Circular Dichroism and Mossbauer and Spectroscopy for Chemist

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Lecture – 12
Chirality and Biology – II

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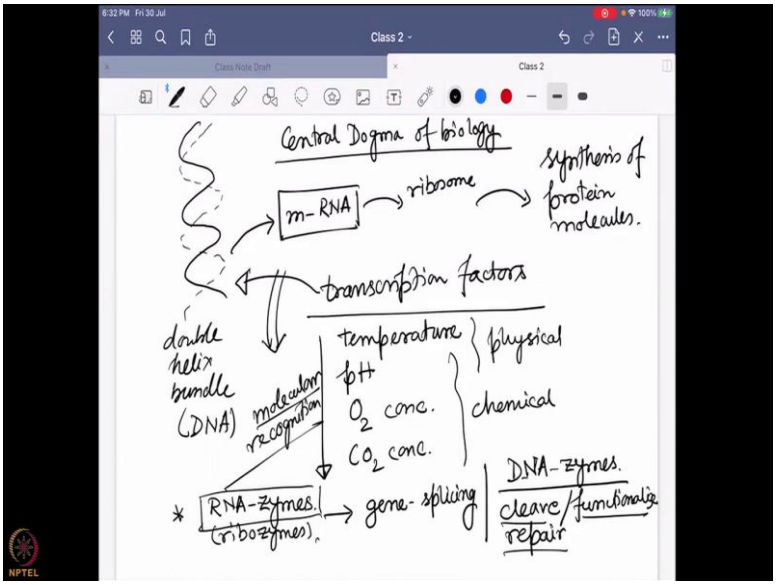

Now, after this talking about this carbohydrate protein, let us talk a little bit about nucleic acid. So, we all know this nucleic acid. Somehow it is connected through this kind of double helical bundle. okay And what we know that this kind of binding generally can be found in DNA. And then the DNA is storing our information which actually opens up during the information passing phenomena.

Transcription and translation and all those things transfer it is information to m RNA which also having some chirality and this m RNA actually interacts with the ribosome and that actually creates the protein molecules that we actually require. So, this whole process, how the DNA interacts with RNA? It interacts with the ribosome and over there how the protein molecules are actually synthesized.

This full system is known as the central dogma of biology. So that, is how the information is passes on now think about that because we are chemist, we are not biologists. So, we want to understand like wait a while how it is actually happening there. So, is the DNA going to open up and interact with the m RNA all the time or it opens up at particular certain conditions? The answer is it opens up only at a particular condition. Just wait a minute sorry about the background noise so.

So, this DNA molecule actually senses some changes in the environment of the biology and only when it actually opens up. So, those kind of phenomena which actually aids to the opening of the DNA. Sometimes they are in generally known as the transcription factors and what are those transcription factors? They can be physical conditions like temperature like someone actually having some wrong metabolism.

The body is heating up, it actually sensed by the DNA and they actually tried to stop it by creating some protein molecules which might going to help you out, it might be pH. It might be the oxygen concentration, it might be the carbon dioxide concentration and so on and so forth. So, this can be physical in nature and they can be chemical in nature, pH I would say it is probably chemical in nature.

Because it is actually nothing but sensing the proton concentration of the solution because all our for example, similar system is generally tried to be near neutral condition, 6.5 to 7.5. But sometimes if the cell is having some malfunctionality, for example, cancerous cells, they actually become very much acidic in nature. It can go even close to three or four. So, at that time the biology censuses and try to respond to it.

So, how these biological responses happen? The DNA somehow detects it or other cofactor somehow detects it and that detection is also coming through molecular recognition. So that, means this transcription factor how it is interacting with this DNA. It is actually nothing but a molecular recognition in certain cases and over here again the chiral nature of the DNA and chiral nature of that particular chemical can be very crucial for ensuring that.

We are actually responding to the correct call, not any false elements. So that is why the molecular recognition, even the DNA are in a very important and additionally, what is recently has been found? The DNA and RNA are not only acting as the simple gene information transfer agents. They can also act as an enzyme. So, for an example, there are certain numbers of systems known as RNA zymes or sometime it is also known as ribozymes.

So, you can take a look into that so, these are very crucial and they actually play a huge role during the gene splicing. So, sometimes the genes has to be restored has to be modified during the evolution and whatever the things happening with the gene. uh Gene and structure and it is conservation or it is modification even some of the RNAs are playing a huge role on controlling, like which particular portion of the DNA or RNA I have to cut it down.

