Biochemical Engineering
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Module No. # 01
Lecture No. # 04
Carbohydrate

Welcome. To the today's lecture, which is on bimolecules? As I have already talked to you about the cell. And I have already mention that cells are the basic component of any living system and when I talked to you about the cells and its different organelles, I have also told you about the fluid which is present inside the living cell. And this fluid is called the protoplasmic fluid. And here some macro and micro molecules are present and today I will be talking to those types of micro and macro molecules.

So, my today's lecture is mainly on the biomolecules which are present in any living cell.

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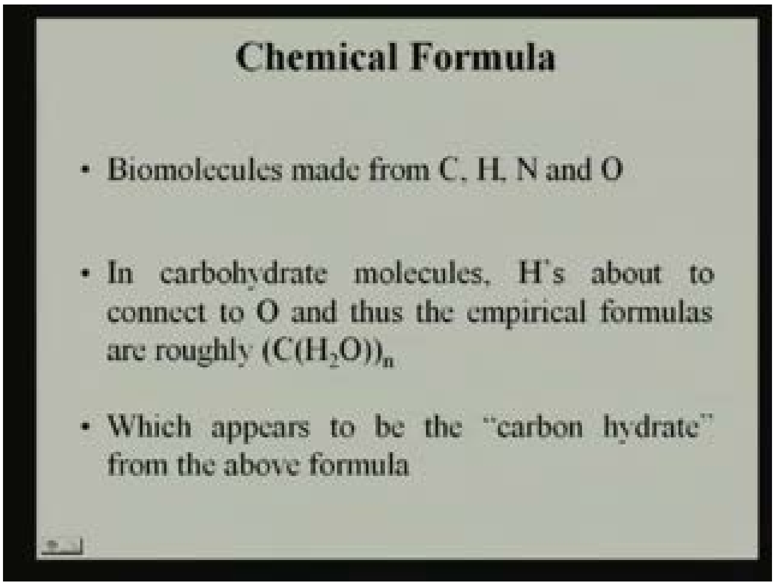

Now, if we see the biomolecules. It mainly made up of the carbon, hydrogen, nitrogen and oxygen. Now if we see these macro molecules which are present in any living cell. We can categorize them into proteins lipids and carbohydrate.

Now, today I will be talking, my lecture will be mainly focused on the carbohydrate molecule. Now, when I have told you that this biological molecules are mainly made up of carbon, hydrogen, nitrogen and oxygen. And when we are talking about carbohydrate, these carbohydrate moieties in this carbohydrate molecules, no nitrogen atoms are there nitrogen molecules are not present in this carbohydrate molecule. If we see the empirical formula of any carbohydrate. Then we can find that it is roughly about c H 2 o to the power n. When n is the number of carbon atom which is present in any carbohydrate molecule. That means if we see this formula it appears that it is a carbon hydrated form.

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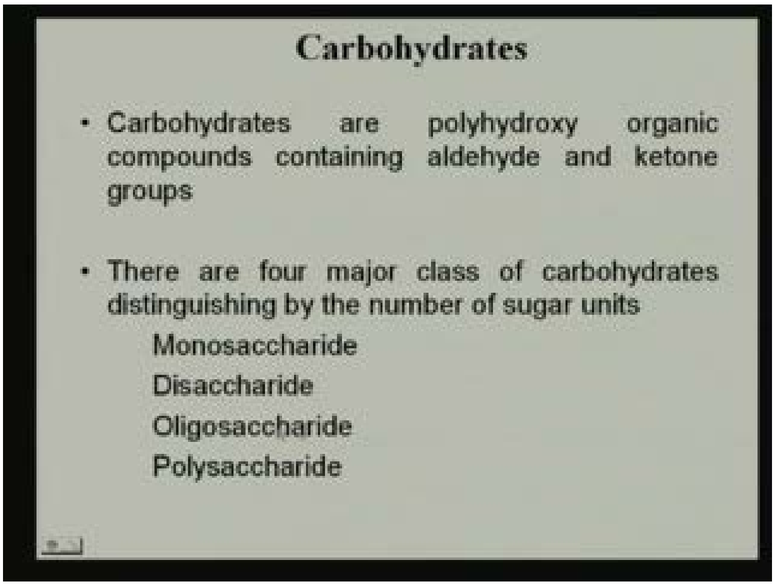

Now, carbohydrates are the polyhydroxy of organic compounds, which contain the aldehyde and ketone. That means that c H o the aldehyde group or c double one o that keto groups are present in the carbohydrate molecule. Now, there are four major classes of carbohydrates which can be distinguished as monosaccharide, disaccharide, oligosaccharides and polysaccharide.

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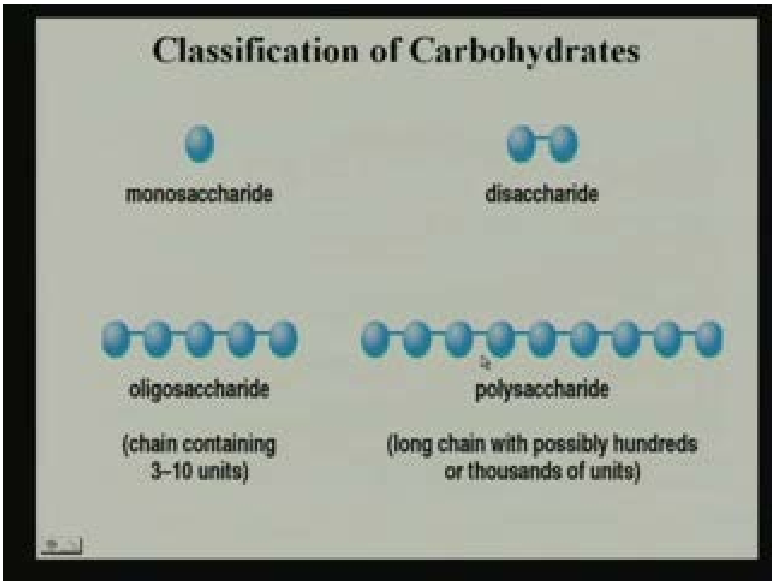

Now, while talking to this. Monosaccharide is a unit sugar molecule. That means it is a single sugar which is present in any carbohydrate.

Now, when disaccharide. When we were talking about the disaccharide, it is the two sugar moieties which are joined together. That is the disaccharide, when we are talking about the sugar molecule which varies its chain length from three to ten units that is called oligosaccharides. And when the number of sugar moieties varies from hundred or thousand units. We call those type of sugar molecules as polysaccharide. That means from unit a single sugar molecule. We can get a long chain sugar moiety, this if we see these monosaccharides.

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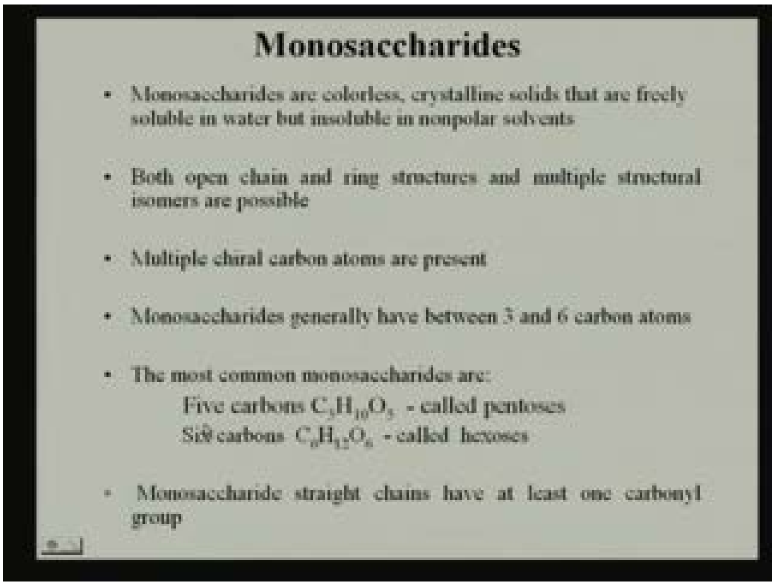

Monosaccharides are the colorless crystalline solids that are freely soluble in water.But, insoluble in non polar solvent. Both it can be found, obtained, it can be found in both open chain and ring structure. And also we can get this monosaccharide in this, in its isomeric form.

Multiple chiral carbon atom is present in this monosaccharides, and monosaccharides are generally it starts from three carbons sugar to seven carbons and so on. So, if we see the most commonly found monosaccharides then.

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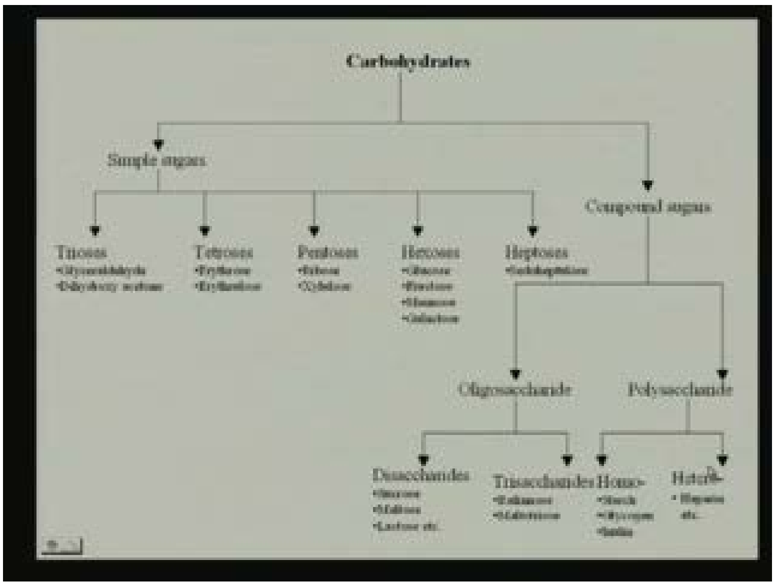

We can classify, categorize this monosaccharides from triose, tetrose, pentose, hexose, heptose and so on. What does it mean triose means? It is the three carbon containing sugar molecule that means glyceraldehydes, dihydroxyacetone. These are the example of three carbon sugar that is the triose sugar .Whereas, in tetrose, four carbon sugar moieties are there like erythrose, erythrulose. In pentoses five carbon sugar the examples are ribose or xylulose in hexoses. We are getting glucose, fructose, mannose, galactose and so on. In case of heptoses seven carbon containing sugar that sedoheptulose are the example of the simple sugar.

