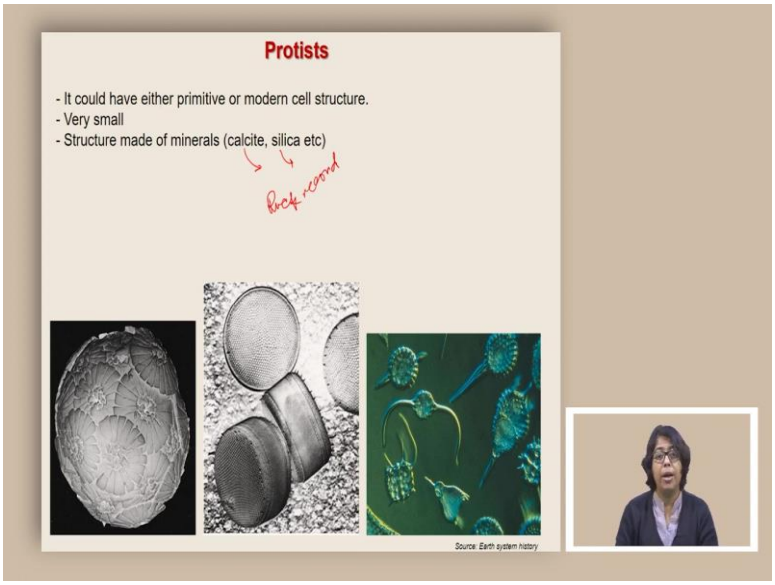


Protists, as we said that protists are part of this unicellular organisms. They are not prokaryotes, and eukaryotes, but they can have single celled organisms, it can have primitive or modern cell structure, it generally is very small. And the structures are made up of minerals, sometimes calcite, sometimes silica, and some of the examples include foraminiferars, radiolarians, coccolithophore, diatoms, these are very important because all these organisms have their external skeleton.

And these skeletons are made up of these minerals. And because they are small, and they come in very large amount, they contribute significantly to the rock record of the ancient ocean, and even of the continent, and therefore, identifying them and analyzing them helps us to reconstruct the history of the rock record and of the life through time.

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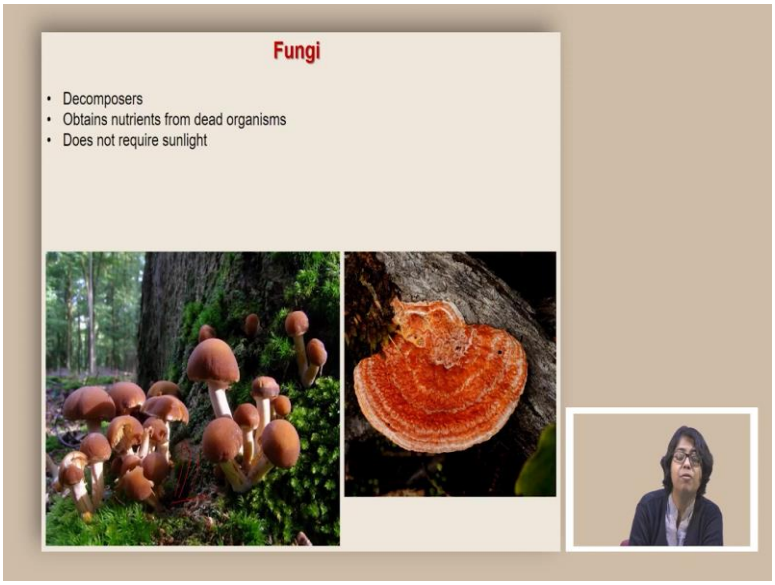


Fungi are decomposer so now we are into the multicellular eukaryotic group. It is a group where they are decomposing existing organisms, and they obtain nutrients from dead organisms. And therefore, they do not really require sunlight. Often we find these fungi very common example is mushroom, in dark, damp places, especially, and places where the tree bark is rotting.

And they extract the nutrients from those, these fungi or the mushrooms as we know them, they are very important because there are times there were times in the geologic past where there was a major scarcity of food, and there was some time when sunlight was not available. These were the times when these fungi proliferated on a regular time, when there is plenty of sunlight, they chose to select a place where there is not enough sunlight, and there is a lot of decomposition.

