Bioinorganic Chemistry
Prof. Debashis Ray
Department of Chemistry
Indian Institute of Technology, Kharagpur

Lecture - 37
Non metals in Biology I

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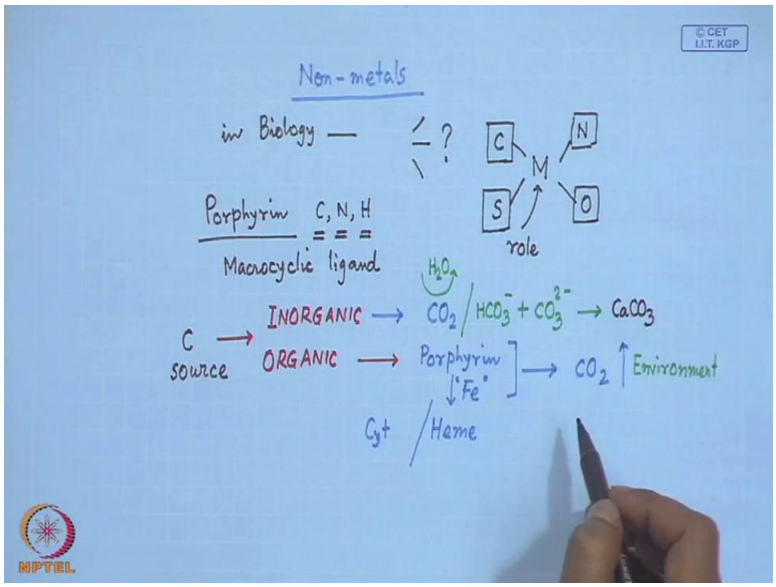

Hello, a very good morning to everybody. So today, we will just see after of so many of this classes based on the metal ions. So, today we will just talk about some non metals and how these different non metals play some important role in different biological reactions and biological transformations. So, if we see that these non metals particularly these non metals and their roles in biology.

So, what are the different metal ions are there, apart from this non metallic environment, because most of these cases, we have seen that for identifying the exact roles of different metal ions in biology. Some important donor groups like nitrogen, oxygen, sometime carbon and sulfur; they are attached to the metal center. And we were focusing our attention on the role of these particular metal ion centers. But we were not focusing our attention on the donor atoms like the non metallic environment what is there, present around these metal center.

So, if we consider that how these transformations can take place starting from the formation of this liegetic environment? So, if we considered that the formation of the

porphyrin. So, it is basically made of, of carbon, nitrogen and hydrogen atoms. So, this macro cyclic ring or the ligand when it is forming so, it has a very interesting biochemical pathway from the elements like carbon, nitrogen and hydrogen.

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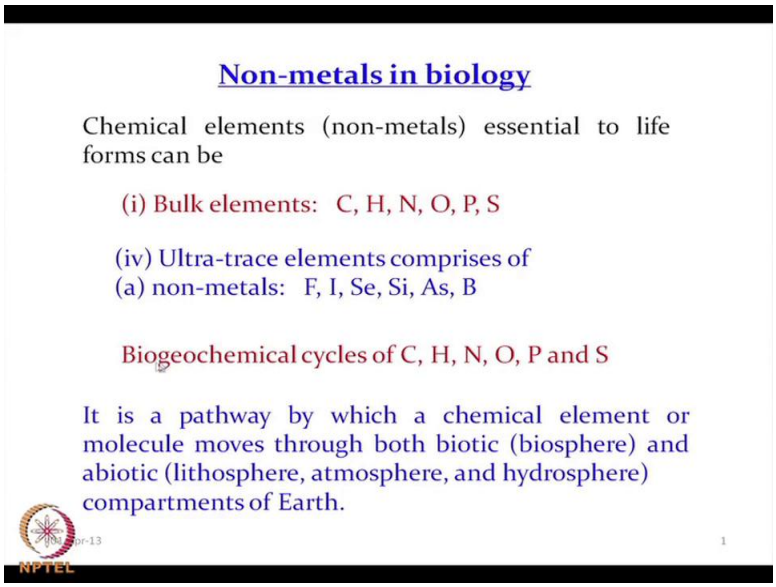

So, basically will see that how these non metals are performing their individual roles in biological transformations and reactions? So, in this first class and 2 or 3 more, we will see one after another of these chemical elements. Because all these chemical elements are essential to life forms they can be in presence of their concentration in terms of their concentration, they can be considered as bulk elements like carbon, hydrogen and nitrogen.

What we have just talking about that this carbon, hydrogen and nitrogen when they can form through some biosynthetic pathways to a porphyrin ring that is a very complex procedure. And complex biochemical transformations can take place, such that ultimately we get the corresponding porphyrin ring or the porphyrin micro cyclic ligand, which can bind the metal ions tightly to give us the heme compound, what is present in our blood.

In the same way, the other bulk elements can also be present there is one is importantly as a oxygen, then phosphorus, and then sulfur. And interestingly these 3 4 or the 5 s that means the carbon, hydrogen, nitrogen, oxygen and sulfur are the major constituents for the formation of the different amino acids also. So, when we form the minus it is in our

system, in all the living systems. We should take the help of the corresponding origin of the corresponding carbon origin, the hydrogen origin, nitrogen origin, oxygen and sulfur. And the phosphorus is most of the cases are present as the phosphates. So, they are present in the different corresponding different corresponding phosphate groups present in this all this biologically important molecules. And apart from that will just one or two classes will see that several ultra trace elements are also they are they belongs to this non metal category.

