Inorganic Chemistry of Life Principles & Properties
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Lecture - 02
Elements in biology and or life

Welcome you back to this course on the Inorganic Chemistry of Life, Principles and Perspectives. And what we have looked at in the previous lecture was as follows, we I try attempted to convince you that there are inorganic ions which are present in enzymes, how they are presented etcetera I have not told you that we will discuss later on, but they are doing a wonderful jobs. Each one of these has an important role, it could be an iron ion, it could be a zinc ion, it could be a copper ion these are the three examples of taking this could be a manganese ion it could be Molybdenum. So, I have taken examples for these just to give you a feel that there are inorganic elements which sit in the biological systems and do real one does.

Now let us continue that spirit and get into further aspects of it and in this particular slide you can see how do we understand all of these ok. So, how do we understand all of these? So in order to understand all of these we have to understand the inorganic chemistry that is going on in the biological systems ok.

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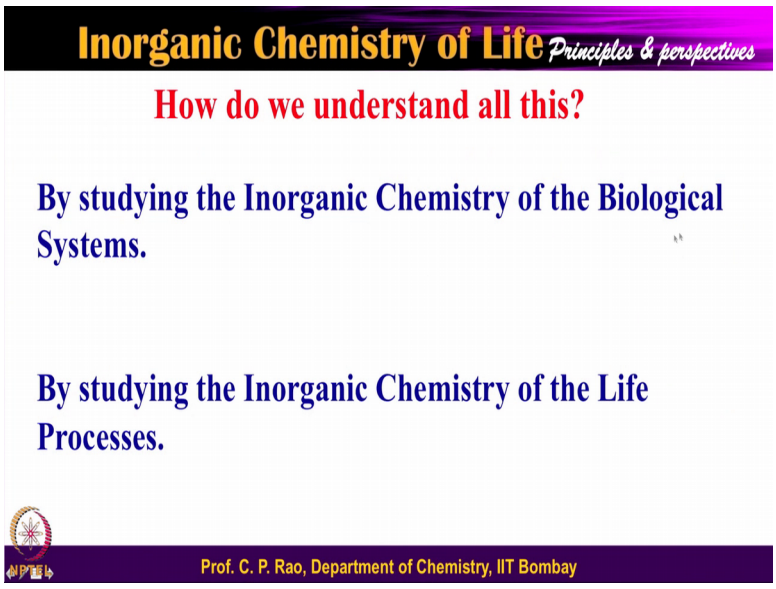

And particularly in the biological systems in the process of the biological molecules even cells etcetera and also by studying these inorganic chemistry processes in the in the life. So, how is inorganic chemistry elements inorganic elements affect the life processes? So, therefore, overall we will try to look at the role of inorganic chemistry elements in biological systems, in simple biological molecules, in cells and in some example for the organ, so the body and how this supplements and the drugs as well.

So, therefore, we will go one by one of into these aspects. So now, the question come says that for a chemist the chemist tool is a periodic table.

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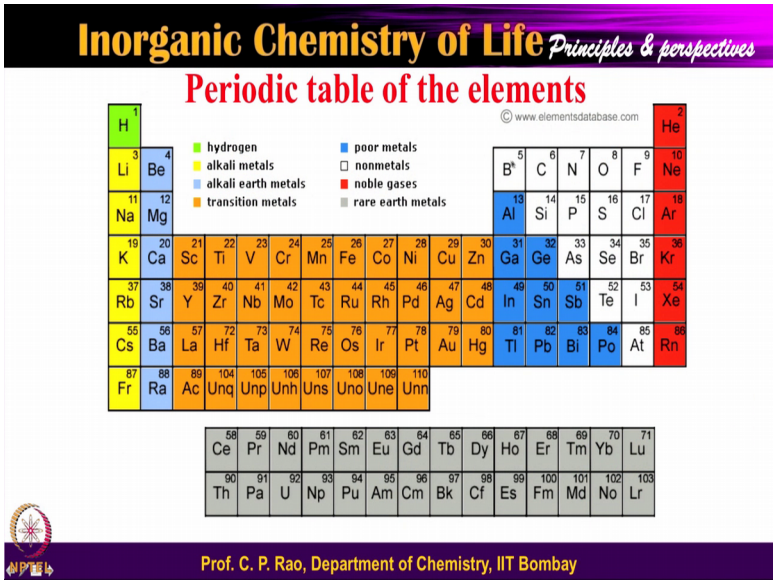