Which particular group I have to look into even over there. It is going through a molecular recognition and again the chiral nature of the RNA molecules which be pretty important factor. So, recently it is found it is not only the RNA but the DNAs, even which is known as a very robust material. It is found that DNA can also even participate in catalysis or some chemical reaction in certain cases.

So, those are also known as DNA zymes. So, what they do, they sometimes also do the similar work like the cleave or functionalize. For example, you need to put a phosphate group in one particular portion. So that, it can recognize a particular molecule as a transcription factor so, for that you have to functionalize the DNA or RNA segment with the phosphate group and this DNA does this reaction through an acid-base reaction.

So, this kind of and cleave a particular DNA at a certain place. So that it can respond to a particular condition. So, those kind of thing and even sometime, repairing of the DNAs or RNA. So, those kind of things are happening over there and again for these particular

interactions you have to do that at particular certain conditions, you cannot miss even by a one base pair and during that how the molecules is certain that this is the thing I have to follow.

The DNA and RNA not only use their own chirality but also the change of the chirality on the backbone of the nucleic acid. They are actually reacting on and both this chirality plays a huge role to find out exactly what is happening and how it can be controlled. So that is why molecular recognition is a huge important factor and biology interacts through the molecular recognition.

So, it is not only the protein, not only the carbohydrate, even the RNAs and DNAs have a huge role to play and now you look into that one step back and take a look into that.

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We have protein in biology, we have carbohydrate in biology, we have DNAs and RNAs in biology and all of them use chirality as one of their very important tool to do the molecular recognition and this molecular recognition is very important not only for their metabolism but also you can say that is how the biology is interacting with the surrounding atmosphere. right So, biology we found it is having a chiral environment.

So now, as Rishab has earlier told us today that if you do a reaction with a chiral environment because biology, it is doing it is reaction with enzyme carbohydrate protein DNA RNA that environment is kind of and if it does a reaction over there, you are going to see a difference of their chiral preference. You are actually going to see a enantiomeric excess. So, in biology, if you throw a set of enantiomers in the same concentration or same equivalent if the biology interacts with them.

They are not going to interact with same with the same rate with the same uh extent of the reaction that will be different and at the end you will say one enantiomer is reacting more than the other. So, you are going to create enantiomeric access. So that, means it is not only that I have to create synthetically a chiral environment but if I allow the biology to interact with something.

I am expected to see some enantiomeric excess everybody agrees to this particular point or not. If anybody has any question, please let me know because this is a very crucial point that biology is chiral and that is why, when It is going to interact with a set of chiral molecules, it is going to distinguish between them. It is going to create an enantiomeric excess. So, with that thing in mind, we are going to go to the next system.

And this particular system that the biology can detect chirality and uses chirality and can invoke enantiomeric access keep that thought in mind we will come back to this point just before we conclude to discuss.

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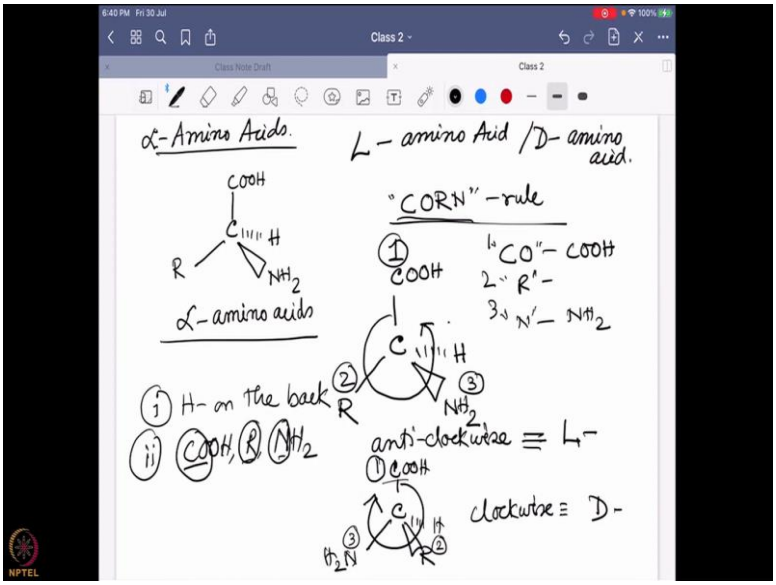

Now with all those things in mind, I am going to define only the amino acids. Today the carbohydrates and RNAs and DNA will discuss later parts carbohydrate probably we are not going to discuss DNA RNA we are going to discuss a little bit better point. So, amino acids, all the natural amino acids which is also you can say it is a alpha amino acids because over here you have a carbon you have a carboxylic acid, you have a R group, you have an amine group and you have an hydrogen.