That fluorine, iodine, selenium, silicon, arsenic and boron, and of these this iodine plays some important role, when they can insert to some aromatic ring like the benzene ring, in different thyroxin type of molecules. Or selenium is also present along with the sulfur bearing amino acid it the cysteine, the selenocysteine groups are play some all some important role, but they are basically present in ultra trace amount and they all play some significant role to the biology in our system.

So, before going into the formation of all these things and they are individual role, we can talk about something related to the different cycles. So, if we can talk about the corresponding biogeochemical cycles of carbon, hydrogen, nitrogen, oxygen, phosphorus, sulfur. So, all these bulk elements can show some interesting biogeochemical cycles, because they can cycle between the formation of the important carbon compounds, and their destruction and they are burning ultimately while giving the energy to the living organisms. And while forming that, it can go from carbon to carbon mono oxide and then to carbon dioxide. So, during that part what we all know. So, we can have the carbon source.

So, this carbon is very important, because this can give rise to 2 types of compounds corresponding compounds, the inorganic carbon based compounds, and organic carbon based compounds. So, within this organic carbon based compounds, what we are just discussing? We are just talking about this example for the porphyrin. So, the formation of this porphyrin is there for the inorganic carbon based compound. So, when this porphyrin is there and when it traps iron, we get the heme system or sometimes we get this that cytochorme systems, where the metalion is present and metalion is bound to that. And from the inorganic point of few, the inorganic carbon based compounds they basically come from the ultimate product, which is obtained from the burning of these organic carbon based compounds.

So, when all organic carbon based compounds are burnt away, we produce carbon dioxide molecule and which is there in the atmosphere. So, carbon dioxide is everywhere surrounding us. So, this is present in our environment. So, this carbon dioxide can be converted to bicarbonate anion when this carbon dioxide what is present in air is reacting with water molecule like in the biological system, the zinc depended reaction which call has a carbonic anhydrase reactions.

So this can form bicarbonate as well as carbonate anions and if the metal ions can participate there for trapping of this bicarbonate and carbonate anion like that of our calcium. We get the corresponding fixation of carbon as inorganic material, in the form of calcium carbonate. So, this particular case that means, we can have some amount of carbon, which can be trapped as the carbonates or bicarbonates or this carbon can be present in some important organic molecule which can further take part in some important reactions in all biochemical transformations.

So, if we consider this cycles, which is considered as one part is biological, second part is geological, and third part is chemical. So, they all play some important role. So, if we consider the individual cycle, if we just consider the chemical transformations that means, the chemical transformations of this carbon has a source. And this carbon can be converted to some amino acid, or some porphyrin ligand. Then it can further be broken down to give us the corresponding carbon monoxide molecule or carbon dioxide molecule.

So, if we consider only the chemical transformations that means, the chemical reactions for that will just consider that it is the chemical cycle for carbon it is also applicable for all other elements. Similarly, if we consider that the cycle is not only based on chemical reactions, but also some geological part is there. So, you can consider as geochemical cycles, because after some transformations like that of our formation of calcium carbonate or any other carbonate material which can be stored under the earth.

So, or above the earth crust. So, the geochemical or geothermal transformations can take place on all these carbonate type of molecules, such that we get some rock material. So, rock formation is also can take place from the fixation of this carbon in our earth then some biological transformation can also take place. So, biological transformation can

help us in assimilating this carbon some other form, where it can be stored on the earth, below the earth, and the earth crust, and in above in the atmosphere, the environment.

So, in all this cases, which is the very complex pathway? So, if we can consider the 3 components of it, the biological part, the geological part, and the chemical part of all the cycles for all these basically these 6 non metal entities. We can consider these path ways where a chemical element or molecule, a compound can be also there, moves through both biotic, where we have the biosphere the living organisms are present. And a biotic that means, the lithosphere where the rocks surface atmosphere and the hydrosphere, the water bearing environment.

So, if they move from one particular part, once sphere to the others sphere that means, the biotic one to the a biotic one. So, if you can have compartmentalized these earth into these two that means, the biotic environment and the, a biotic environment. So, when we talk about this complex cyclic process, we should consider their storing of these non metallic parts, that the non metallic elements in biosphere, in lithosphere, in atmosphere and in hydrosphere, because when they are stored in the lithosphere.

We can consider this the formation of this carbon has coal or petrol petroleum products or the natural gases, but when we consider the corresponding oxidized form, the degraded form of the carbon in the atmosphere. We talk about much about the corresponding accumulation of carbon dioxide in the atmosphere. So, this particular cycle goes on. So, when we have the carbon dioxide in the atmosphere, our challenge would be how we can fix this particular carbon dioxide into the corresponding stable form. That means we can take out this particular carbon dioxide in gases environment to some other form. Particularly in the lithosphere or in the biosphere that means through photo synthesizes whether we can use that particular carbon dioxide for the transformation to some biological product, or in the rock formation through calcium carbonate formation.

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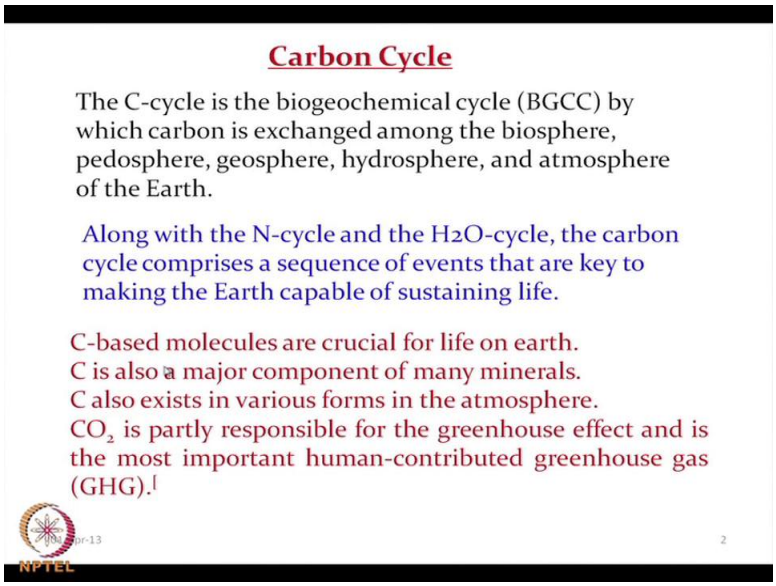