That means this carbohydrates can be once again divided into simple sugar and the compound sugar. Simple sugar means, it is a unit sugar molecule varying its carbon skeleton structure from three carbon to seven carbon and so on. When we are talking about this compound sugar then this compound sugar is once again divided into oligosaccharides and polysaccharides incase of this oligosaccharides it is divided into disaccharide trisaccharides disaccharide means two sugar moieties are joined together like sucrose maltose lactose and so on while talking to this trisaccharide it is the raffinose maltotriose that means three sugar moieties adjoined linked together.

While talking to this polysaccharide that means here n number of sugar moieties are connected together. It can be divided into homopolysaccharide and heteropolysaccharide .So, homopolysaccharide the name itself indicates that, it is a single monosaccharide sugar which is present in n number of units. And they form the starch glycogen molecule and so on. In case of heteropolysaccharide there are plenty of examples, that means along with a sugar it is a complex molecule.

That means along with a sugar some other biomolecules are linked and it forms the different type of complex sugar structure. Say it may be the two sugar moieties, say for example, one pentose got linked with one hexose and in this way the units are repeated. And it forms the hemicelluloses, so, it is not a single pure compound. But, it is the mixture of two different one pentose sugar and one hexose sugar in case of hemicellulose compound.

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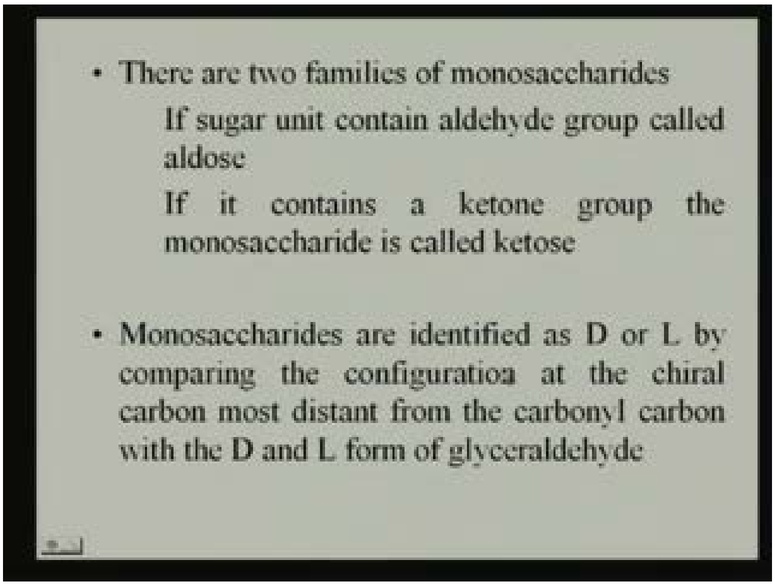

Now, besides that classification we mainly see that in monosaccharide, that there are two different families are there. In one group aldehydic group is present, that means in that particular group C H O is present. That means those type of sugars are called the aldose sugar. In another group the ketone group is present and we call that type of monosaccharides as the ketose sugar .Besides these monosaccharides are also identified by its D and L form.

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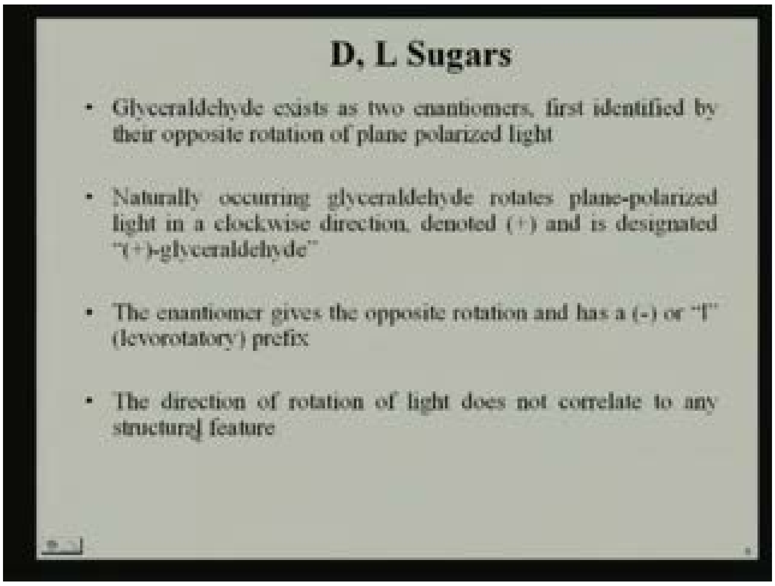

That means it is the either D form or L form. In most of the biological cases, we mainly get the sugar moieties in D form that means dextrorotatory.

Now, when the glyceraldehyde molecule. Glyceraldehyde is the simplest sugar molecule which is three carbon sugar, and when it this glyceraldehyde exist as two enantiomer. First identify it by their opposite rotation of plane polarized light and when it rotates in the clockwise direction it is denoted as plus and is designated as plus glyceraldehyde. When this enantiomer gives the opposite rotation, that is in the anti clockwise form .It is denoted by the symbol negative and it is the levorotatory form. The direction of rotation of light does not correlate to any structural feature that means, How to distinguish the D form and the L form?

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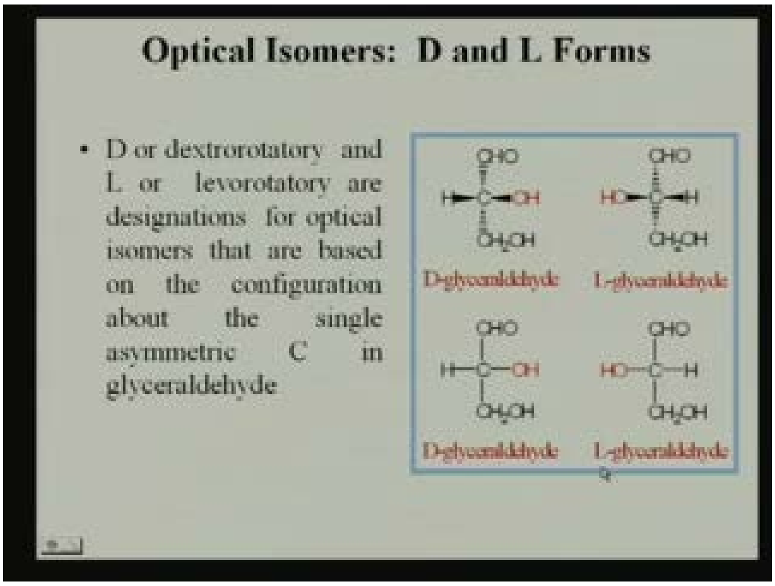

Now, this is the structure of glyceraldehyde. Now, here this carbonyl carbon that C H O group is present. C H O that is the aldehydic group, as it is a an aldose sugar. Now here this is the chiral carbon. Chiral carbon means the four valances are occupied by four different groups. And here, if we see this chiral carbon, which is far from this carbonyl carbon. The hydroxyl group which is present is on the right side indicating its dextrorotary group that D form. Whereas, in case of this structure, here you see here the hydroxyl group is present on the left side indicating that it is the levorotatory L form.

So, this is the structure of glyceraldehyde. This is a three carbon sugar C H O C H O H and C H to O H .Here this O H is on the right hand side indicates it is the D form. And here it is the left side indicating the L form of glyceraldehydes.

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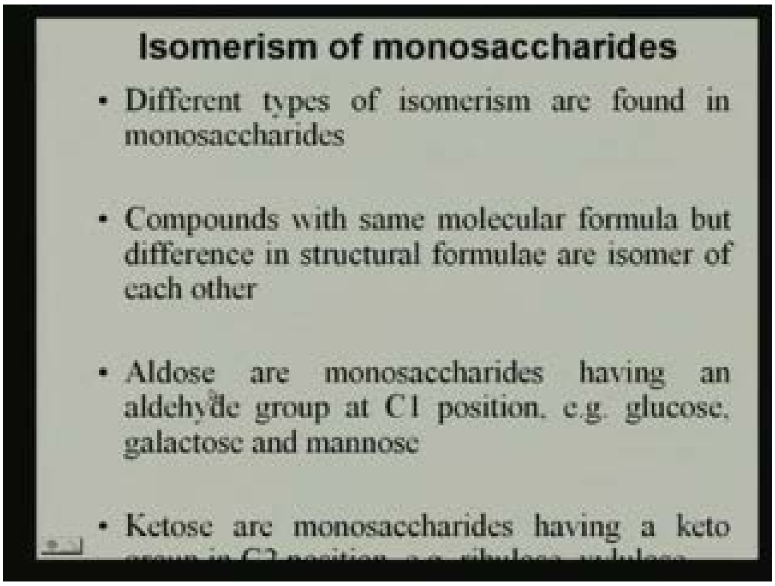

Now, another characteristics of the monosaccharide is its isomerism. Now in most of the monosaccharide isomerism is a very common phenomenon. Compound with the same molecular formula, but different in structural formula is the isomer to each other now.

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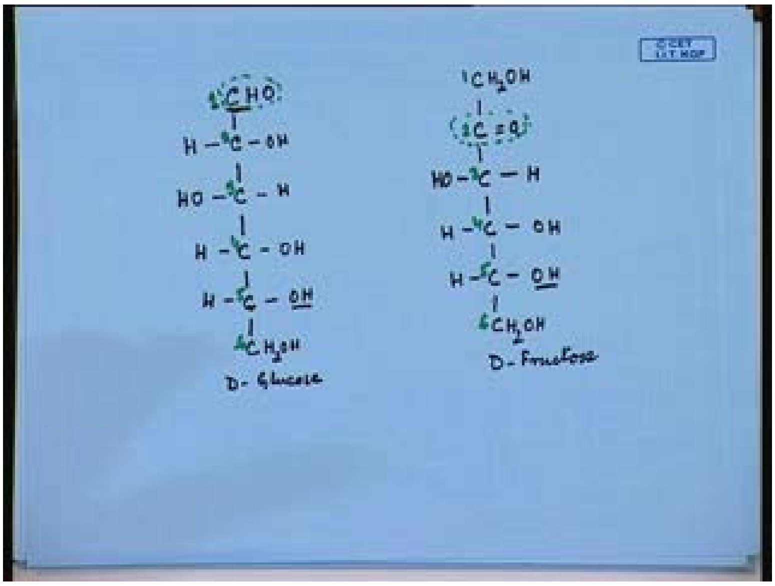

As, I have told you that, if we see the aldehydic sugar and one keto sugar. Then, in case of aldehydic sugar, the first carbon atom, which is there, it is the C H O. That aldehydic group, it occupies the first carbon atom of this skeletal structure. And if we do the numbering one, two, three, four, five and six. This is the hexose sugar; first carbon is occupied by the C H O. That is the aldehydic group whereas, in case of keto sugar what is there if we do the numbering one, two, three, four,five and six. We will find that carbon atom number two is occupied by the C double one O that keto will grow.