So therefore, identifying evidence of fungi in the fossil record helps us to understand what the environment was during that time. Now, very rarely do we find such kind of full fungi getting preserved, but they have spores and pollens which can be identified, and then can be linked to the existence of the existence of fungi. So it is primarily the spores that tell us that the fungi was there.

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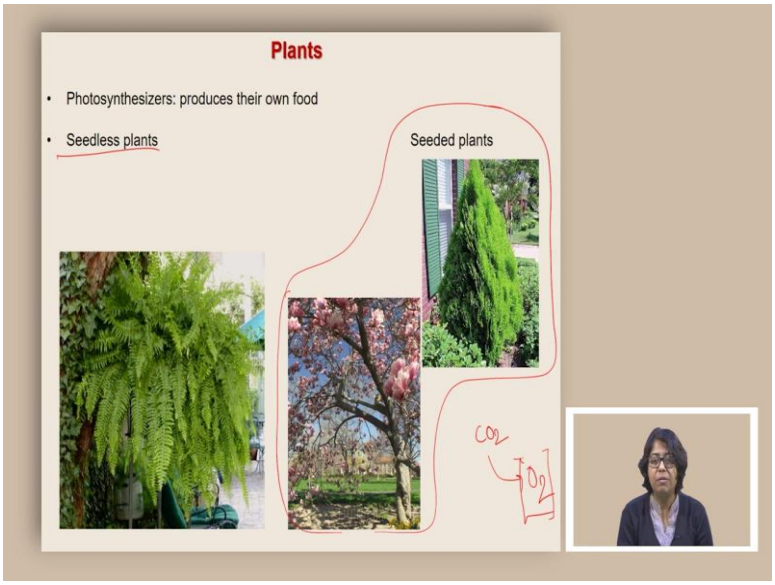


This is probably one of the most widely varying kingdom that is the plants. The primary criteria to call something a plant is going to be the photosynthesis, but there are some other plants which primarily derived their food from other sources, such as extracting existing organisms. So there are some plants which can eat other organisms, but to a general degree, plants are photosynthesizers they produce their own food, there can be different types, one is seedless plants, and bees do not have properly developed seeds.

On the other hand, the more common ones that we are familiar with are the seeded plants, which have very well protected seeds. And because these seeds have different preservation, and they look differently, it is possible to reconstruct what kind of plants were there in the past, just by looking at the pollens and sometimes their seeds, because the seeds survive much better than delicate plants. And these plants have very important contribution to overall existence of life, because majority of them consume carbon dioxide from the atmosphere and produce oxygen and this oxygen basically changes the entire atmospheric system.

So, if we compare the other planets with the Earth, one of the major differences that we see is the amount of oxygen in the atmosphere and plants are the major source for releasing this kind of oxygen in the atmosphere. So, without the plants, the proliferation of life that we see today around us would not have been possible.

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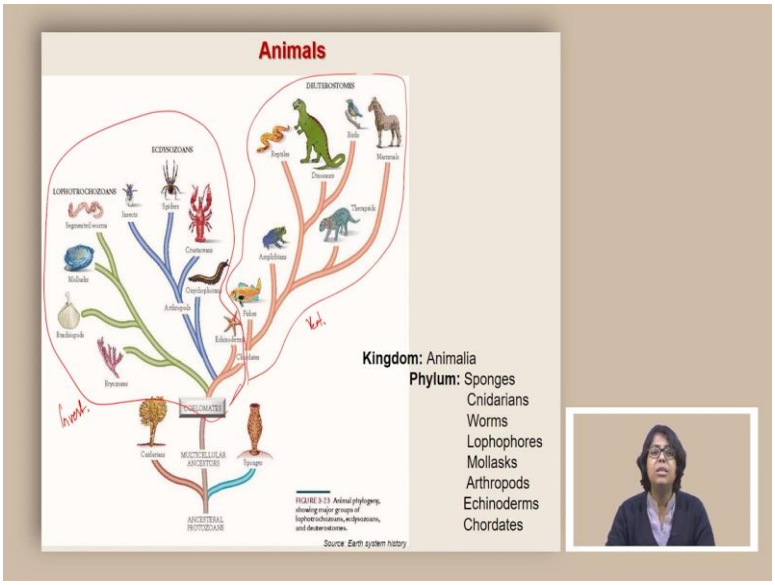


Now, we are coming to the animals, the animals are wide, different and diverse in terms of their nature. So, the major grouping that we are going to do is something based on whether they have a skeleton a particular type of skeleton or not. So, when we think about us as humans, we have something called a backbone and the scientific name for it is spinal cord, and in fact, there is a nerve cord which goes through it.

