Geomorphic Processes: Landforms and Landscapes
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Lecture - 2
Introduction to Geomorphic Processes:
Landforms and Landscape
(Part – II)

Welcome back.

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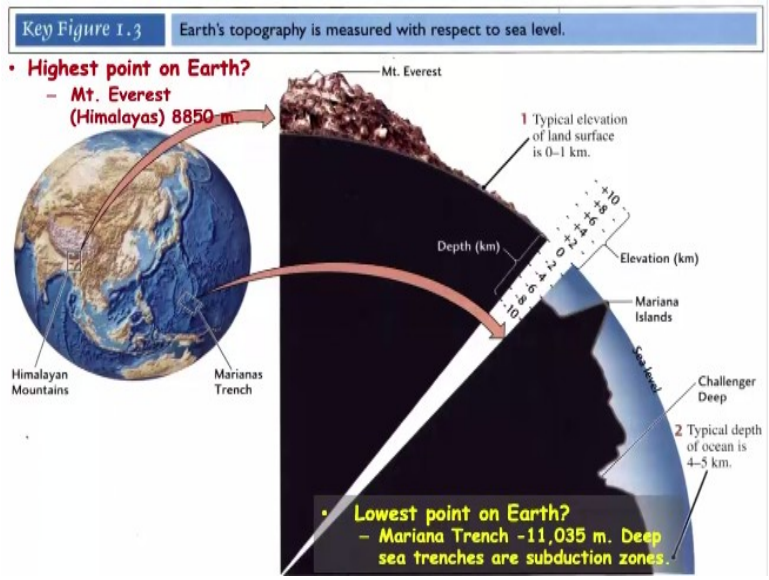

So, in the last lecture, we were talking about the highest and the deepest point on the earth. So, the highest point on earth is Mount Everest and the lowest point on the earth is Mariana Trench,

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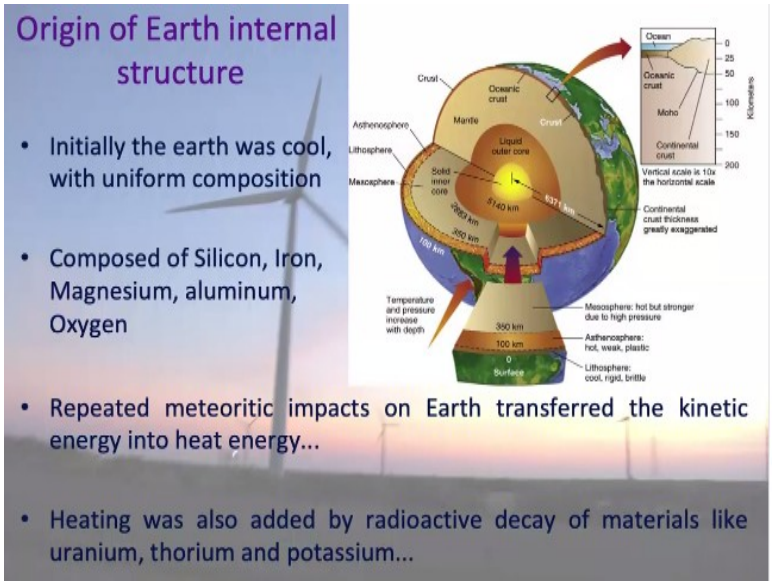

On further talking about the origin of earth internal structure, so if you look at, we are not going to get into the details of the different type of layers or the different layers in the earth interior, but we are going to talk quickly about that how these different layers were formed, that is basically the internet structure. So, what we see here is that we have, it is not homogeneous, we have crust, everywhere we have the oceanic crust, we have lithospheric crust, we have mantle, we have liquid, outer core, and then we are having solid inner core.

So, initially, the earth was cool with the uniform composition, but further because of the meteoritic impacts the things got changed. So initially if you take as a whole, it was composed of silicon, iron, magnesium, aluminum, and oxygen. Repeated meteoritic impact on earth transferred the kinetic energy into the heat energy. Now, this heating process resulted into the segregation of this material. So, heating was also added not only from the kinetic energy, but also through the radioactive material, decay of the radioactive material like uranium, thorium and potassium and this resulted into the segregation.

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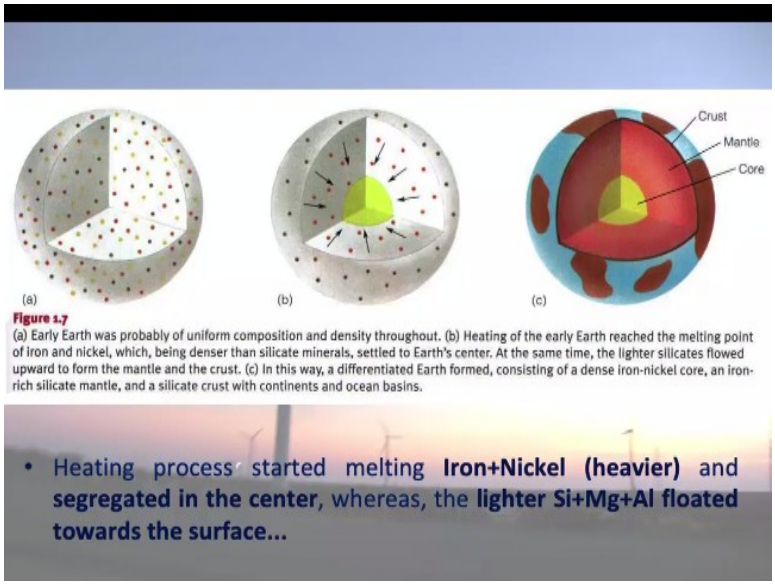

So, heating process started melting iron and nickel, which were heavier and segregated in the center, where we see the formation or the collection of the heavier material at the center and the core mainly holds this and then whereas the lighter one we see silica, magnesium and aluminum which floated towards the surface. So, most of the rocks, which we see are the formation of the rocks in the crust and the mantle region are comprised of silica, magnesium and aluminium. So, this is the basic information about the origin of the internal structure of the earth.