And everyone knows the periodic table of elements, which is introduced as early as ninth tenth standard in the high school. Therefore, you have a large number of boxes here, on the left side, in the centre, in the right side, in the bottom and come to these bit later stage and you have elements you know spread over all this. So, when you have elements of all these as you can see that so many elements you have is it true, that all of these elements are important in the life or only certain elements are important in the life? This needs to be understood. So, as we keep going further in the next few slides or so we will certainly understand this.

So, right now let us say yes there are large number of elements, in fact, today it is 118 elements are there. Though this particular thing shows you know 104 elements but we have 118 elements. Of these elements which are things are important in the life

processes; this we need to understand that. So, which of these elements are important? So therefore, this is concerned with; so we will try to understand what are the kinds of elements in the periodic table which are important.

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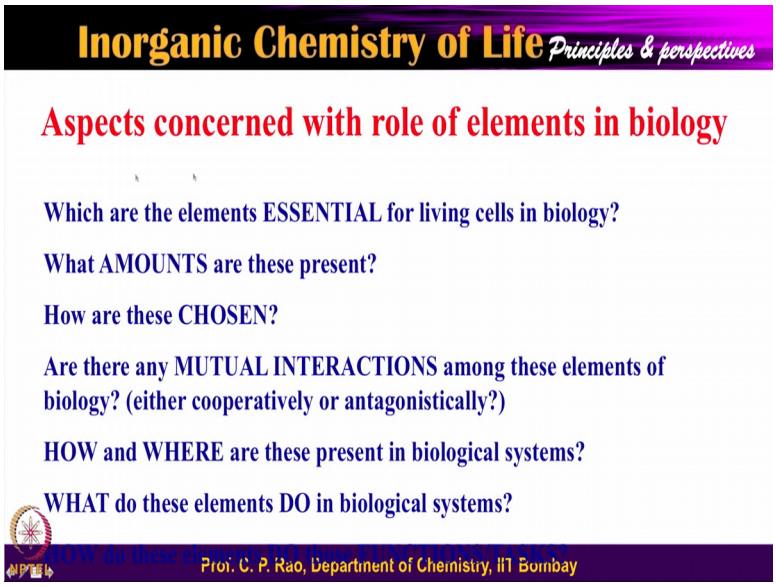

So, therefore, let us look at the aspects that are concerned with the role of elements in biology. What are the aspects that concerned? So, when you say some of the elements are used by the life, which are the elements are used by the life? So, the question number one is that which are these elements essential for living cells in biology? And that is not sufficient enough. How much what amount these present? These two are there and how come who chooses these? It is also an important thing, It is also very curious aspect.

And then, so when you choose this when you have one element then no problem, when you have two elements which one of these will have a more, which one of these will have a less, when you have a three when you have more, more than one element there can be mutual interactions among themselves, some may be dominant over the other which I will explain you later on. They may make their friendship to a cooperative way and they may extend their interactions even antagonistically. I will explain both these terms bit later with proper connectivity meaning as well as connectivity.

So, you have which are the things essential, how much amount they are there, who chooses all these, how are these been chosen and whether you have any interactions in this, if so, where are these present, how are these present, a bit of it you already noted

from my earlier slides that they are present in the one of at least one of the things is that they are present in enzymes and how they are present I am not taught to you we will see all these. So, there they are what do they do in the biological systems? So, therefore, this is all is important when you look at the inorganic role of these elements in the biological, because as you can see there are so many elements are there and know whether all these elements are essential or only part of these essential all elements are essential that we need to understand this; for that this questions arise in now at this stage ok.

