Evolution of the Earth and Life
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Course Structure

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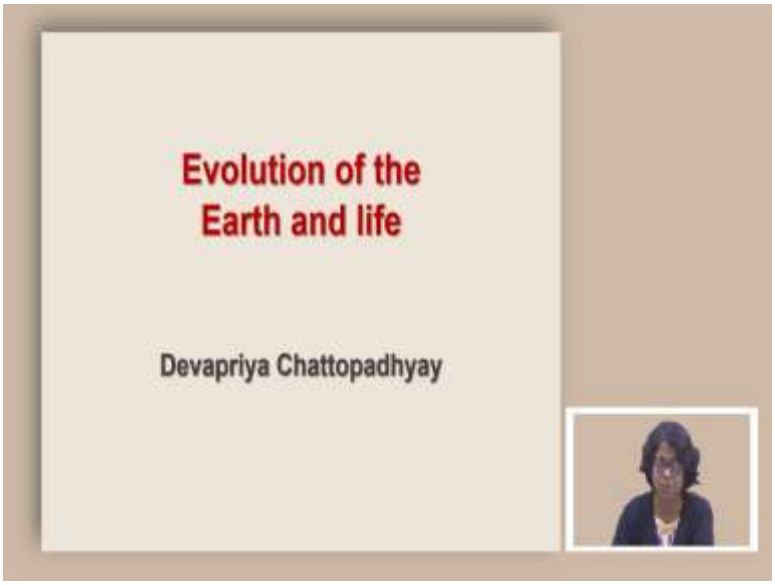

Welcome to the course Evolution of the Earth and Life. Today we are going to talk about the structure of the course, and what we are going to cover in the course.

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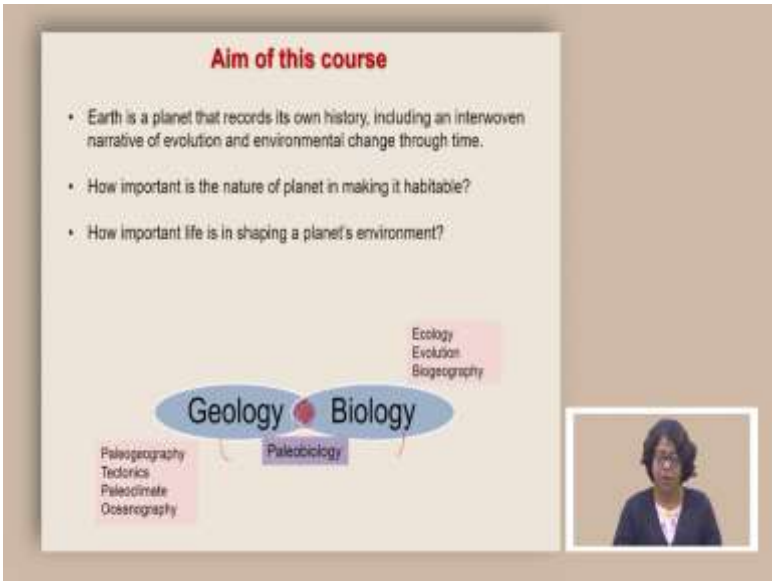

Earth is a planet that records its own history, including the interwoven narrative of evolution and environmental change through time. And it is very important to ask this question that how important is the nature of planet in making it habitable? Why do we have only one

planet? According to the recent scientific understanding, which supports life in the solar system? Is there a very special thing about the earth that makes it habitable?

Another important question that one may ask is, how does the planet change if it actually has life on it. And that is very important, because if we actually understand how the planet changes with life in it, probably it can also give us some indication what to look for, if we are searching for life, outside Earth, what kind of indications in terms of the planets outside the planets morphology, the atmosphere should be looked for, as an evidence of life.

So this course, tries to answer some of these questions by looking at the history of the Earth as well as life. So there are two disciplines that we will try to cover. And we are going to primarily focus at the interface of these two disciplines. One discipline is the discipline of Geology; geo means the Earth. And logy comes from the word logos, which means study, or knowledge.

Biology, as we all know, it is the study of the life form. And this course will somewhat reside somewhere in the intersection. And this intersection often is also called paleo biology, palaeontology. Now, the whole goal of this course is going to be using different tools from both geology as well as biology to understand the history of the earth and life as it progressed. And once we understood that, it would be an interesting challenge, to use those things, to understand our surrounding better, and also probably use it to look for the evidence of life outside the earth.

