Circular Dichroism and Mossbauer and Spectroscopy for Chemists
Prof. Arnab Dutta
Department of Chemistry
Indian Institute of Technology – Bombay

Lecture – 11
Chirality and Biology - I

So, some of you might be thinking like okay this is fine. We are learning about optical activity but why do I care about optical activity?

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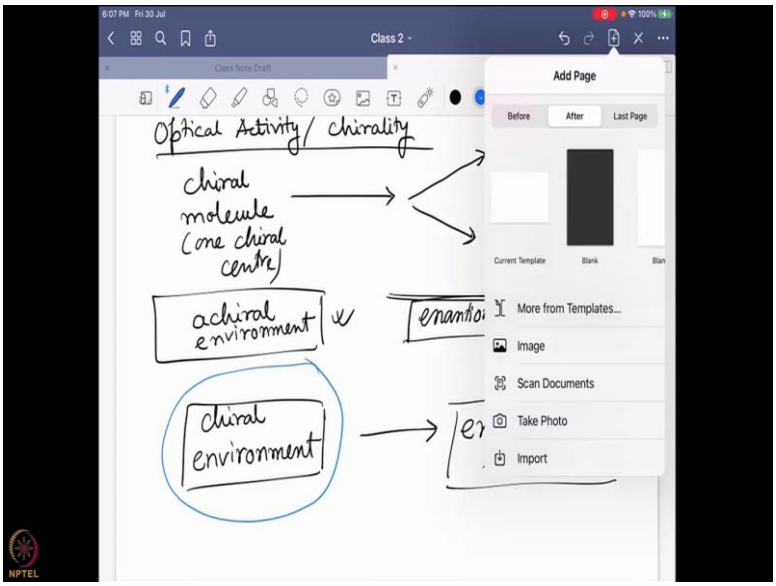

What is the specialty about this optical activity thing. Now, this optical activity or as we said chirality, is a very important factor why so? So, before going into the details of that let me just inform you some facts that you already probably know from the organic chemistry background especially. So, if you have a chiral molecule a chiral molecule if you have. how many different enantiomers you can have from this chiral molecule?

If it has only one chiral center, anyone okay let me call some names sir two okay so, who is this? So, please tell yourself yeah, Rishab right, yes, sir yeah Rishab right very rightly said. So, there will be two different enantiomer so, I just say enantiomer A and enantiomer B and that is perfectly right. So, Rishab help me a little bit more if I want to say synthesize these two enantiomers A and B what should be the ratios of these two enantiomers?

If I synthesize them. I mean the product ratio. What should be the ratio? We expect, if I synthesize this enantiomers A and B. Sir uh for racemic mixture yeah. You tell me when I am going to say, find a racemic mixture and when I can get an enantiomeric excess. Sir, for racemic mixture, 50, 50%, 50% enantiomer A and 50% enantiomer B and for excess more than 50% anything uh means that if enantiomer A is in excess that it would be more than 50% and B will be less than 50%, okay correctly said.

So, yes that should be 50, 50 with respect to the ratio, if I am doing it synthetically without using any chiral center. okay If I am doing doing that in the a chiral environment. I am going to get both the enantiomer in the same equivalent. So, in the terms of enantiomeric excess, we would say it is going to be 0 no enantiomeric axis. Both of them will be prepared in the same amount. Why? Because I am using a air chiral environment in this reaction. Right

And when I can get a enantiomeric excess? When I am using a chiral environment. So, if I use a chiral environment then only I can expect some enantiomeric excess. I hope everybody agrees with me. This is like 1 0 1 of chiral synthetic chemistry in organic section and the factors or the facts even same even in the inorganic chemistry. So, if you want to have an enantiomeric excess one particular instrument more than the other, you have to use a chiral environment. Otherwise, you cannot have it.