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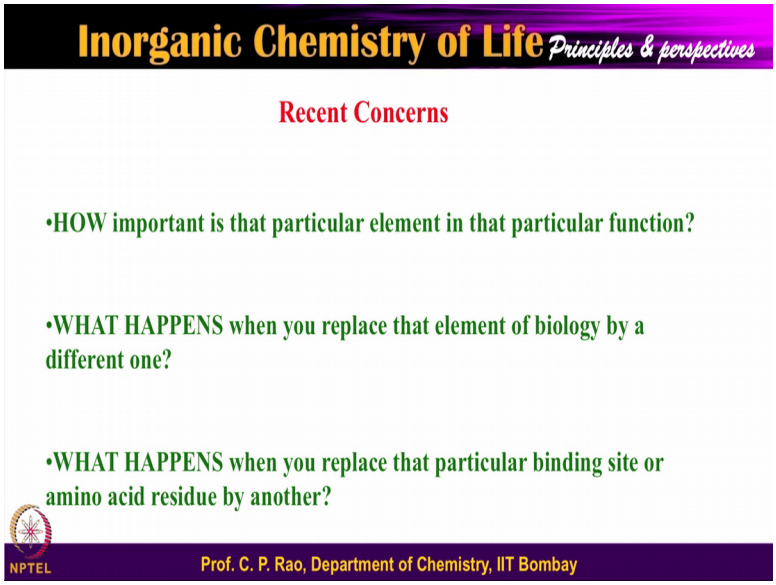

So, keeping these things aside in the recent literature there are other queries have come up. How important is a particular element? When you say a particular element or a particular ion is important in for a particular function, how important is this? How do we know how important is this? So, we will know what happens by asking a question, I will remove that ion what happens to the enzyme? I will put another ion what will happen to the enzyme? Whether, the enzyme becomes a new enzyme, whether the enzyme become completely passive with no reactivity?

So, these are some of the things in the modern concerns that have. So, when I replace one of the already present ion in the biological systems by another one, then what happens? I can not only change the ion that is being present, these ions are bound by the amino acid residues, which I will come later stage and those residues I can also play with it. So, if I change the ion if I change the amino acid residue what will happen to the

process of those you know enzymes? So, all these are additional recent concerns besides the concerns which explain to you in the previous slide in that ok. So, therefore, what I would like to propose in this particular course is very you know generally speaking.

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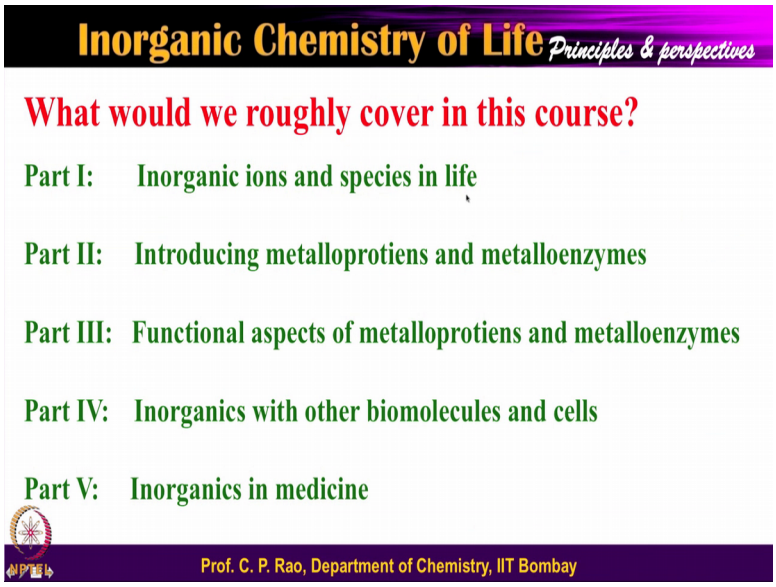

So, we will first need to look at the inorganic ion, inorganic species and what their role in life is and that is what I call it is a introductory role. In fact, such an introductory role is very well suited to even to you know twelfth standard students to drag them, or to attract them into taking a profession on the science kind of a profession. So in fact, it can attract even the students of twelfth standard thing of course this is very useful for bachelor masters students as well too.

And once I complete that, I would enter into the metalloprotiens and metalloenzymes is a huge area of which in the first stage, I will just introduce what they are doing and etcetera. So, those are the things I will be looking at and once I introduce what kind of a metalloprotiens, metalloenzymes, their classification, their functions all of these are briefly being mentioned. We will smoothly get in to the next topic as a part III is how they function, what function and how they function. These I referred as a function aspects of metalloprotiens and metalloenzymes.

