

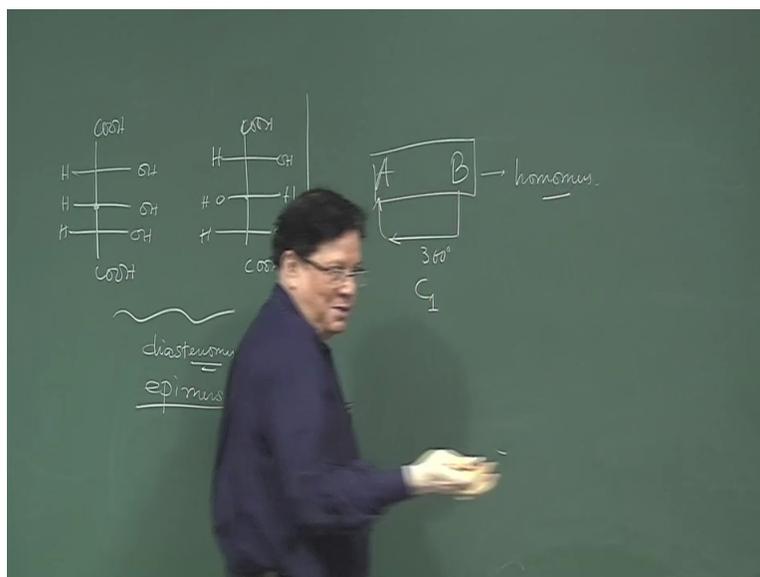
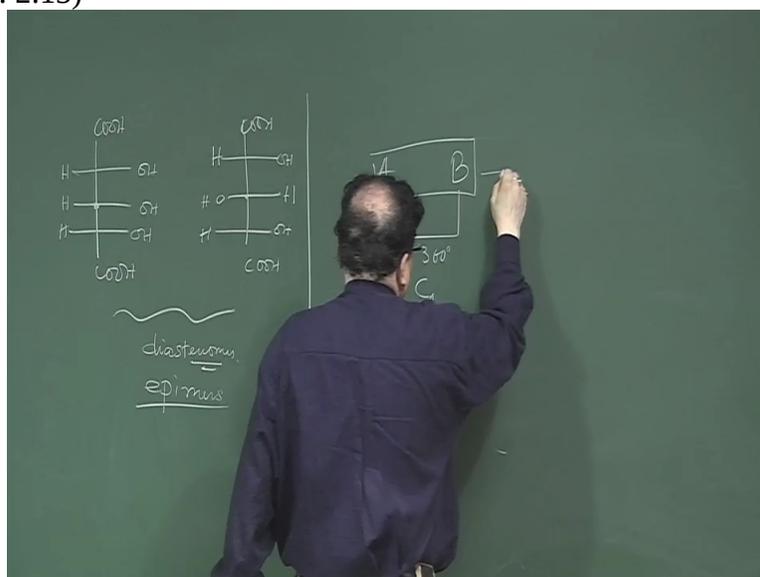
**Course on Stereochemistry**  
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**Module No 02**  
**Lecture 07: Absolute Configuration**

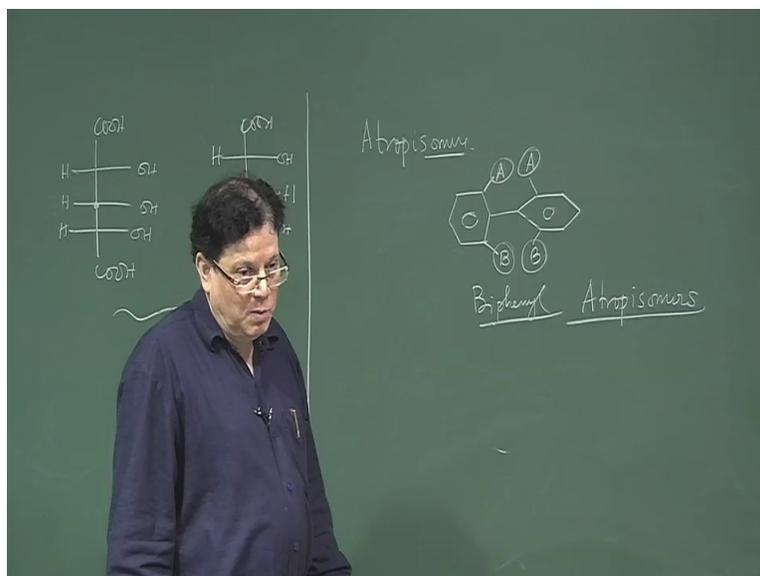
Ok, welcome back to this course on stereochemistry. Today we will be learning the nomenclatures of molecules which can exhibit stereoisomerism like if the nomenclature that you know for constitutional isomers, similarly there is a set of nomenclature system for molecules which can show stereoisomerism but before we move onto the topic, let me just revisit what was stereoisomers and how many different types of stereoisomers are there.