So, we see that the basic thing the first cycle, what we can consider is our carbon cycle where the carbon is present over there. And this particular cycle, we now considered as, it has 3 components, the biological components, the geological component, and the chemical components. So, we consider then at BGCC, so, bio geo chemical cycle. How carbon cycle can be handled by all 3 compartments of this cyclic process? So, we see there that carbon is exchanged, among the biosphere the pedosphere, the geosphere, hydrosphere and atmosphere of the earth. So, one from, one part to the other, carbon is moving and we get the corresponding transform from in all these cases. So, in the next case will see that like that of our carbon cycle, we can have the corresponding nitrogen cycle also, and the corresponding hydro cycle. That means, how the hydrosphere is there and hydrosphere is forming over this accumulation of this water molecule and disappearance of the, this water molecule from there.

So, in this particular case when we talk about the corresponding water cycle, we are also talking about like that our carbon cycle, and nitrogen cycle, the cycle which involved now two other non metallic elements that means, the hydrogen and oxygen. So, how oxygen is cycling, because one of the components of this oxygen cycle would be the molecular oxygen that means that dioxygen that is O 2 molecule, and also in the upper atmosphere that mean the troposphere we find that ozone is also forming over there.

And in some cases, the reactive oxygen species that means, the hydroxides and the oxides can also form, because some metallic oxides and hydroxides are also forming over there and they can be stored in the geo sphere. So, these three together, we this carbon cycle that means, the nitrogen cycle, the water cycle and the carbon cycle they all belongs to a sequence of events where the key to making the earth capable of sustaining light. So, if we want to live nicely, over our earth.

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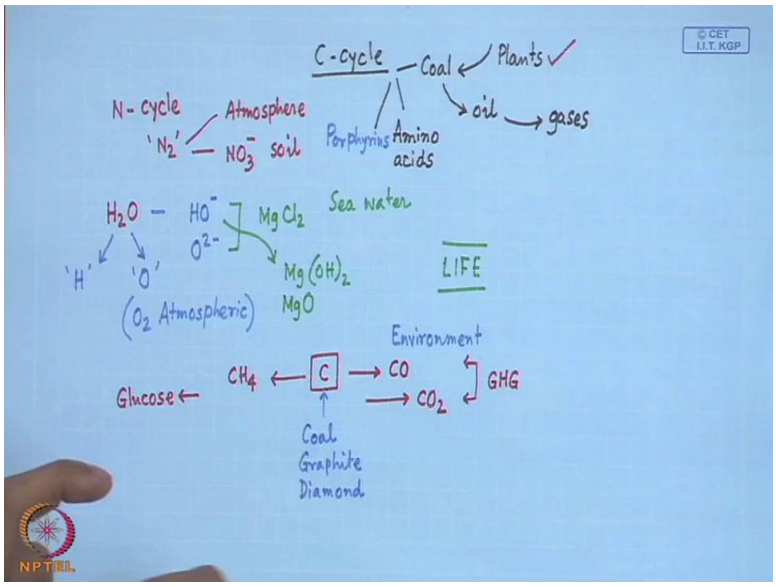

So, we can have at the top, we have the carbon cycle. So, which basically can give us so many things, it can give us the stoned coal through the formation of plants and other living organisms. So, plants are there which can take part some useful role to the formation of coal, then oil and gases, the natural gases. So, this particular carbon cycle can also give rise when they are incorporated in different amino acids through some biosynthetic pathways.

And it can be good ligands for the other metal centers or the metal ions through the formation of the corresponding peptides and polypeptides and some useful co factors like porphyrins. So, all these together that means, the, per formation of the porphyrin, the amino acids, and the corresponding plants generation of the plants. And when the plants are died, we get through some years of time; we get the coal and in one part also goes to oil and other part also goes to gases.

So, the second part basically will be dealing when nitrogen is coming into the cycle, we will talk about the corresponding nitrogen cycle. So, when nitrogen cycle is based on the dinitrogen gas which is present in our atmosphere. And all the nitrogen bearing compounds, we can get from there because this is also very useful compounds one such example is if we can get the simple nitrate ions. So, that basically goes to the soil and is very basic requirement for the plants and other living organisms. And we are also human system is also dependent on the nitrogen's very much. This nitrogen is present in the porphyrin system also this nitrogen is also present in the different amino acids also.

So, the nitrogen cycle is very important to that respect then when we consider that compound not the individual non metallic element like oxygen and hydrogen, because the formation of this water molecule, it can also come from the photosynthesis. And in this particular case, we can consider or we can take care of both the 2 non metallic element that means, we can take care of hydrogen. And we can take care of oxygen along with the available dioxygen molecule in the atmosphere, what we see in case of dinitrogen.

So, we have atmospheric, oxygen molecule. So, these two can be considered for this hydrosphere, and this go for several important reactions, because these can provide hydroxide anion or the o 2 minus so, once we get these as the anions. So, like that of our formation of the corresponding calcium carbonate here also we see that the different metal ions, such has if magnesium is present. So, the sea water this magnesium when present with chloride we get magnesium chloride, but when they are taken I by the hydroxide and oxides we get, magnesium hydroxide, or magnesium oxide.

