Earth Sciences for Civil Engineering
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Module 1
Lecture No 1
Introduction to Geosciences in Civil Engineering

Hello everybody, my name is Javed Malik. I belong to Department of Earth Sciences at IIT, Kanpur and my specialisation is Paleo-seismological and Paleo Tsunamis. So basically, I look for the signatures of ancient earthquakes and ancient Tsunamis reserved in the sediments and preserved on the land forms. And mostly, our research work is along Himalayas and in Andaman and Nicobar and in Kutch region. So mostly I deal with the one of the hazards.

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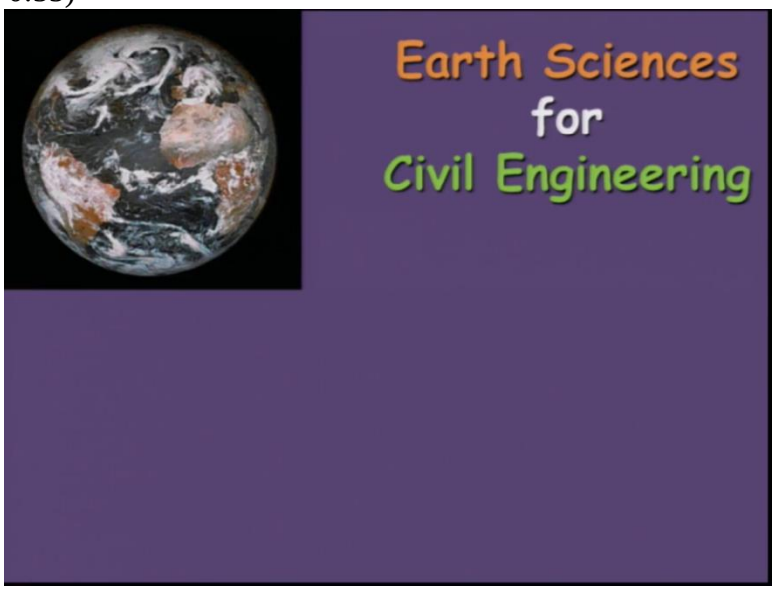

Now this course with them offering, I am extremely happy to offer this course because most of the time, we ignore most of the earth processes which are taking place along this. And this course is extremely important for the civil engineers in particular because we keep on doing a lot of construction and as we know that in couple of years or maybe in the past one decade, we had a boom of construction which is going on. And we are not very much concerned about the hazards or the earth processes which are taking place around us.

So every day if you move on this earth surface, a lot many processes are taking place and we should be aware of that. And in particularly for civil engineers, it is most important because we are coming up with a lot many townships, bridges, roads and all that. And we need to understand

that what type of constructions we are doing? What is the foundation on which we are putting the structure? And what will be the hazard which will be associated with the plate motions or any other related features on the Earth's surface.

So mostly what we can do is, of course is we talk about the hazards, we can minimise the hazards, understanding it and of course when we are coming up with some major townships, we need to know the land use better and all that, okay and the construction material.

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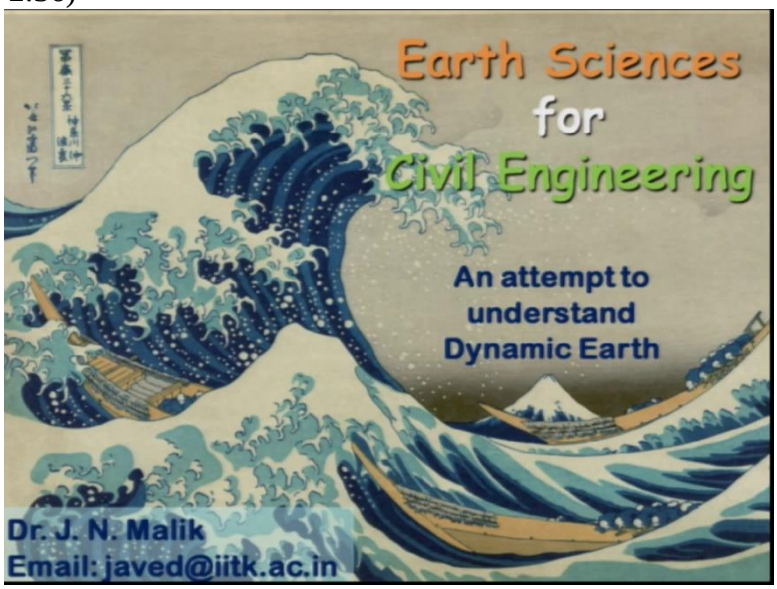

This is a picture of Tsunami which is from Japan and which talks about that how tsunami can affect the day-to-day life in any region, particularly in coastal regions and all that. So now what we will basically try to do is that let us have an attempt to understand the dynamic Earth and understand the processes which are cutting around us.

So I believe that you might be having the course content with you people but we will start slowly and then try to understand point by point and go into the greater details when we are talking about the individual aspects of geosciences or earth sciences. So this particular lecture, the 1st lecture, we will talk about the importance of geo-sciences in civil engineering and as a whole and then we will get onto the plate tectonics where we are going to talk about the rock cycles, how the rock cycles and the plate tectonics is linked, how do you not are formed and all that.

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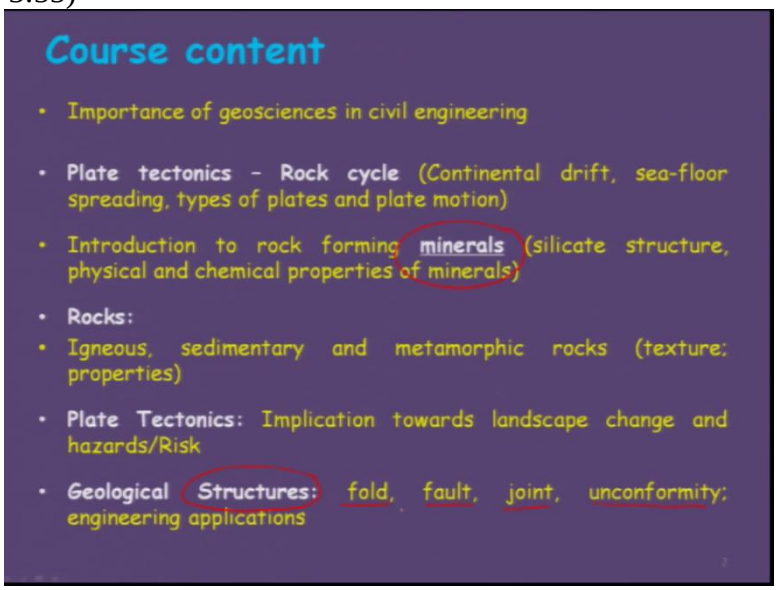

And while discussing about plate tectonics, we will talk about the Continental drift, seafloor spreading, and type of plate motions and all that. And different types of plates like continental plates and oceanic plates and all that. And then we will talk about the different type of rocks. But before moving to the different type of rocks, we will discuss about what is minerals? And what are the different types of minerals? How they are formed? At what temperature they melt? What is the importance of magma flow and all that?