This up to this if you take it, it comes more of a biological inorganic chemistry. Now I would like to add in my course not just the metalloprotiens and metalloenzymes, I would like to take even the inorganic ions or inorganic species, how they have interact with

other bio molecules, how they interact the cells, how they interact the organs. These are some of the aspects I would like to introduce in this course as a very new component and a very elegant kind of a component to give a kind of a completion to the course that will be giving this.

It is not only that I also wanted to add another perspectives, which are coming where the inorganic ions, inorganic species, inorganic complexes acting like a medicines; how, what and how these are some of the aspects. So, the overall I would like to sort of divide this into five parts, part of the inorganic ions and species in life and introducing the metalloprotiens and metalloenzymes, the functional aspects of metalloprotiens and metalloenzymes and then I will talk about the other biomolecules and cells, how the inorganics will interact with them and what their role in the medicinal aspects.

So, this is the some of the coverage aspects of this particular course at this stage. Having mentioned that what; so, what I said? I said that we will try to go through these five parts of the topics, the initial introduction or the inorganic ions and spaces then just introduce the metalloproteins and metalloenzymes what they do etcetera. And how diverse they are and then going to how they are doing it, that is called functions. So the functional aspects of these metalloprotiens and metalloenzymes.

So, as I said this particular part is mainly covered in the biological inorganic chemistry but I would like to take up in this particular course a few more aspects. The aspects of the inorganics with other biomolecules and cells as well and then also would like to see the inorganic ions and species how they act in medicine kind of things ok. So, with these let us again look back into this, so the periodic table, you have the alkali alkyl earth ions, you have the main group elements, you have a transition ions and you have a inner transition ions in these things ok, so we will get back to this a bit later.

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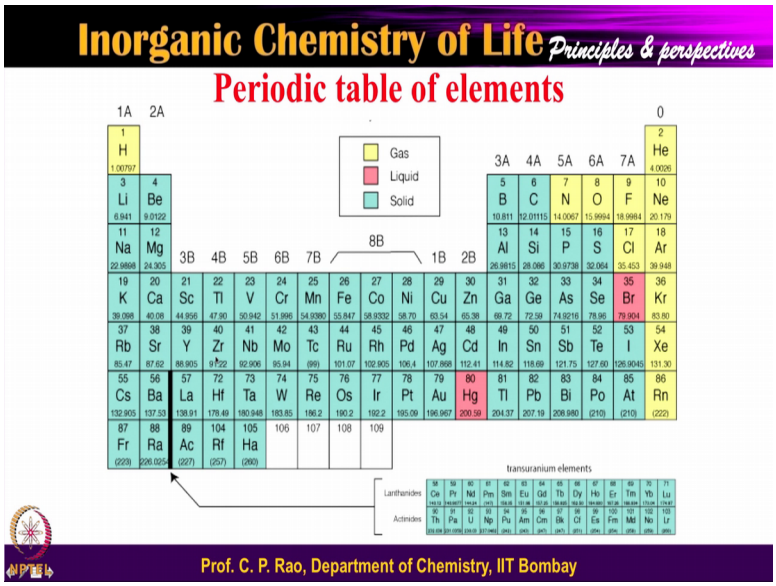

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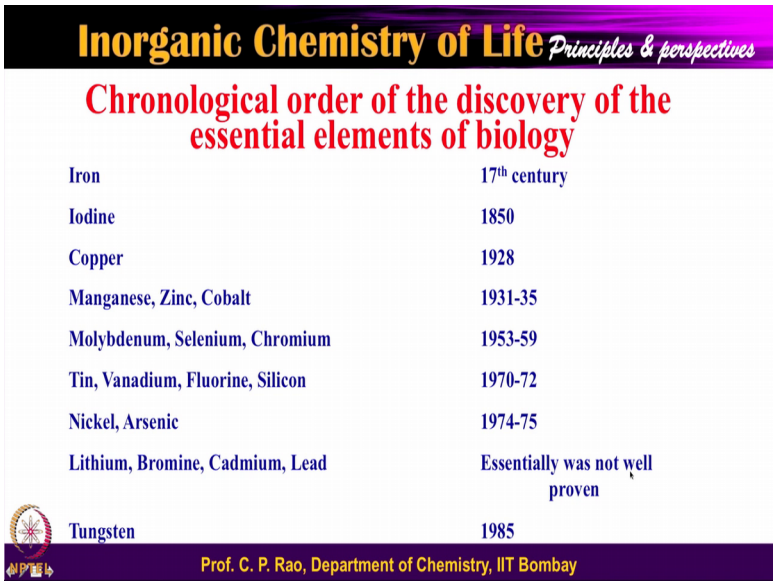

So, having seen this now we need to identify which are the elements are important or which are the elements have been chosen by the life. So, for this I would take you back 2 to 300 years back into the into the history of life.

