hello everyone i welcome you all in ah fourth lecture of biomolecules ah before going to the lecture content ah i will like to give a recap of ah you know last classes and we have in we have discussed already in the last class ah regarding the structural formulas of monosaccharide ah we have also discussed about the pyronic structure we have discussed about the furon structure and ah muta rotation and glycoside formation so ah let us continue with the glycoside formation ah in glycoside formation we discussed about the treatment of alpha d glucose with methanol in presence of hcl so as we know alpha d glucose has ah poly hydroxy group in its framework in presence of methanol and hydrochloric acid it forms two glucosides methyl alpha d gluco pyronoside and methyl beta d glucopinocyte so c s three hcl and what happens basically one molecule of water come out of from the molecule to make it more clear i will use the color code while making the structure so that you can understand the changes happening in the you know sugar mighty so this is the main scaffold and changes happening here at the anomeric position and it forms methyl alpha d gluco pyranoside methyl alpha d gluco pyranoside side its melting point is 165 degree centigrade and specific rotation which is denoted by alpha d 25 is plus 1 5 8 the other product is methyl beta diglucopyronoside which is very much similar to the alpha d glucopyranoside however methoxy group here attached with the enomeric carbon at the you know equatorial position so again i will use color code to make it more clear here it becomes this is methyl beta d gluco pyranoside melting point is one o seven degree centigrade and specific rotation is negative thirty three now you can see here this both molecule has formed from the same starting material only difference is position of ocs3 that methoxy group in one case it is equatorial in the alpha d glucopyranoside and in the other case it is equatorial in one case axial in the alpha gluco participate and in ah beta d gluco pyrocide it is equatorial carbohydrate ah generally these are called acetyls and ah carbohydrate crystals are generally ah called acetyls are called glycosides and that is why here i have named methyl alpha d glucopyranoside pyron is the six member ring in both the cases and alpha is the position of reflects the position of methoxy group so methyl alpha d glucopyranoside methyl beta d glucopyranoside so carbohydrate crystals are called glycosides and and acetyl of glucose acetyl of glucose is called a glucoside glycoside is the general terminology and for the glucose it is glucoside glucoside similarly acetals of mannose are menonoside manon side acetyl of fructose fructose are fructoside so it is very much clear that

carbohydrate in presence of acl   gaseous hydrochloric acid and alcohol forms
glycoside and particularly in case of glucose   we call them glucoside similarly for mannose
manure mannoside and for fructose fructoside   what is the mechanism of this reaction so
let us talk about the you know mechanism for   this reaction mechanism for the formation
of glycoside mechanism for the reaction what happens in presence of acid
so here first i will draw glucose and in presence of a seed
so here i am adding this reaction is reversible
here you can see this reaction is reversible
so in   presence of acid what happens that it takes proton
from the acid and it forms protonated species
so i will keep the whole structure same but the
hydroxyl of a numeric position will get protonated   and that will get converted to o h
two now it will have positive charge once it attains positive charge
what happens that lone pair of oxygen of the pyron ring will assist in elimination
of this water molecule and again the second step is also
reversible if it is minus h two o it will give axonium species you can see here
now we get the oxonium species now this oxonium species which is s p two
hybridized have two phases for the attack   and these two phase after the attack will give
the corresponding two ah you know glycosides   ah if attack is taking place from the beta phase
then it will give beta d gluco pyro pyranoside   and if attack is taking place from the alpha
phase then it will give you methyl alpha d gluco   pyrinoside
so let us attack water molecule again
i will use the colour code to make it very clear
so if attack is taking place from the from the top face and if
attack is taking place from the bottom face
so if attack is taking place from the top face then it will give you
corresponding beta d gluco pyrinosite again this one is
reaction this reaction is reversible so   let me draw the structure of the
molecule and it will go to the equatorial position now this sp 2 hybridized carbon
becomes sp3 hybridized after the attack and here again acid counter ah base
abstract this proton and leads to the removal of h a with the corresponding
methyl beta d glucopyranoside
so one thing is very clear
that the structure of product   the final product is completely dependent on
that you know at what phase on this auxinium   species that auxinium intermediate
alcohol is attacking
so this becomes methyl beta d glucopyranoside if it attacks from the bottom face
so that i will write on the another page or i will
continue here itself if attack is taking place
so here you can see that i have put axial positive charge is there and
again the counter base of the acid will abstract the proton from the
corresponding compound minus h a
will lead to the methyl alpha d gly gluco pyrocide methyl alpha d gluco