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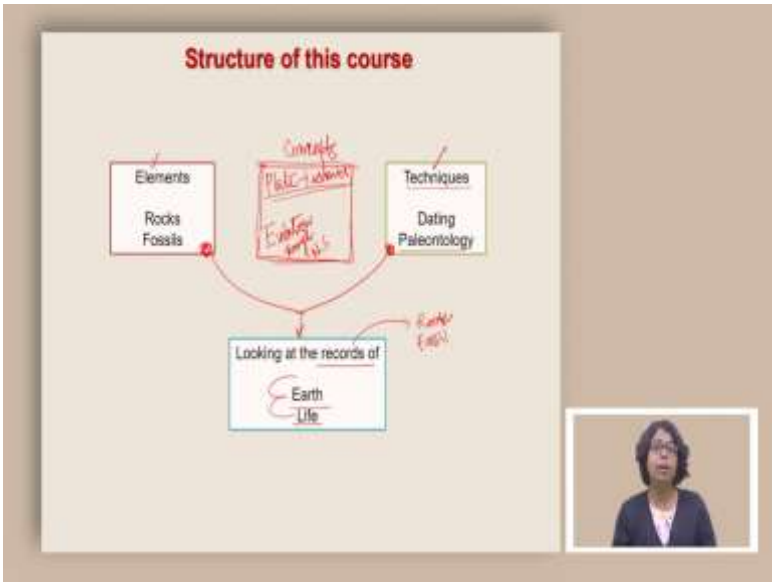

Now we come to the structure of the course. And if we look at the structure of the course, the course has primarily three components. The first component, I am going to call it the elements. So, these are materials that we study to look for the record, these materials include Rocks, Rocks, also include minerals, which they are made up of, we look for Fossils, Fossils are remnant of past life, and these are going to be the elements that we will be studying. And because we have to use these eventually, we will study how they form, what different types we can expect and how do we recognise these different types.

All of these we will try to connect with some general concepts rather than looking for a lot of information. So that if you remember these general concepts, it would be easier for you to recognise some of these patterns without memorizing a lot of information. We will also try to understand some of the techniques and these techniques include some of the techniques by which we date Rocks, these are called Dating Techniques.

We will also try to understand how to read the Rock record in terms of life and that is the goal of Palaeontology. These techniques, again come with a lot of advanced modelling. But for the simplicity sake, we are going to avoid some of these more complex parts in this particular course. And we are only going to focus on the basic principle, these basic principles would help us to understand how these techniques work, where these techniques can be used. And more importantly, what are some of the limitations of these techniques.

So that, when we read the record, we will also be aware of the assumptions of limitations. Finally, once we are comfortable with the elements, as well as the techniques, we are going to use it to look at the record of the Earth as well as life to understand how the planet changed over time. Now, this record will be in the form of rock, will be in the form of fossils. And we will use the techniques that we learned in the beginning of the course and the understanding of the elements to read each set of changes, to look at how, what it is telling us.

Now, let us try to understand how we can do it. So, once we know the basic elements of geology and biology, we will also know some basic techniques, we will look into a specific timeframe and ask these questions, the general questions, what was the earth like? And how do we really reconstruct back in time, when we really do not have any way to be present there at that point of time. The second point that we are going to do is to ask this question, that if the Earth looked like this, if the Earth had this kind of an atmosphere, this kind of land, this kind of a sea what kind of life it can support.

So we will build the expectation of what kind of life it can support, and then check the fossil record, whether we are finding that kind of a life, if we are finding something different, then we also have to link it to the condition in the earth, what might have led to the appearance of that particular group or more importantly, selection of that particular group, because of which you see them in a large number. So it will also have a general idea of how groups are changing.

So two major concepts that we will be using throughout the course. And we will have a special mention of these concepts. Apart from these event elements and techniques are. From geology, it is called plate tectonics. So plate tectonics is one of the major advancement in geology, which is a general theory or general working that connects all the spheres of the earth. And it is very important to understand it very well. And we will do it at the beginning of the course.