Stereoisomers are the molecules which had the same constitution, same connectivity. However, the arrangement of the groups in the space are different. In case of a there is another in stereoisomers, we have Enantiomers on one side and Diastereomers on the other side. Enantiomers are the ones which are mirror images, non-superimposable mirror images of each other.

Diastereomers are the ones which are not mirror images of each other but they have the same molecular formula and same constitution okay? Now in Diastereomers if there are more number of chiral centres which are now modern terminology known as stereogenic are present if there are more than 1 stereogenic centres present. And in between 2 molecules, 2 Diastereomers, there is difference in the arrangement of the atoms in only one stereogenic centre, then that is called Diastereomers.

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That means if you have now you know what your fisher projections formula. So if I draw the fisher projection formula of a molecule which looks like this, and compare that with another molecule which looks like this one, now these are Diastereomers because they are not mirror images of each other but having the same constitution. So they are Diastereomers.

But these Diastereomers differ in the arrangement of groups around this carbon only because the arrangement of groups around this carbon and that carbon remains the same. So that will be called a special class which we have given the name Apomers. So Apomers are Diastereomers which differ in the arrangement of groups around 1 stereogenic centre in a multi-stereogenic compound okay?

There is another, just to begin with means in the beginning, we should have actually said another one which was like isomers, we have if the molecules are same, if 2 molecules are same, then they are called homomers. Homomers, because we started with isomers, isomers are different molecules with same molecular formula but then if 2 molecules have same molecule formula and if they are same, then they are called homomers.

Of course, you can tell that why we have given we are bringing in this term, homomers but there are certain cases where this concept is required because homomers are molecules which are related by a  $C_1$  axis. That means if one molecule if a molecule, there are 2 molecules, A and B and if I rotate that molecule by 360 degree, I get B around an axis.

That means it has got C<sub>1</sub>, then these 2 will be called homomers. Homomers are basically molecules, they are same molecules which are related by a C<sub>1</sub> symmetry. Just to bring in the concept of symmetry, we have this special class or special nomenclatures for same molecules as homomers okay? Now there is another 3<sup>rd</sup> set which we did not, another nomen system which we have not spelt out yet and those are called atrop isomers.

So we have Diastereomers, amongst the Diastereomers we have Apmers, a special class where there they are differing in the configuration at only one stereogenic centre. Atrop isomers again, a special class of molecules which are having again the same configuration, same constitution same constitution but they are different. So they are stereoisomers but these stereoisomers are interconvertible by rotation.

Suppose we have a system like this, 2 dial rings connected by a single bond. Then because of the steel bulk of these A and B groups, these 2 links take up an orthogonal orientation. And to convert and while doing that, they exhibit stereoisomerism. They will come back to this biphenyls, these are called biphenyls. We will come back to this biphenyl system later on. But right now just remember that this biphenyl with different groups at these ortho positions, they can exhibit stereoisomerism.

And to convert this one set into the other one, you have to rotate the biphenyl ring, one of the ring and then by 180 degree to get to the iser, other isomer. To make it clear, let me again just repeat that these type of systems, they exhibit stereoisomerism. They can they actually in particular they show enantiomerism so they can exist in two pairs of enantiomers but usually what happens in the normal case where we have stereogenic centres, to go from this to this molecule, you have to break one bond.