pyranoside now again i will explain
the mechanism of the reaction what happen in the presence of acid first protonation of the
enumeric alcohol is taking place and then with the help of the ring oxygen removal of water molecule
is taking place that lead to the formation of auxinium intermediate now this auxonium
intermediate have carbon which is sp2 hybridized where you know attack can take
place from the bottom face or from the top face if attack is taking place from the top
face then that leads to the formation of methyl d glucopyranoside and if
attack is taking place from the bottom face then it leads to the formation
of methyl alpha d glucopyranoside
so one thing i would like
to mention that this attack attack by alcohol oxygen occurs on either face of
resonance stabilized carbocation carbocation now glycosides are you can see here these
all reactions are in equilibrium they are all reversible here that attack of acid which
leads to the removal of water molecule from the you know ah acetyl and then further
attack by the alcohol these all steps are reversible and that is why glycosides
are stable in basic solution important point glycosides are stable in basic
solution because they are acetyl and if we have acidic
solution glycoside under can undergo hydrolysis to produce the corresponding sugar and
alcohol as a side product in acidic solution acidic solution it gets hydrolyzed
gets hydrolyzed to produce alcohol and sugar the alcohol obtained here after
the hydrolysis is known as a glycan the alcohol obtained by hydrolysis
hydrolysis of a glycoside is known as a glicon this point you need to remember
that you know when ah glycoside glycoside get hydrolyzed it
generates alcohol and which is known as a glycan to make it more clear i will
like to give you on a specific example and there i am taking a very simple
glycoside where the alcohol alkyl
group is presented with the r
so here i am not expressing the o r substituents are you know ah
stereochemistry now this gets hydrolyzed in the presence of a seed and it will
generate the sugar
so and alcohol
so this is sugar and this is a glicon a glycon now what is the mechanism for this a
glycan formation if we go to the reverse ah pathway what just now i discussed about the
glycoside formation if we do the reverse ah chemistry then we can lead to the you know
glucose molecule if we start with the you know ah gluco glucoside ah and as well as alcohol so
let us discuss the mechanism of this hydrolysis
so again i am taking methyl beta d glucopyronoside methyl beta d gluco pyrocide
in presence of acid here i have taken you know hydronium hydronium ion thats you know ah protonated water
molecule as acid

so it will take the proton and it will form the protonated methoxy substitution now it gets protonated once it is protonated again the
ring oxygen will help in elimination of this you know protonated methoxy group in the form of methanol
so again minus c s three o h that will generate the axonium species as an intermediate now again two possibility exist over here
at this s p two hybridized carbon one that ah attack can take place from the top
face and other attack can take place from the bottom face of on this sp two hybridized
you know carbon atom
so again let me write water molecule which is available
there in the reaction mixture from the top face this is a and the other possibility if it attacks from the bottom phase
so here also attack by water occurs on either
face of the resonance stabilized carbocation and this will lead to the corresponding hemi acetyl corresponding acetyl again this water molecule will be protonated and this will lose the h plus with
the help of water molecule water molecule will take the
proton and it will generate beta d glucopyranose beta d glucopyranose beta glucopyranose and same way if here if we add hydronium species then again it can get
transferred to the corresponding protonated moiety which can go back to again corresponding resonance
stabilize ah carbocation here also i will like to add methanol just to
so that you know
these all reactions are reversible now the second possibility if
attack takes place from the from the bottom face that will lead to the alpha d glucopyranose in a similar way first it will give
the corresponding protonated species and that will further get processed for the removal of h plus to give the you know alpha d glucopyranose this alpha and beta this represents the
orientation of hydroxyl group at the anomeric position this has to be you know remember every time when i pronounce this symbol
so this is a alpha d gluco pyranose
so let me go through again
so we started
with the methyl d glucopyranoside in presence of hydronium species it gets protonated that step
is also reversible and then ah with the you know um lone pair ah push from the ring oxygen it
liberates the methanol and generates the resonance stabilized carbocation which can be attacked from
the top face or from the bottom face if attack takes place for the water molecule from the top
face that generates the beta d glucopyranose and if attack takes place from the bottom face then it
generates ah alpha d glucopyranose the hydrolyzed sugar moiety as i discussed the concept of
a glycan and alcohol ah by the hydrolysis of ah glycoside
so let me explain it again
ah here i am taking example of salicyn salicin a molecule its a glycosides which has sugar as well as alcohol
so let me write the structure of salicyne