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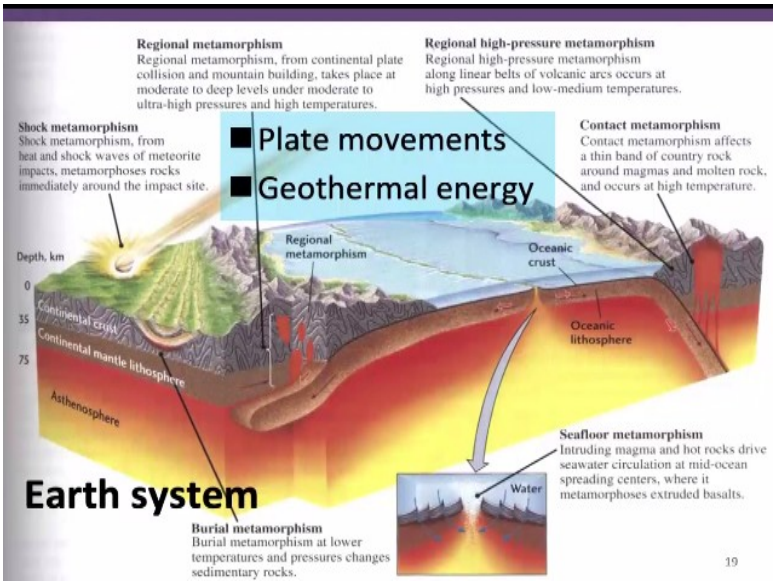

Now, about the processes. Earth as a system if you take, we have internal and external processes. For example, plate motion, plate tectonics, geothermal energy which is an internal process again. So, we will briefly talk about the earth as a system in coming few slides.

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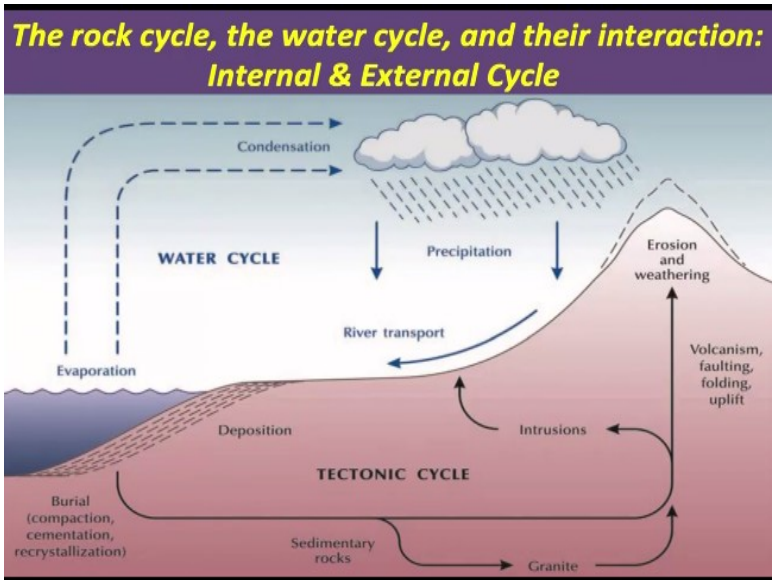

Now, interconnection of our internal linking of the rock cycle, water cycle, and the internal and external cycle. So, internal cycle if you talk about is the tectonic cycle and the external cycle here what we see is basically the rainfall or the river transport and all that. So, basically what you see here is the connectivity or the interaction of the internal and external cycle or we can say also the rock and the water cycle.

So, tectonic cycle is the internal process, endogenic processes where the plate motion or the plate movement results into basically the formation of the new crust, burial of the rocks, compaction and cementation in the ocean, and if you go take the sediment rocks further deeper, they will result into the formation of metamorphic rocks and then the intrusion and the mountain building activities as well as the volcanic activities will be resulted because of the internal processes, that is the plate motion, either the subducting plate or the plates which are moving apart from one another.

Further the ocean will be resulted because of the terrain or different agents like glacial that is the ice or Aeolian activity that is wind and then mainly which we are talking about the precipitation. So, we will have the river transport and then further it will be deposited into the ocean. So, this is the connection base mainly between the water, rock cycle and internal and external cycle

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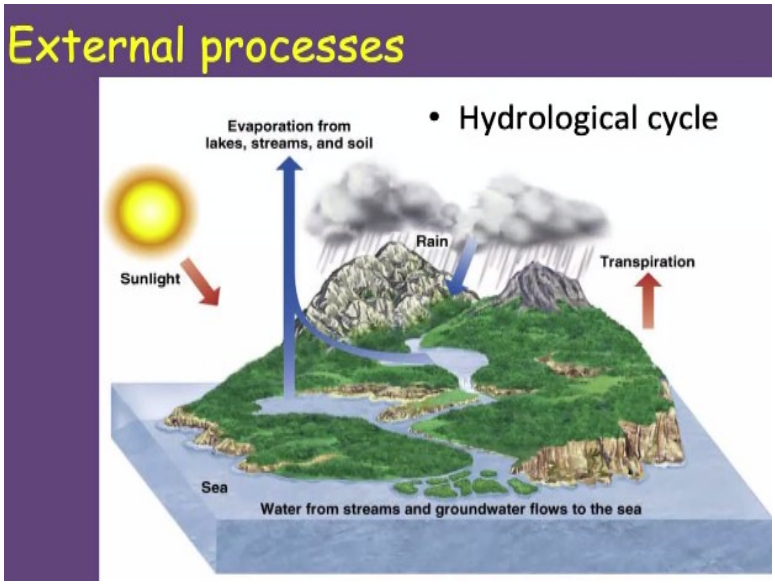