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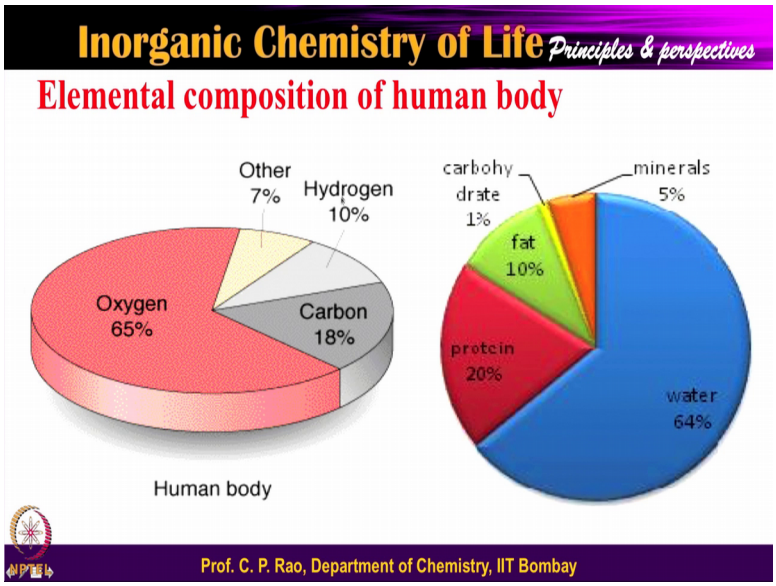

So, if you look at the history of life in a cloth in a in history of life the essential elements as you can see as early as in 17th century people know that the Iron is essential. And people have come to know in mid 80's mid 19th century which is 1850 people knew that the Iodine is also important. In the early 1900's people knew that the copper is essential and then 1930's people have started understanding this Manganese is essential, Zinc is essential, Cobalt is essential.

So, so many ions have been started adding to this one to the other one to the other. So, molybdenum then comes in 50s to 60s Molybdenum, Selenium, Chromium also. Some of them may look to you it is a it is puzzling; some of these ion you may think that they are toxic I will explain you that as well. And some more ions have been identified at a later stage in 70s, early 70s like Tin, Vanadium, Fluorine, Silicon etcetera. And bit later Nickel, Arsenic you may say that arsenic is a poisonous.

So, any element that you would come to know after a while can be poisonous, when you have a large concentration but they could be even essential elements at the lower concentration which I will convince you in the next later few slides. And one step later people have tried to find out that there is some role of Lithium, Bromine, Cadmium, Lead etcetera, but not proven so much and very recently just about in the past let say 30-40 years Tungsten has also been found to be involved. In fact, tungsten is not found to be

involved in the normal life of the human, but it is found in the life where the life grows at a very high temperature. Where is the life of high temperatures; in the lava.

So if you see lava eruptions have got high temperature 300, 350, 400 degree Celsius where certain kind of species bacterial species or grow and in that the tungsten and tungsten takes the role of molybdenum, tungsten takes the role of the molybdenum in this. So, therefore, as we can see that this is the way that starting from last 200, 250 years, we have started learning understanding the involvement of the ions or elements in the biological processes even including the human body kind of thing. So, having seen such a kind of a you know hierarchical kind of a development a chronological kind of development sorry is not hierarchical it is a chronological which is a time based. So, time based is referred as a chronological aspects.

So, you know iron, then you know iodine, then you know copper, then you know zinc, then you know many other ions are required, but still they are limited in number as you can see. Now if you come and look at now we will take a big leap or jump and look at the composition of the human body. So, look at initially on the right side of this, so on the right side of this as you see that the body has huge amount of water 64, which is almost two-thirds is a is the water and 1 4, one-fifth is only the protein and about one-tenth is a fat and you have much less is a carbohydrate and some minerals etcetera. So, whatever you have real important elements are all within this particular thing. So, water being the maximum followed by protein, followed by fat and the remaining, but it is very essential to understand what these elements present in these mineral category we will come to know in a while.