So, this is D glucose, why it is D glucose? See the chiral carbon, which is far from this carbonyl carbon. And hydroxyl group is present on the right hand side. So, this is D glucose and this is D fructose. So, this is the structure of D glucose and D fructose.

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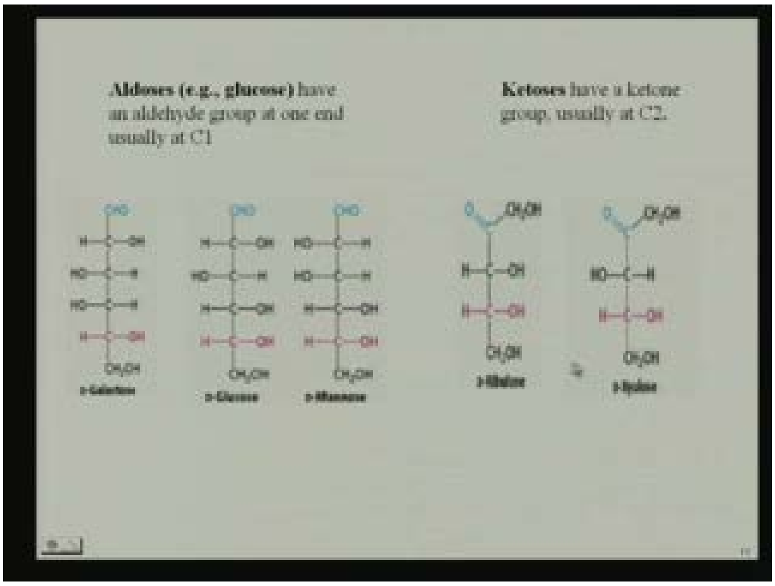

Now, if we see this basic structure of glucose. Then we can find that it has got the isomerization. What is that if we see the other hexose sugar like D mannose and D galactose. So, here this is the chiral carbon which is far from the this carbonyl carbon and hydroxyl group is present on the right hand side on each of the sugar indicating there is D galactose D glucose D mannose and so on.

Now, when we compare the anomeric, this isomerization. Then what we will find that? See the carbon atom number. This is the first carbon, this is the second carbon, and if we see the structure of this second carbon. We can find that this hydroxyl group is present in case of glucose. It is present on the right hand side, whereas, in case of mannose it is present in the left hand side. That means it is just opposite with respect to that carbon atom number two. That means these are the mirror image to each other or it is the epimer in case of the galactose and glucose.

If we see the fourth carbon atom that means one, two, three and this fourth carbon atom. We will find that this hydroxyl group is on the right hand side. Whereas, here the hydroxyl group is present on the left hand side indicating that galactose and glucose are isomer to each other with respect to the carbon atom number four. So, this is the example of the aldehydic sugar .When we are coming to this keto sugar ,we can find that see here, I have already mention that carbon atom two is the ketyl group.

So, here if we do the numbering, this is carbon atom one, two, three, four , five. And that is why it is the ribose sugar. That means it is five carbon containing sugar, if we see the third carbon atom three .Then you, we can find that in case of ribulose, the hydroxyl group is present on the right hand side. Whereas, in case of zylulose, the hydroxyl group is present on the left hand side. That means they are isomer to each other with respect to the carbon atom number three and as the hydroxyl group is present on the chiral carbon far from this the carbonyl carbon it is the D form of sugar.

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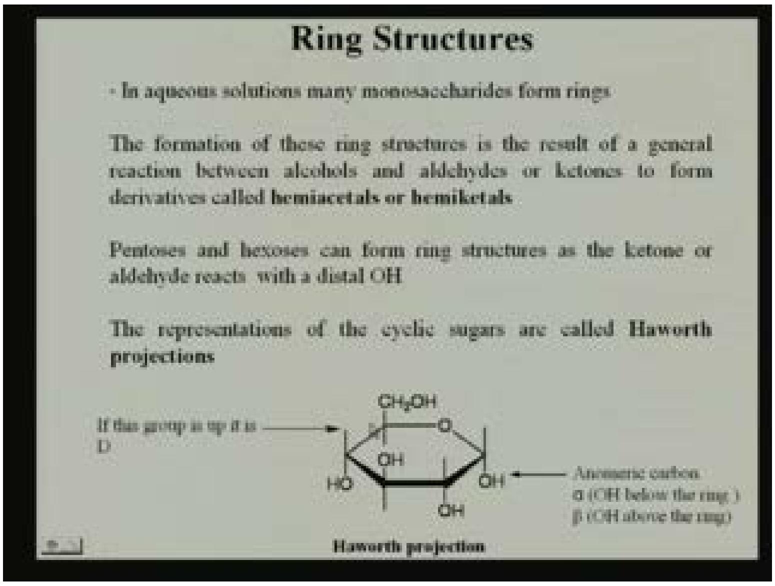

Now, coming to the another characteristics of this monosaccharide. Now when we are talking about this monosaccharide, we can find that in aqueous solution. Many monosaccharides they form the ring like structure. The formation of these ring structure is the result of a general reaction between the alcohol and the aldehydic group. Or the ketyl or ketone group which is present in the monosaccharide and it forms the derivatives which are called either hemiacetals in case of aldehyde. Or hemiketal in case of keto derivative sugar. Pentoses and hexoses can form the ring like structure, as the ketone or aldehyde reacts with the distal hydroxyl group which is present and this type of representation is called Haworth projection.

Now, when we are talking about this. That means what we are talking about the simple straight chain of glucose. Now what they are telling, that this there is a tendency of this first carbon and the fifth carbon. This is the tendency, this is it is in a ring like structure. What they are doing? That just coming very close to each other. That if, we are doing the numbering, this is the first carbon, second, third, fourth and fifth. Now here this fifth carbon, you see this C H O H now you see the structure here .This C H O H .So, here this O H and H is there, and it is forming the ring like structure.

Now, this is the tendency which is there commonly found in case of the monosaccharides.

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Now, these structures are denoted as the pyran and the furan ring. Now what is pyran and furan? It is a heterocyclic organic compound. The five carbon atom and one oxygen atoms are present in a ring structure. And the term pyran is also often applied to the saturated ring analog which is more properly referred to as tetrahydropyran. In this context the monosaccharides containing a six membered ring structure are known as the pyranoses. Now, here if you see this is the pyran structure and if we see the carbon number one, two, three, four and five and six is joined together. And this fifth carbon is getting join in this particular pyran ring. That means in this ring, five carbons are present .In case of furan, we can get that four carbons along with the oxygen ring. That is the monosaccharides containing a six membered ring system are also known as the furanose. And it consists of five member aromatic ring with four carbon atom and one oxygen molecule in its code structure.

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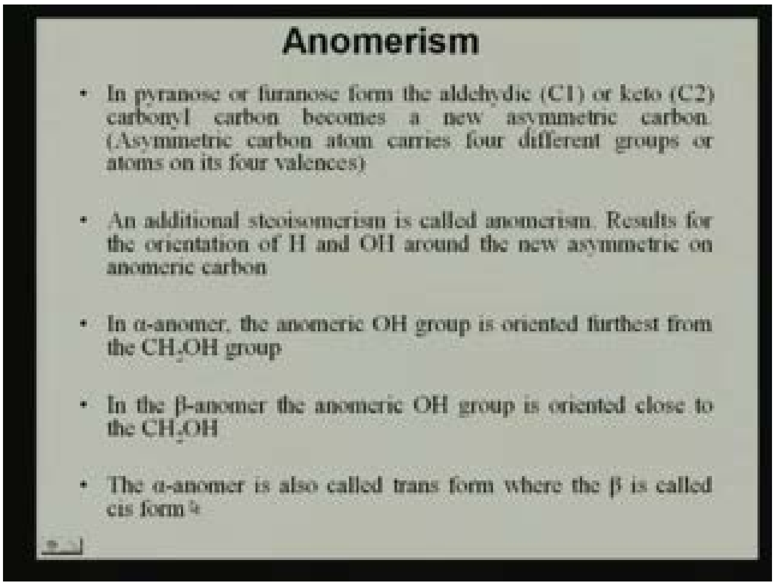

So, if we see the anomerism that is that pyranose and furanose form the aldehydic. That is C one and for keto it is the carbon atom two. Carbonyl carbon becomes a new asymmetric carbon to this carbon skeletal structure. The additional stereoisomerism is called anomerism, the results of the orientation of H and O H around the new asymmetric carbon atom .On the anomeric carbon, which is present in this chain. The Alfa anomer is the anomeric hydroxyl group which is oriented furthest. From the C H 2 OH group and in beta anomer, the hydroxyl group is oriented close to the C H 2 O H group. What does it mean?

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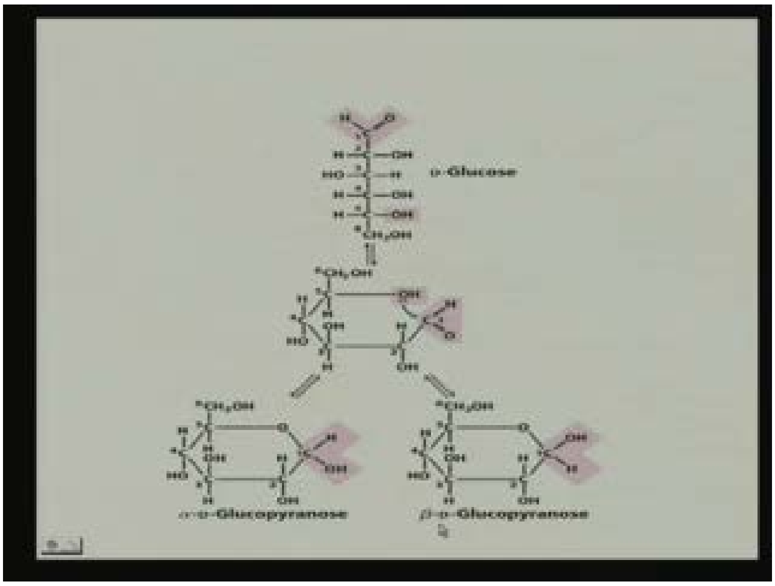

It means that if this is the glucose structure. This is the first carbon, which is the aldehydic group. The carbonyl carbon and I told you that first carbon and fifth carbon, they can form the ring like structure.

Now, what is happening? If we see this is the carbon number one, two, three, four ,five and six. This five carbon compound this chiral carbon C C H and O H. This O H , here this oxygen is having the lone pair of electron which is sharing with this carbonyl carbon. And they form this ring like structure and when they form this ring like structure depending upon the orientation of this hydroxyl group. If this hydroxyl group is oriented furthest from this C H 2 O H group .That means if this is the downwards that, and far from this CH 2 O H 2, then it is called as Alfa. Or the Trans form and when it is oriented this hydroxyl group is close to that of this C H 2 O H group. Then it is the beta form or it is called the cis form.