External processes, so one is the tectonic processes, which is internal and external processes we can talk about and we can say hydrological cycle, which is operating on the surface, which erodes the landscape, which sculpture the landscape, and the other processes which are involved is the exchange of the energy and the sediments. So, this is the part of the external processes.

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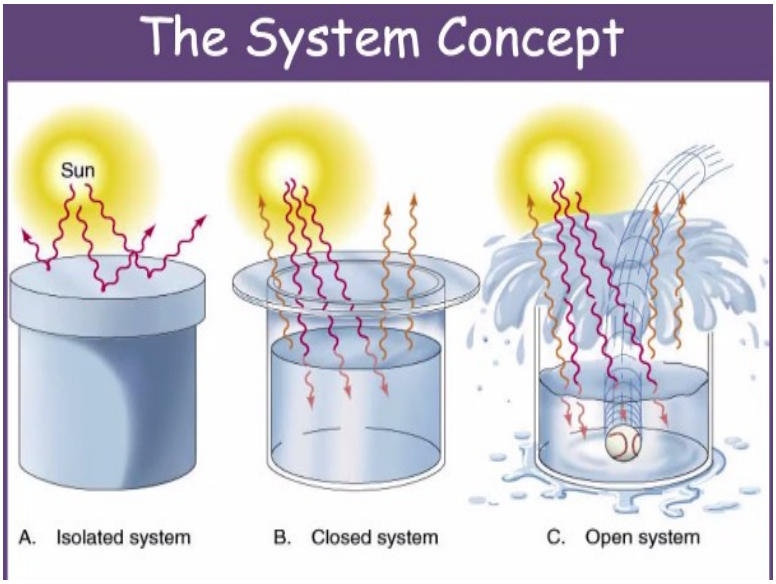

Now system concept. As earth as a whole, we can take first of all let us look at that, what we see as a system. We may have isolated system, we may have closed system, we may have open system. So, what are these different types of systems which we are talking about, and then we will look at the system, earth as a system, whether it is open, isolated or closed system.

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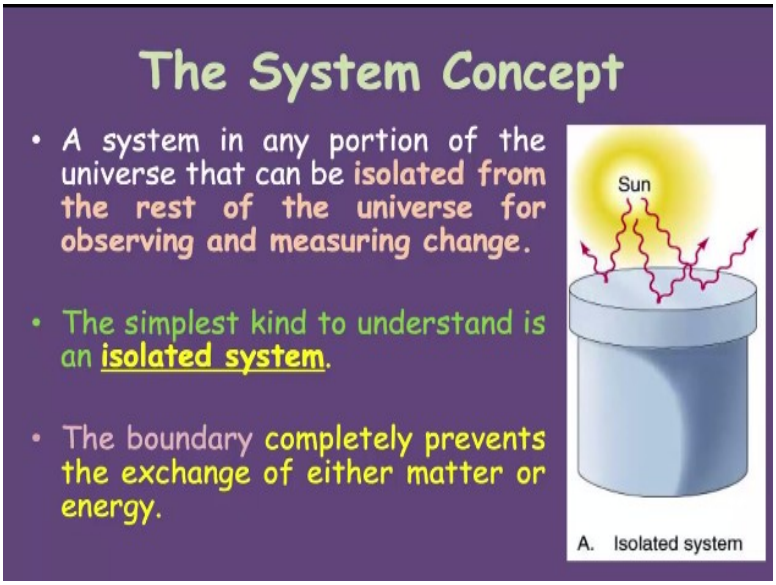

So, if we talk about the closed system or the isolated system, let us say take first. Then the isolated system is the system in any portion of the universe that can be isolated from the rest of the universe from observing and measuring changes. So, basically what we are talking, we are talking about the complete isolation where the boundaries completely prevent the exchange of either matter or energy.

So, nothing has been exchanged, either metal or energy nothing has been exchanged. So, it is completely, the boundaries completely prevents the exchange. So, this type of system are termed as the isolated system.

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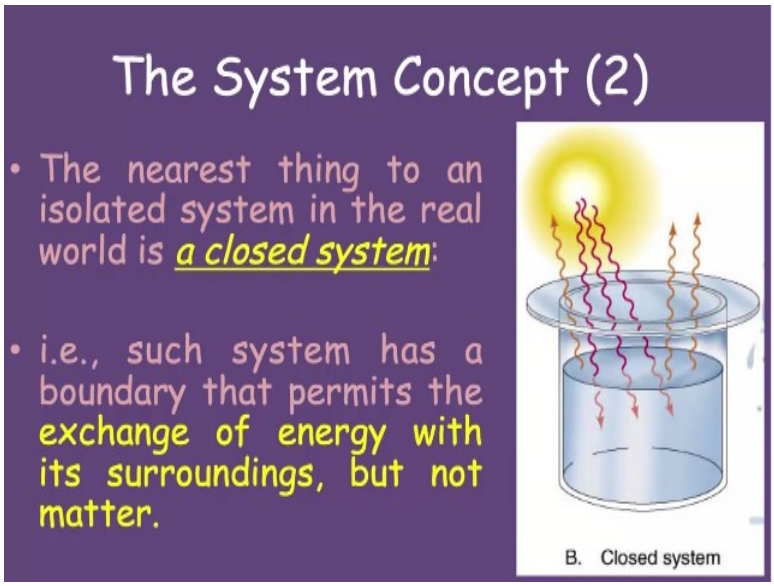