so this is the sugar part
and now i will use color code to represent alcohol part this is carbohydrate mighty and this is a glycan moiety this is egg like convoy t now i hope you understand that you know ah when we will do hydrolysis it will generate
the this aerial alcohol and corresponding sugar this carbohydrate moiety and this in total
is known as ah glycoside this is a glycoside which by hydrolysis can generate sugar as well as alcohol now i would like to discuss about the enomeric effect what is the numeric effect ah
so enomeric effect we saw that beta d glucose is more stable beta d glucose is more stable than alpha d glucose then alpha
d glucose let me explain it again why beta d glucose is more stable
let me take the structure here this two is structure first i will take
so here you can see that in the case of beta d glucopyranose hydroxyl group is staying quite open it does not have interaction with the other substituent
so it will have less strain in this scaffold
whereas in the case of alpha d glucopyranose there are substituent this hydroxyl group is
there this h is there this has certain steric reservation alpha d glucopyranose and that is the
reason beta d glucose in the cyclic form is more stable ah than the alpha d glucose
so here in the beta d glucose hydroxyl
is oriented in the equatorial position whereas in the alpha d glucose hydroxyl
is oriented at the axial position however the preference for the o h
group for the equatorial position equatorial position is not as large as expected as large as expected why is it
so if we see in the alpha d glucose hydroxyl is axial
and it has steric you know component in it whereas in the case of beta d glucose it has very minimal
you know steric and it should be it is stable so population of beta d glucose should be very
high but in the reality relative amounts relative amounts of beta d glucose and alpha d glucose is two is to one relative amounts of beta d glucose and alpha d glucose are two is to one why why
so much you know still preference for the alpha d glucose
we can understand it by comparing with the cyclohexanol let us take example of cyclohexanol cyclohexanol here if we take beta as well as alpha cyclohexanol in this case relative
amounts for the equatorial and axial is 5.
4 is to 1 here we have huge difference you can
see that in the equatorial it is five point four and here is to one that cyclohexanol mixture has
this is the ratio whereas in the case of glucose ah it is two is to one
so in the case of
glucose still we have preference for the alpha d glucose whereas in the case of you know
cyclohexanol we have huge preference for the you know equatorial hydroxyl group therefore
there must be a factor which is governing for the alpha glucose formation what is that factor

let us discuss about that when glucose reacts reacts with an alcohol to form glucoside alcohol to form a glucoside glucoside major product is the alpha glucoside major product is the alpha glucoside alpha glucosine because acetyl formation is reversible as i showed in the mechanism that was the reason i was explaining the mechanism ah so first alpha glucoside forms as a major product and then again because of the reversibility it gets equilibrated with the beta glucoside the alpha glucoside now the it supports the hypothesis that alpha glucoside side must be more stable than the beta glucan then the beta glucoside the preference of certain substituents bonded to the anomeric carbon for the axial position is called now to explain this phenomena i am introducing this concept so ah the preference of certain substituents the preference for certain substitu substituent substituents bonded to the anomeric carbon for the axial position is called the anomeric effect now let me explain it enormic effect i have introduced the terminology of enomeric effect what is this enumerative effect because that that only can suggest that why is so much preference is there for the alpha d glucose ah as i al i have already mentioned that formation of alpha glucoside is ah more during the reaction in comparison to the beta glucoside even we know that there is a steric component in the alpha glucoside and since the reaction is reversible it equilibrate to the corresponding two is to one mixture which i you know ah mentioned ah for the you know glucoside formation ah for the you know ah hydrolyzed glucose ah composition so let me explain this enormic effect what is the cenomeric effect again i will draw the chair conformation of the pyron here if i keep a substituent at the axial position and let me draw another chair conformation where i will keep the substituent at the enomeric carbon at the equatorial position in the first case oxygen is having two orbitals for the lone pair xia these are the axial lone pair axial lone pair now this anti binding orbital of the this axial substituent which is empty is parallel with the axial lone pair of the pyron oxygen similarly i will draw orbitals of the equatorial attached structure now in the equatorial star attached structure anti-binding empty orbital is not parallel to the lone pair orbitals now what is responsible for the enomeric effect if the substituent is axial one of the ring oxygen lone pair is parallel to the antibonding orbital of this you know ah sigma band anti bonding orbital c j bond the molecule then can be stabilized by hyper conjugation whereas in the equatorial attached structure the antibonding sigma star orbital which is empty is not you know parallel to the lone pair orbitals and hence the electron cannot be transferred through the hyper conjugation this phenomena which strengthens the formation of ah you know alpha glucoside is called like you know enormic effect which is not possible in the equatorial whereas it is possible in the axial now i will talk about the reducing and non reducing sugars reducing and non reducing sugar because glycosides are acetyl they are not in equilibrium with the open chain they are always in the you know ah cyclic form without being in equilibrium with a compound that has a ah carbonyl group they can be oxidized by the ah tolerance reagent and glycoside therefore are non reducing sugars glycosides are non reducing sugar glycosides are non reducing sugar why is it so as i mentioned that glycosides are acetyl they are not in equilibrium with the open chain aldehyde are ketone in aqueous solution and without being in equilibrium with a compound that has a carbonyl group they cannot be oxidized by tolerance reagent glycosides therefore are not non reducing sugars they cannot be reduce the oxidizing reagent hemiacetal on the other hand are in equilibrium are in equilibrium with the open chain equilibrium with the open chain it will be done with the open chain so they can reduce the oxidizing agent so they can reduce the oxidizing agent agent and therefore is classified as reducing sugar reducing let me explain again glycosides are acetyl they are not in equilibrium with the open chain aldehyde archetone and that is why you know these compound since does not have ah aldehyde or ketone as a carbonyl group they cannot be oxidized by tolerance reagent and hence they are called non reducing sugar whereas in the case of hemiacetal which can easily equilibrate into the open chain aldehyde are ketone form they can be you know oxidized by ah tolerance reagent and hence they are called the reducing sugar now an acetal is a non reducing sugar and acetyl is a non reducing sugar again point to remember is glycosides are non reducing sugar because they cannot convert into the you know open chain ah compound which has carbonyl in its framework hence they are called non reducing sugar whereas hemiacetal which can easily get transformed to the open chain compound which has carbon in this framework either aldehyde or ketone group and then they can get oxidized by the tolerance reagent and that is why they are called reducing sugar now to make you understand this in a better way i will like to ah give you an example from ah our day to day life that you know we we we all are hearing about the you know diabetes you know it is a