We will talk about that. And then, coming to the rocks. As it is known, we have different types of rocks which are produced at different locations. Like igneous rocks, they are related to volcanic eruptions and volcanic intrusions and then we are having sedimentary rocks, we are having metamorphic rocks. Sedimentary rocks or the rocks which are formed from the eroded material or the sediments when they get compacted or solidify.

And the metamorphic rocks usually are seen which metamorphose, the material which is metamorphosed at the crater that of the earth interior under greater pressure and temperature. So we will try to look at the properties of these rocks and then, when we are talking about minerals, then we will be able to talk about how the different minerals are important in terms of their hardness and all that. This also will help us in understanding the different types of rocks because as a civil engineer, you need to know that what type of material for the construction part.

And what are the materials which are available in the near source, near the construction area? So that is also important as a part of the exercise, as part of the resource. Then we will talk about the plate tectonics, implication towards landscape change and hazards and risk. Now plate motions have resulted into a drastic sculpturing of the landscape over the time. And one of the best example what we see in the Indian subcontinent is the Himalayan formation, the formation of the Himalaya. Himalaya was formed because of the plate motions, when the Indian plate collided with the Eurasian plate.

That also we will talk when we are discussing the plate motions and the plate tectonics. Then, this particular, there is a geological structure. That is extremely important when we are trying to put up any single structure in any particular area. And these all features like fold, fault, joints, unconformities are seen in most of the rocks because the plate is under compression or plate is under, the tectonic forces are deforming the plate. So we will be able to see this type of geological structures at most of the places.

And we need to know because these geological features will affect the strength of the material. So it can reduce the strength of the material and it can result into a devastation if we are putting any structure without knowing it, on the surface. So this is extremely important and to avoid the major disaster, we need to understand the geological structure. So we will talk about that.

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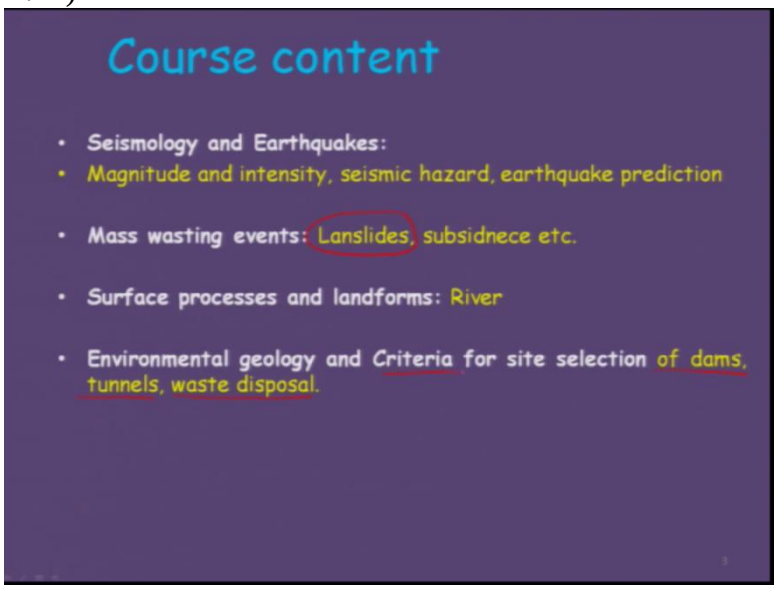

And then of course, we will talk about the seismology of earthquakes, where we will talk about, what is magnitude? What is intensity? When magnitude scale was developed and what if we

study the intensity, how it helps and all that? So basically, the intensity were being used in the earlier period when the magnitude scale was not developed or the equipment was not developed. There is a seismograph. But now we have the seismometers which can measure the energy released during an earthquake and we can have the magnitude in no time.

And then related seismic hazards, related to earthquakes. I will talk in terms of, particularly in terms of Indian subcontinent. And then earthquake predictions, we will talk about that. Of course, we cannot predict very precisely but of course, we can have the understanding that when the next earthquake will occur and in which particular area and along which zone. So that at least we can minimise the hazard and risk in that part. So we can save people but we cannot rule out the possibility of the occurrence of the earthquake in any particular region.

And then coming to the mass wasting, we have been hearing that during the monsoon season, we have a lot of landslides in the areas and of course the subsidence is related to the sub-solution activities subsurface. But the landslides are mostly seen on the surface in the hilly regions during the monsoon. Again, this all deals with the material, what type of material are there along the slope. And then of course, we will talk about the surface processes.

And in this course, we will be talking more about the river landforms, related to river or the frugal landforms. What are the importance of that? And how they are formed? And how to identify them actually? That is also important for us. Then we are going to talk about the environmental geology and criteria for site selection. So in environmental geology, we will talk a little bit about how the waste disposal in any region affects the groundwater or maybe the nearby environment.

And the criteria for site selection of course is very much important. Here, we have given only 2 points, structures like dams and tunnels, that is particularly in hilly areas. But we can also apply this elsewhere. When you know about the rocks, you know about the soil, you know about the landscape and all that, you can apply all that knowledge while selecting the site for any particular region.