Then comes in closed system. Now closed system the nearest thing to an isolated system in the real world is the closed system that is set system, that is such system has a boundary that

permits the exchange of energy with its surroundings, but not the matter. So here, we will have exchange of energy, but not matter. So, before getting into the further discussion, this is very much similar, what we see earth as a system. So earth as a system could be classified as a closed system. Let us see further.

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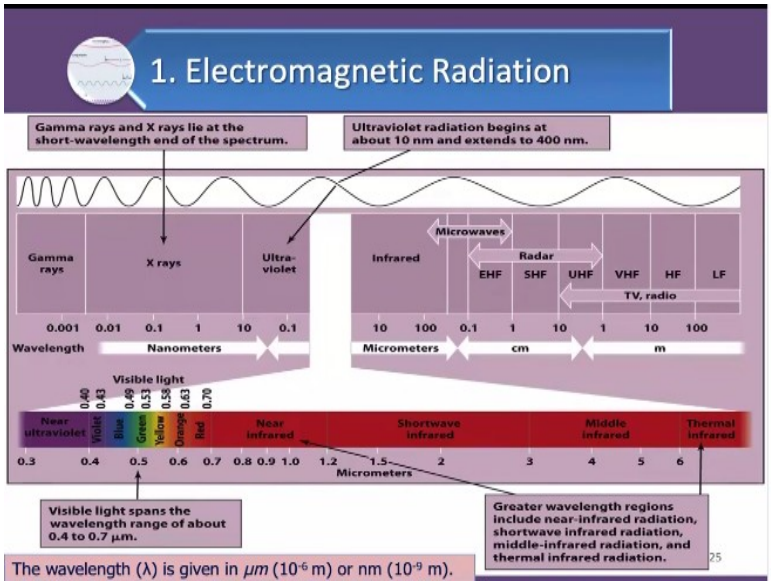

Now, we have different frequency of electromagnetic waves or radiation which is coming from sun onto the earth's surface, which passes through the atmosphere and then reflected back into the atmosphere.

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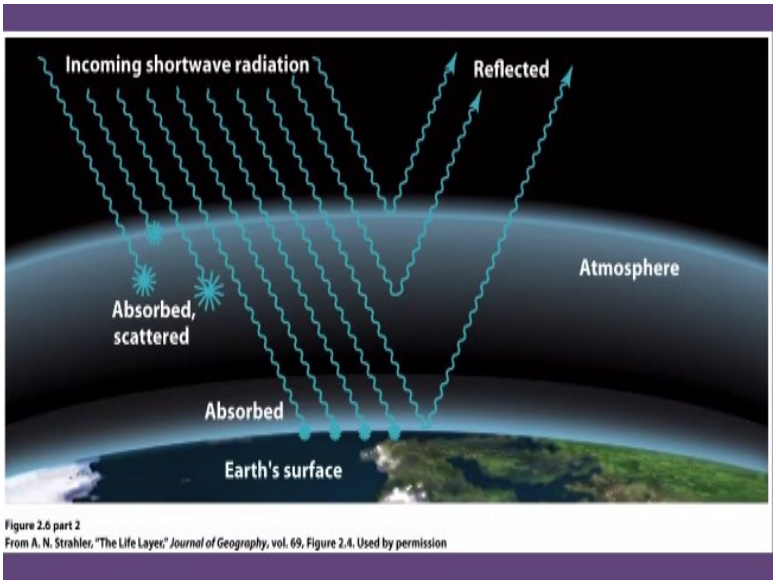

Figure 2.6 part 2
From A. N. Strahler, "The Life Layer," *Journal of Geography*, vol. 69, Figure 2.4. Used by permission

So, incoming shorter waves that is the radiation which is partly absorbed by the atmosphere and some which passes through the atmosphere is absorbed by the earth's surface and then

radiated back into the atmosphere, and some which is not been absorbed is reflected back into the atmosphere in form of long waves.

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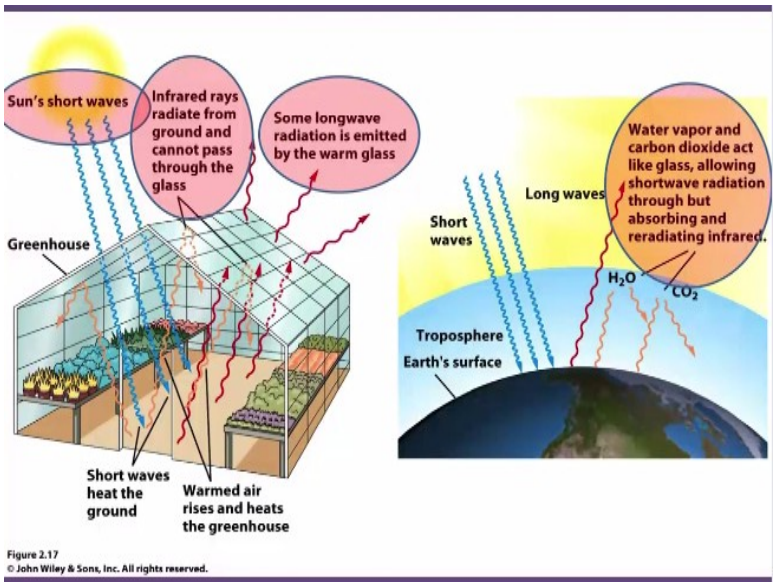

So, this is a very simple example which talks about the greenhouse effect. So, here the shorter waves or the shortwave radiation coming from the sun passes through the glass of the roof and gets into the earth, now that is what resembles the atmosphere and the earth's surface. So, short wave coming and getting into the atmosphere through atmosphere to the earth's surface and then see infrared radiation from ground which is radiated back into the atmosphere but cannot pass through the atmosphere which is radiated back to the earth's surface.