So, alfa anomer is called as Trans form. Whereas, beta is called the cis form, that means this is the trans, and this is the cis orientation. Of this glucopyranose alfa t glucopyranose and beta t glucopryranose.

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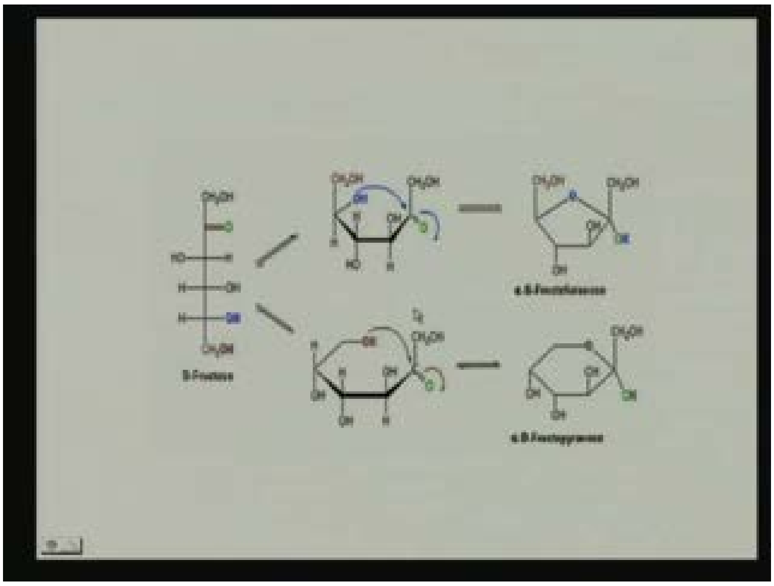

Similarly, in case of this D fructose, when we are talking about that means here, this second carbon is the ketoyl carbon and here the fourth carbon has got this. This is the chiral carbon which is farthest from this carbonyl carbon and O H is on the right hand side and they can form the ring like orientation.

Now, if this second carbon and fourth carbon, they form this ring. We call this structure, if it is like this. This first, second, third, and fourth, and fifth. This is the fifth carbon; this is first, second, third, fourth and fifth. That means second carbon and the fifth carbon, when they come close to each other .They share this lone pair of electron and form this ring structure. And it is called the Alfa D fructofuranose, when it is the five carbon ring that is the pyran ring. Then you see this is the second carbon, third fourth, fifth and here the sixth carbon is coming to the picture. And here this O H group of this sixth carbon is coming and forming this ring and it is called Alfa D fructofuranose and this is the structure that ring formation with the glucose and the ketoyl group.

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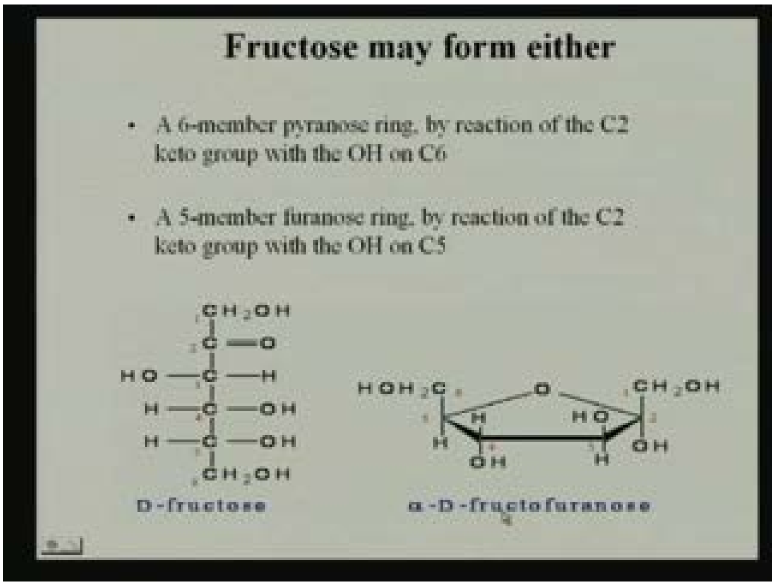

Now, here you see that a six member pyranoses ring by the reaction with C two keto group with the O H on C, six and a five member furanose ring by reaction with C two keto group with the O H on C five. So, this is the alfa D fructofuranose. what I have told you here the same thing is that Alfa d fructofuranose structure.

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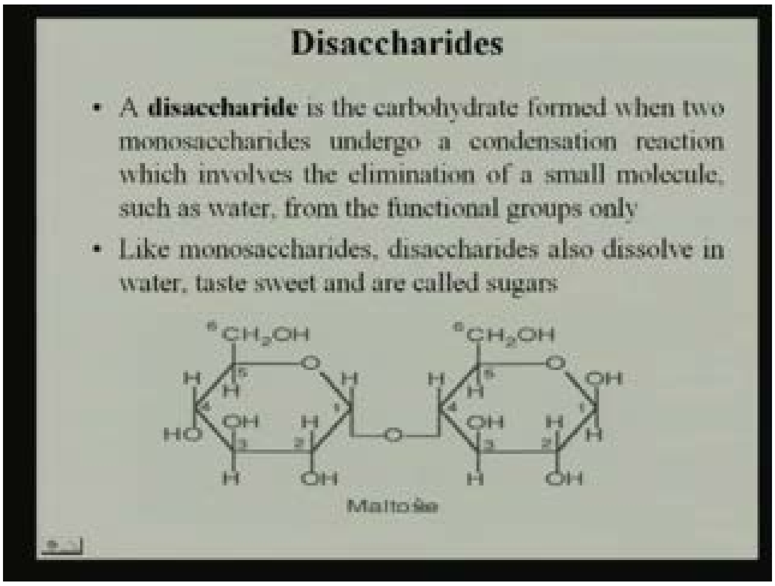

So, this is all about the monosaccharide and its possible orientation. What we are getting in the solution form in the ring form and it is very commonly found. Now coming to the disaccharide. Disaccharide means when two such sugar moieties are linked together.

That means a disaccharide is a carbohydrate formed when two monosaccharides undergo a condensation reaction which involves the elimination of a small molecule such as water.

That means when such types of bondings are there that release one molecule of water. Out of this from the functional groups only like monosaccharide, disaccharides also dissolved in water it taste sweet and are called sugar and this is one of the example.

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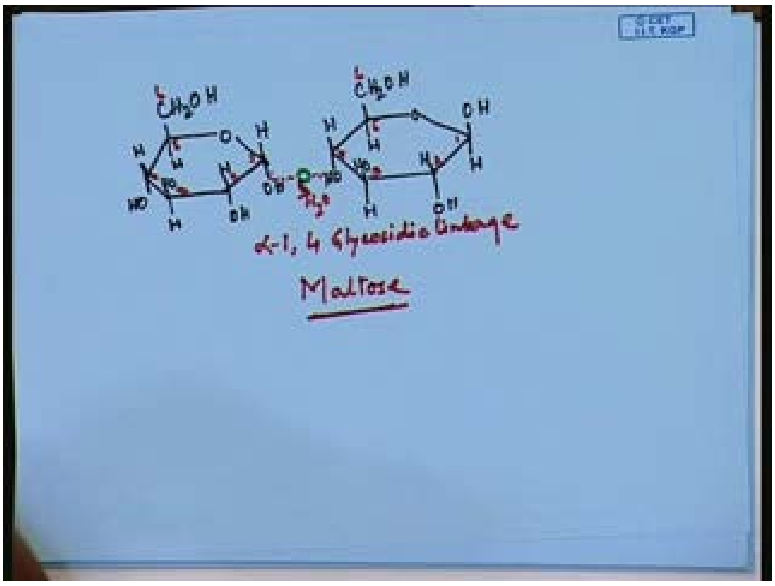

Now, when we are talking about the glucose molecule. So, if we draw the structure of so, if we talking about the, if we are talking about the glucose molecule. And when such two glucose molecule, moieties are present say.

So, this is one glucose moieties and this is glucose. Now when this is and if we do the numbering .And if we are doing the numbering likes this one, two, three, four, five and six. Similarly, one, two, three, four, five and six. So, here when this two glucose molecules are linked together .That means here if two glucose molecules are coming with each other, they form the bond with a release of one molecule of H 2 O. This is the linkage and when this is this bonding are forms it is called Alfa. One four glycosidic linkage. So, this is a first carbon is getting linked with the fourth carbon of the another sugar moieties. And they are forming the glycosidic linkage. So, when one glucose molecule is getting linked with another glucose molecule the bonding is called glycosidic bonding and it release a molecule of water from this bonding.

So, one molecule of water is being released to stabilize. This maltose is one of such example.

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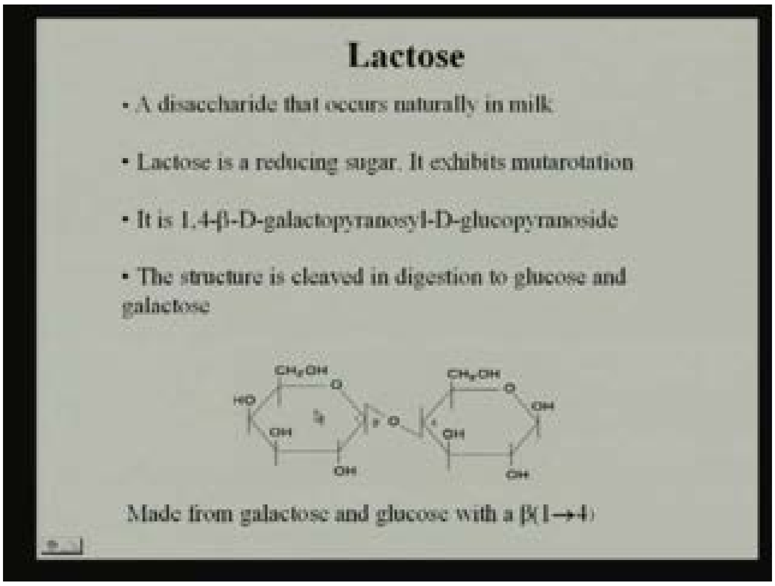

Coming to the lactose a disaccharide that occurs mainly in milk. Lactose is a reducing sugar and it exhibits mutarotation, this it forms with the one four beta d galactopyranosyl and one d glucopyranoside .That means when one galactose and glucose moieties are joined together with a beta one four glycosidic linkages it is called the, it forms the lactose molecule. So, one galactose and one glucose is joined together with beta one four glycosidic linkage. And here it is alpha one four glycosidic linkage incase of maltose. So, this is alfa one four glycosidic linkage, this linkage. But, here what is happening, this is the beta one four glycosidic linkage is formed. Where one galactose and one glucose molecule is joined together and when this bonds are getting split then we get one glucose and one galactose.