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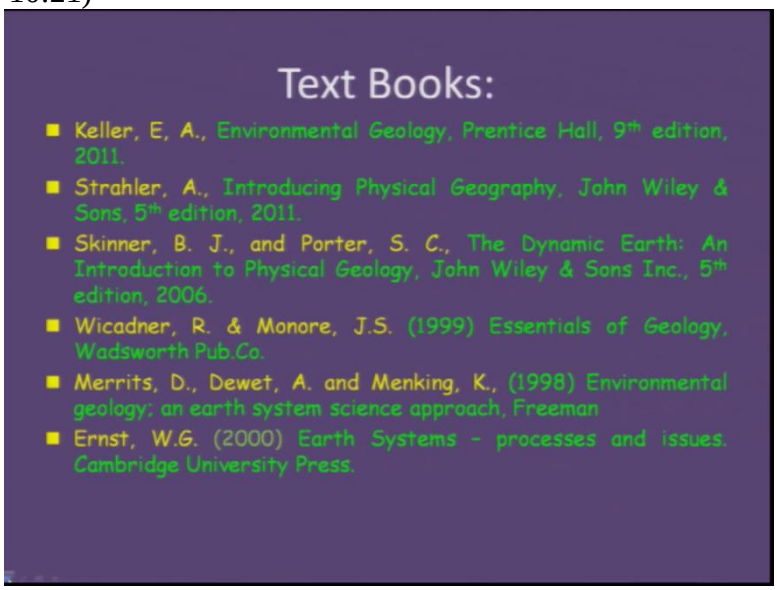

These are the textbooks. I am not very sure that these will be available but most of the slides which I am going to teach will be available to people. But these are some books which you can refer for the basic earth sciences.

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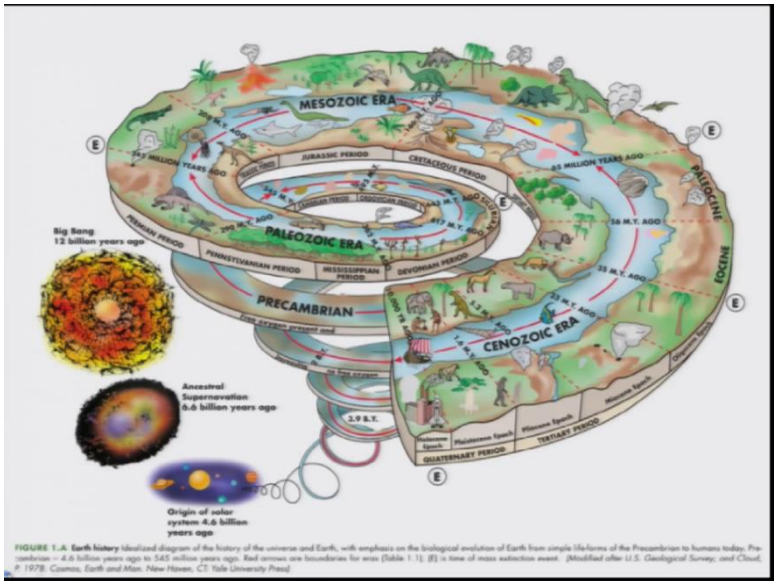

So let us move ahead. So 1st look at the planet, if we look at the earth as a complete system, what we see is, this is a very good story which is mostly available in many of the textbooks which talks about how the solar system evolved over the time and then what exactly happened. So if you look at this one, you can look from here. So we are having, this was the 1st event which talks about that around 12 to 13 billion years ago, there was a big bang. So this was like a giant explosion which resulted into the formation of galaxies and all that.

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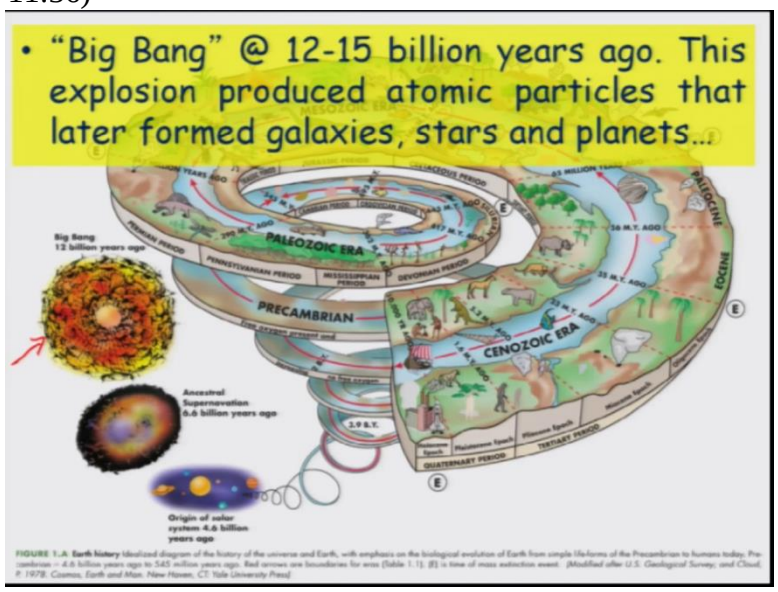