So, there is a vertebral protection about around the nerve cord. So, any group which has such an arrangement, they are called vertebrates. So vertebrates will have things which has these kind of backbones, there are some very early vertebrates, which do not have these vertebral column they will have these nerve cord but not a proper vertebral column they are often called the caudate.

So this is basically part of the caudate. But then there is another group of animals which do not belong to it. They are also very prolific, but they belong to something where they do not have these backbone. So, we can call them something called invertebrates. Again, this is not really a proper classification in terms of the characters, but this is a way to remember the animals relatively quickly. So, these would be part of the vertebrates and this would be part of the invertebrates. Now, let us take a look at how these groups differ.

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So, first we are going to look at the invertebrates. So, the first group that we are going to look at would be the sponge. So, the sponge has this structure which has porous holes in the wall and then there is a single cavity. So, they basically take water from the outside and from the water, they absorb the nutrients and then leave the water out, this is the way they sort of survive, and they have very primitive structure, they although they are multicellular, their cells are not differentiated.

So, all the cells sort of look the same, the sponges can have a structure which has exoskeleton and this structure can be made up of silica or glass. And therefore, you can have parts of these things getting into the fossil record and that is how we recognize the sponges. The second group that we are going to talk about it is called Cnidaria it includes the corals and the jellyfishes. And these jellyfishes and corals they look very different, because the corals actually have calcium carbonate structure and it looks quite hard.

On the other hand jellyfishes do not have any exoskeleton to speak of, they look very soft. And the way it is connected is basically if you look at the coral structure, what you will see that in individual coral light, it actually has this structure, where there is a Pipelight thing and then there are filaments coming out if you simply invert it, you are basically going to get a structure which is of the jellyfish.

So, this is just to show that they are actually connected in terms of their common ancestors, but they basically changed in terms of which part of the life phase they primarily show during their life. And for both sponges as well as the dairy and some especially in corals, we see

asexual reproduction, whereas in jellyfishes and so on, sometimes we see sexual reproduction.

So, these are some of the differences between the sponges and a group called Cnidarian and other important aspect for these Cnidarian is they have something called a stinging cell. And the stinging cell is a character that is present in corals as well as in jellyfish and that is also a common character between the 2 which belongs to the same phylum called Cnidaria.

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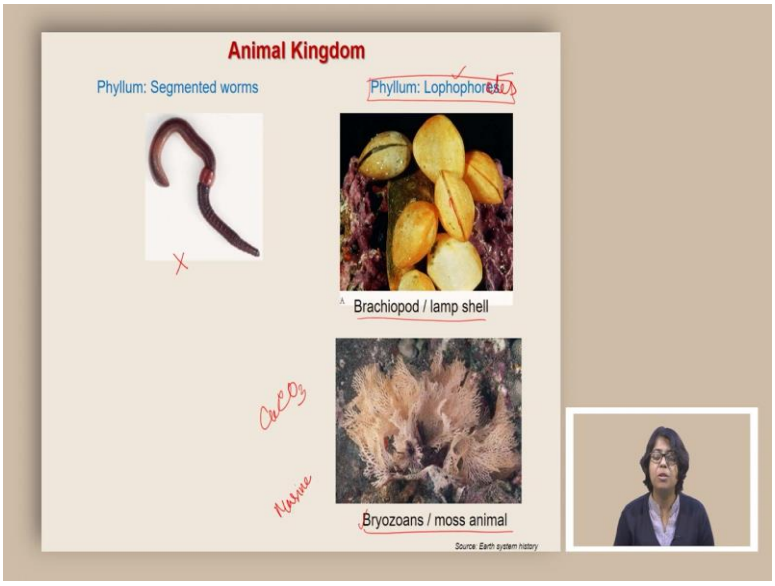


Now, we are coming to different groups, another phylum which is called segmented worms, but we are not going to talk about so much simply because they do not really get preserved so, well in the fossil record because they do not have strong exoskeleton. So, although they are very diverse in modern day we have very little understanding of how they change over time, because of their lack of fossil record.