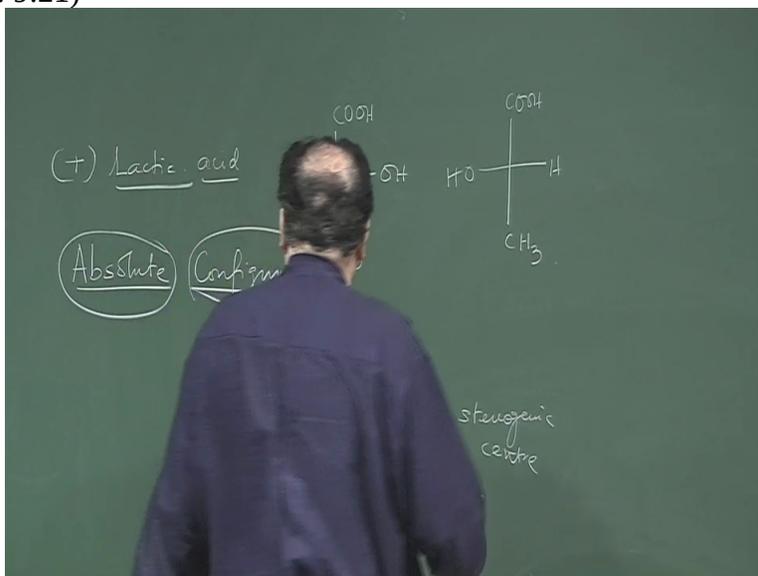
When you exchange these 2, then you interchange this position of this OH and H, you have to break a bond and then remake it. Here, you do not have to break. When you have the 2, that entantio, pair of enantiomers having this type of formala, you just rotate 1 ring by 180 degree to get to the other form. So atrop, these are called a special class of enantiomerism but they are known as Atrop isomers.

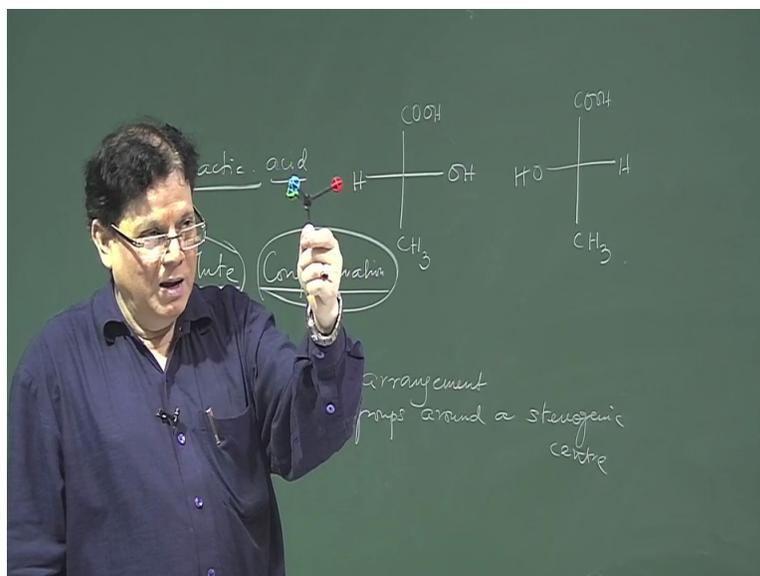
So Atrop isomers are stereoisomers which are interconvertible by rotation. Stereoisomers which are interconvertible by rotation. So we will come back to this Atrop isomers issue later on. So basically now we have in isomerism, we have the homomers which are basically same molecules. Then we have constitutional isomers, then we have stereoisomers and in the stereoisomers, we have different classes, enantiomers and Diastereomers.

Enantiomers, there is another special class which is called Atrop isomer which are interconvertible by rotation. And Diastereomers, you have a special class which are called Apmers where the difference is in the configuration or the arrangement of groups in the space around a single stereogenic centre. Apmers arise only in case of molecules where there are multi-stereogenic centres present. Okay?

Now let us go into this nomenclature system of stereoisomers okay? Now, how do you introduce the nomenclatures system? Why it is required in case of stereoisomers? Now we know that some molecules which are chiral, they have the ability to rotate the plane of plane polarised light. Now if I ask someone to write the structure of + lactic acid + lactic acid okay?

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That means the lactic acid which rotates the plane of plane polarised light into the clockwise direction. So if asked someone to write + lactic acid, what happens? You know fisher projection formula now that was been introduced. So lactic acid is having a stereogenic centre which is attached to a carboxy which is attached to a OH which is attached to a methyl and which is attached to a hydrogen.

Now this molecule can exist as a pair of enantiomers. So you have, you can write the other enantiomers, OH, COH, the mirror image of it. Now if I ask, which one is the + lactic acid? It is not possible to know because from fisher projection formula, we cannot tell which one is + or which one is - okay? So we have to, so in order to write the correct formula of + lactic acid, if I know the, if I know the absolute arrangement of the groups in space of + lactic acid, then I have to have some way to describe its name.