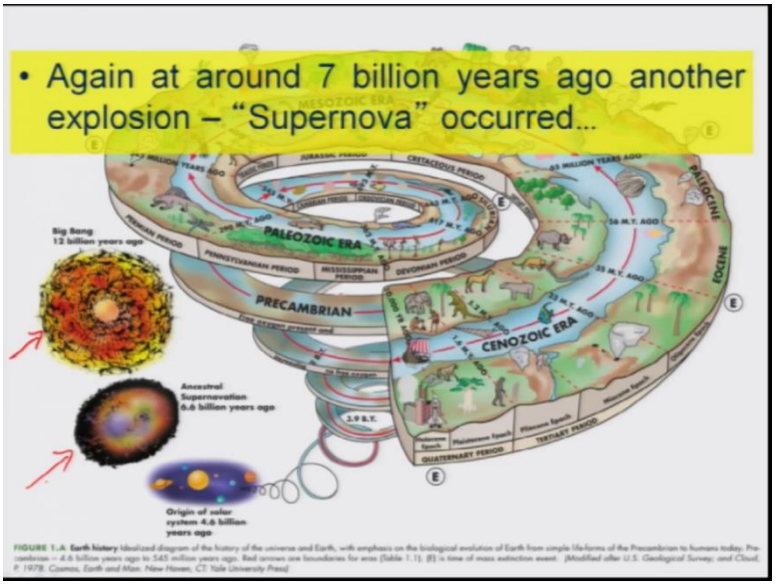

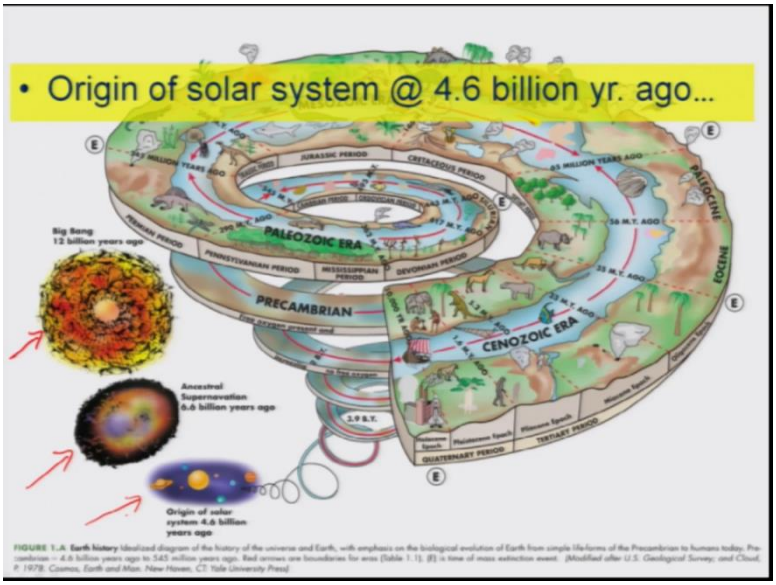

So this was one event which we call the Big Bang event which occurred around 12 to 15 billion years ago. And this explosion produced atomic particles that later formed galaxies, stars and planets. Later, there was another one which was at around 6 to 7 billion years ago and that was which was very much similar and known as supernova and then finally the earth came in that is the solar system came in at around 4.6 billion years ago. Now this is the time when the things started in the earth.

And if you look at this whole spiral picture, it talks about the various eras. Then it talks about the epochs and then it talks about the period. So these are the different timeframe what we call the geological timescale which has an era. Then you are having the epoch and then you are having

the period. So right now we are in the holocen epoch which is almost like 10,000 years old. But now probably because of the added effects by the human, we will be having another epoch which probably will be named as Anthropocene.

So we start with almost like 4.6 billion years back. What happened we will slowly get into the era or that what we call the Precambrians. Then we are getting into the paleozoic and then we are having the Cenozoic part.

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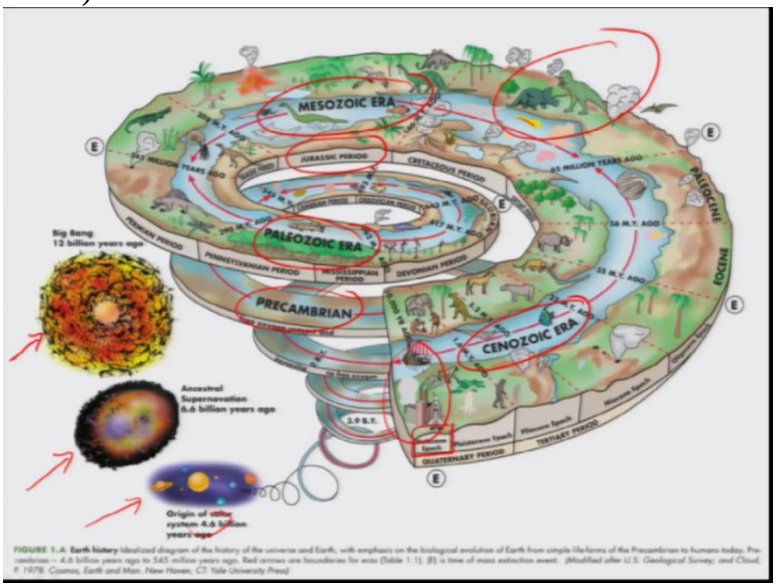

And then one is the Mesozoic one. So this one is the most well-known because of the extinction which happened here during the Jurassic periods. So this is the period what we are talking about extinctions of the dinosaur and all that.

So many events occurred during this overall period right up to the Cenozoic era and that is how the earth evolved. And this is the last is the phase, that is what we see. This is the time when the industrialisation came in actually. So this is the Holocene epoch is the most important one and mostly we try to if we have to try to understand the hazard part, we mostly take the Holocene epoch for understanding the hazard and all that. Nevertheless, for the rocks and all that, we cannot leave any part of this.

We need to have the understanding of all this. Because different rocks formed and the rocks that older and younger. Still we are having the younger rocks which are almost couple of hundred

years old. And then if you go back, maybe you are having rocks which are as old as 290 million years old.

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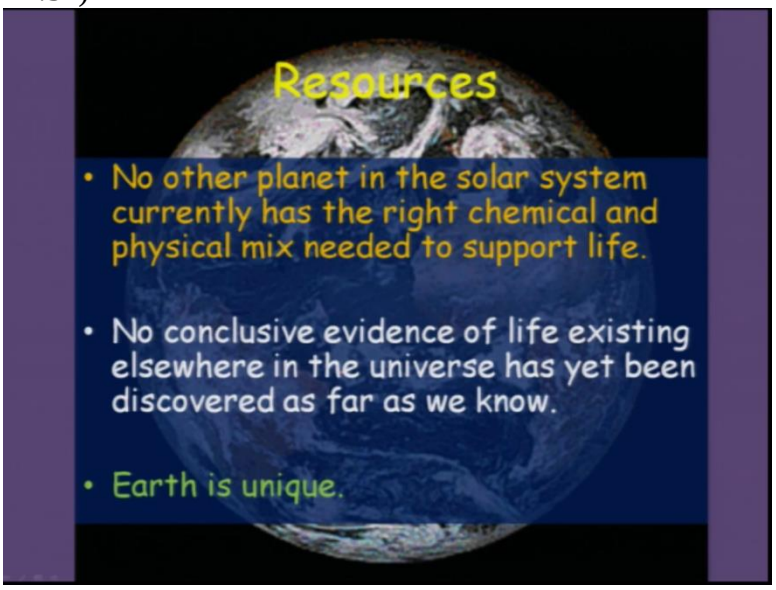

Now if we are talking about the earth, then no other planet in the solar system currently has the right chemical and physical mix which is needed to support life. And until now, no conclusive evidence of life exists elsewhere in the universe. So in that sense, earth is a unique planet amongst the solar system.