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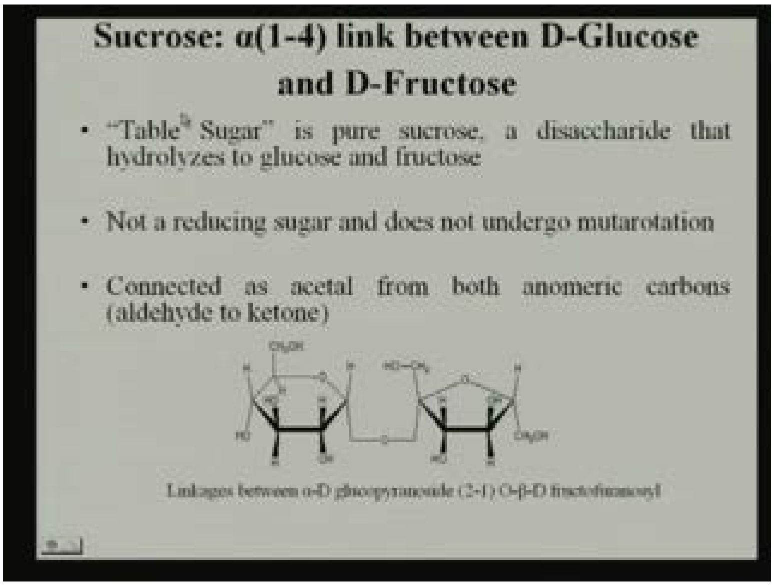

Now, coming to the another disaccharide which is very interesting, and generally we use that disaccharide as a table sugar. And it is the non reducing sugar and does not undergo mutarotation. It is connected with the acetal form from both anomeric carbon, that is one aldehydic and one ketone. So, see this structure, here when one glucose is getting linked with one fructose molecule, that two one linkages is there. That means first carbon and second carbon is getting linked with the first carbon of the glucose molecule. Is then it forms the sucrose molecule and this sucrose is one of the example of the normal table sugar.

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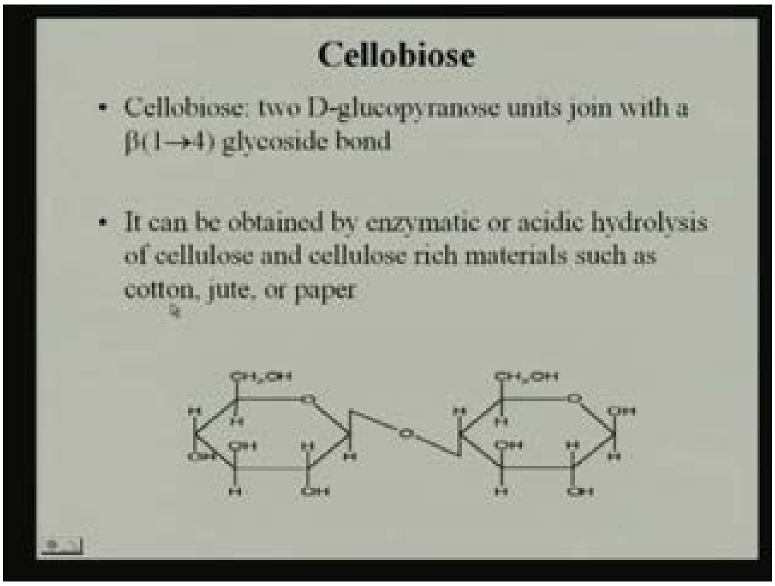

Coming to this cellobiose. Cellobiose is the two D glucopryranose unit which is joined by beta one four glycosidic bond.

Now earlier, what I was talking to you about maltose, lactose, sucrose. Those disaccharides are the sugar molecule. But, here what I am talking about this cellobiose, it is a non sugar disaccharide molecule. Here you see one glucose is connected with the another glucose moieties with beta one four glycosidic linkages. It can be obtained and it can be cleaved by enzymatic method with the help of the enzyme cellobiose .And this type of compound is very commonly found in cotton jute paper etcetera.

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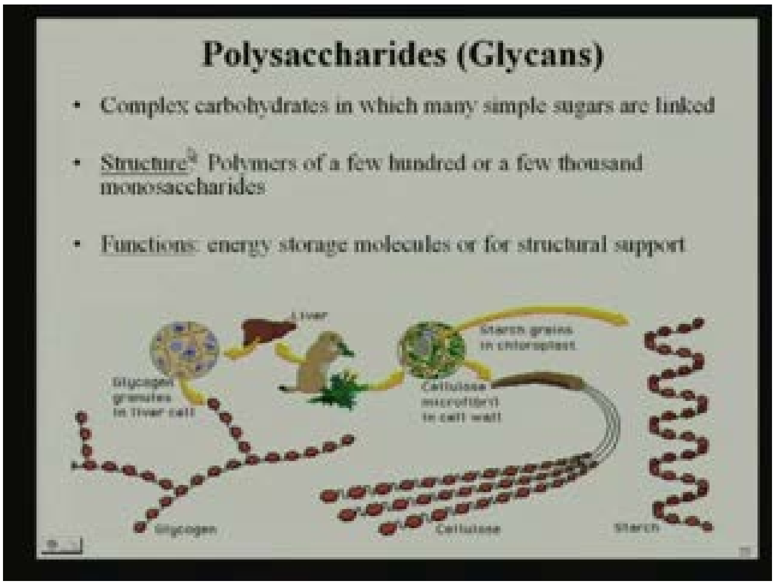

Now,coming to the polysaccharide. One of the example is the glycan molecule ,the complex carbohydrate in which many simple sugars are linked and mainly this polysaccharide. And glycan I have already talked to you about the glycan unit,if you remember when I have talked to you about the bacterial cell structure. Then I told you that nam and nag n-acetyl glucosamine n-acetylmuramic acid, those are the glycan chains which are giving the strength to the cell wall of the bacteria. Similarly, this is the, this is a polymer of the carbohydrate moieties. And here its function is that energy storage molecule or the it gives the structural support.

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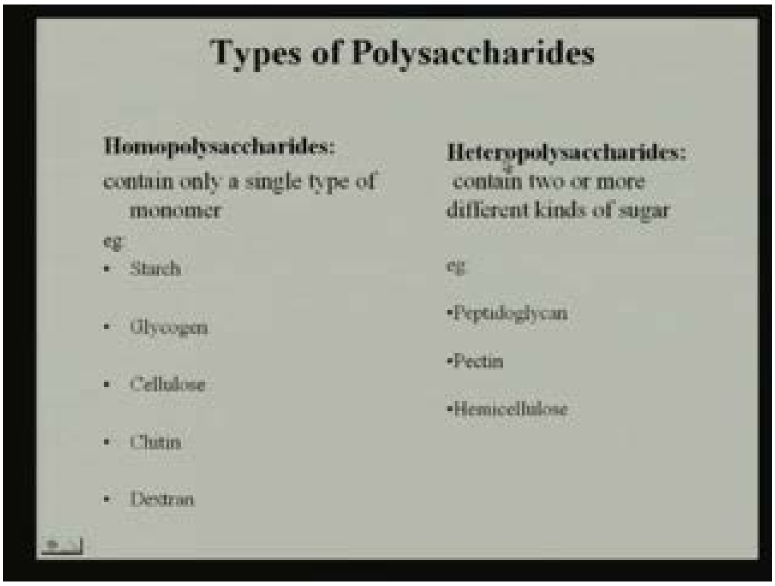

Now, if we see the polysaccharide, as I have already discussed to you, that it maybe the homopolysaccharide or the heteropolysaccharide.

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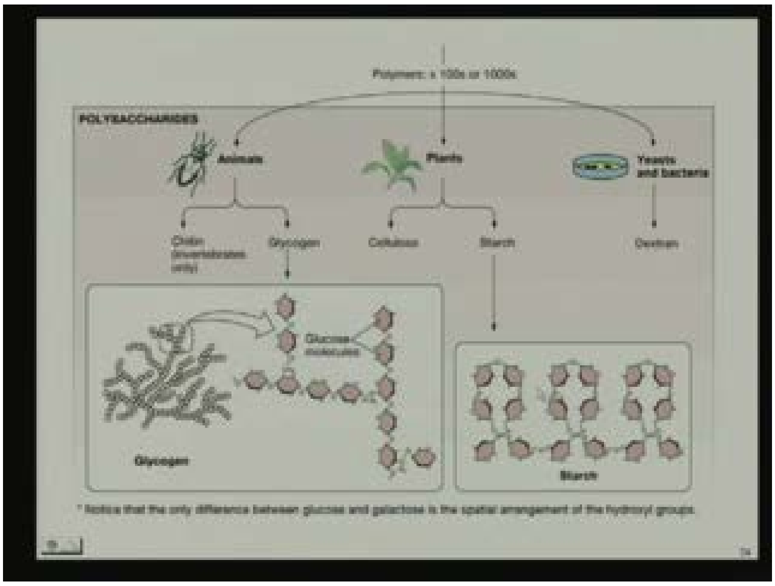

Now, coming to this homopolysaccharide, that if we are talking about this animal system. Then chitin is one of the polysaccharide which is present on the exoskeleton of cockroach.

Now, this is the cockroach, where this in this compound, this biomolecule is present on the exoskeleton. Whereas, glycogen is used as a storage food material in case of the animal system. We have the glycogen which is the storage food system in liver incase of plant cellulose and starch are the example of polysaccharide. Cellulose is beta one four linkage and starch is that Alfa one, four and one , six glycosidic linkages.

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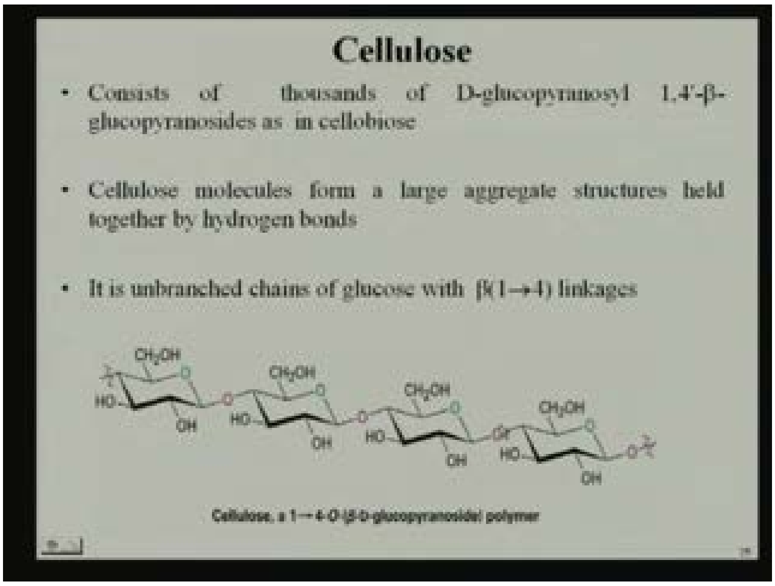

Now, this cellulose, it consist of the beta one, four glucopyranosides of the cellobiose. And cellulose molecule form a large aggregate structure held together by the hydrogen bonds.