Because simple saying + lactic acid, lines me in trouble that I can have 2 options. Okay? And for that reason, to describe the exact three-dimensional arrangement of groups in space, we need a nomenclature system in case of stereoisomers okay? Now so basically we have now the nomenclature system is basically for for knowing for depicting the configuration of a molecule of a stereoisomer. Configuration, I wrote absolute, I will come back to this little later.

1<sup>st</sup> let me explain what is meant by configuration. Configuration is the precise arrangement of groups around a stereogenic centre. That is what is called configuration okay? Now configuration, that means if I suppose this is one molecule, suppose this is lactic acid and suppose this is lactic acid I have to assume something suppose this red is the carboxy, this is the methyl, this is the H and this is the OH.

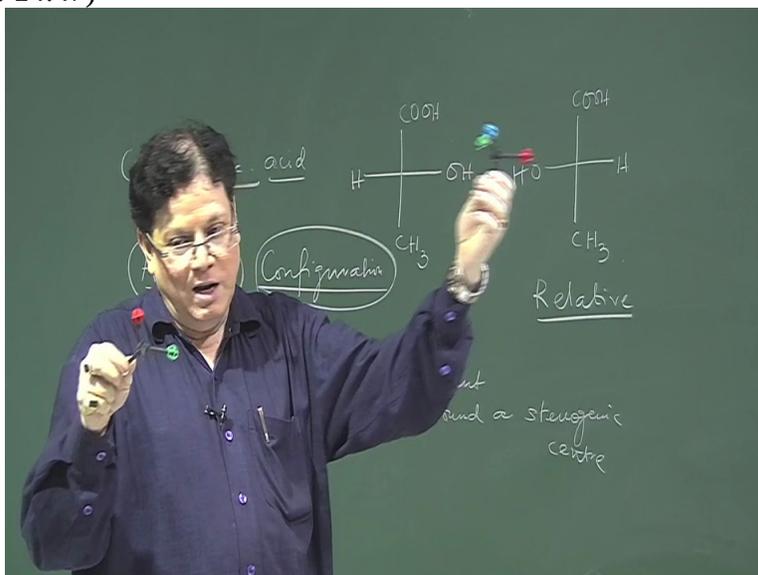
And if I know that this actually rotates the the plane of plane polarisation into the clockwise direction, then it becomes + lactic acid. Now the question is, how to depict this molecule? How to, in the three-dimensional formula that how to know that I have actually, this one is + or this one is -, how to know that? For that, the nomenclature system is required okay? I cannot say that you write it in such a way that the carboxy, that + lactic acid is the one where the carboxy is at the top, the methyl is at the bottom, the OH is at the right, the H is that the left.

That is the way to describe lactic acid, + lactic acid okay? But that means, it requires lot of sentences, lot of things and if the molecule is more complicated, then you have to tell more and more that how to draw the structure of a chiral compound okay or a stereoisomer. So to solve that issue (( ))(13:26) so absolute configuration configuration is the precise arrangement of groups around a stereogenic centre.

Now if you use the word precise, then it becomes absolute configuration. That means you really know what is the, where are these blue, where is the blue group going, where is the green ball going, where is the red ball going, there is the white ball going, okay? So if you know that, that becomes absolute configuration of the molecule. And this is only obtained this is very difficult to determine, the absolute configuration. This is only obtained by X section stenography.

You can actually determine the absolute arrangement of the ligands in the three-dimensional space. Now there is another term which is called relative configuration. So like absolute configuration, we have relative configuration. Now what is relative configuration? Relative configuration is if I cannot if I have a molecule which I a chiral molecule I want to determine its configuration but I do not have a crystal, I cannot do a crystallography.