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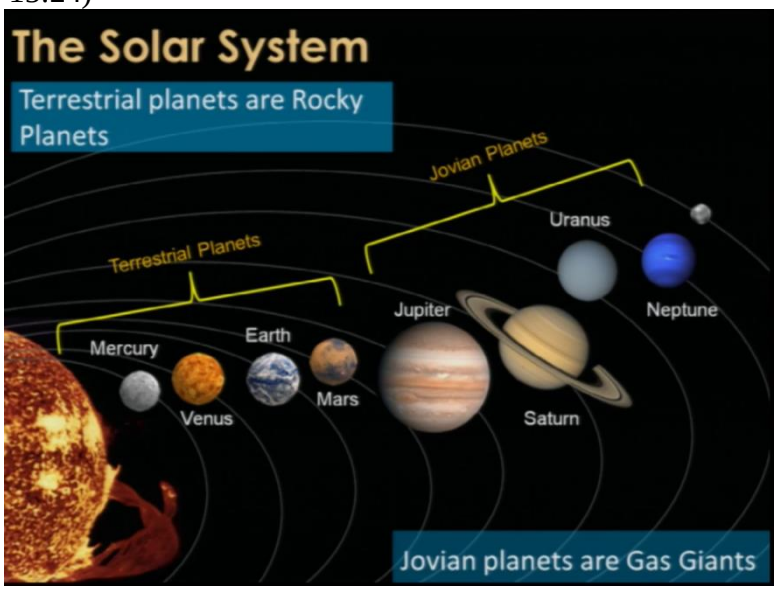

Now just broadly, very quickly we will look at what we are having? We are having the solar system. And then we are having Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, and Pluto of course. This Pluto is gone now. So we have planets, terrestrial planets which have

been classified as and then we are having the rest which are the Giants and gaseous planets. This is earthy Jovian planets.

So terrestrial still planets are rocky planets which are the closer to the sun and another one is Jovian planets. Of course, I understand that you people know but let us move slowly and get into the domain of our sciences.

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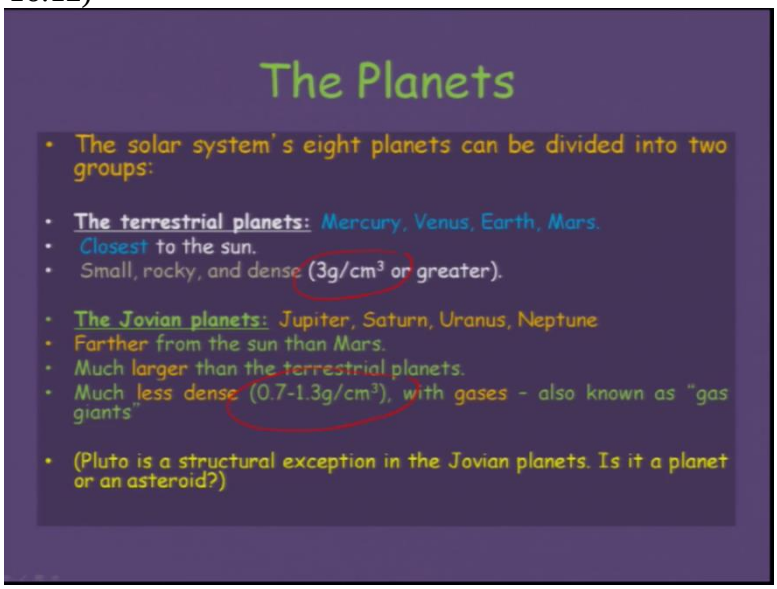

So the planet if you look at the solar system, eight planets can be divided into the terrestrial, this we have already about. So I will just move ahead and then we are having couple of, around 4, the having Jupiter, Saturn, Uranus are Jovian planets and they are the farthest and much larger as compared to the terrestrial planets. And comparatively less denser. As we see here, they are much much denser as compared to these.

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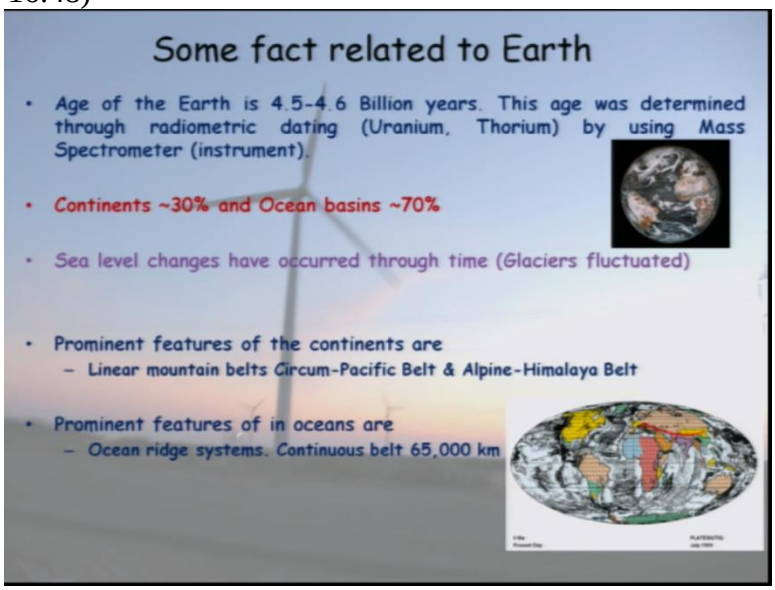

Now some facts which we all see and we all understand about the earth. So age of the earth is around, this you should remember that the age of the earth is around 4.5 to 4.6 billion years ago. And this age was determined from the radiometric dating of thorium by mass spectrometer. And then what we are having? That continents covers the area around the globe is almost 30% and the rest of the area, almost 70% is covered by ocean. And then, sea level changes have occurred through time.