So, these are the common structure of all the alpha amino acids found in the biology naturally. So, over here first we will try to understand this alpha amino acids we found how we can find out whether it is a L amino acid or a D amino acid. This is alpha Greek term and this is capital how to differentiate that. So, for that you have to just remember the simple rule called CORN.

So, what is CORN rule so, over here? What you have to do is simply put the carbon draw, it is integral geometry, put the hydrogen on the back that is the first thing. Hydrogen on the back that means it should take the back most position the wage bond. Then put the groups carboxylic acid group R group in institute and then follow the CORN. The CORN stand for carboxylic acid then R then the amine group.

Just find out exactly how these groups are oriented and put it 1, 2 3. So, over here this is 1, this is 2, this is 3 hydrogen on the back and then orient carboxylic acid R group and NH 2 group as 1 2 3. This is not exactly the CIP rule. This rule defined much earlier than the CIP rules. So, it is a little bit qualitative in nature and over there this carboxylic acid CO are in group you just find out and see how they are connected.

So, put 1 2 3 and see how they are connected so, over there you can see they are connected anti-clockwise. So, if they are connected anti-clockwise that will be an L-amino acid. And the same system say carboxylic acid, hydrogen and now say I exchange the R with the NH 2 so, now find the CORN carboxylic acid at the top R over here three over here. So now, connect there in the clockwise, if it is clockwise, it is going to be D amino acid. Okay

So that, is you figure it out a L acid and D amino acid. So, in the exam if I ask you the question like draw this L amino acid, if I ask

you to draw the structure. You have to ensure that you have drawn that in the particular orientation because this AL and D is actually showing their special orientation specific, special or three dimensional orientation and it has to be correct.

It has to follow this simple CORN put the hydrogen on the back carboxylic R and NH_2 group such a way that they can be connected in the anti-clockwise. Then it is L if it is kind of clockwise it is D. Fine

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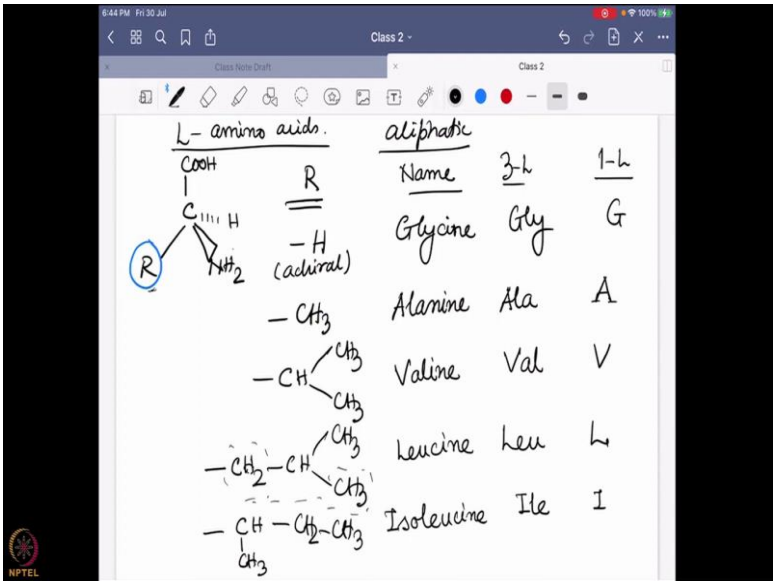

Now most of the amino acid found in biology majority of them are a L amino acids. So, very rarely you see or you counter a D amino acid we will come into that later, when the D amino it can be found. So, it is mostly found in a L amino acid and the DNA amino acid can be interconvert among themselves. We will come into that later, typically via hydrolysis. okay So, now what we are going to cover there are 20 naturally occurring amino acid.