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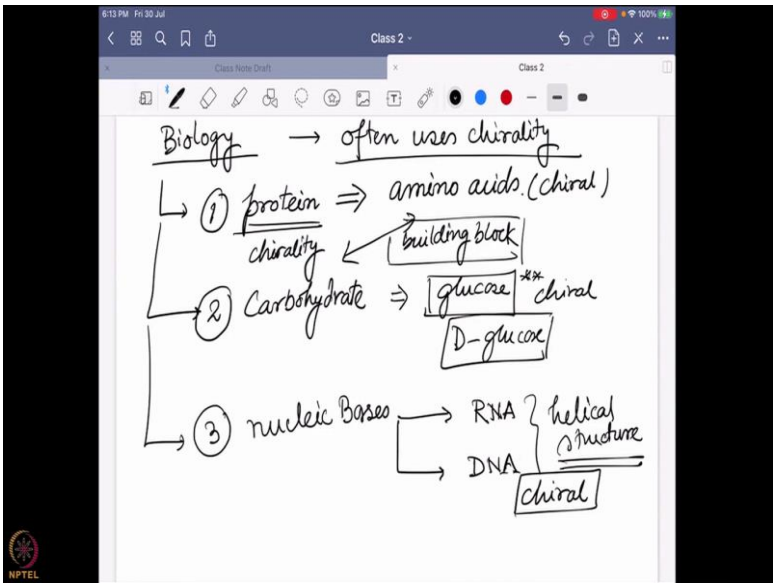

Now, take a look into biology. So, if we take a look into biology, we will find chirality is quite relevant sorry quite prevalent in biology. Okay Biology often use the chirality so, what is the proof of that? So, for the proof of that I will tell about three different set of molecules which can be recognized as the backbone of biology. First one so I am talking about protein, so, protein can be obviously regarded as one of the very significant backbone, which is actually playing a huge role during the formation of different entities all around the world.

Say it from our skin to form our teeth everywhere we can find proteins all around and these proteins are actually made out of amino acids and we will come into a few minutes that there are 20 different, naturally occurring amino acids present in biology. And over there, except one all of them are chiral in nature. So, if the building block itself of the protein is actually chiral, obviously the molecule they are going to produce is also going to be chiral

So, this protein structure actually has chirality and one of the reason for that is that the building block is actually chiral. And we will look into a few of the coming classes that not only this building blocks but the protein structure overall. When it forms this three

dimensional structure it can also induce a few amount of extra chirality around it we will come into that later.

But for now, we understand that okay the simple structure of protein is nothing but a polymer protein structure is nothing but a polymer which is connected through different amino acids and each of the amino acids, except one are all chirals. Obviously, the polymer it is producing is going to be chiral. So, it is going to be nothing but a polymer of multiple chiral centres present over there. So, it is going to be chiral. So, protein is a chiral center.

Second one, the carbohydrate. So, carbohydrate also plays a huge role in biology. For example, all of us are right now running on the energy of ATP and the ATP energy is actually honest from the glucose. And this glucose is one of the carbohydrate system which is also chiral. You say it is a D-glucose from it is original structure and if you gone through the chemistry of the carbohydrates.

Now you know what why it is called D-glucose and all those things I am not going into the details but ensure it is nothing to do with the glucon-D those two D probably are not connected. So, D-glucose is also chiral in nature. Now, in a cellular system, when the protein is formed and especially the proteins found on the cell membrane, they also contains a lot of carbohydrate molecules.

So that also creates another center of chirality, another center of optical active molecule connected to it. So, this carbohydrate molecules also induce an another set of chirality around it. So, just a minute sorry about it. So, the third molecule that we are going to talk about is the nucleic bases. If you look into the nucleic bases, these are known as the basic system that is not only looking on into our genetic material or they are carrying our genetic information.

But they are also known to even act as uh some of the enzymes, even that will come into a little bit later. And these are also is record as one of the backbone of our biology. So that, is why that is a very important material and as we know the nucleic bases depending on what is actually there, you can differentiate them as RNAs or DNAs, depending on which kind of ribose you are using deoxyribose, or proxyribose or natural ribose.

So, depending on that you can have RNA or DNA molecule and all of them either DNA or RNA can form a helical structure and those helical structure can be optically active or chiral. For example, the most famous one the double helix system that has been discussed and discovered by Watson and Crick which actually faced them Nobel prize. That is also actually a chiral molecule.

So, chirality present all around the biology from the protein to carbohydrate to nucleic bases and all this chirality what is the role of this? Why it is important.