That is what we call as the Glacier fluctuations. And prominent, linear features which exist on the earth surface. So one is the Circum Pacific belt and Alpine Himalayan belt on the earth. So we are having this area. And then we are having a prominent feature of oceanic ridges. An oceanic ridge system which is covering almost 65,000 km which exists like this over here. So it goes around the earth and then we are having that.

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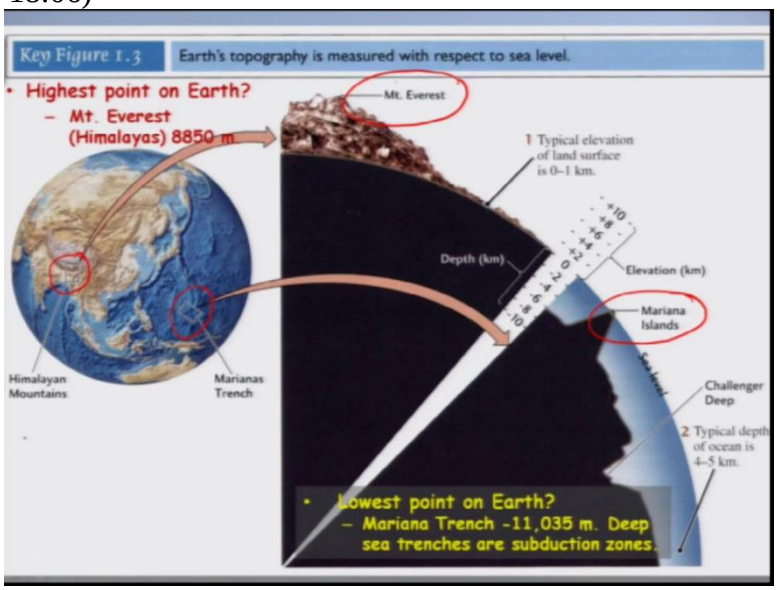

So we have several prominent features. And another, most important one which we also know is the highest area, that is the Everest and the deepest part, which we are having the Marianna trench. So the highest location on the earth surface is Mount Everest. Almost like 8800 m high and then we are having the lowest point which is almost 11,000 m deep and that exists in the trench area, in the Mariana trench, which is known as Marianna trench.

So it is located here. And Everest of course is in the Himalayan region. So these are the facts which are with the added. So these are the facts which are with the earth, within the earth system.

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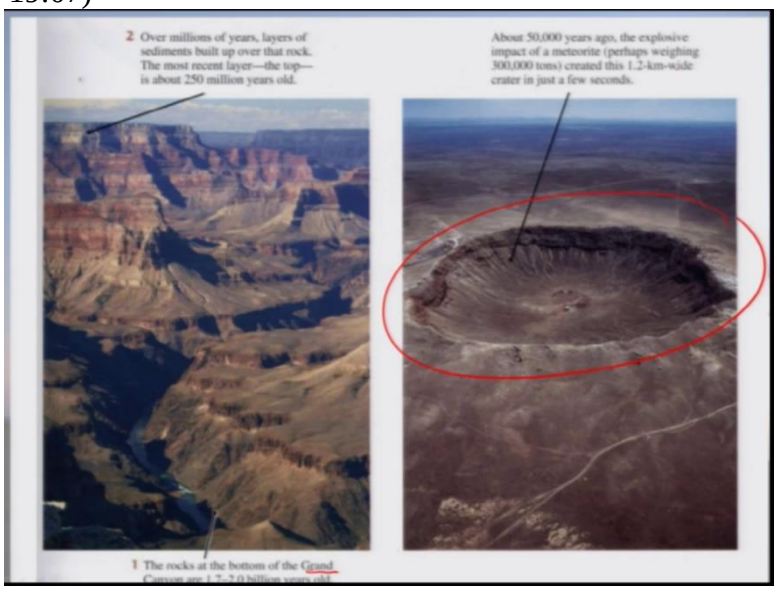

Then another one, if you look at this, this is from Arizona. And if you see the Grand Canyon, then add the base, the rocks which are seen are as old as 1.7 to 2 billion years old whereas at the top, it is almost like 250 million years old. So it has a history of deposition in this region. So if you look at the geology studies, probably, of course they have studied this. So they can talk about how they were deposited and when they were deposited. Whether there was a period of non-deposition.

And then, whether there was some event which affected the areas in terms of the climate or in terms of the tectonics. So this is what we have. And then another picture here, this is a big crater. And the crater is almost like 1.2 km wide. This is also from Arizona. It says about 50,000 years ago, the explosive impact of a meteorite, which was about 3 lakh tonnes in weight created created this 1.2 km wide crater and just in a few seconds. So we have lot and lot to know and lot many surprising things which comes in front of us when we talk about the earth.

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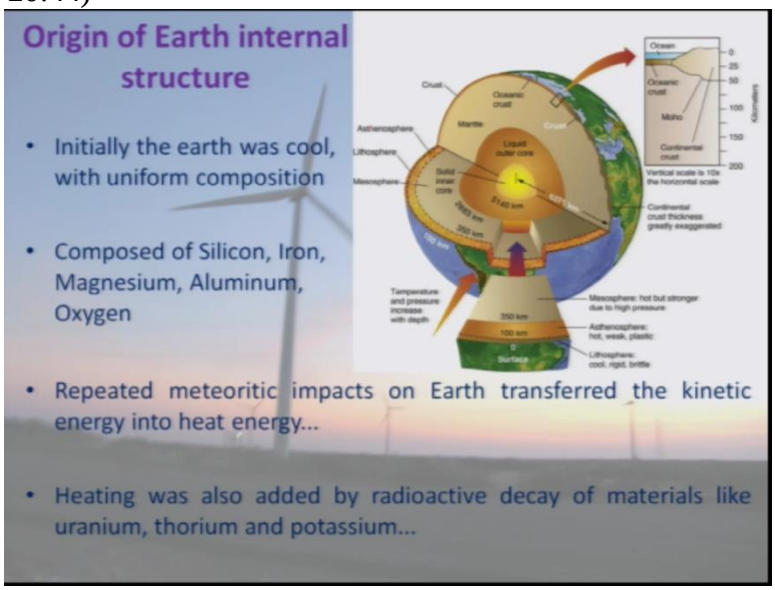

Now if we talk about the origin of Earth in particular and we look at the internal structure, what we see is that we are having different layers. It is not homogenous. Of course, the internal structure of earth, I will talk later. But just to talk here, we are having inner core, then we are having the outer core. Inner core is massively hot, the outer core is liquid. Then we are having mantle.