So, those are the infrared rays radiated from ground and cannot pass through the glass or the atmosphere. Further, some long waves, radiation is emitted by the warm glass. So, that goes into the atmosphere and that is how we talk about the greenhouse effect and that is how the earth's surface or the environment has been created, where we can sustain the life on the earth.

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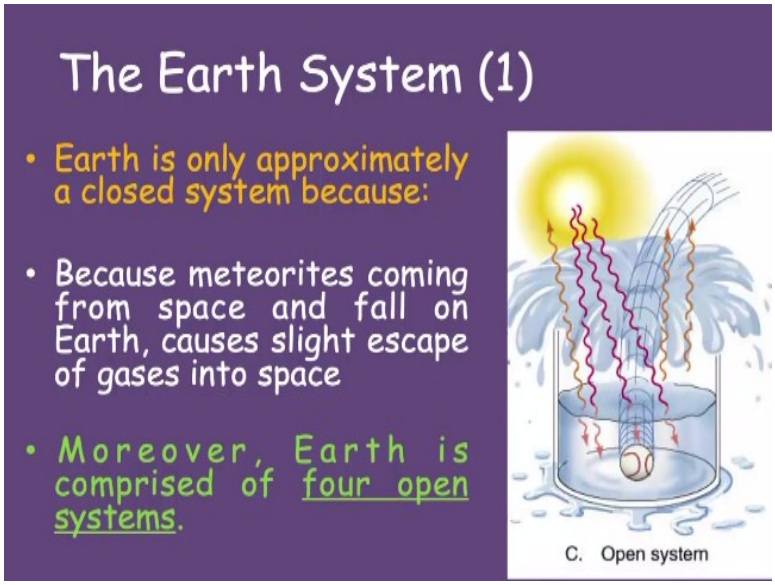

Now, this was the example of a closed system where energy is exchanged, but not the matter. So, looking to this, we can say that the earth is a closed system. Earth is only approximately closed system. Now, why is it so? This is a question which one can ask. Because we know that we have signatures of meteoritic impacts on the earth's surface, so, these meteorites which are coming from the space have fallen on the earth's surface. So, while doing so, they have resulted into the escaping of gases into the space.

So, they have in a way punctured the atmosphere. Hence, we can say moreover, earth is comprised of 4 open system, but over here we can say earth is approximately a closed system because sometime it also exchange matter, but most of the time, it only exchange energy.

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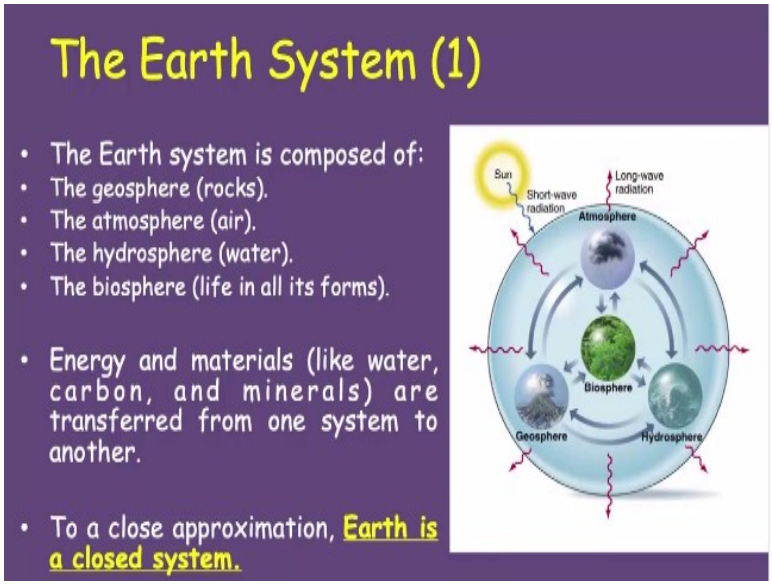

Further looking to the 4 open system within earth if you look at, then we have geosphere which talks about the rocks, then we have atmosphere it talks about the air, hydrosphere we talk about the water, and biosphere which is mainly related to the life in all its form. Now these are all open system. Energy and material like water, carbon and minerals are transferred from one system to another. Hence, we consider this all 4 systems as an open system, whereas earth in total is approximately closed system

