

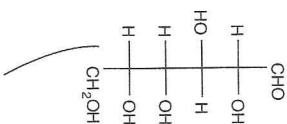
N.B. all structures are in the D-series

Appendix: Drawing sugars

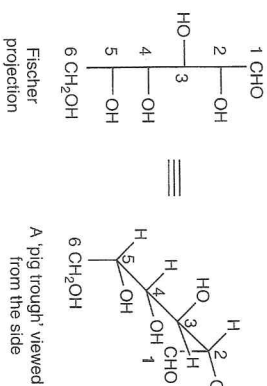
We shall use the example of D-glucose drawn in its pyranose form but the principle is the same for any sugar of any size, including furanoses.

Stage 1: Taking the Fischer projection and converting it into a 'pig trough'

Make sure you are happy with what a Fischer projection represents. It often helps to build a model the first time you try this. The Fischer projection is a representation of what you see from above. The carbon-carbon bonds above and below those in the chain point into the page and the bonds to the left and right stick out from the page.



You can also draw a Fischer projection with the H atoms shown, like this. They are omitted in the Fischer projection on the right but added in the 'pig trough'.

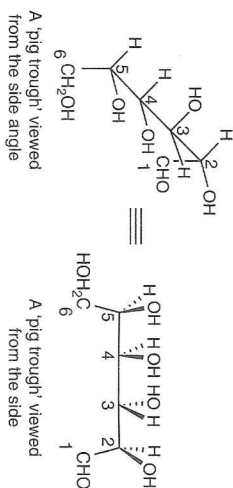


To see what this looks like, in your mind's eye imagine the carbon backbone of the Fischer projection as the base of a 'pig trough' with the C-1 aldehyde (-CHO) and C-6 primary alcohol (-CH₂OH) groups forming the ends of the 'trough' directed away from you and the C-H and C-OH bonds on C-2, -3, -4, -5 making up the sides of the 'trough' sticking towards you. Viewed from a side angle, the 'trough' would look like that on the right.

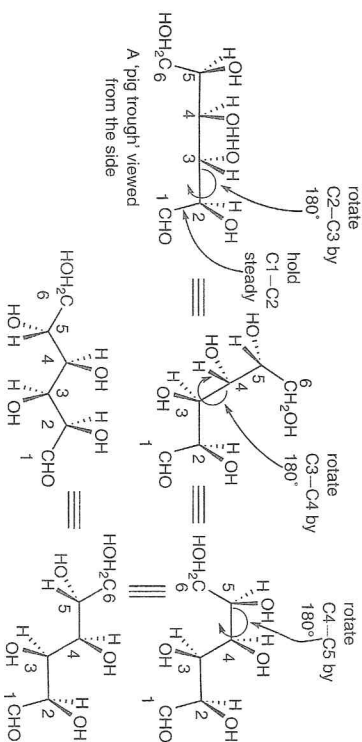
Stage 2: Converting the 'pig trough' into a zigzag representation

In Chapter 2, we highlighted the importance of knowing how to convert Fischer representations into zigzag representations. Zigzag formulae place all of the carbon atoms C-1, -2, -3, -4, -5, -6 in the plane of the paper. This is, therefore, the first step of converting the 'trough' to the zigzag. This is best done by imagining the trough viewed directly from the side, that is, at 90° rather than at the side angled view we reached in Stage 1.

Once done, we can see how the C-OH and C-H bonds stick in and out of the plane of the page and we have represented this in the usual dotted and wedged fashion.



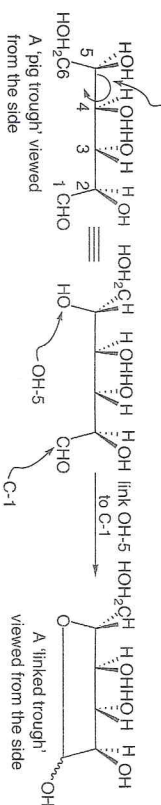
The final part is to convert the C-1, -2, -3, -4, -5, -6 carbon chain from a straight form to the zigzag we require. To do this imagine holding the C1-C2 bond steady and rotate the C2-C3 bond by 180°. As you can see, this introduces the first of our zigs. Next rotate the C3-C4 by 180° then the C4-C5 and so on.