So, not only providing water molecule to the system and the corresponding reactions, which are basically dependent on the water molecule? Because entire biosphere is dependent on these water molecules. We can see like that of the storing of calcium carbonate, we can have magnesium hydroxide and magnesium oxide in the sea water. So, this can be stored and so the individual anionic form has hydroxide ions and the oxide ions are very important when we consider the water cycle. So, these 3 cycles are very much dependent. So, we if we can have because the carbon cycle is also we can get for the photosynthesis then, this water formation is also coming from the photosynthesis. So, if we can have life so, so life our present form of life is very much dependent on all

these cycles, the non metallic cycles that the carbon cycle, nitrogen cycle and the water cycle, and some other cycles which are of important.

So, if we can have this so different carbon based molecules also we can see in this particular point, because if we have the corresponding amino acids. So, all these amino acids can have the carbon based skeletal structure so amino acids, then proteins, then polypeptides, this for porphyrins. So, all these biological important molecules particularly the entire organic chemistry, and the entire biochemistry is dependent on large number of carbon based compounds and molecule, and they are very much crucial for life on earth.

So, if we talk about the energy giving molecules like a t p and a d p molecules they are also based on carbon. So, the energy giving molecules we are very much dependent on these molecules for our very much survival. So, they are also carbon based, they are also when we talk in terms of the corresponding geological cycle that means, they are the major component of many minerals also. The carbonate minerals and the bio carbonate minerals and it can also exist in various forms in the atmosphere. So, when they are present as carbon dioxide, they can also be present as carbon monoxide and methane also. So, carbon is also a very good component for the methane also, and methane is also providing sometime some energy and sometime it is also a corresponding greenhouse gas.

So, during the formation of this carbon dioxide molecule, we cannot ignore that which is responsible for its corresponding greenhouse effect that means the rise in temperature of the atmosphere. And they are mostly created by the human being, because all this g h g that means, the greenhouse gases are originating from the burning of carbon based fossil fuels like that of oil, the petroleum products, the coal burning, the natural gas burning or some LPG type of gas burning.

So, all these gases when they are burnt because all these gases are mostly form, from the carbon and hydrogen atoms. So, when they are also burnt they give rise to carbon dioxide as the ultimate product and water has the ultimate form. So, they are basically responsible for their contribution to the generation of the different greenhouse gases. So, while studying the carbon cycle, we cannot ignore the corresponding effect for the corresponding carbon dioxide molecule as a typical greenhouse gas.

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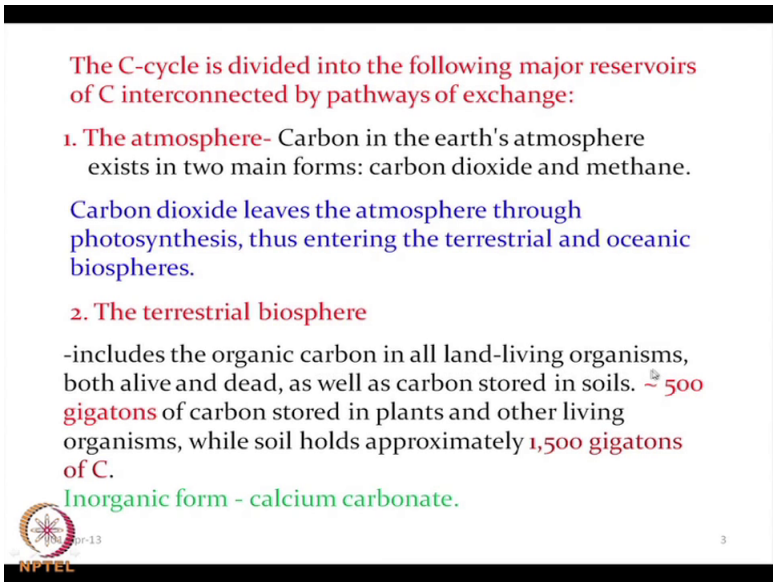

So, we should be able to concern about the corresponding environment. So, depending upon the corresponding reservation that means, how we store, how we accumulate the different carbon based material or carbon based compounds. We can divide the entire carbon cycle into some major reservoirs, where the carbon can be interconnected by pathways of exchange, because carbon can be considered has in one form to the other. So, when we see that, within the carbon cycle if we have the carbon and some interesting carbon based compounds like methane, or we can have the glucose formation, and all these.

So, you can have the corresponding exchange pathways, between the corresponding burning process or the oxidation process to the generation of carbon monoxide and carbon dioxide. So, all these carbon, they all bear typical carbon atoms. So, glucose has carbon, methane has carbon, and these carbon if we just consider this only carbon, the carbon mineral, the carbon mineral source, which we present in the coal. So, coal has the carbon, then graphite has the carbon, and diamond has the carbon.

So, all are typical carbon reservoirs and when we burn so in the environment in the atmosphere, see then the environment, we have carbon monoxide and carbon dioxide, along with water vapors. And they all form basically the corresponding heating of the atmosphere, because they are the typical greenhouse gases. And the reduced form of the carbon that means, the methane also is a typical contributor towards the corresponding

greenhouse effect, because this can also contribute for the rise in temperature of the environment or the atmosphere.