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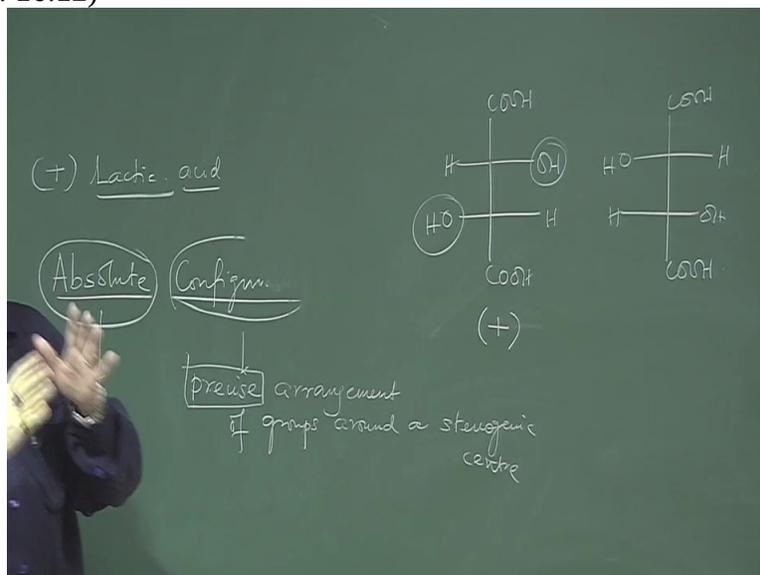


Then what is my option? My option is that if I can if I can synthesise these molecules starting from a compound which has got known configuration, so I convert this slowly into by different steps and then make the molecule that is in my right hand. Then although, I did not directly determine the absolute configuration of this molecule, but what I am now able to see that this has got a similar configuration or a different configuration that depends on the sequence of steps in between.

Suppose that is the similar configuration like what it has, then this configuration becomes relative configuration because you are not directly determining the configuration of this. It is determined starting from a molecule of known configuration or the other way you can actually convert this one into a molecule of known configuration. So then the configuration of this becomes relative configuration because this configuration is determined in relation to the configuration of this.

So if you know the configuration of the molecule in the left-hand then you know the configuration of the molecule in the right hand okay? So that is relative configuration. There is another type of relative configuration and that is in molecules where there are more than 1 stereogenic centre is present.

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Like say, I draw the structure of optically active tartaric acid. So this is the structure of optically active tartaric acid. Okay? Now optically active tartaric acid can be + or can be -, dextro or livo. Again if I suppose we think that this is, it may not be true but suppose for the time being, let us say that this is + tartaric acid, this is the + one, the dextro form okay? But I do not know the exact configuration of this carbons.

What I know is that if I draw it in the fisher projection, the 2 OH is actually are on the opposite side okay? So if I say that + tartaric acid is that molecule where the 2 OHes are on the opposite side, then how many structures you can draw? You can, see this is one possibility. If I only say that the OHes are on the opposite sides, then you have to draw the other structure also.

If + tartaric acid is described only by that fact that in the fisher projection formula that you bring, where you put the carboxy in the right perspective because the main chain in the fisher projection is kept in the by allowing the vertical line and then if I say the what the hottest + tartaric acid? The one where there are OHes are on the opposite sides okay? But still you cannot write one unified formula.

You have to write both these 2. Okay? But this is what I am saying that the 2 OHes are on the opposite side, that means if I can determine the configuration of this, then I can determine the configuration of this because I already know that they are on the opposite sides okay? So here