Stage 3: Converting the 'pig trough' into a ring structure

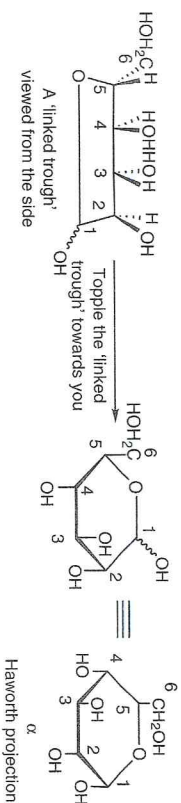
The 'trough' is also a good starting point for working out how to draw the cyclised or ring structures of sugars.

rotate C4-C5
until OH is in the plane of the paper



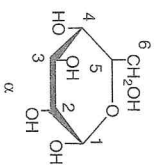
Conversion to a pyranose structure requires the linking of the OH group at position 5 to the anomeric C-1 carbon. To do this we need to rotate OH-5 to a position in the plane of the paper so that it's in a good position to link to C-1.

This can be accomplished by rotation around the C4–C5 carbon–carbon bond. The poised OH-5 can be linked to C-1 to form a lactol (hemiacetal) in a 'linked trough' structure.

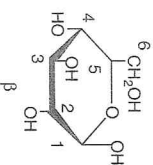


Finally, this 'linked trough' structure can be converted to a Haworth projection simply by 'toppling' this structure over towards you.

We have arbitrarily chosen to show the α -anomer configuration here, by drawing the OH group at C-1 down.



Alternatively, we could have chosen to show the β configuration.

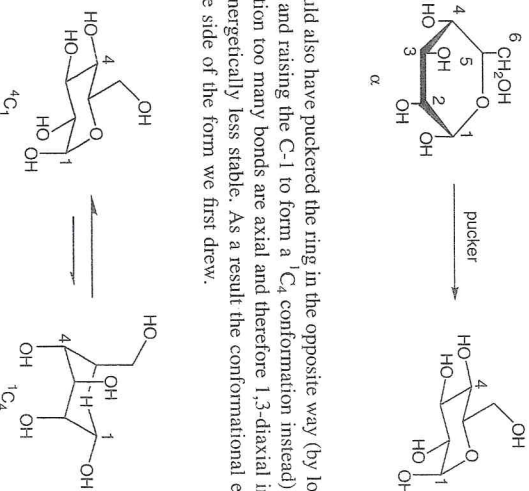


Don't draw chairs like this:

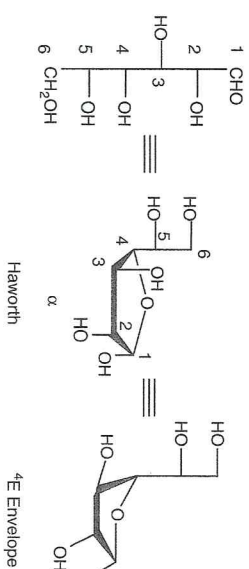


Not only does it look terrible but it also takes the substituent bonds harder to draw and axial bonds harder to distinguish from equatorial ones.

We could also have puckered the ring in the opposite way (by lowering the C-4 atom and raising the C-1 to form a 1C_4 conformation instead) but in this conformation too many bonds are axial and therefore 1,3-diaxial interactions make it energetically less stable. As a result the conformational equilibrium lies on the side of the form we first draw.