The second point or the second concept that we will be using again and again is the concept of evolution, particularly evolution through natural selection. And these two concepts are fundamental to this course. Now, many of you may have had a background on plate tectonics or evolution through natural selection, but what we will do for this course, is to have dedicated lectures and assignments to ensure that you have a better understanding of the concepts of plate tectonics as well as evolution, because without these two concepts.

It would be very difficult to build the history of the Earth as well as history of life, because these are one or these are some of the fundamental governing principles that on which we are going to look at. So, these are going to be the major structure of the course. Now we are going to go into the details of the course that what can you expect in this course in terms of the beginning, the middle part, as well as the end part?

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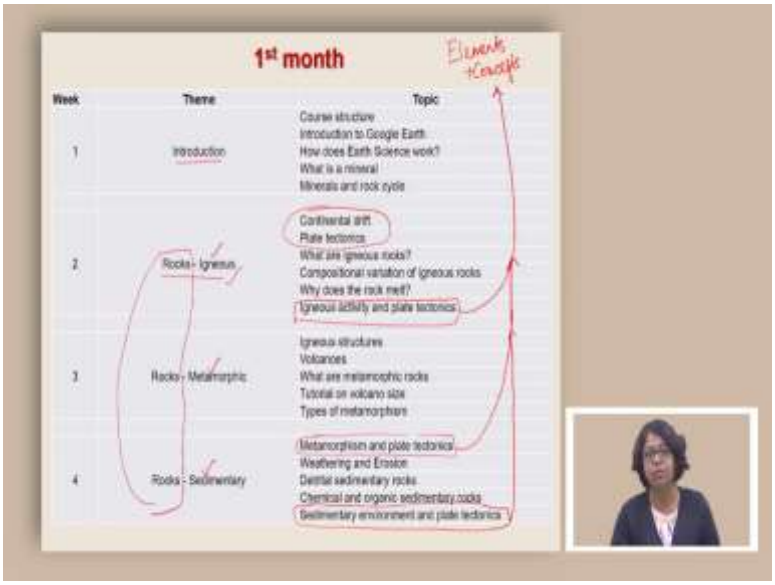

The beginning of this course, the first four weeks of this course, it we will primarily focus on the elements, the ones that we talked about. So it will have components of the elements. But it will also have some component of the concepts, because we are going to cover plate tectonics in this first part.

So, if I roughly divide this first part of the course, the first one third of the course, the first four weeks of the course, will see that the first week, we will devote on the introduction and which will include the basics of what is a mineral what is rock cycle and how minerals are connected with rock cycles. It will also tell you something about how the Earth system science works. Because Earth Science is often quite unique and quite different from many other scientists.

And what are some of the key points key aspects of earth signs that makes it unique? And how should you think about it, and how your thinking process should be geared towards that sciences. So that we will cover in the first week, the next three weeks we will spend on developing our understanding of the elements as well as concepts. So the first, in the second week, we are going to cover plate tectonics, starting from its historical background, and moving onwards to the present understanding of plate tectonics, and where we find it, how we find it.

What are the evidences, what were some of the pitfalls of the original idea how that got mended? So it will take on a journey of how we understand a particular theory and how it came to be. We will also include more things into our elements list. And because of that, we

are going to cover three types of rocks these three major types of rocks, igneous, metamorphic, and sedimentary rocks. So we are going to have detailed discussion of each of these rock types.

Where can you expect it? What are the different types? How do you recognise it? If you recognise a name, what does it tell you about its formation. But as I mentioned at the beginning, that every time we will try to link these elements to a concept, and therefore what we are going to do, every time we talk about a particular rock, we will finally try to link it to our general concept of plate tectonics.

So if you look at the igneous rocks, we talk about different types of igneous rocks, how they are generated, what are some of the processes involved in it, how the different parts of the earth is basically interacting to form these rocks. But then finally, we will also talk about how it is linked to plate tectonic activities, because that is our link to the concept. And hopefully, this will help you to remember and internalize that distribution of different types of rock and where you can expect it through a process rather than simple in discrete information.

Then we will also talk about metamorphic rocks. And again, after talking about the types and simple classification will again link it to this general concept of plate tectonics. And where can you find these rocks, which you can predict from the plate tectonic setting. Finally, we will talk about sedimentary rocks which we find at the very surface of the earth, and it also interacts with other spheres such as biosphere hydrosphere. atmosphere, and therefore brings a fantastic record of different types of interaction between these spheres.