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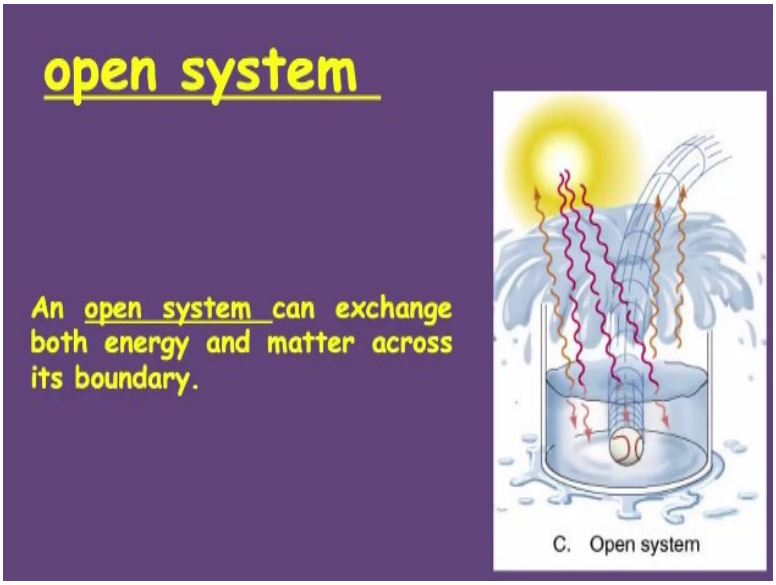

Open system, an open system can exchange both energy and matter across its boundaries.

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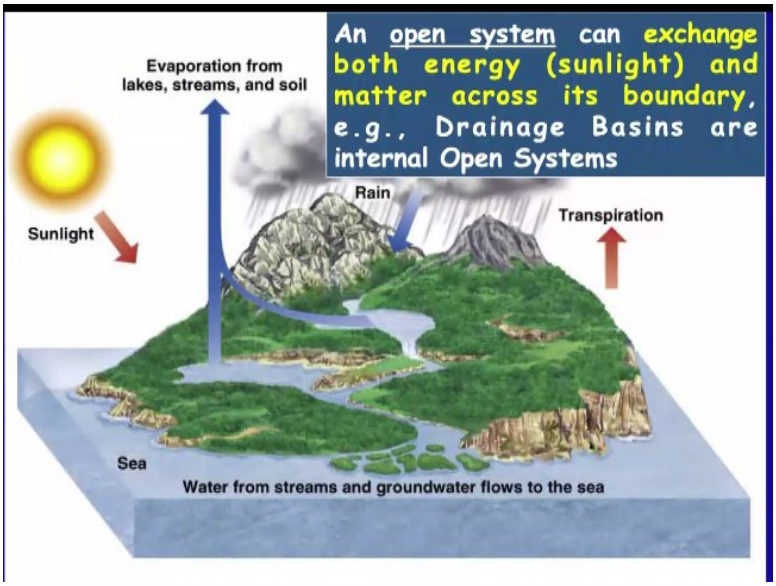

For example, hydrological cycle is an open system. So, an open system can exchange both energy, that is it is exchanging the sunlight, and matter across its boundary. Example, the drainage basins are internal open system where they exchange energy as well as the exchange

the sediments supply. So, it exchanges the matter as well as the energy. So hence it is an open system.

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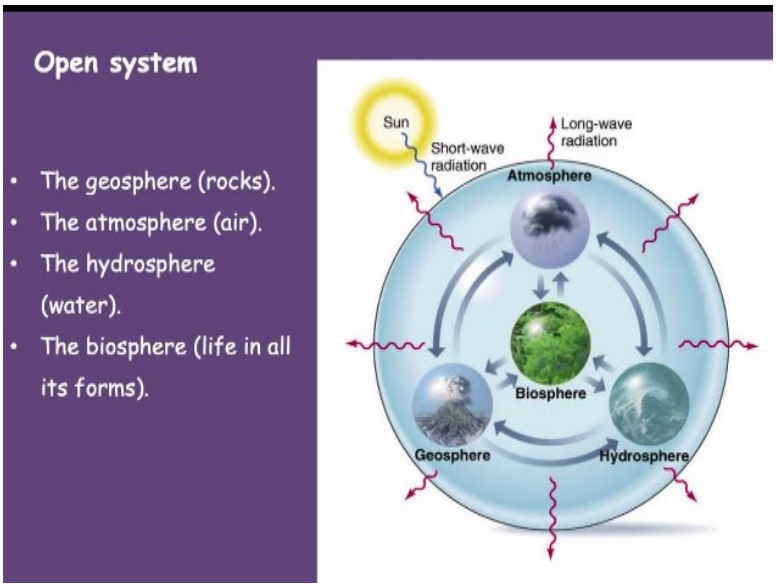

So this is what we were talking about, the open system. The earth has 4 open systems, geosphere, atmosphere, hydrosphere and biosphere.

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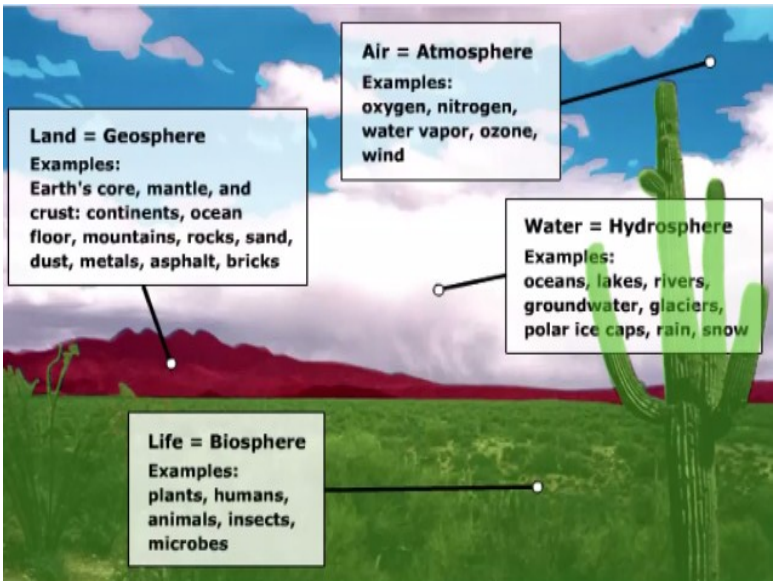

Further, geosphere where we talk about land, that is earth's core, mantle, and crust, continents, ocean floor, mountains, rocks, sand, dust, metals, asphalt, bricks. These are all related to geosphere. The hydrosphere examples are ocean, lakes, rivers, groundwater, glaciers, polar ice caps, rain and snow. Then comes the atmosphere, we talk about oxygen, nitrogen, water vapor, ozone and wind. Then biosphere; plants humans, animals, insects, microbes. So, these are basically the four open systems.