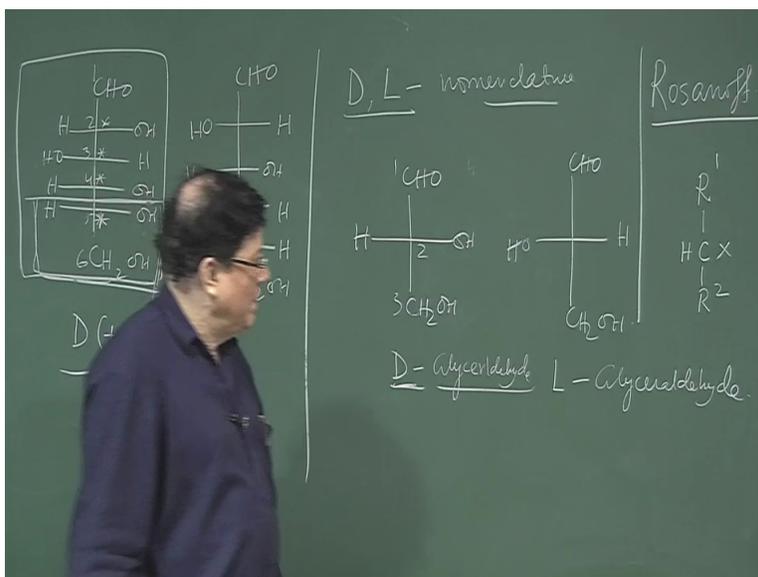
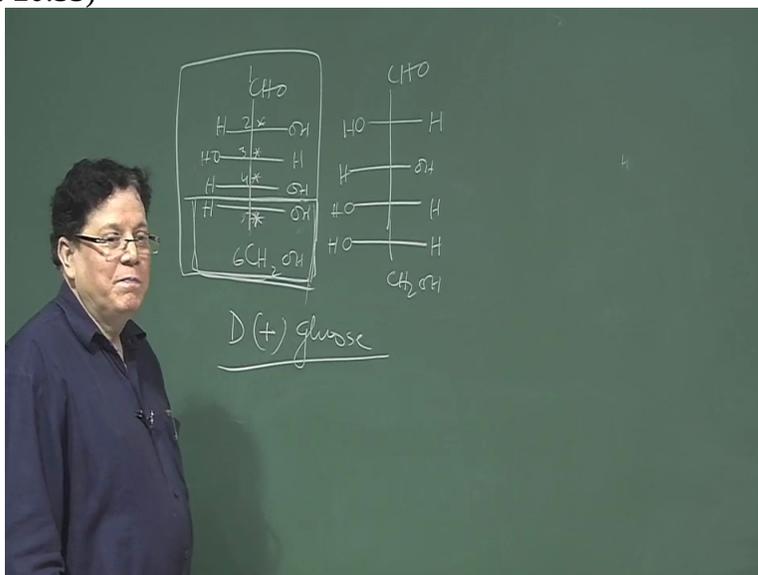
basically what we are talking about is the relation between the 2 configurations. So relative configuration, one is that if you have a known configuration of a molecule which is determined by x-ray, and then if you can convert it to another molecule than these molecule's relative configuration you know because you know the configuration of your starting material.

So that is one type of relative configuration. The other is that in a multi-stereogenic centre, the relation between the 2 configurations of the of the stereogenic centres is called the relative configuration. So the other nomenclature systems which can because there is another tartaric acid which is where the 2 OHes are on the same side okay? So if I ask you to now differentiate between +, - or this one, that tartaric acid which is the meso tartaric acid, I have to have some nomenclatures systems okay?

Mesotartaric acid is easier one because you know that it has got it has to have a plane of symmetry, it is easier to write but if the groups are different here, then that plane of symmetry is gone okay? But if I want to tell a student to write the structure of a compound, structure of a compound where the 2 OHes are on the both sides, then he has to write another compound. Unless it is a meso so that is the other compound.

So that means what I am saying? I am telling the configuration of one in relation to the other. Okay, that is relative configuration. And we will today we will discuss the nomenclature system of both, the absolute and the relative configuration. We will start with the absolute configuration, okay? Now the whole story started when Emile Fisher, he was trying to determine the structure of carbohydrate and the one he tried to do was the naturally occurring, + glucose okay? So he wanted to know what is the absolute configuration of + glucose.

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And ultimately, he ended up with the possibility of 2 structures for + glucose, one is this one. This is a big molecule because this is a carbohydrate. This is called aldohexoses. So we ended up that + glucose is either this one or + glucose is the mirror image of this. That means, he could not get a crystal of + glucose to determine the absolute configuration. So one of these is + glucose.

And he assumed, he assumed that the + glucose is the one is the right-hand one because he assumed that in + glucose, there are see in this molecule, how many stereogenic centres are there? This is one, this is another one, this is the 3<sup>rd</sup> one, this is the 4<sup>th</sup> one. There are 4

stereogenic groups okay? So he assumed that the last stereogenic centre, the OH is on the right side. Now he knew the relative configuration.

See, he knew that the the 1<sup>st</sup> the 1<sup>st</sup> OH if it is on the right side in the 2<sup>nd</sup> OH will be on the left side and if it is on the left side, 3<sup>rd</sup> OH will be on the right side and the 4<sup>th</sup> OH will be on the right side. So that means he knew the relative stereochemistry, relative configuration. But to know the absolute configuration at that time, he could not have the exact crystallography structure.