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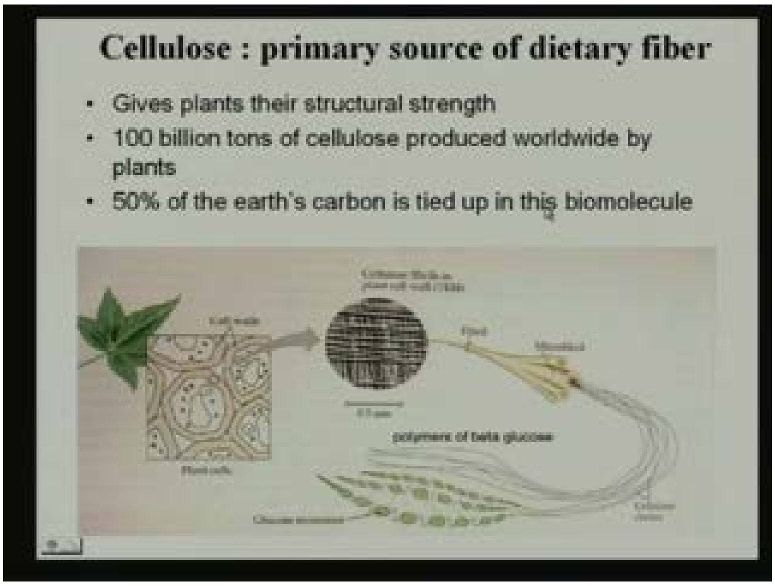

It is the beta one, four linkages which are there in a linear unbranched structure. And it gives the plant the strength or the stability that it protects the plant. Hundred billion tons of cellulose produced worldwide by the plant and fifty percent of the earth's carbon is tied up with this biomolecule.

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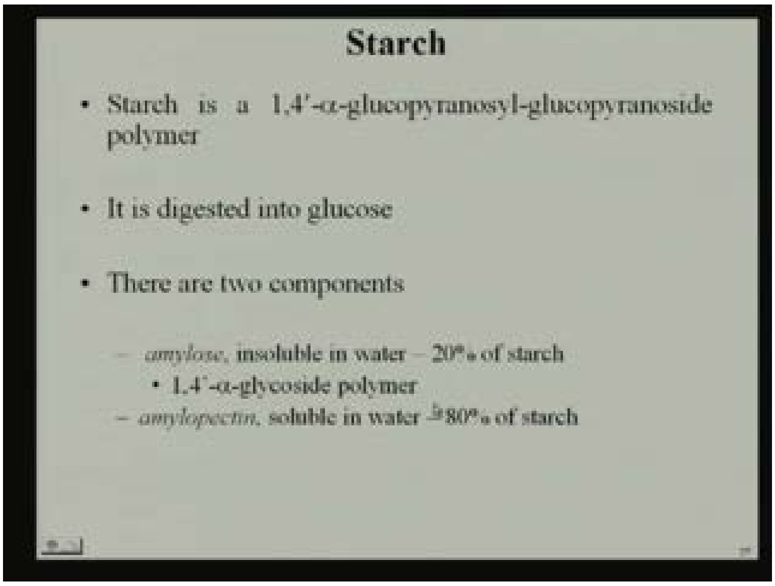

While talking to you about the starch I have told you starch is mainly composed of the amylose and amylopectin .Now amylose is insoluble in water and it composed mainly twenty percent of this starch. The Alfa one, four glycosidic linkage is the link of glucose moieties. In case of amylopectin, it is soluble in water and contains eighty percent of the starch.

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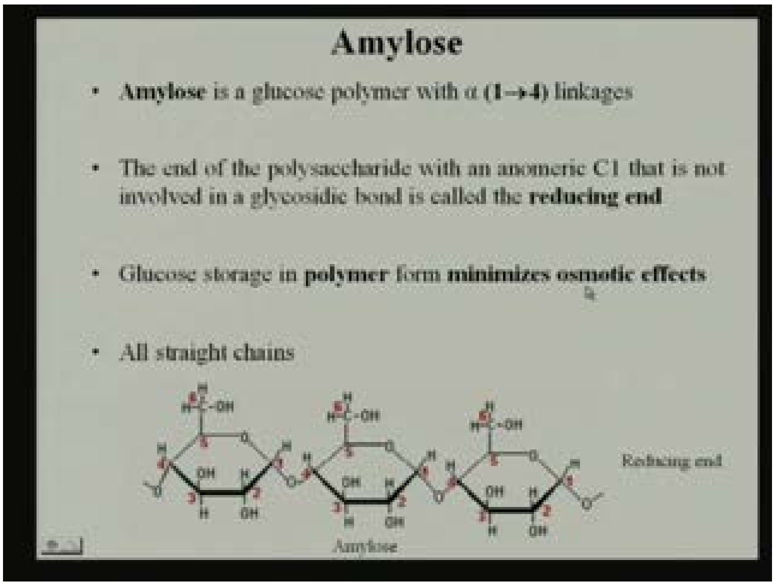

If we see the structure of amylose. We can find that as I have told that alfa one, four glycosidic linkage is there in case of this amylose molecule. And the end of this polysaccharide with the anomeric C. One carbon that is not involved in the glycosidic bond and that is the reason it is called the reducing end glucose. Storage in polymer form minimizes the osmotic effect and it is the straight chain molecule.

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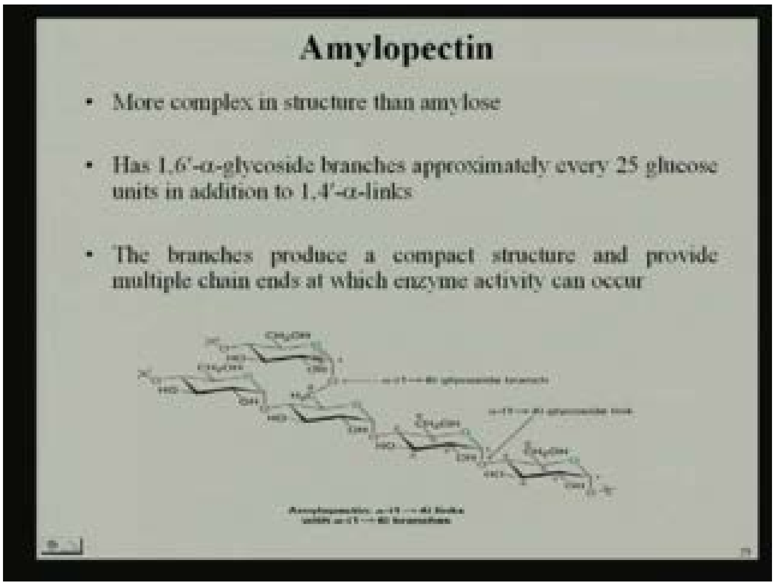

Whereas, in case of amylopectin it is a branched chain. Of this alpha one, four and alpha one, six, so, obviously this structure is little bit more complexed than that of the amylose structure. And each with the each every twenty five glucose stretch in moieties there is a branched chain of alpha one, six glycosidic linkage.

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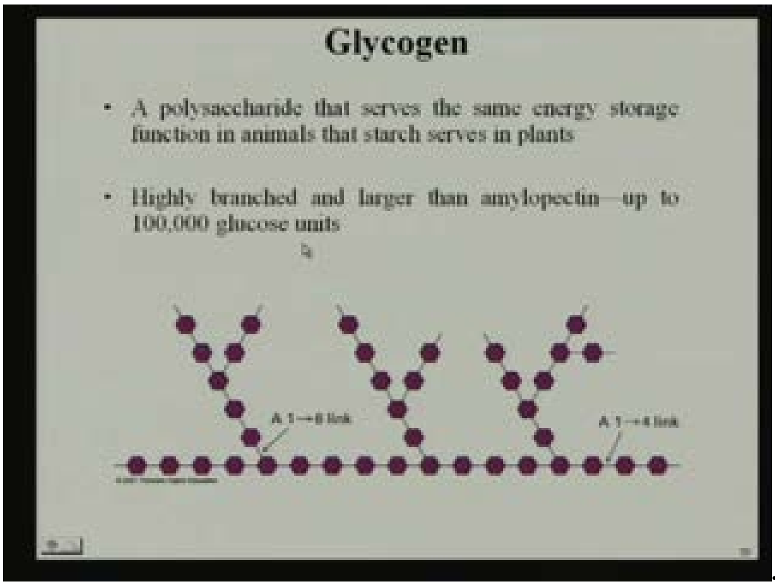

Now, when we are talking about the glycogen. Glycogen is the storage food material of animal. Whereas, starch is the storage food material of plant, now when we see here also the structure is alpha one, four and one, six linkages. So, straight chain is the alpha one, four linkage and whenever this branching is there. Then it is alpha one, six linkages, now when we are talking about alpha one, six linkage .That means here, then, how it is different from that of starch? Here the frequency of branching is more compared to that of the starch molecule. It is a highly branched and larger than amylopectin up to one lack glucose units are present in case of glycogen.

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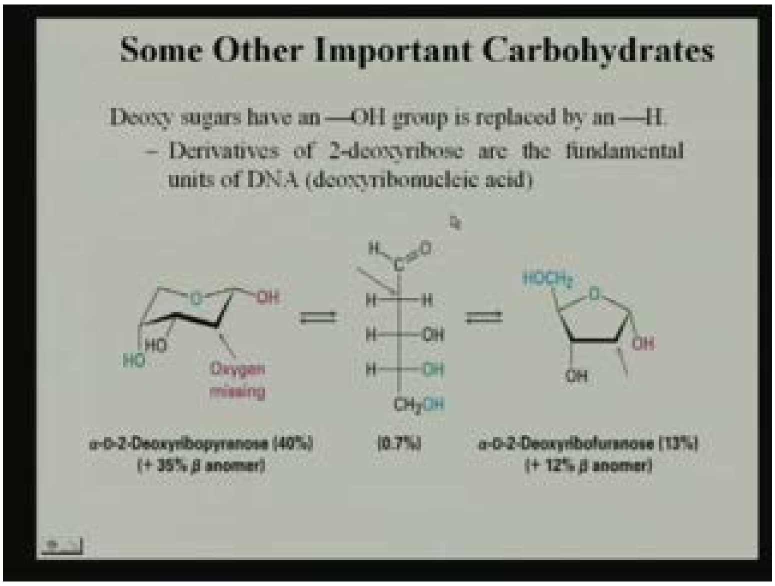

Now, when we are talking about the other carbohydrate molecule which are present in different, other along with other biomolecules. Now while talking to the nucleus, I have told you about d n a and r n a deoxy sugar have the, have an O H group which is replaced by an hydrogen. That means one oxygen is missing in deoxy sugar, it is the derivatives of two deoxyribose and are the fundamental unit of d n a molecules. And this is the ribose sugar which is present in the r n a molecule and this carbohydrate moieties are playing a very important role in this structure of d n a and r n a.