And we will also link it to how we can guess the plate tectonics setting and movement of the plates using records from sediments and sedimentary rocks. So the important point to recognise is in each of these themes be it the rock theme igneous rock, metamorphic rock and sedimentary rock every time we are going to connect it to a process.

And therefore, your understanding should be very clear, we will reiterate it again and again, so that you can connect it to the plate tectonics setting in every case. And plate tectonic would be the guiding general principle based on which we are going to understand the working of the Earth, especially at the shallow as well as deeper level.

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In the second phase of the course, we are going to move on to a bit of life. So first we will talk about what is life? And what kind of life do we see today? What can we infer from different types of life, about their relatedness, then we are going to specifically talk about some of the concept.

So this particular lecture is again building the concept of evolution. And, on top of it, we are also going to learn a bit of elements. And these elements are going to include the life how many different types of major, how many different types of life do we have on Earth? How do they look like when did they appear? Can we talk about some similarity between them? How do we even know some groups are connected and others are not? How are they connected?

So, we will ask all these questions in the diversity of life. And we will also try to understand how to develop a mechanism to understand it. Finally, we will also talk about how the record of life look like. So in other words, we are going to talk about a bit about fossils. What are the different types of fossils? And how do we recognise a particular fossil where were they formed?

How did they form? So, these would be part of this lecture? And all of these are going to basically develop our understanding about the elements as well as the concept related to life. And that is something that we are going to cover in the middle part of the course, at the beginning of the second part or I would say the middle of the course, the first week, we will talk about life. Now, we will move on to a part which we will call techniques.

Now, these techniques will include the dating of the rock, but part of it will also come from here because this is also part of the technique that we will be using in dating of the rock. So, in here, we are going to talk about different methods of dating the rock, some methods are more qualitative, whereas other methods are more quantitative, what is the need of a qualitative method versus quantitative method?

How are they related how one uses it and then we are also going to use some of the common methods to as examples to display, how each of these methods work. Once we are done with the concepts, elements and techniques, we are going to move on to build record or in other words, we are going to start reconstructing the record of the earth and life through time. And we will first start with the early development of Earth. And we will use various techniques that we learned in this part as well as some understanding about the concept as well as elements to reconstruct the very early history of the Earth.

We will use other elements such as meteorites observation from other planets, but those are not part of the elements that we discussed in the first part of the course. We will basically build it as we go along because then it will be easier for you to connect it to the immediate discussion. In the final part of the second part of the course. We are going to talk about the development of very early life, we will basically define how this transition happened from non-life to life.

What was the condition like at that point of time? Where was the setting where this transition happened? And once we are comfortable with this idea of moving from non-life to life, we will go for the evidences that we have of the early life, what is the nature of the evidences? What are the things that we learn, what are the things that we are not sure about? And we will basically tease apart different kinds of methods that are used to reconstruct this history.

Here in this part, we are also going to use a bit of concept about stable isotopes. And this is a technique that we are going to use on multiple stages. Because this is one of the very important techniques that people use in earth sciences. So, we will start talking about it when we discussed the early life and evidences, but we will also build on to it as we move to the last part of the course.

So, apart from the general concepts that I mentioned at the beginning about evolution, and plate tectonics, and techniques, like dating techniques, we will also be building some of the

more concepts and techniques as we go along. And one of the important techniques is the stable isotopes. How do we look at it? What do they tell how to use it for different purposes?

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The final part of the course will be primarily dedicated to look at the history of Earth and life, and what we will learn about their interaction. So, there are three particular times in geologic timescale that we will talk about, and we will move from oldest to the youngest part. And moving on, it is going to tell us how the life evolved through time. So, Palaeozoic is one of the older part of the timescale, where there was abundant life, then we have this middle life, and then finally, more recent life.

And what we are going to target in these particular times are the major evolutionary transitions. What were the major changes that we see in the ecosystem? What were the major changes in life that we see today? What were the major groups and how do we find one group all of a sudden, is it a sudden phenomenon or do we see links from the older group to the newer group. So, as a point, we will try to emphasize examples of such transitions.

So, we will talk about transitions, such as transitions from fishes to tetrapod, it can also be called from water to land. So, this is a transition that shows you how groups moved from water to land. We will talk about some of the major events in the Middle life and how they are connected to groups that we see. We will talk about at depth about extinctions. This extinction is a phenomenon which basically talks about the annihilation or wiping out of an entire group.