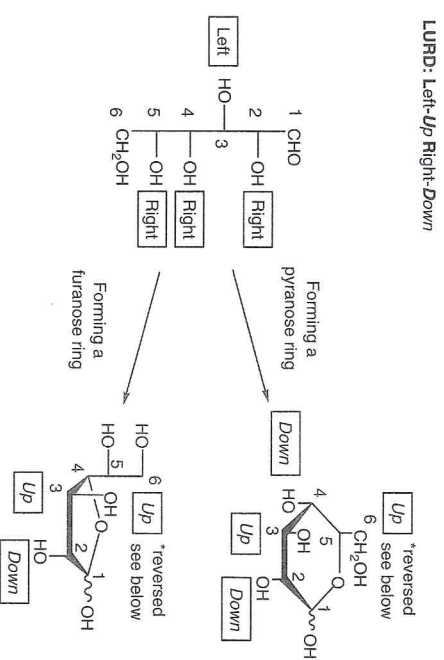
For 5-membered (furanose) rings the same 'linked trough' approach can be used except that in Stage 3 the C3–C4 carbon–carbon bond is rotated to place OH-4 in a down position suitable for linking to C-1.



We tend to leave furanose forms in the 'unpuckered' Haworth projection as, unlike 6-membered rings, things are easier to manipulate in this form than their more realistic envelope conformation.

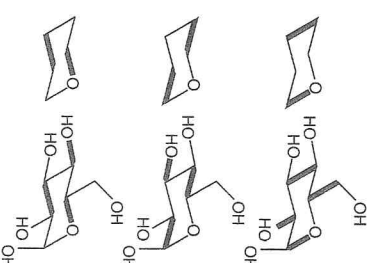
The LURD Trick

This handy mnemonic can be used to check if structures are drawn correctly:



Note that the LURD rule is reversed at the carbon atom that forms the ring. That is, what would have been a *Down* OH using the LURD trick in both of the examples shown here is actually an *Up* side chain instead.

For D-glucose, the Fischer projection has hydroxyl groups directed *Right-Left-Right-Right*. Therefore, using the LURD mnemonic, we would expect *Down-Up-Down-Down*. However, the rule is reversed at the atom that forms the ring. This gives us a final arrangement of *Down-Up-Down-Up* for the *substituents* in D-glucopyranose and *Down-Up-Up* for the *substituents* in D-glucofuranose.



In each drawing below the thickened bonds are parallel—use this to help you draw the conformation and substituent bonds of a chair correctly.

SUGAR PROTECTION: A QUICK GUIDE

Ⓚ

bulky
esters
+ ethers

1° OH

all
OHs

Small
esters
+
ethers

Ⓚ / Ⓣ

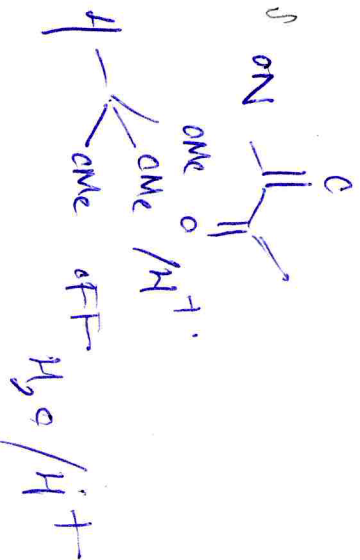
1,3
diols

benzylidened

ON $\text{R}_2\text{CHO} / \text{H}^+$
OFF $\text{H}_2\text{O} / \text{H}^+$

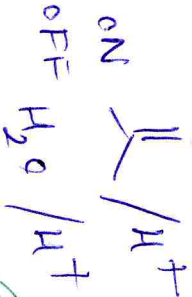
trans
1,2
diols

before diacetals



cis 1,2 diols

acetals

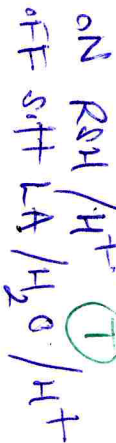


Ⓣ

Ⓚ possible

c-1

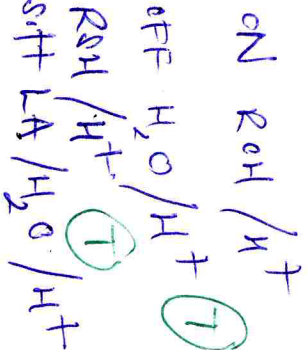
open chain
diminoacetal



Ⓣ

c-1

pyranoside
furanoside



Ⓣ