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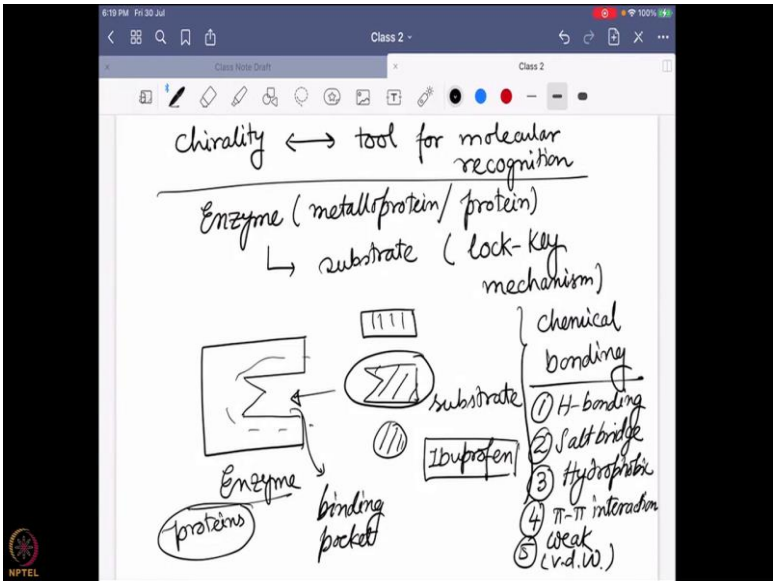

And the important factor is coming this chirality is actually employed as a tool for molecular recognition is tool for molecular recognition but we are moving by molecular recognition. So, I will give you an example that we learned from the very beginning of our biology 1 0 1 probably from our 6th standard. We always try to understand that how an enzyme works. The enzymes mostly made out of say, metallic proteins or simple proteins.

And this system interacts with a substrate and each of the enzyme has it is own unique way to interact with the substrate. It does not go ahead and interact with any substrate. It has a very preferred way to interact with a particular substrate, even in the presence of thousands of them and we learned them that they actually work which is we learned as a lock and key mechanism and we all look into those things.

So, for example, this kind of say cartoon characters. So, say this is my enzyme and this is my substrate coming. So, if there are other substrates are also present. Among them, it will specifically choose the one which actually fits it very nicely. So, over there this kind of system we know. So, this is what we say, the binding pocket and this is what we say the substrate and the substrate very nicely fits into the binding pocket.

Now, the question is how actual actually it is happening? It is not the lego formation in the molecule. The molecule has to recognize that which molecule is coming. It is not only the fitting of the shape but also the property of it and those properties are actually defined by a lot of bonding interaction, chemical bonding interactions. And what kind of chemical bonding interaction can play big role over there?

Various kinds, hydrogen bonding, salt bridge interaction, salt bridge interaction means there is a positive end on the substrate negative and on the enzyme or vice versa. They are going to create some ionic interaction. There is a possibility of hydrophobic interactions. There is a possibility of pi pi interactions. There is a possibility of weak bonding interactions which is known as the Van der Waals interactions.

All those things come into together but it is not only the bonding but which particular direction the bonding is coming into because imagine

this is happening in a three dimensional way not only two dimension. So, the actual orientation of this bonding interaction plays a huge role into the molecular recognition and this molecular recognition is triggered by the three dimensional orientation of the molecule and now look into the enzyme.

This enzyme is made out of proteins and proteins are already chiral. So that, actually uses it is chiral environment to find it out whether this is the substrate, I am going to work on there or not. For an example, whenever we are taking a medicine most of the medicine, if you take a look, not the very generic medicine but the specific medicines they are actually chrial, one of the most common example take ibuprofen.

If you take a look into that molecule, you find this is probably having a chirality and this chirality is actually properly detected by the enzyme which is going to react with that and create the active species. So that, the reaction can go forward or this particular molecule can showcase their medicinal activity and that is actually initiated by the molecular interaction. And this molecular interaction or molecular recognition is actually triggered by the chirality.

So that is why chirality plays a huge role in terms of the molecular recognition in biology. fine. So, any question is up to here because this is a very important factor. I want to ensure that everybody of everyone of you is actually following it properly. Anybody have any questions up to here that molecular recognition is very important from biology point of view and biology uses chirality as one of it is tool to ensure that the molecular recognition is happening over there any questions or query. Okay.