On the other hand, there are phyllum which are called (()) (19:20) or lophophores. They have different kinds of animals such as brachiopods these are lamps shells, bryozoans these are most animals, all of them have again, a skeleton and exoskeleton which is made up of calcium carbonate and therefore they get preserved very well. Now brachiopods or the lamp shells they have 2 valves that means they can open and close these valves as they want and they are soft tissue is always inside the valves.

And for the bryozoan they create a math like thing, and they often attach themselves to other organisms. And all of these lophophores and bryozoans these are marine animals. So we

primarily look at the Marine groups and we will find them. The same is true for cnidarians too, they are primarily marine animals.

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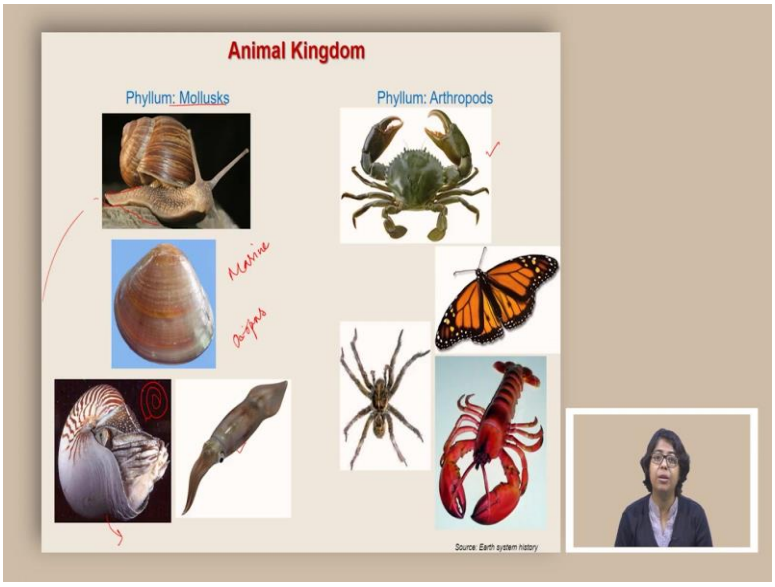


Now, we are coming to 2 more kingdoms which are one of very very diverse kingdoms. One group is called Mollusks, this mollusks include the snails that clams, the octopus, the squid, and some of the extinct animals, such as cephalopods, such as Ammonites, one of the groups are representing that is called Nautilus, which is still surviving today. But some related groups like this which are coiled, are no longer existing. These are called Ammonites.

Now, what is common between all of these which belongs to mollusks, one major criteria is that all of them have a strong muscular foot. And this is one of the major criteria. The other criteria that they have calcium carbonate shells, exoskeleton outside their body is not always true for certain organisms, which lost their shells towards later part, such as these squids, where we find not a very hard exoskeleton but more of an internal skeleton.

We also have Octopus, octopus is basically part of these mollusks, which do not have a skeleton either. So although generally mollusks should have these calcium carbonate exoskeleton, some of the groups do not have it. Another extremely diverse group that we find today are the arthropods. These arthropods include crabs, spiders, lobsters, butterflies, so they are really diverse. And mollusks are primarily Marine, but we also find them on the land, but generally they are aquatic, the arthropods, you can find them in Marine in the terrestrial room everywhere.

And they are one of the most diverse groups on the land, as well as in the water. And they also have primarily these lobsters and crabs, they have an exoskeleton, which is made up of organic material along with calcium carbonate. So these things also get preserved very well.