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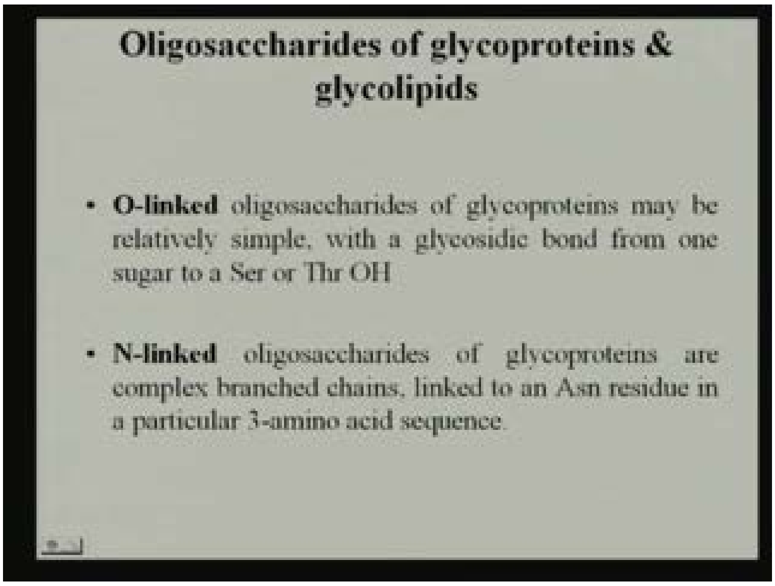

Now, besides this, the oligosaccharides of glycoprotein and glycolipids are also playing a significant role. I think, if you remember, I have already mentioned during this while talking to you that cell structure of bacteria .There I have told that some lipoprotein, some glycoprotein, some glycolipids are present on the cell structure of cell wall of the bacteria. So, here when one glucose that carbohydrate moiety is linked with the protein moieties or any carbohydrate moieties are linked with any lipid moieties. They form this glycoprotein or glycolipid and so on, it is making the structure little more complex.

Now, the hydroxyl the O H group in case of the the amino linked amino sugar. The hydroxyl group is replaced by the amino group of the amino acids or the protein moieties. So, similar way this type of linkages is also found in case of this lipoprotein, glycoprotein and so on.

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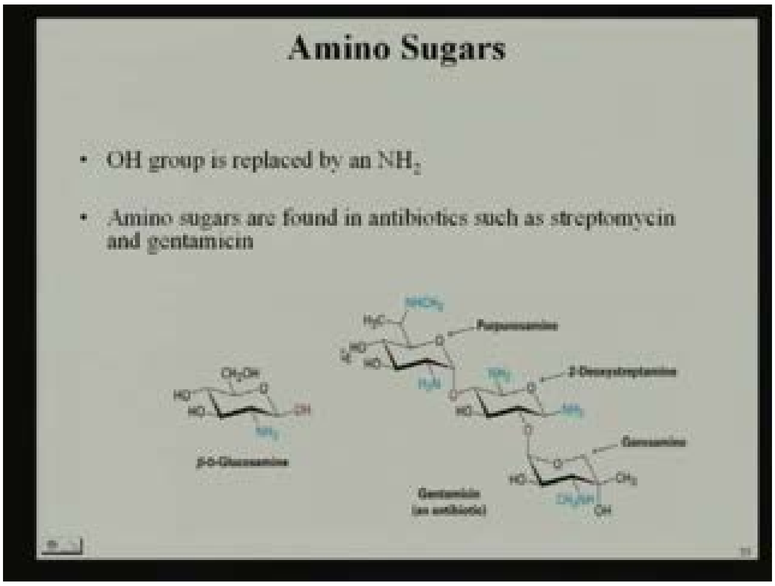

So, when we were talking about this amino sugar, this O H group as I have already told you that ,it is replaced by this amino group .Which is present and amino sugar are found in antibiotics. Say for example, that gentamicin, it is also present in glucosamine, that glucosamine is one of the component of the cell wall of bacteria. So these types of complex structures are found.

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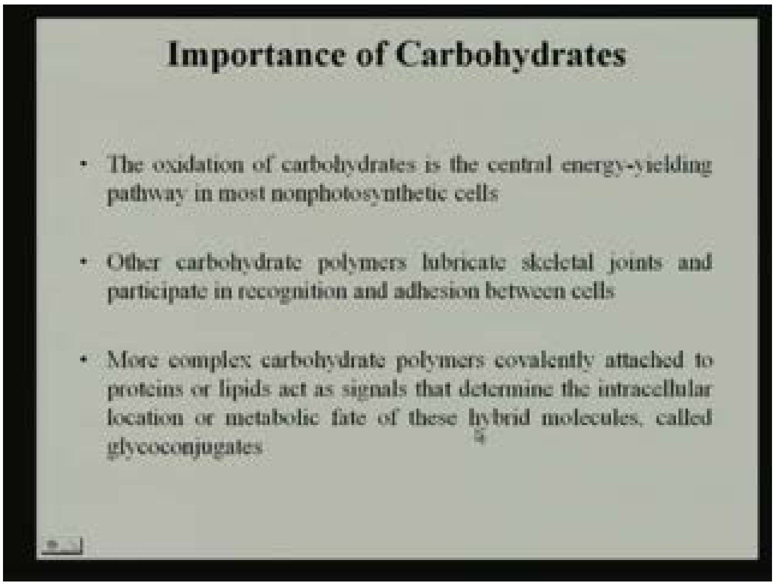

Now, if we come to the importance of carbohydrate, then we can find that when this carbohydrates are getting oxidized. It gives the energy and to which type of cells the nonphotosynthetic cells like r other carbohydrate polymers lubricate the skeleton joint. And participate in recognition and adhesion between the cells. More complex carbohydrate polymers covalently attached to proteins or lipid act as a signals that determine the intracellular location or metabolic fate of the hybrid molecule which are otherwise known as the glycoconjugates.

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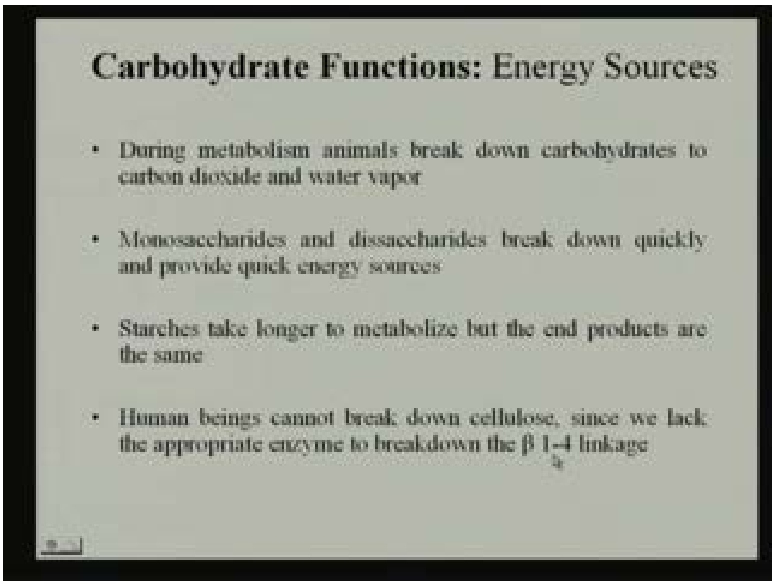

Now, if we see the different functions of carbohydrate, then it can be used as the energy sources during metabolism. The animal breakdown this carbohydrate to carbon dioxide and water vapor monosaccharides and disaccharides break down quickly the and provide a quick energy sources. And starches take a longer to time to metabolize, but, the end products are the glucose moieties. Human being cannot break down the cellulose as because they do not have the enzyme which can degrade the cellulose molecule. That means we do not have cellulase enzyme which is present in any types that cattle. They lack the appropriate enzyme which cannot break the beta one, four glycosidic linkage which is there in the basic skeleton structure of cellulose molecule.

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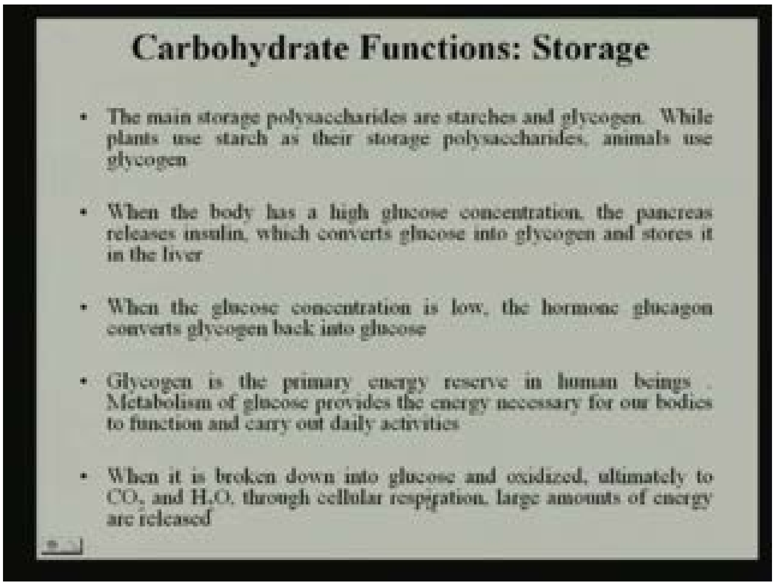

Now, if we see the other function of carbohydrate then it is acting as the storage molecule, as I have told you that glycogen is the storage material, where it is getting stored in the liver.

Now, the main storage polysaccharides are starch and glycogen. Starch incase of plant and glycogen, in case of the animal system. Now when the body has the high amount of glucose then the pancreatic release the insulin. The body can sense that body has got the system. The cell is having higher concentration of cellulose molecule. Then what this insulin is doing? The pancreas releases this insulin and it converts this glucose to glycogen and with this glycogen is getting stored in liver. When glucose concentration is low, suppose body is in need, in summer I think many of you are sweating and sometimes we are feeling restless.