So here is you that + glucose, the last, that means this one, so if you number it, 1, 2, 3, 5, 6. So the C5 carbon which is the last stereogenic centre and that, in the IUPAC nomenclature system, in that the OH is on the right side and he called this as D + glucose, D + glucose okay? So that is your D + glucose. And from this, a nomenclature system ultimately came out and that is, after that is the olden nomenclature system that is called DL nomenclature system.

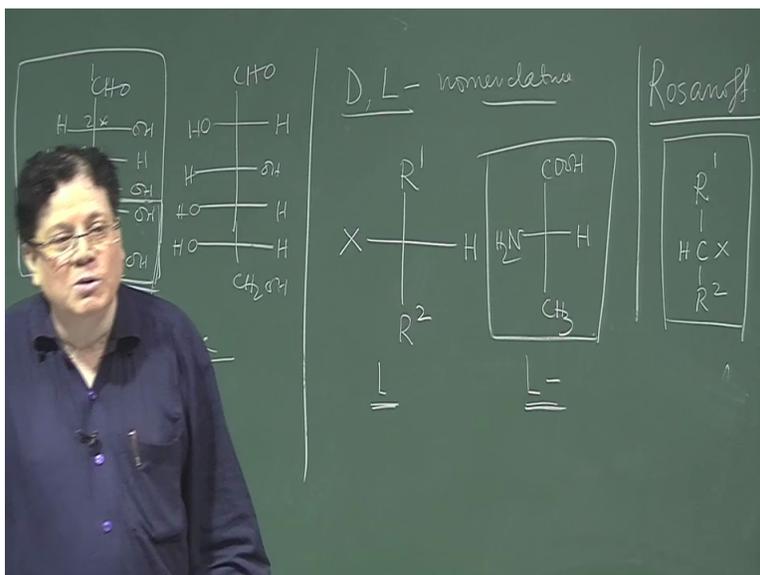
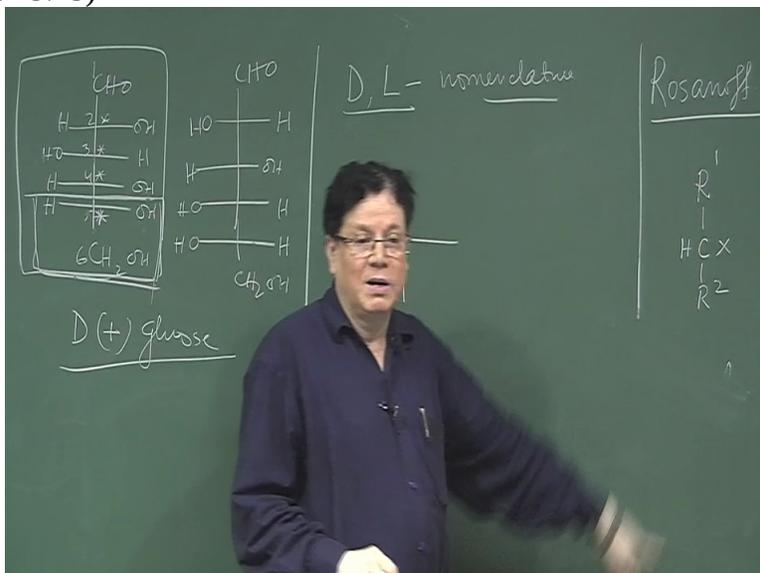
What is DL nomenclature system? DL nomenclature system is that if you have a molecule, it again started from this concept that if you have a molecule like this which is say glyceraldehyde, so if you have glyceraldehyde and right it in the proper fisher projection formula, proper means proper in the sense what is required for naming it according to D and L because Fisher projection formula, you can place the 4 ligands in at your will, you can put the OH here, the CH<sub>2</sub>OH there.

But if you are trying to determine the absolute configuration, then you write it in such a way that the most oxidised group is at the top. 1<sup>st</sup> of all, the carbon chain has to be in the vertical axis and then keep the the more oxidised carbon at the top and the less oxidised carbon at the bottom. There is another way of saying this that if you want to name it in the IUPAC nomenclature system, this belongs to number 1 and this is the 2 and this is the 3.

So either you say that I put the most oxidised group at the top and then the the less oxidised group at the bottom. Then if I see that the heteroatom, that means the OH is on the right side, that will be called D configuration. And the opposite one will be called the L configuration. So this is D glyceraldehyde and this is L glyceraldehyde. Remember this is not -, this is just a hyphen, D-glyceraldehyde because from the structure that is given, it is not possible to predict what would be the sign of rotation.