So, we can have the different pathways for this carbon cycle and which are interconnected. So, the first of it is the atmosphere. So, we should be very much concerned about the atmosphere, how carbon cycle or the presence of the carbon molecules can contribute towards the corresponding concentration of the molecules like carbon dioxide and methane within the atmosphere. So, basically within the atmosphere, apart from its presence as carbon monoxide, it can only be present in 2 main forms. One is carbon dioxide, the C O 2 molecules and another is the methane molecule the C H 4 molecule. So, this particular one that means, it is increasing in the environment the carbon dioxide concentration is increasing within the atmosphere through human activities. That means, when we burn several other molecule over for a through our respiration also, we go for burning of our food material. We also eliminate carbon dioxide to the atmosphere, but the only pathway where we can fix the carbon dioxide.

So, if we can consider that the concentration of carbon dioxide is increasing day by day within the atmosphere or within the environment. We can think of that, if we can consider the reverse pathway that means the photosynthetic pathway, utilizing the carbon dioxide molecule and water molecule for the formation of the glucose. We can consider that the rate of this reaction, the rate of photosynthetic reaction, in the presence of the sunlight can also increase through the increase in carbon dioxide molecule. Because stomata is are getting more and more carbon dioxide molecule for useful photosynthesis.

So, useful photosynthetic pathway can fix the carbon dioxide molecule in the glucose molecule. And it is different transfer form, or this particular carbon dioxide can enter into the oceanic biosphere has I told u earlier that this carbon dioxide molecule depending upon the P H of the water medium. In absence of any catalytic activity, it can simply react with water molecule giving rise to corresponding carbonic acid molecule.

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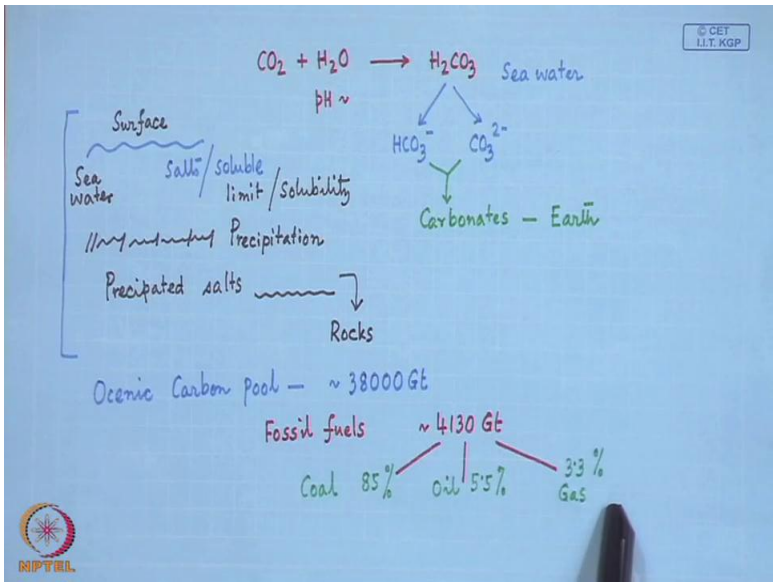

So, this carbonic acid, molecule formation so, whatever carbon dioxide is present in our hand, which is immediately can react with, the water molecule, at some optimum P H value. If it is acetic towards acetic that means, below less than 7, the corresponding conversation to carbonic acid is more. And this particular formation of carbonic acid in water that means, the sea water is important, and it can give rise to the bicarbonate anion and carbonate anion and these anions, if we are able to fix it.

So, if we can able to fix these anions so, corresponding carbonates and bicarbonates, and that belongs to a geological sample. So, it can be stored on the earth. So, earth can take care of storing the different carbonates. So, from the gas to the solid to the earth surface, we can store the different carbonates. So, the carbon cycle can run between these. So, through this that means, through photosynthesis it can be a part of our living system has useful biological molecule as oceanic biosphere. It can be stored as the carbonic acid and the corresponding bicarbonates and the carbonates self will form definitely.

And it can enter into the terrestrial environment, through the formation of the stabilized carbonate and bicarbonate in the solid inorganic form. So, inorganic carbonates and bicarbonates can be stored there, and we basically consider that carbon dioxide is basically fixing in that fashion. So, after atmosphere, if we consider the terrestrial biosphere; the terrestrial biosphere, how they are basically changed or manipulated by

the presence of the carbon cycle. We just considered in the different form that it includes also the organic carbon.

So, organic carbon should be present over there in all land living organisms, because the entire system is made carbons. So, all living organisms are made up of carbon. So, in the terrestrial biosphere, we have all carbon based compounds present over there, they can be alive, they can be dead also. So, the dead matter; the dead trees ultimately giving us corresponding coal or the oil. So, they are basically the corresponding useful carbon reserve. So, this can and other typical form that carbon itself, in the carbon form they can be stored in the soils also.

So, what is the corresponding amount of this stored carbon? So, about 500 gigatons of this amount of carbon can be stored in plants and other living organisms. So, this is the corresponding reserve within the carbon cycle that, how much carbon, we can have in this particular planet. So, about 500 gigatons basically, if we consider the entire plant and entire living organisms of the human being and the other living animal kingdom. We can consider this amount of carbon is present and the soil also holds few more. So, three times more which is 1500 gigatons of carbon.

So, the entire biosphere, terrestrial biosphere the amount of carbon basically available over there, because these are very useful carbon, they can be used as the corresponding fell material, we can burn this particular carbon for our energy. So, this amount of carbon is present in the terrestrial biosphere, which is not there in the atmosphere. So, when we burn this particular organic carbon, we just produce the corresponding use of the oxygen and forming the carbon monoxide and carbon dioxide and which is ultimately going to the atmosphere. And inorganic form has, I already told you that that can be stored in the form of calcium carbonate. So, in the terrestrial biosphere also, we can store this particular carbon as different carbonates.