How does it happen? How many times did it happen in the long past? Can we comment about something in terms of the rate? Are we in the middle of another mass extinction? Does these rate compare? So all of these questions we will try to go through during this part of the course. And we will also talk about some interesting organisms such as dinosaurs, which peaks everybody's curiosity and we will see how they are connected to other groups that we still see today. And we will ask this question are the dinosaurs really extinct?

Finally, we will come to the more recent part of the history of the earth and life where we will talk about the importance of climate change. And this climate change is not the most recent climate change, we will see the record of climate, and how do we read it. And we will talk about especially constructing the past climate. And once you have constructed what does it tell us about the changes in the climate? Is it the first time we are facing the climate change? Or was it part of the Earth's history, which also shows several events of climate change, and we are going to discuss these things.

Finally, we will come to the very end of this course. And we will look at the very young record of the planets. That is why it is called quaternary and beyond, it will also merge into something which we can which is popularly known as Anthropocene, a time where with human domination, so we are going to talk about the changes that was brought with human evolution.

What was the effect on the biota around us? What we see now, and what was happening when the human ancestors started, or had its footprints on the earth. Finally, we will also touch upon something about the environmental crisis of today's world. What can we do about it? What do we learn from the past and whether the past actually teaches us something to do about these environmental crises? And this is going to be the overall structure of the course. Now, we are going to focus on a little bit detail about different aspects of this course.

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The course has an integral part of assignments. And for many of these assignments, we are using interactive learning tools such as Google Earth, PaleoDB, and many others. So I will just briefly talk about Google Earth, Google Earth is an open access app, where you can look at the Globe, and you can basically rotate the globe, you can find a particular spot, you can do a lot more self-learning using this particular app.

Not only that, it also has a very detailed picture satellite imageries of particular places, you get the latitude and longitude of a particular area. These are the important information to locate an area. So unless you have the latitude and longitude, it becomes difficult to find a location on the planet. On top of it, if it is in a region where there is a height change, then the same latitude and longitude we have multiple locations unless you are specifying the height or altitude.

So that information also comes in Google Earth. So we have designed multiple assignments for you, which will require Google Earth and there is also an in depth tutorial about Google Earth telling you exactly how to use it, how to navigate through it, and what other things you can do. So those are going to be targeted towards your assignment. PaleoDB is another open access portal where a number of fossil occurrences are recorded.

Now the Paleo biology database as it is known, what you can do, you can actually plot all kinds of fossils. On the present day map, you can also reconstruct how the Earth looked like, couple of million years ago, you can reconstruct how the continents look like what was their configuration, you can develop something called paleo geographic map using paleo biology

database. And most importantly, you can know where some of the organisms were at a particular time of and that helps you to understand some of the concepts of plate tectonics.

It also helps you to understand some of the concepts of evolution and these will be an integral part of the course. So we will have another in depth tutorial session and in depth demonstration of how to use PaleoDB what are the features and how you can use it. Apart from Google Earth and paleoDB, there will be other assignments where you will be asked to either solve a numerical or you will be asked to solve some of the problems related to rocks trader and arranging them in terms of ages, you might also be asked to solve some of the questions related to stable isotopes, but all of these we will be covering in the course and you will be expected to follow some of the instructions in the assignment to do hands on activity. So, the purpose of this course and the assignment is to give you a flavour of the hands on activity that are associated with earth sciences.

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Finally, every lecture will have detailed links to different materials that we covered in the lecture. So, you would be encouraged to go to some of these materials and explore some more. There would be a list of additional textbooks which you should be able to check and learn more. Every lecture will contain a question for you to think about.

So, those questions would be a quick check for you whether you got most of the concepts correct in the lecture. And every week we will also have a discussion on those questions and some related other questions. Finally, there would be some discussions on general doubts

many of the times over the years, there are questions which I can anticipate that would be creating a lot of doubt.

So, I have already had discussions on those common doubts and talk in depth about many of the related concepts. So, I hope that in this course you actually enjoy learning it and also get a flavour of how Earth Science works. And you can have an Hands-on activity to help you learn and enjoy and appreciate the fun and wondrous journey we have in Earth Sciences. Thank you.