And then we are having another layer which is partially molten, it is the Asthenosphere and then we are having a very thin crust which is made up of the Continental and the oceanic crust. So what happened initially was that initially, the earth was cool with uniform composition. Right from the beginning, it never had a very similar composition what we see now. But it was almost homogeneous, uniform composition composed of silica, iron, magnesium and aluminium and oxygen.

Now repeated meteoritic impact in the past. Now we cannot have the meteoritic impact, there are reasons for that. Because it cannot enter into the atmosphere which is surrounding the earth. So in the initial stages, the meteoritic impact on the Earth transferred the kinetic energy into heat energy. And this started heating up the earth in which the heat was also added up from the radioactive material like uranium, thorium and potassium which existed in the earth interior.

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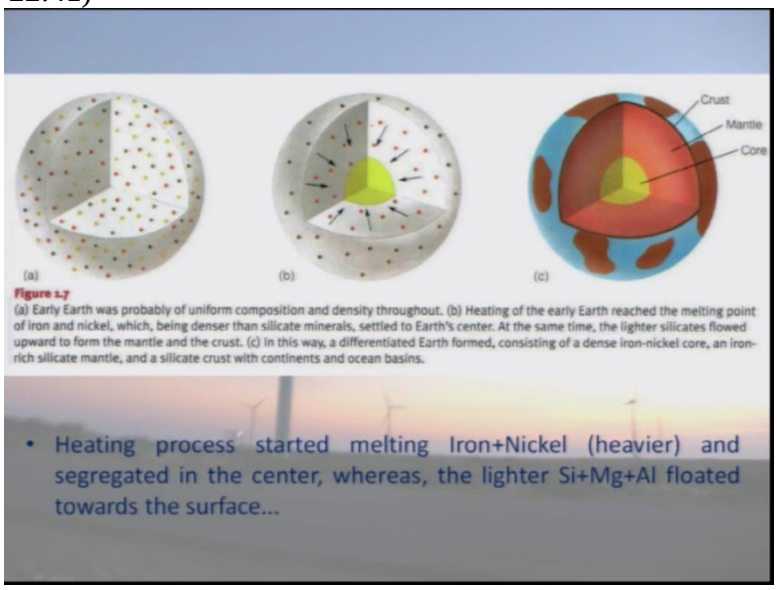

So later, what happened was that because of the heat which was generated, heavier particles, the heavy materials like iron and nickel, they started segregating at the Centre. And that is one of the reasons why we are having the core which is comprised of iron and nickel. And the lighter ones like silica, magnesium and aluminium, they floated towards the surface.

And this is one of the reasons why we see that the crust is mostly made up of the lighter material which we call silica, magnesium and aluminium. And most of the rocks are comprised of this material. Whereas the deeper part of interior of earth is with the heavier material.

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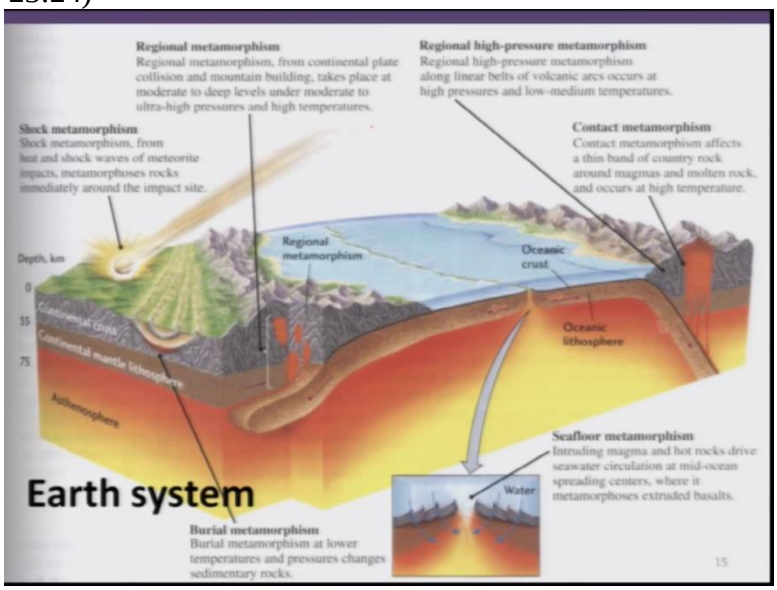

Now we will move to and try to understand what is the earth system as a whole. So if we look at the earth system, then we talk here about the internal and external processes which has produced different types of landforms and still, the process is ongoing, the internal process and the external process which are responsible for shaping of the landscapes. So we are having the internal, we are having the plate motions and all that and then external.

So these are the internal ones. And of course, these plate motions for the heat which has been generated in the interior of earth also generates the geothermal energy or it was, heat is responsible for producing the geothermal energy also.

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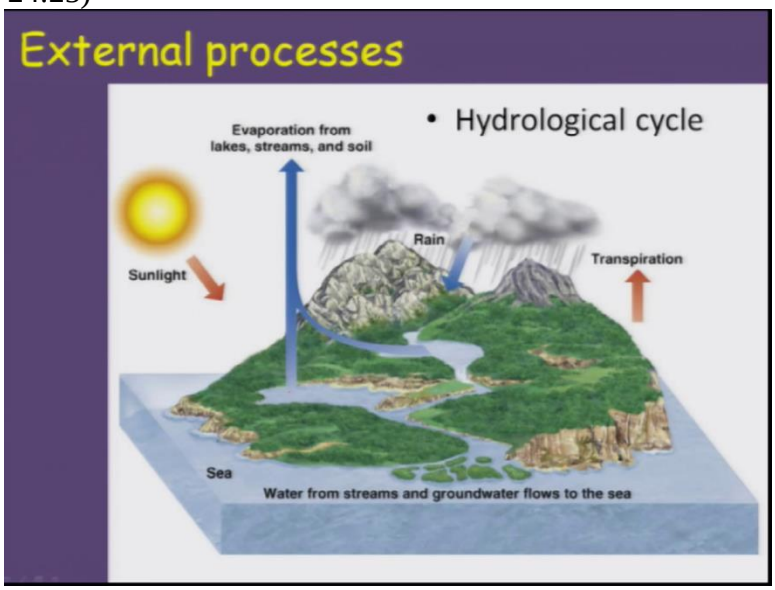

So plate motions are internal processes whereas the external processes for example, there is a hydrological cycle. So these are the 2 main processes which we see around us.