And if we take immediate glucose water then we get some energy. What does it mean? that means body was in need in summer .We are when a person is sweating, we are giving that glucose water, so when that body is in need of glucose that means glucose concentration in the cell is low. Then the hormone glucagon converts this glycogen back to glucose and glycogen is the primary energy reserve in a human being. The metabolism of glucose provides the energy necessary for our body to function and carry out the daily activities. When it is broken down into glucose and oxidized. Ultimately carbon dioxide and water is released through the cellular respiratory process.

So, this is the major function the storage function of carbohydrate.

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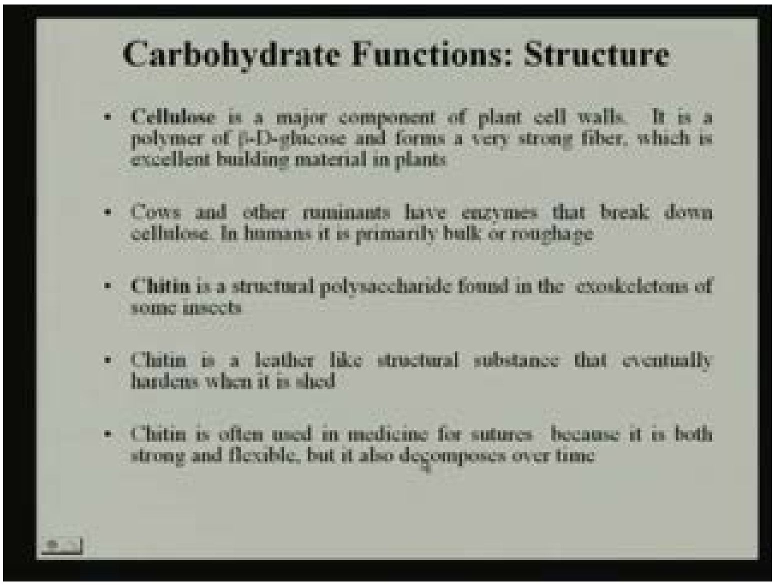

Now, if we see the function of carbohydrate as the structural stability. Then we can find that cellulose has got. Cellulose is present in every plant cell and in the plant cell this cellulose is giving a strong support .That means it has got the fiber like structure, which is excellent building material of the plant.

Now, when I have already told that cow the cattle they have this enzyme called cellulase which is absent in case of human being. And that is the reason why we sometimes take green vegetable which act as an roughage for the system. If we consider chitin, I have told you this chitin is the structural component which is present in most of the this exoskeleton structure of the insect. Chitins are is leather like structure and it is the substance that eventually gives the hardness. When it is shed chitin is often used in medicine for structure .Because it is a both strong and flexible, but, is also decomposed over time.

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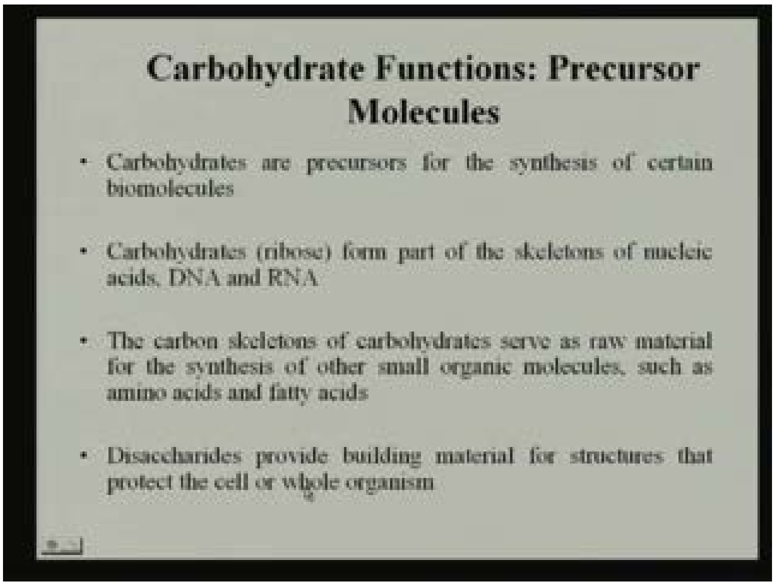

Now, if we see the carbohydrate as a precursor molecule. Then we can find that carbohydrate that ribose or deoxy ribose, they are the basic skeleton structure for d n a and r n a. The carbon skeleton of carbohydrate serves as the raw material for the synthesis of other small organic molecule such as amino acids and fatty acid. Disaccharides provide the building material for structure and protect the cell or whole organisms also.

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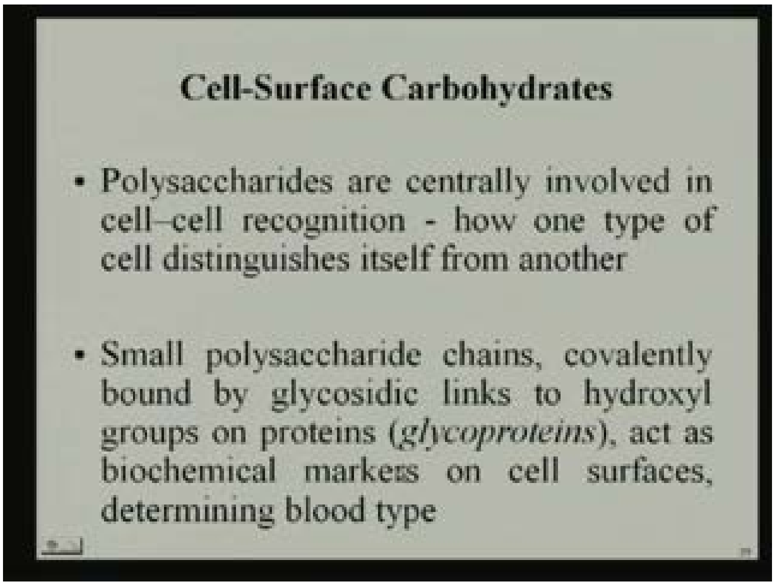

Now. When we are talking about the different structure and function of this carbohydrate. The polysaccharides are centrally involved in cell recognition, how one type of cell is distinguished from another type of cell? Can also be possible. Because of this carbohydrate moieties, some polysaccharide chain covalently bound by the glycosidic linkage to the hydroxyl group of the protein, which is called the glycoprotein. And act as the biochemical marker on the cell surface and also determines the blood group.

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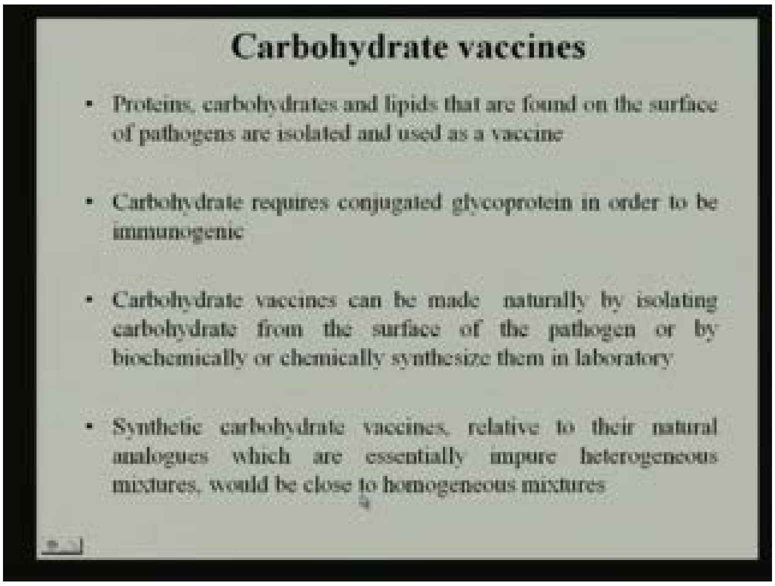

Now, when we are talking about this carbohydrate as a vaccine. Now, protein carbohydrate and lipid as I have mentioned that these are the three macro molecules which are found on the cell surface of the pathogens too are isolated and used as a vaccine. Carbohydrate requires the conjugated glycoprotein in order to be the immunogenic carbohydrate vaccine can be made naturally by isolating the carbohydrate from the surface of the pathogen or by biochemically or chemically synthesized. Which is possible in the laboratory, synthetic carbohydrate vaccine relative to their natural analog which are essentially impure. heterogeneous mixture would be close to homogeneous mixture.

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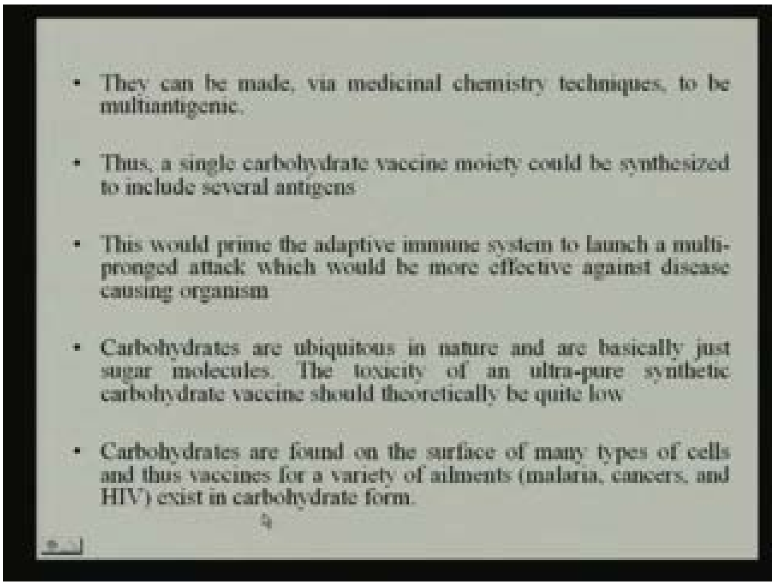

They can be made via medicinal chemistry technique or by antigenic. Thus a single carbohydrate vaccine moiety could be synthesized in two include the several antigens. This would prime the adaptive immune system to launch a multipronged attack which would be more effective against the disease causing organism.

Carbohydrates are ubiquitous in nature and are basically just the sugar moieties. The toxicity of an ultra pure synthetic carbohydrate vaccine would theoretically be quite low. Carbohydrates are found on the surface of many types of cells and thus vaccine for a variety of ailment. That is the malaria, cancer and H I V exist in carbohydrate form and this is all about the carbohydrate and its role in the biological system in the living cell system. I think with this particular, this biomolecule you will have some idea that how this micro as well as macro molecules are playing a significant role in the living system. So with this today, I am concluding .Thank you very much.