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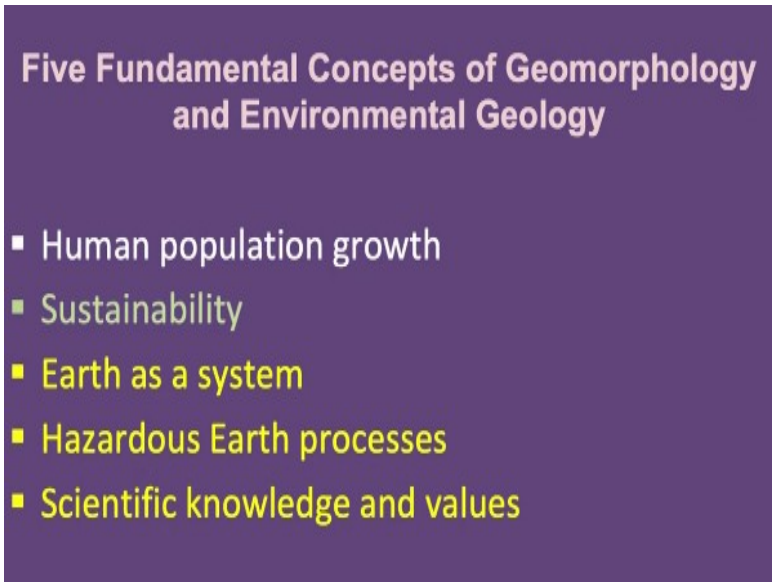

Now, there are 5 fundamental concepts of geomorphology and environmental geology, which we will be discussing in coming few slides. One is the human population, sustainability, earth as a system, hazardous earth processes, scientific knowledge and values. In this, we are not going to talk about the first two, that is the human population growth, we will very briefly touch, and sustainability, but we are going to talk in the overall course about the earth as a system we have already discussed to some extent, hazardous earth processes, scientific knowledge and values we will talk in coming few slides. So, these are the 5 fundamental concepts of geomorphology.

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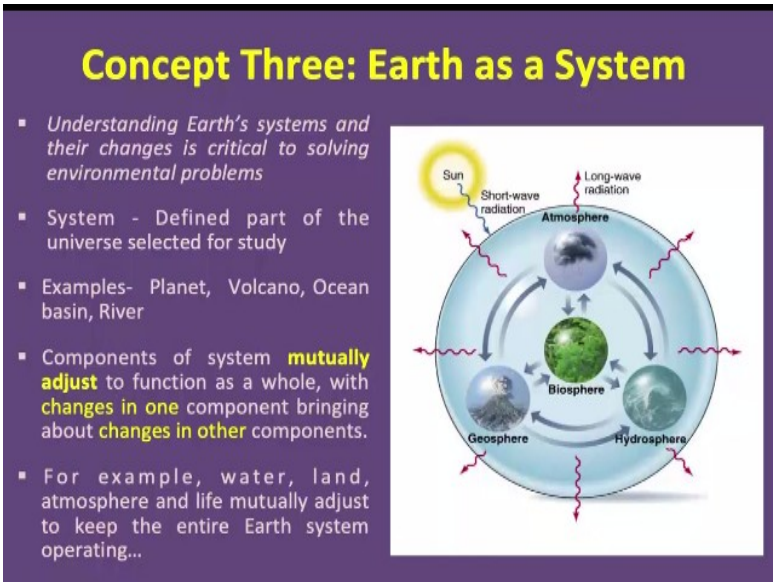

Concept 3, earth as a system. Now, understanding earth as a system and their changes is critical to solving environmental problems. So, basically the system defined part of the

universe selected for the study. So, what particularly which system you are going to study and which system you want to study and why, these are the various questions. So, for example you want to study planet, you want to talk about the volcanoes, you want to talk about ocean basins or you want to talk about or study in detail the river system.

Now, as we were talking about the atmosphere, biosphere, geosphere and hydrosphere, these all as a system, whatever it is, we were talking about the open system, they are all interconnected. So component of system mutually adjust to function as a whole, with changes in one component bringing about changes in another components. So, this part is extremely important because effect on one system is going to bring effect on another system.

So, for example, water, land, atmospheres and life mutually adjust to keep the entire system operating because system cannot come on like at standstill, it needs to keep rolling. So, they mutually adjust, if there is changes in one system, it will be definitely affected on the another one or it will be reflected on the another one, but they will be mutually adjusted, they will keep adjusting mutually and keep rolling on. So, the entire earth system keeps operating by mutual adjustments.