So, I am going to draw the structure general structure of it I will put out their name and how they actually expressed with three letter and one letter code because this I will be important in the later part of the class. So, over there I am going to say this is particular this particular code that means you have to understand which particular amino acid I am talking about. So, for that what I am going to do over here is the following.

I am going to draw the structure general structure of the L amino acid. So, the rest of the thing will be same what will be the changing thing will be the R group. So, over there I am going to write the structure of the R group, the name of the amino acid, the three letter code and the one letter code. So, they are actually explained in either of them. So, the first set of the system I am going to talk about are known as the aliphatic amino acid.

That means the R group is pretty typically an aliphatic group. So, the first example of that is when R is equal to nothing but a hydrogen. So, now you can imagine if I put hydrogen in the place of R that is not going to be a chiral molecule anymore. Because it is going to have a sigma plane going through that carboxylic acid group, carbon and NH_2 plane. So that is the only air chiral amino acid and the name of this amino acid is Glycine.

See letter word Gly one letter word G. So that, means if I want to give you an example like this will be a protein group and over there, there is a G G G chain. That means you have to understand I am saying there will be glycine, glycine, glycine, connected to it. okay The second one is the next one you can think about put a methyl group over there. in the place of r. The rest of them are same. This is known as Alanine see letter code Ala, one letter code A.

The next one comes an isopropyl. The name of this is Valine, three letter word Val, one letter word V. Then the chain actually extends a bit and extra CH_2 group added over here. This is known as Leucine, three letter word Leu, one letter word L. And then there is a another amino acid which is nothing but very similar to the structure but an isomer of that. So, what happens over there? One of the CH_3 shifts over here and then it is CH_2 CH_3.

So, you can say one of the CH_3 over here shifts down and this is isomer. So, it is known as Isoleucine so, in the name it is saying that it is isomorphic three letter word Ile, one letter word I. So, these are the five different amino acids can be found in biology which is having simple aliphatic groups in it is uh structure as an R group.

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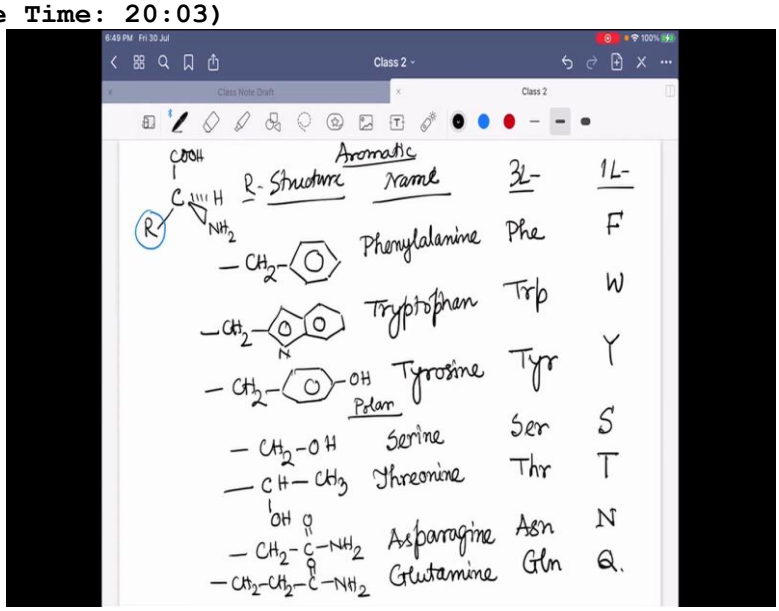

Next again, I am just drawing the group I am drawing and over here, I am mostly following this R group. So, again I am going to write the name over here sorry the structure over here first then the name of the amino acid, the three letter code and the one letter code. So, after aliphatic we look into aromatic groups that means there is an aromatic group present over there. The simple one we found it is a CH_2 and then a phenyl group because putting a phenyl group very close to will be a little bit tricky.

So, biology finds out that let us put a CH_2 spacer in between them and you can say that this is nothing but a Alanine derivative where Alanine was CH_3 but instead of one hydrogen, I am putting a phenyl group. So that, is why the name comes Phenylalanine. Three letter word Phe, one letter word F. Because it pronounced with like F pronunciation, F phonetics, why it is not p? You will come into that just when we will be completing this part.

Then comes this particular CH_2 group then this particular heteroaromatic system which is nothing but indole group present over here and the name of this is Tryptophan, three letter word Trp, one letter word W again why not t will come into that any very soon. The next one is come. The phenol group, the name of this is Tyrosine three letter word Tyr, one letter Y. So, these are the three different aromatic compounds we can have over here.