Instead of looking at this kind of a compositional way let us look at the elemental type of compositional way. So, the elemental type of compositional way is that the maximum element in all this is oxygen, two-thirds going two-thirds with water two-thirds of the oxygen. And then you have a carbon which is about 18 percent. You see the protein is 20 percent, you can see the carbon is 18 percent. So, goes well very well with it. That means most of the carbon is coming from the protein, most of the oxygen is coming from the water etcetera, etcetera. And then you have 10 percent of the hydrogen because hydrogen is present in the protein as well as in the water and other things. These other is very, very essential and important that is what we need to understand. Highlight these things that is

what is going to be important in this particular course on inorganic chemistry of life in this.

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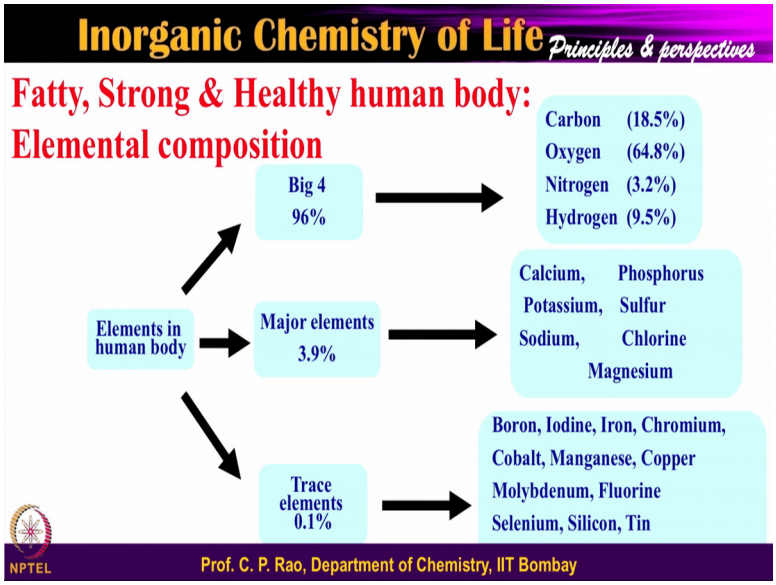

So, let us go to the little further, so having said that we have carbon, oxygen, nitrogen, hydrogen, and you see on this carbon is around 18.5, oxygen 64.8, nitrogen 3.2, hydrogen 9.5, see you add them all together you will get something like 96 percent; that means, we as a human bodies we are so fat, but in this fatty body what we have is mainly these elements.

Let us look at these as I mention in the previous slide the carbon, oxygen, nitrogen, hydrogen, these are present in 18.5 percent carbon, 64.8 percent oxygen, 3.2 percent of nitrogen and 9.5 percent of the hydrogen. So, these are the kinds of major elements. So, if we add up add them together you will get a big 96 big 4 the 4 is 4 elements, the big 4 is because the whole body is dictated, the whole body composition the whole body weight is dictated by the big 4 the big 4 is this.

So, will you be happy to have this 4 and have nothing else and if, so then you will not be functioning as a human. Then you will be just functioning like a just as a fatty body, nothing more than that. Then what you need to have a human life? To human life you need not only the fatty body components like this 4, but you also need certain major elements. These major elements are macrominerals also referred as macrominerals and these are calcium, the potassium, sodium, say phosphorus, sulphur, chloride of course,

magnesium all of these. So, these are major elements, so after this 96 percent you have this 3.9 percent. What is left? The left is 100 minus 96 plus 3.9 this becomes 0.1. So, the 0.1 is the one which you have seen so; obviously, 0.1.

So, when you have a 0.1 what would you understand that 0.1 obviously, is very, very small when you compare with a 100. So, therefore, this is this 1 1000th part of a 100 percent of that. So, you have something when you a vary such a small you called it is a trace. So, the word trace is coming from the concentrations that you present, but not their role is trace. Their role is very, very important. So, if you have big 4 elements you will have fatty body you will not have any life at all, then you have this big 4 plus major elements you have a strong body you have a fat you have a strong body, but still you cannot do functions.