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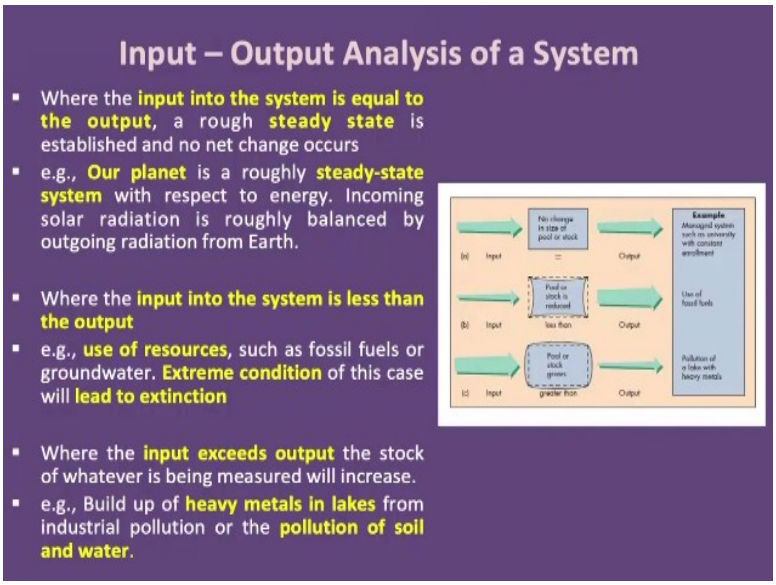

So, let us see the example of input and output analysis of a system where net changes depend on the relative rate of the input and output. So, here the examples have been shown, 3 example A, B and C where we talk about the input and output and the arrows shows the input and the output products. So in A, no change in the size of the pool. So, the input and the

output is almost same and B one, the input is less, but the output is more, now this will reduce the stock in the pool and the third is input is more and output is less.

So, this will increase the stock in pool. So, if you look at this example where the input into the system is equal that is the first one. So this says it is an steady state. So, our planet is roughly in steady state with respect to energy, incoming solar radiation is roughly balanced by the outgoing radiation from the earth. So, our planet is almost in this steady state. The another one is the example which talk about the input into the system is less than the output, example which is given is the use of resources.

For example, best example which can be given here is the fossil fuel, the consumption is so high, we do not have that much of stock available with us, so which will result into the extinction of this resource in future. So, basically what we are doing is we are reducing the stock in the pool. Third is the input exceeds output, this will increase the stock in the pool. So, example is the building up of heavy metals in lake from industry pollution or the pollution of soil water, so there is no output, output is very less, but input is so high.

So this will increase the input or this will increase the pool size or the stock in the pool. So, these are the 3 examples of steady state of our earth system, that use of resources based on which we see that the input is less but the output is very large, and then third is input is large, the output is very less.

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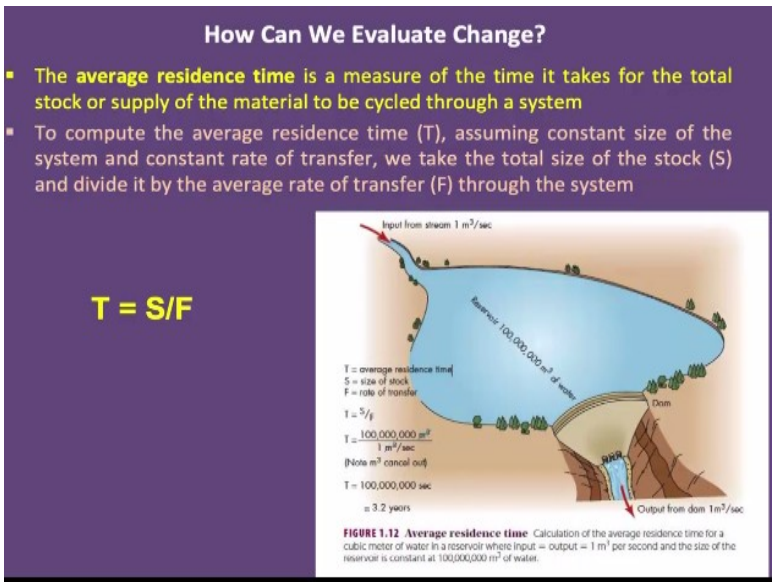

So, next, how can we evaluate the changes? So basically, we look at the residual time. For example, the average residual time or residence time is a measure of time it takes for that stock or supply of the material to be cycled through a system. Now to compute the average residence time T assuming constant size of the system and concentrate of transfer, we take the total size of the stock S and divide it by the average rate of transfer F through the system.

This will give you the residence time, that is T = S divided F will give you the residence time. Now even based on this, one can talk about that what will be the system whether it will be in steady state or whether it will be having the less stock remain in the pool or whether it will be having an excess stock in the pool.

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TABLE 13.1 The World's Water Supply (Selected Examples)

Location	Surface Area (km^2)	Water Volume (km^3)	Percentage of Total Water	Estimated Average Residence Time
Oceans	361,000,000	1,230,000,000	97.2	Thousands of years
Atmosphere	510,000,000	12,700	0.001	9 days
Rivers and streams	—	1,200	0.0001	2 weeks
Groundwater; shallow to depth of 0.8 km	130,000,000	4,000,000	0.31	Hundreds to many thousands of years
Lakes (freshwater)	855,000	123,000	0.009	Tens of years
Ice caps and glaciers	28,200,000	28,600,000	2.15	Up to tens of thousands of years and longer

Data from U.S. Geological Survey.

So, this is an example which has been shown of world's water supply and the estimated average residence time in ocean, atmospheres, rivers and streams, groundwater, lakes, ice caps and glaciers. For example, if you look at, the ground water at shallow depth of around 8 eight kilometers, the residence time is around 100 to many 1000s of years. So, we will stop here and we will continue in the next lecture.