Then comes some of the polar systems, so one of the beginning ones comes CH_2OH. So, these are the structure of this R group over here I am drawing CH 2 OH if alcohol group. The name is Serine three letter word Ser, one letter code S. Then comes a variation of it where it forms a secondary alcohol first it was the primary alcohol then it is a secondary alcohol which group comes a little bit closer.

The name of that is Threonine three letter word Thr and that is where the one letter word T was used. So that, is where crypto current tyrosine does not get their one letter code with T they have to be happy with Y and W respectively. So, these are the two different polar groups you can have and additionally, we can have two other compounds which are can be the amide bonds, CH_2 and then an amide bond and this name is Asparagine three letter code Asn, one letter code N.

And then there will be another variation of it where instead of one carbon, there are two carbon in between and then we have the amide bond and the name of the system is Glutamine and the three letter code is Gln, one letter code is Q. So, with this we complete the aromatic and polar set of the molecules.

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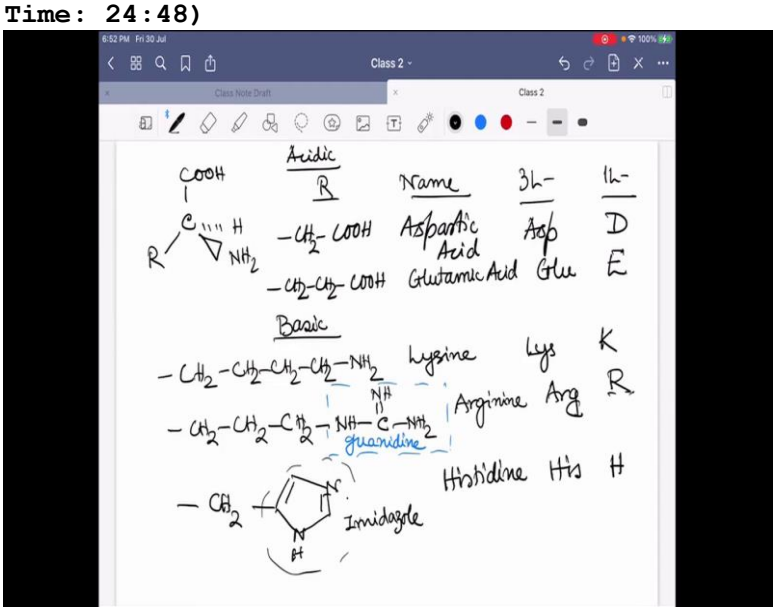

Then we actually move towards the acidic set of the molecule and over here again should draw the structure. So, the acidity group is nothing but the same amide bonds we have drawn earlier they are acidic instead of I might put acid group and that will be the systems I am going to have. So, it will be $COOH-CH(NH_2)-CH_2-COOH$ which is known as Aspartic acid, three letter from Asp.

And it is carboxylate from it is known as Aspartate one letter code D because A is already been taken and then this extra CH_2 connect in between them is known as the Glutamic acid or known as the glutamate in it is decarboxylated form three letter word Glu, one letter word E. So,

these are the two different acidic group you can have then comes the basic groups. Over there you can have very interesting structures, four 4 CH_2 chains and then a primary amine group.

There is a long chain and then you having a primary amine. This is known as Lysine three letter word Lys and one letter code K. And then you can have another one from the same basic group it is known as Arginine, where you have the three CH_2 groups and then you have over here a guanidine group over here and this particular set is known as Arginine three letter word Arg, one letter word R.

And then the another one we have in the basic format which you can also consider in the arithmetic format but you put it in the basic format because it mostly plays it is role in the basic system where you have a imidazole group over here. So, this is nothing but a imidazole group. The name of the system is actually histidine the amino acid, His and H. So, these are all the acidic and basic groups falls into the natural amino acids.