So, if you have the big 4 you have the macrominerals and you also have the trace elements then you are a perfect human body, where what I mean by perfect human body is that you can really function like a human body. So, from this slide what you need to understand just having 96 percent is not good enough to say that I am a human being. I cannot function like a human being. Suppose you take an exam and if you get a 96 percent marks you are absolutely happy, but you cannot be very happy if you take have just these 4 elements. And then people who get a 99.9 percent of the marks they are of course, absolutely toppers and there will be flashed everywhere across the news media and they are the top guys, who will be selected by all the high level institutes etcetera.

But here after adding 96 plus 3.9, 99.9, still I would say this is just a skeleton with some fat but nothing more than that no life in it. So, if I want to put add life to this I have to add trace elements this 0.1 percent. So, for a bioinorganic chemist biological inorganic chemistry, and if you have want to have real life of your body is the 4 elements big 4 elements, macrominerals are not sufficient enough you need to have the all the trace elements. So, is like it is like you know you used to hear the lord Brahma makes the human body, first you make the body then you put what is essential components then you put what will be the further function as exactly similar way that you would see over here too.

So, therefore, we are going to have an important you know entire course which is dependent on these trace elements are mostly to some extent these elements as well but

nothing on the carbon, oxygen, nitrogen, hydrogen at all in this particular course, we do not need that. So, therefore, a healthy body requires not only the bulk elements like big 4, not only the macrominerals all these 7 also need all this is about dozen trace elements 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12. So, this dozen essential elements are absolutely important in that.

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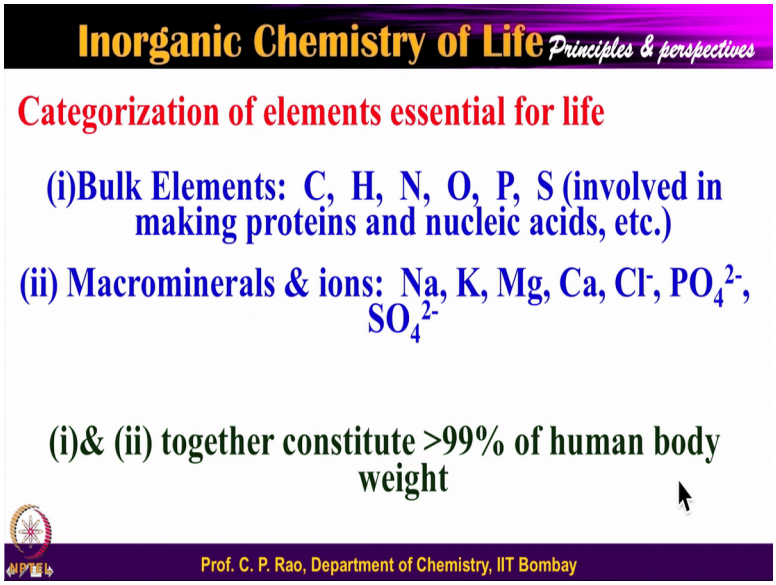

So, having said that let me let me recapitulate what we have said in the previous slide and trying to explain and make you to understand made this into categories. So, therefore, the element that are required to bulk are called carbon, hydrogen, nitrogen, oxygen, phosphorus, sulphur, these are all involved in making the main molecular mantel like for example proteins, for example nucleic acid, polysaccharides, lipids they are all formed from carbon, hydrogen, nitrogen, oxygen, phosphorus and sulphur.

So, therefore, your whole body is built with these ones, then the macrominerals and some other ones like sodium, potassium, magnesium, calcium and then chloride, phosphate, sulphate, etcetera. So, all of these are also important and as you have seen from the previous slide that together all of these is greater than 99 in fact, this is 99.1.