lifestyle disease and ah you know ah here it has become very common you know in every family we we are learning that you know x is getting ah diabetes in very
early age which was not earlier ah
so much i believe that you know at some point our
lifestyle is ah you know getting responsible for this
so such a early detection
of diabetes for the diabetes test you know we generally measure the blood sugar level in our body
so how does it happen ah basically let us discuss about
that we can understand this you know in a more elaborated way
so measuring
the blood glucose level in diabetes blood glucose levels in diabetes how do we measure the blood glucose level the
objective here is just to get aware with the redu again with the reducing sugar and the non
reducing sugar i just now discussed that you know what is reducing sugar and what is non reducing
sugar same concept again i will bring here so glucose in the blood stream reacts with glucose in the blood stream reacts with reacts with an amine group amine group amine group of the hemoglobin hemoglobin to form at an amine it is a simple reaction of carbonyl with
the amine group and that means subsequently subsequently undergoes an irreversible rearrangement undergoes an irreversible rearrangement irreversible rearrangement to a more stable alpha amino ketone alpha amino ketone known as hemoglobin a one c hemoglobin a one c now i will write it
in the equation form same reaction
so here i am writing open chain form of glucose this reacts with the amine of hemoglobin in presence of trace acid as further
here ah water molecule is coming out so trace acid is already there
in the biological system hemoglobin now this will go for the rearrangement meant and it will get converted to corresponding amine this imine will get converted
to corresponding amine ch2 nh hemoglobin and this internal alpha position hydroxyl
will get converted to the carbonyl molecule is known as hemoglobin a1c thus measuring the hemoglobin a1c label is a way to determine whether the blood glucose level of diabetic patient is being controlled or not
so whatever because it will it
will get it will form from the you know glucose available in the blood stream by this reaction
that hemoglobin amine will react and inform the hemoglobin a1c this one label determines that
you know how much sugar is available there in the blood glucose and by knowing that we can easily
control the our diet and that way we can know that you know how much amount is needed if you are
we are taking excessive intake then we have to cut down
so this this is our in day to day life
where like you know basically what is happening here hydroxyl is getting oxidized through this
rearrangement to the corresponding carbonyl ah to form the hemoglobin a1c this is the reaction
taking place ah while measuring the blood glucose level ah in diabetic patient

ah now i will stop here

so um today we discussed about the basically ah various type of reactions first we talked about the formation of you know glycoside and then we discussed its mechanism then again we discussed about the ah you know reducing and non reducing sugars and then we talked about the ah how ah one can ah you know measure the level of glucose in the blood stream by reacting it with the ah hemoglobin amine which get by the rearrangement ah gets converted to the corresponding amino ketone and we generally ah while measuring blood glucose level we measure that ah level in the ah diabetic patients body ok thank you very much we will again continue with the next you