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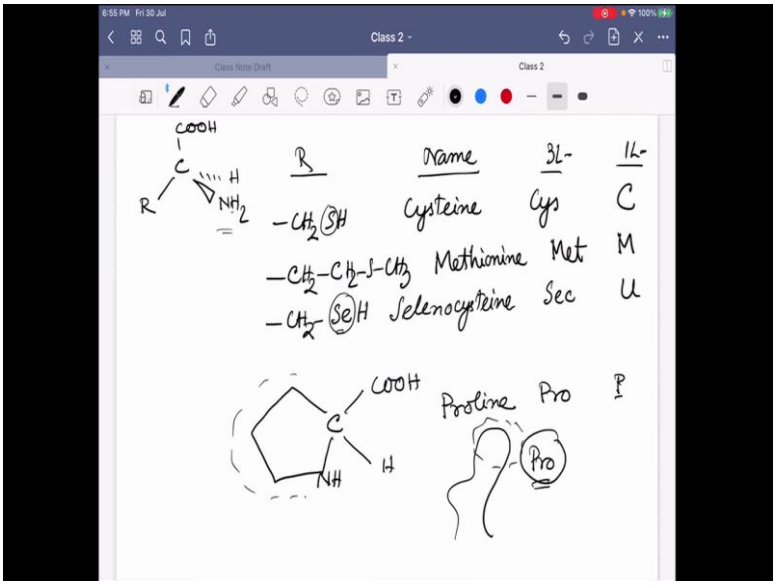

And we have only a few of them left. okay We are going to draw the structure and three letter and one letter. So, for that we are going to have other two molecules which are actually having we put it in as a special group but you can also consider it in the polar group which actually has Thiol groups present CH 2 SH. The name of the system is Cysteine three letter word Cys, one letter word C.

And then you can have another version of thiol but not exactly thiol but it thioether and this is known, as methionine three letter word Met, one letter word M. And then there is another version which is very rarely found but it is having very important factor present in the terms of enzymatic activity is a selenium version of the cysteine instead of sulphur, you have a selenium and the name is Selenocysteine three letter word Sec one letter word U.

And with all them, considering almost all of them and one important amino acid which is very important and a little bit different structure present is this one where it is actually a secondary amine completes the circle because it is more like a completes a circle complete make a cycle out of it. So, it is a two degree amine present instead of one

degree amine commonly present and the name of this amino acid is Proline, three letter word Pro one letter word P.

And this is very important to develop the turns into the protein structure because generally amino acids when they form they form in a linear fashion but if you want to create a turn you put Proline over there and due to the background, the back the structure of this Proline backbone, you automatically create a turn. So that, is why creating a turn in the protein structure, especially say on these regions. So, Prolines are actually been used over there.

So, these are the different amino acid structures. So, today we learned mostly about the molecular recognition.

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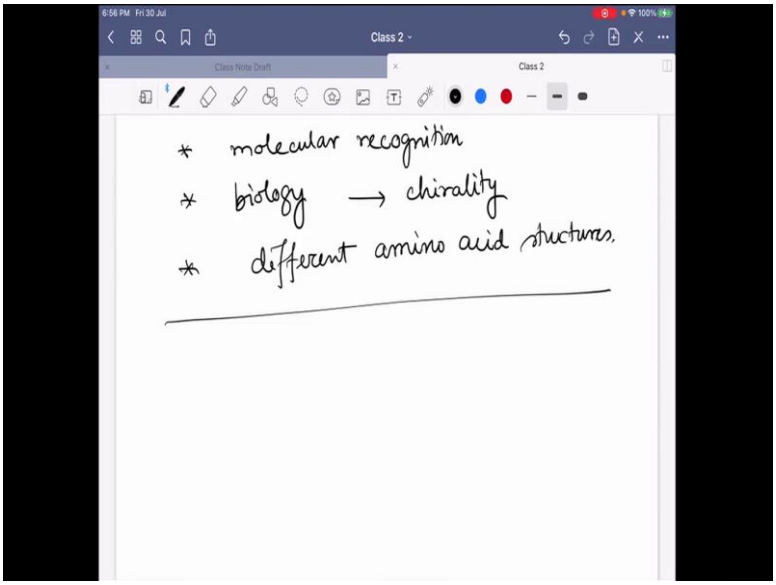

How it is important and we found that biology, use, molecular recognition a lot and they use chirality as one of their tool and we also know about the different amino acid structures. Those will be pretty much important for your exams and the assignments. So, with that we will stop over here. The next class we will start-up from there.

And then we will find out some interesting facts that how the biology interacting with this chirality can affect. And can be used even as a sign of life in later in the real world. So that, we will discuss later so, we will stop it over here. If anybody has any question, please quiet and I am stopped recording.