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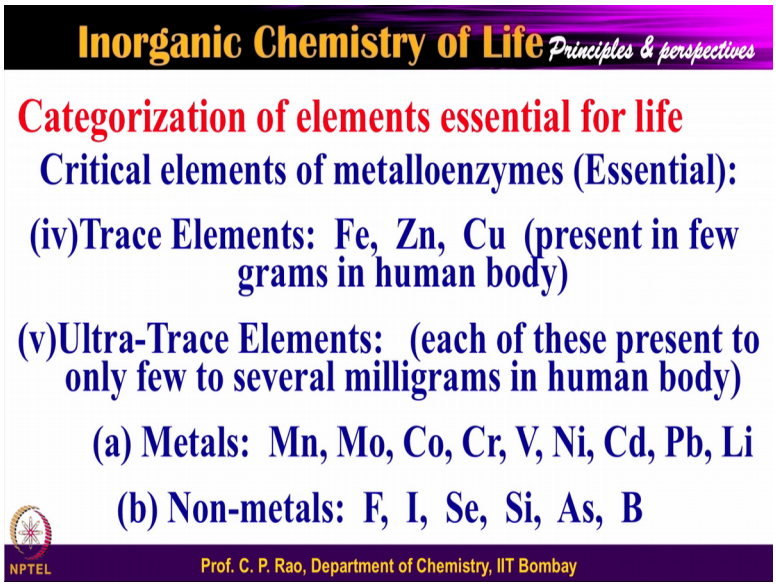

So, the rest is the category three, so in this category three is the one as I said earlier is absolutely important. So, who gives the life to the body human body? It is these elements which will add the life to the body. If these elements are not there life is removed from the body and it is basically non-functional body, so non-functional body to a functional body. So, therefore, you require the trace elements to be added in into that. So, in this depending upon the concentrations this can be divided into two parts and the in the first part we call as a Trace and the second part we call as a Ultra-Trace. So, trace elements are those where these are present about a couple of grams per 70 kilograms bodyweight; a couple of grams for a 70 kilograms of body weight.

So, such kind of things are trace elements and those which are present a few milligrams for a body weight of 70 kilograms of body weight and they are called ultra-trace. Both trace and ultra-trace elements are very important in life and these are the ones which add life to you basically the body and of these let us make one next categorization is the metals and nonmetals kind a thing. So, therefore, you have a manganese, molybdenum, cobalt, chromium, vanadium, nickel, cadmium, lead, lithium, these are coming from the metal interaction and there are some non-metals are also coming up and these non-metals are fluorine, fluorine, iodine, selenium, silicon, arsenic, boron, some of these may think little unusual to you, I will explain that now a little and more a later. So, I will think the silicon; obviously, very small amount of silicon is required very trace ultra-trace amounts of silicon is required, but it is not found any of the enzyme yet.

The arsenic very small amount of the arsenic is required, but yet it is not found any in any of the enzyme, but still they are required at very small concentrations of these of these ones. So, now, you understand the life means it is not just the fat containing body life does not mean fat plus the macrominerals, the life human life means the fat containing aspects, macro mineral containing aspects and the trace elements. So, therefore, I would like to sort of define a human life in the following way.

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So, fat items plus macro minerals plus I will write in a different color this one it is the trace and ultra-trace elements ok. So, that the human life if you are or emphasizing on the term life so that life comes only when you add these when you do not add this there is no life at all.

So, therefore, so these are some of the important aspects that one need to be realizing that ok. So, without this just a fat items the fat body and with the macro minerals you will have a strong body but you will not have any functional that fat plus macro minerals plus the trace elements that if you make then becomes absolutely full life of these.

So, to sum up what I have talked to you is in the first part of the lecture, I have talked to you the inorganic elements of present in some aspects such as called the enzymes but I am not explain you how they are. Then the next stage we have looked at that which are the ions in the periodic are important and that also we are looked that and only certain kind of elements, then we have looked at the chronological order how this has come up

from very early days knowing from iron to iodine to copper etcetera and several more of this and then we know what is the composition today human body composition.

Human body composition we have looked at there are 4 elements like carbon, nitrogen, oxygen, these kinds of elements will make the total body weight into more than 90's 9 percent. and then there are some elements which are which are basically called macrominerals together is 99.9 and it is that 0.1 percent of the element which we categorized as trace and ultra-trace elements.

And these trace and ultra-trace elements indeed add life to the body and then you can say just the life is really human life only when you add all these. This is where in this particular lecture that I will I would like to focus. Then we will see the aspects following that how these or where these are present and those kind of details will be seen in the next lecture.

Thank you very much.