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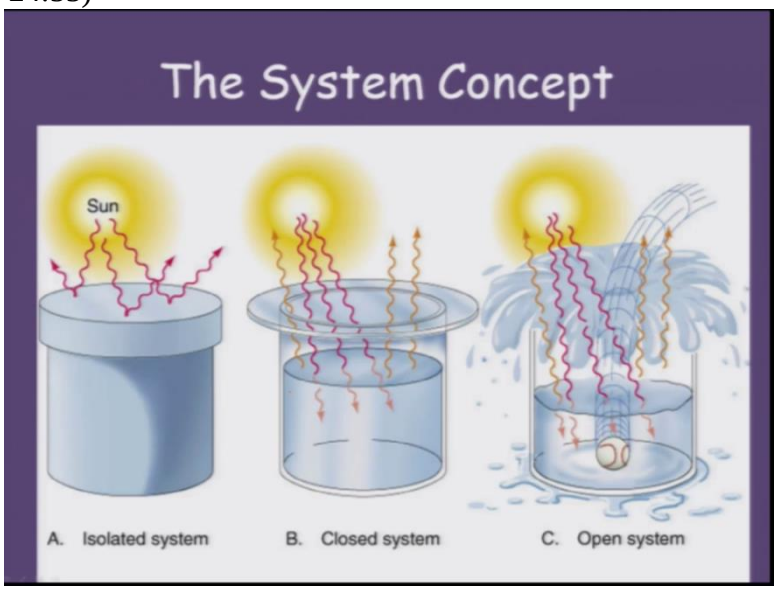

Now if you look at the, as I told that this is the earth system, so system concept if you look at, we have 3 types. We have, either there is an isolated system. Either we are looking at a closed system or we are looking totally at an open system. So let us look at and try to understand that what type of system we see or the earth is. Either earth is a closed system or it is an open system. And if it is an open system, why is it open altogether partially closed system? Let us look at those.

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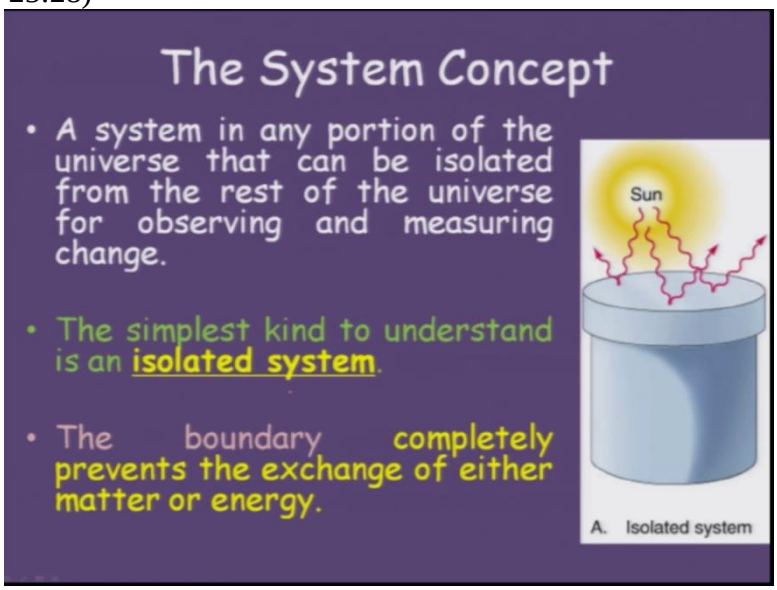

So the system concept when comes, we can talk about the isolated one. It is system in any portion of the universe that can be isolated from the rest of the universe from observing and measuring the changes. The simplest kind of understanding we can talk about for the isolated system is that boundaries completely prevents the exchange of either material or energy.

So it will not allow to exchange material or energy and it will have a very definite boundary. And that is what we call as an isolated system.

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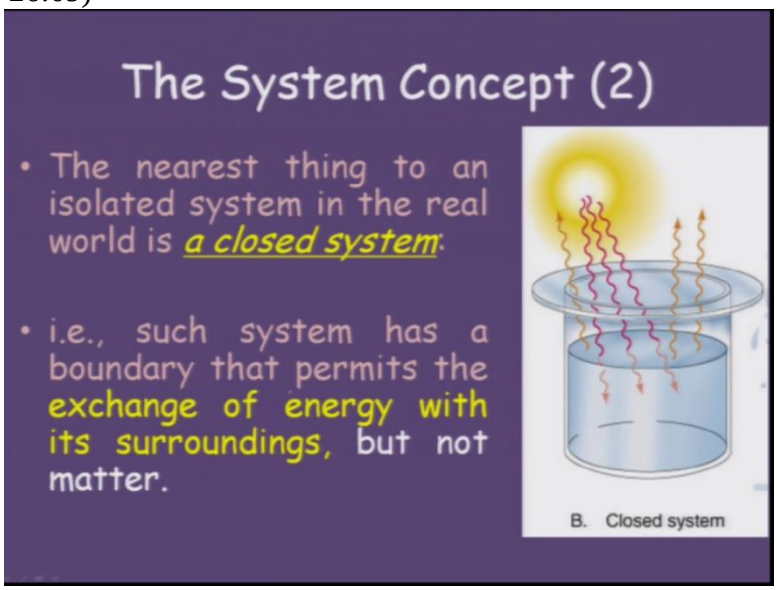

Then we are having another one, which is your closed system. But in the closed system, we will have some transfer of energy. That is the exchange of energy with its surrounding but not the matter. So it will just exchange the energy. Keep in mind that this is for example, we are looking at the sun here. So we are having the radiations coming in and we are having the radiations which are going out. So try to just understand.

So whether we should call this a closed system or not, we will see ahead. But in short, the closed system is the system which exchanges the energy with the surroundings but not the matter. Thank you. We will continue in the next lecture after this.