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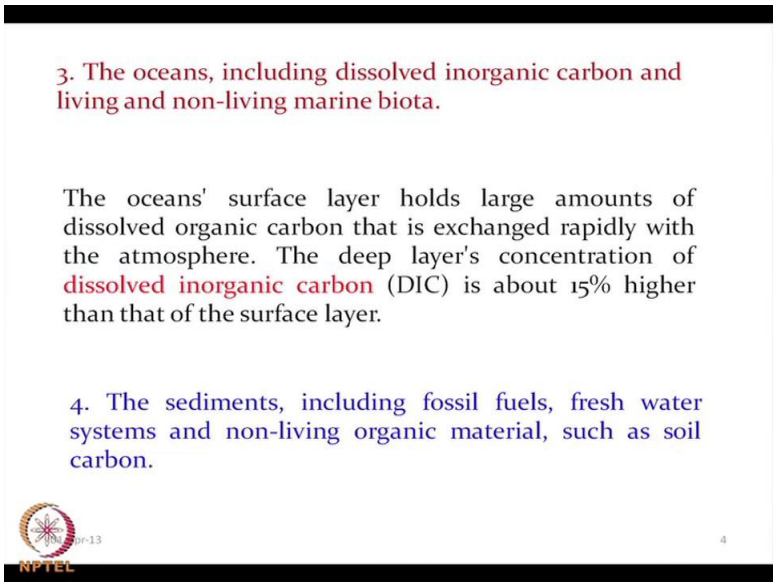

In the third case, where we seen that the ocean is also playing some important role. It can have some dissolved inorganic carbon or the typical carbonates and bicarbonates and living and non living marine biota. So, the living non living marine organisms are there and these living and non living marine organisms can have some organic part or the living part which is made up of carbon only, and in the solution case, where we can have the corresponding, inorganic carbon as, carbonates and bicarbonates.

So, all these if they are forming as the corresponding sodium salt, or the magnesium salt or the calcium salt. So, several all these alkali and alkaline earth metal ions are also present in oceans. So, when these are there they basically trap these carbonates and bicarbonates to form the corresponding salts. And these salts ultimately getting deposited under the sea level, but initially they are present in the soluble form, and they are present in sea water as their corresponding solubility limit. So, they some corresponding solubility limit and up to that particular solubility limit, they are soluble in the corresponding sea water.

So, this particular case that means, the ocean surface layer, when they basically holds large amount of dissolved organic carbon. So, in the surface layer we can have some dissolved organic carbon. So, they are partly soluble in ocean water and which can be exchanged rapidly with the atmosphere. So, if they are oxidized we produce, the corresponding gases and they go and populate the corresponding atmosphere, but what

about the deep layer oceanic concentration, the deep layers concentration. So, in the deep layers of the ocean, we have the dissolved inorganic carbon. And this dissolved inorganic carbon is nothing but our corresponding carbonates and bicarbonates and when they are getting available, they are present in as the corresponding sediments.

So, if we have the ocean layer. So, we have the huge amount of salts. So, salts have the corresponding carbonates and the bicarbonates. So, these salts are present in the soluble form and these soluble salts are present in the water level so, at the surface so, at the surface. Basically we can have these salts present and after that, we can have the precipitation the typical chemical reaction from there is the precipitation of this salts, because we can have the solubility limit. So, solubility limit is there, limit for the corresponding solubility of the different salts, it can be sodium salt, it can be magnesium salt or it can be calcium salts.

So, depending upon the different salt, what we are forming. So, these 2 anions if they are getting precipitated their solubility products are different their solubility range is also different they are getting precipitated at the bottom layer. So, the deep layer concentration for this precipitated salts. So, we have there basically, initially so, precipitated salts. So, precipitated salts are there. So, they are basically stored, and this storing basically ultimately responsible for the conversation of the different under sea rock, corals and rocks are forming over there.

So, the dissolved organic carbon so, this particular organic, inorganic carbon is about 15 percent higher than that of the surface layer. So, whatever amount we have at the surface is different than that of what is stored in form of the corresponding precipitation. So, deep layer concentration is always different from the other parts. So, we thus have the corresponding sediments, so if being the sediments, we can have the fossil fuels also. Because the sea is typical source for the drilling of the petroleum products, drilling of the corresponding natural gases then all these. So, under sea storage of these fossil fuels are important through the carbon cycle.

So, fossil fuels what we are getting from the undersea drilling. So, under sea drilling gives us the useful amount of oil and along with that oil we also get the corresponding natural gases, which are very useful fossil fuels. So, if we have the corresponding inorganic carbon over there. And if those inorganic carbons along with some organic part

can transform to some, fossil fuels under pressure that means, under geological transformation.

So, these sediments along with some fresh water systems and non living organic material such as soil carbon. So, soil carbon is also present and that particular soil carbon is also contributes some amount towards the system of this particular sedimentation and non living organic material. That means the dead organic materials are also present and those materials can be transformed to some fossil fuel or some rock materials. So sediments are there and these sediments within the sea level can give something, which is important to generate the corresponding fossil fuels.

So, what we can have their therefore, that if we have this particular ocean thing that means, the entire ocean is there in our hand. And from the bottom, we get the corresponding fossil fuels at different levels they are getting stored. So, definitely we can have oceanic origin of these carbon atoms, therefore, oceanic carbon pool we can have. And that particular pool can give rise to the corresponding fossil fuels and all other and the amount also can be estimated in terms of the corresponding giga ton amount, what we have estimated for the corresponding carbon storage.