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These are groups which are relatively little known to us, these are called Echinoderms, so derms means skin, and Echino means spine. So it is a spiny skinned organism. Some of the common examples of these are Sea urchins. So, these are ball like thing, which has a lot of spikes and spines, and they live in water exclusively in the marine region, and generally they live in relatively deeper part. And this is another example of Echinoderms this is called a sea Lily.

So, it has a stock and then it has a flower like structure. So, although it looks like a plant, it is an animal, so it basically receives the water absorb the nutrients from it, and then leave the water out. So, these are sea lilies and this is sea arching, these are all examples of these external domes, they also have the skeletons, which is made up of calcium carbonate. So, these also get preserved quite well.

Now, we come to this large group called Chordata. And this chordates are the groups where vertebrates also belong, so there are certain chordates where we do not have these vertebral column. So these are some of the primitive coordinates and some of them are even represented in the fossil record. But then there are other chordates, which actually have these vertebral support around their nerve cord.

And those are called vertebrates, like fish, like the frog, which is an amphibian, like a reptile like the crocodile like a bird, which we see and also the mammal. So we have fish, amphibian, reptile, bird, and mammal and we will see that some of these relationships are not as well distinct as we think they are. But overall, these are some of the most common animals that we see on the land as well as in the water. They are generally big, much bigger than many of the invertebrate groups that we talked about, and their fossil records also show that they have high diversity throughout and especially particular during particular times of the geologic record.

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Now, let us take an example of how it works. So, if we start with this particular animal, we all know that it is a dog. But now, if we go through this classification, this hierarchy classification, it looks quite interesting, it belongs to domain Eukarya, because it has an eukaryotic cell, it belongs to Kingdom Animalia it belongs to this animal group. Then, there is another subgroup which is called phylum.

And we saw that the ones which have vertebral columns, definitely the dog has it, it belongs to the phylum Chordata. And then it has a mammary gland it lays young pups not lay eggs, and therefore it belongs to the class Mammalia then it comes to the further subdivision which is called an order, the order is carnivora. So this is basically indicating that this is part of the group which eat flesh, then it has a family, at a family level. It has a name called candidates primarily because of the tooth structure.

So that is where it gets differentiated from things like maybe the big cats. And then we farther go down and we find a genus name, which is Canis. So even if Canidae include things like Wolf, the genus is very specific to the dog. And then we also have a species which is Canis lupus, which is true for this particular type of dog.

So this is the hierarchic arrangement of different structures, different stages of classification of tree of life. And we use that to know how groups are related and also what groups we are looking at. This is an interesting game that you might want to take a look at. This basically asks you about the diversity of life. And also you can play a game of a remote island where you can have a development of different communities by choosing from this entire tree of life.

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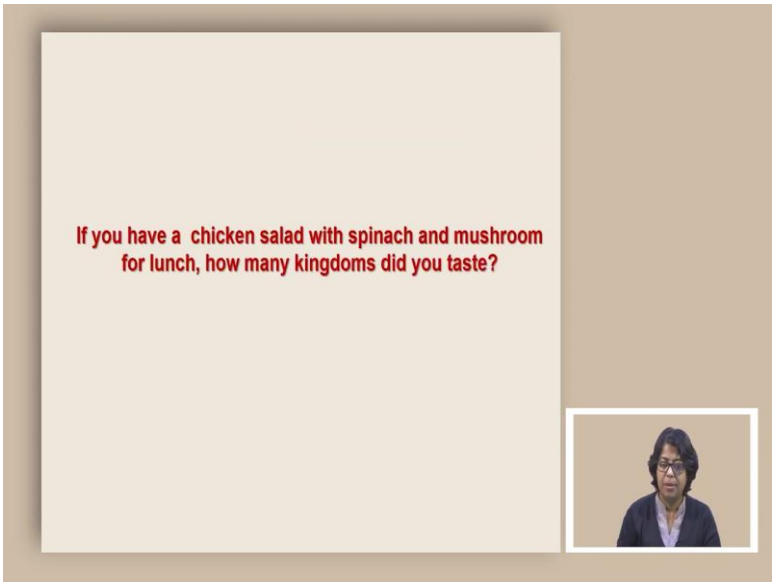

Here are some resources that I used for making the slides and here is a question for you to think about. Thank you.