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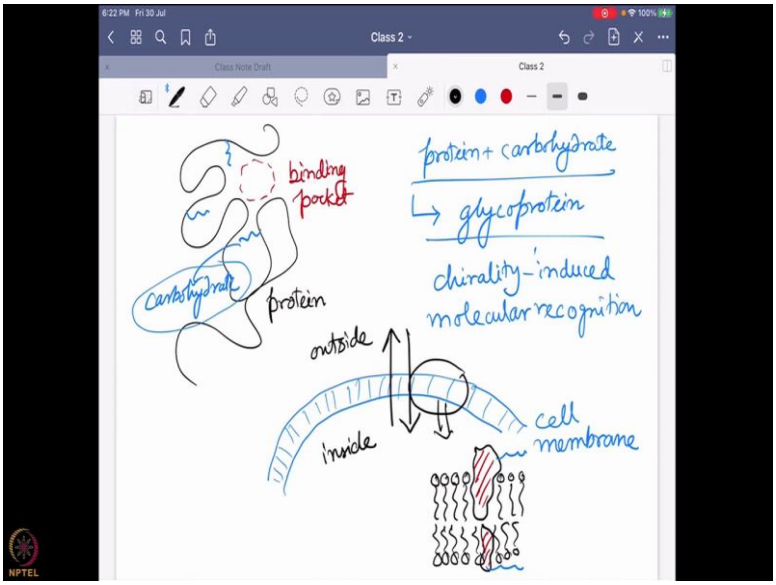

So, if not we will go to the next part that when we talk about this particular interaction. So, I am just say, for example, drawing a particular protein structure. So, it is not only a proteins structure that always create a particular binding pocket and binds to a substrate. There are some other helpful things also come to your it is

way too. So, for example, sometime, it also has some carbohydrate molecules present over there.

And those molecules which actually has protein plus carbohydrate both present and they both act together for a particular molecular recognition or particular activity. Those are known as the glycoproteins and those also play a huge role into this molecular recognition and this molecular recognition again, you can see the carbohydrate whatever it is coming over there that is chiral. The protein backbone is chiral.

So, again, this molecular recognition through glycoprotein also happens apparently through the chirality. So, you can say it is a chirality induced molecular recognition and that is very important factor. Why? Because most of this such kind of glycoproteins, where it is found, it is generally found on the cell membrane. okay So, it is found on the cell membrane. So, if you look into the cell membrane and if I want to cut it off a chunk of it and look very carefully over there.

You will find that what is there you will find there are lipid molecules present is a bilayer of the lipid in such a way and over there in between there is a protein in depth over there. Something like that and what is this protein? These are sometimes known as the simple inter-membrane or trans-membrane protein and if it does have some uh carbohydrate part, you can say it is a glycoprotein

And this kind of inter-membrane or trans-membrane proteins are very critical because they actually controls what are the things can go into or go out from the cell to the outside and to the inside of the cell. So, the overall functionality of a cellular system is hugely controlled by this traffic around this cell membrane and over there, there are the guards which actually, controls and check the ID cards of the molecules which is passing through.

And their ID cards are molecular recognition and how they check it. So, their ID card reader is nothing but chirality. So that, is how the glycoproteins and the transmembrane proteins play a huge role during the molecular recognition and during the controlling the transportation of different systems, different proteins, different biomolecules, different molecules towards inside the cell.

So, now you can understand if you want to in create a drug molecule and just push the drug molecule inside the human body or any living body, it does not mean it will always go through if you put a totally wrong molecule or molecular structure with respect to chirality, it might not even recognize it and even it not may even let it pass through from the outside to the inside of the cell.

So that, it can even get metabolized and induce or influence the overall molecule cellular functionalities and act as a drug. So that, is it is very much important to learn how the biology is actually working over there. What is the particular chirality? You probably would need and that is why you probably wondered earlier like why so many of the biomolecules or bio relevant molecules are chiral in nature.

Because as I said earlier, the biology reads the molecule or recognize the molecule through the chirality and that is why it is very much

important. So, I hope you got an idea like why chirality is a very important phenomena and that is why we are interested to know about chirality and a particular spectroscopic method or technology that can help us to understand what is the chirality and how it is oriented in three dimension.