Sign of rotation is entirely an experimental thing. From the structure, you cannot tell what will be the sign of rotation of this compound. So what we can say only that this is D glyceraldehyde and this is L glyceraldehyde okay? So so this was the initial nomenclature system. That means if you have, it was extended to other systems, not only OH they tried to, there was a scientist, Rosanoff, he gave some rules.

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He said that if you have a compound like this, R1, C, H, X and R2, and if I want to write suppose I ask you to write the L configuration of this, then how do you write it? 1<sup>st</sup> you decide amongst

the R1 and R2, which one is more oxidised. Suppose R1 is the more oxidised group leader or R1 contains the number-one carbon in the IUPAC nomenclature system okay? Because in IUPAC nomenclature, that is the rule that oxidised carbon given the number-one group.

So R1 at the top, R2 big less oxidised, at the bottom. See if I am asked to write the L configuration of this, then X is here, H is there. So this is the molecule in L configuration. Okay? So basically, this DL nomenclature system is applicable for systems like this. That means, two alkyl groups, a heteroatom and H. This DL nomenclature system is still being used in carbohydrate chemistry as well as in amino acid chemistry.

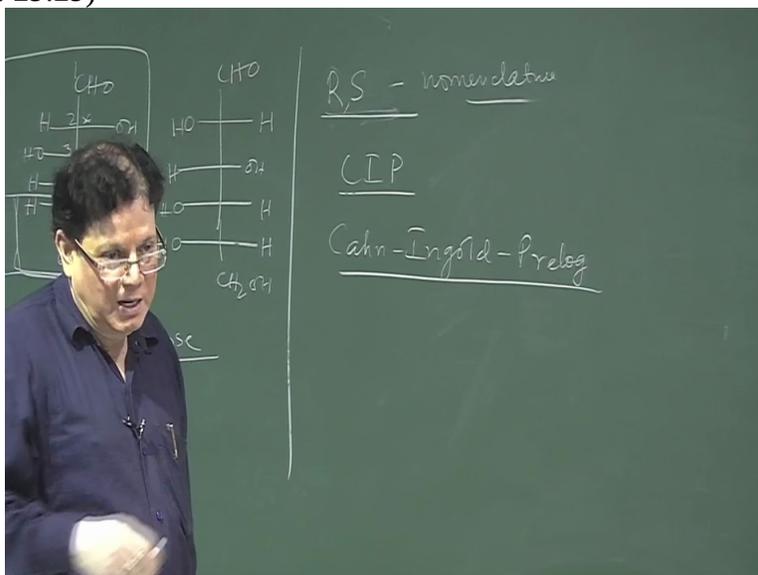
In amino acids, we know that amino acids have a carboxy group, and alkyl group and then an and H<sub>2</sub> and a OH. So according to DL nomenclature, this has been written in correct format because the most oxidised group at the top and then you are seeing the heteroatom to the left. So that becomes L and this is the configuration of natural, the amino acids which makes the proteins in our body okay? So they have the L configuration.

However, this method of absolute configuration is not universal, is not very general. Why? Because suppose you do not, in many cases you may not have any heteroatom, you may have another R, 3NR<sub>4</sub>. Then what are you going to do? There is no heteroatom. So DL nomenclature will not be applicable here. Similarly, if you have 2 heteroatoms now, X and Y, so this is not applicable here, DL nomenclature.

Again if you have 2 heteroatoms, you cannot really tell which one is which because there is no such rule which heteroatom has to be placed on the right or which heteroatom has to be considered on the left, okay? So DL nomenclature system is not universal. It has a historical story and then Rosanof tried to extend it further to to name the absolute configuration of compounds which have again I tell you it is applicable for compounds which have got R1, R2, X and Hydrotem.

For that system, it is applicable. Otherwise, for many other systems, it fails. So these Communists the see the community, sorry the community felt the need for the introduction of a another methodology which is applicable to all systems and that is what is called RS nomenclature, okay?

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RS nomenclature. And this RS nomenclature is also known as CIP nomenclature system because this was this was proposed by 3 scientists, Cahn, Ingold and Prelog. So these 3 scientists met with each other and then proposed a very beautiful, very nice and a very simplified way to give absolute configuration nomenclature to compounds with exhibit stereoisomerism okay? Thank you.