So, here also about 38000 giga ton of this carbon fossil are there and which can be stored year after another. And from that particular carbon pool oceanic carbon pool, which includes also the different carbonates, the metal carbonates, the metal ion carbonates are also there. But if we can consider that how much of these is present as the corresponding fossil fuel, we can have the fossil fuels, which has a stored of about 4130 giga ton. So, it includes all that means, all different categories, because through this particular category, if we have considered that this is oceanic carbon pool. And from the land basically we are getting out the coal, but from this entire carbon pool we can have the corresponding percentage wise contribution of the different constituents.

So, 85 percent of that goes to coal, which is the biggest reserve for that then we can have the oil which is about only 5.5 percent which is our oil reserve, and less than that which is about 3.3 percent if the corresponding gases, what we get basically as the along with the petroleum product or as the corresponding natural gas. So, these basically stored house, and from there we just basically get the sum amount of estimation that how much

we can have as the corresponding fuel, for the typical carbon cycle as the corresponding carbon pool.

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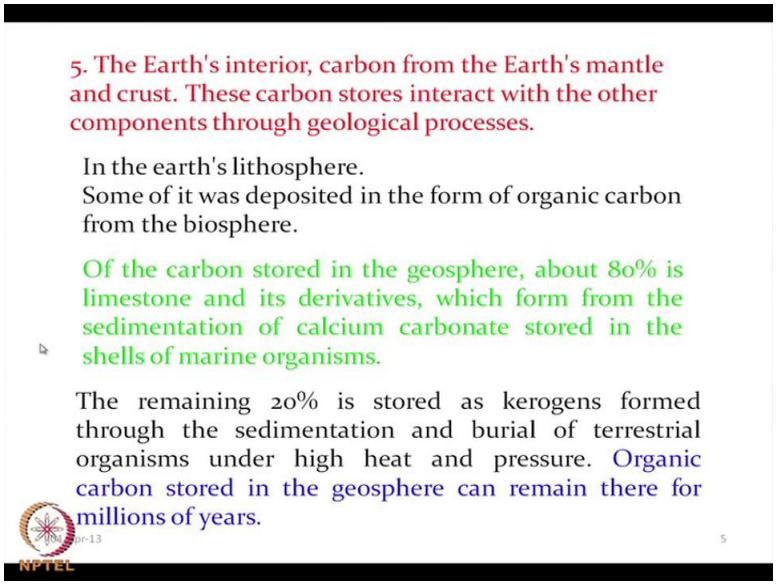

So, this particular case, you can have. So, if we go beyond that that means, from the oceanic pool to the earth interior that means, in the earth interior we can have the earth mantle and the crust. So, mantle is there, so if we can go down to the mantle or the crust. We can have some carbon compounds over there, and the storing of the carbon over there, still can interact with the other components. That means, if we can have one form stored over there which can slowly transform to the other form through a long living geological process. Because the geological time trend for all these conversations are very long, they are several 100 years or 1000 years or several 100 1000 years of the processes during which the one form of this carbon, which we are getting in the from the living system from the atmosphere as through the fixation of the gases through different geological transformations.

So, in the earth lithosphere, what we get there, so within the earth lithosphere, some of it was deposited in the form of organic carbon from the biosphere. So, the formation of the coal and the formation of fuel material or the petroleum product, we can consider that these are basically directly going from the organic carbon. So if we can have organic carbon, which is basically within the biological carbon cycle, and from that biological carbon cycle, which is basically related to the organic carbon cycle. And that organic

carbon cycle, which is coming from the biosphere can grow through the deposition of carbon as coal and the fuel within the earth lithosphere through some complex geological processes.

So, biological cycle is highly dependent on the geological cycle, and we can have side by side the corresponding chemical transformations. So, when we store these in the geo sphere, and if we just consider the corresponding carbonates formation of this corresponding carbonates. So, about 80 percent of that is in the form of the limestone. So, basically the major amount of this corresponding formation of this carbon, the fixation of the carbon through, geological transformations, and we consider the entire geological sphere as the corresponding geo sphere. So, about 80 percent which is the major amount, is in the form of the corresponding limestone and there derivatives, from where which basically the sedimentation of calcium carbonate which is basically a part of the corresponding processes, what we consider as the corresponding bio mineralization. So, if we can consider these two cycles together, that means the corresponding biological cycle, and the geological cycles.

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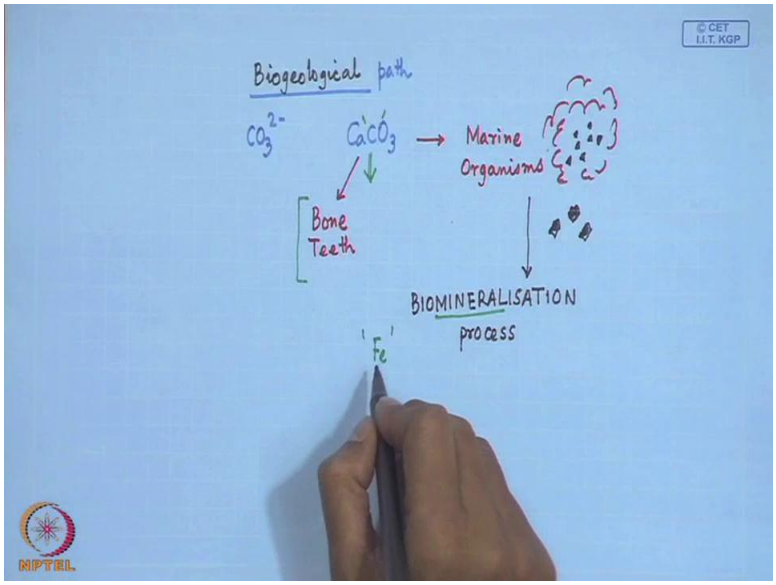

So, this biogeological cycle so, we are taking apart the corresponding chemical part, so this biogeological path. So, biology geological path basically we can have, and that biogeological path is basically responsible for the fixation of the different carbon material, as the carbonates. And if we just think of that calcium carbonate is stored over

there, and there are some important marine organisms. So, if this calcium carbonate because this we all know this is a very important and the constituent part of the living organisms. In our body also they are forming has the bone; they are their present in teeth. So, in all the living system also, we can store these calcium carbonate or the different appetites stored in the living organisms.

So, this calcium carbonate is also they are stored in the different marine organisms in the marine system also so, this marine organisms. So, we have the living backbone. So, we have the living polypeptide chain, and all these protein chain, and within which the small crystals of these. So, small crystallites are formed. So, small crystallites are formed over there, and they are ultimately getting giving to some bigger crystals and these ultimately form the corresponding shells in the marine organisms. And all these processes where basically is a mineralization process, we call them as the corresponding biomineralization process mineralization process.

So, this basically a typical mineralization process, which is different from the geological one, where we see that the geological processes are responsible for storing the corresponding important carbon compounds under the earth crust, as the corresponding typical minerals, but when the biological system is responsible through this biogeological pathway, where we basically considering the corresponding carbon cycles. So, it is only the carbon where we are talking about so, this particular carbon when they are getting mineralized within the biological system, which is also true for the formation of bone teeth and other hard material in our living system.

We consider these has the typical biomineralization process, which is also responsible for the storing of the iron in the ferritin molecule in our body, for the useful synthesis of the hemoglobin and myoglobin or any other iron dependent important compounds, such has the different cytchromes. So in the marine organisms therefore, this calcium carbonate can be stored, and through this particular biomineralization process. So, 80 percent goes as the limestone.

So, what about the remaining part? The remaining 20 percent is stored in kerogens form through the sedimentation and burial of terrestrial organisms, under high heat and pressure condition. So, under the earth, geological condition is pretty unique where we get some chemical transformations, what we cannot get in some atmospheric pressure

and room temperature or some little bit higher than the room temperature. It is very high heat condition, and the pressure is also very high, and we consider this particular situation as typical hydro thermal conditions. So, hydro is the corresponding water if water is also available.

So, high heat condition and high pressure condition along with the water molecule, we consider that the corresponding hydro thermal condition. And that hydro thermal condition is responsible for transforming the biological material the plant origins, how this plant origin can be transformed to some coal origin? So, this can be in a very high heat and very high pressure condition the organic carbon therefore, can be stored in the geo sphere and can remain there for millions of years. So, the time span is also very high, we have a typical hydro thermal reaction condition. So, that particular hydro thermal reaction condition can give us some important clue, that through millions of years this particular reaction can take place, and we basically transform this plant material to the coal material.

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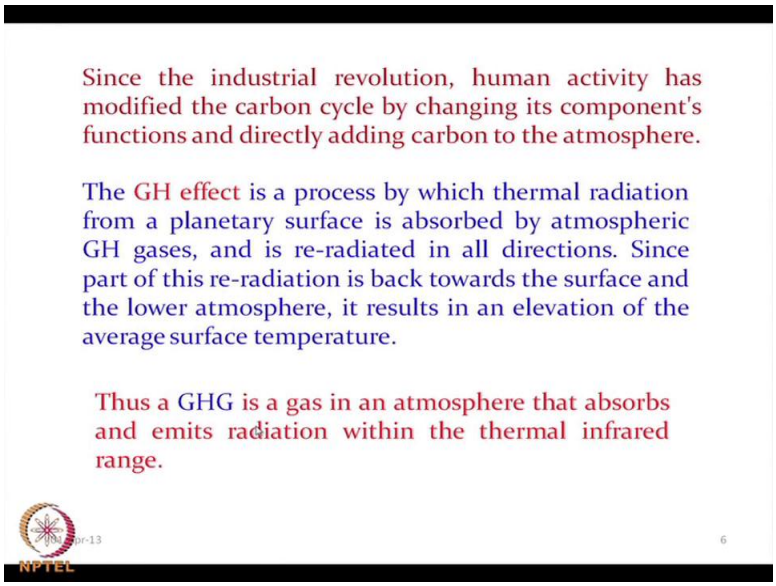

So, this particular one, we just basically, destroying. So, the industrial revolution human activity, can directly contribute to the carbon cycle, the end form of the carbon cycle, because the components of these can be converted directly to the carbon to the atmosphere. So, burning of these all these fossil fuels, what we are forming through this biomineralization process can be converted to the useful carbon dioxide molecules. So,

we can have the greenhouse effect. And this particular effect is corresponding responsible for the storing of the thermal radiation on the surface.

And the temperature average temperature on the earth is rising, because there radiation is stored also through the envelope of the corresponding greenhouse gases of carbon dioxide and methane molecule and the average temperature is also increasing over there. So, all these greenhouse gases, what is forming which belongs to the corresponding carbon cycles, the end product of the carbon cycle, where the carbon matter is oxidized to carbon dioxide or sometime it is also forming the methane molecule. And this particular greenhouse gas, which is a gas in an atmosphere that, absorbs and emits radiation within the thermal infrared region.

Because the carbon monoxide has well has the dioxide particularly, the dioxide can absorb the corresponding infrared radiation at the 647 centimeters inwards, at that particular radiation is coming from the solar radiation, and which is responsible for the corresponding absorption of this particular radiation and the corresponding rise in the average surface temperature. So, whatever greenhouse gas we can have then particular greenhouse gas one is the carbon dioxide, which is also coming from the carbon cycles. So therefore, the effect of this greenhouse is also a part from our carbon cycle, what we are just studying in this class.

Thank you.