Lab 8B • 05/10/12

[lab quiz]

[aldol condensation – ideal mixed aldol condensation]

Here's our bad example first. Imagine we have a mixture of two aldehydes like this: propanal and ethanal. Let's say we [used] sodium hydroxide as the base to deprotonate, instead of something like LDA. Hydroxide is strong enough that it can deprotonate these aldehydes, but it does so reversbly. [Although] there will be an effect of the alkyl group on the propanal [that] will make it a little bit different in acidity from ethanal, since they are so close in structure, that difference in pKa is going to be small enough that, for the purposes of discussion, we can imagine that you have about a 50/50 chance of making the enolate from one or the other – might be more like 40/60, because there's going to be a little effect from hyperconjugation of that extra alkyl group. Let's simplify and say there's about 50/50 of the two enolates that would form. Once the enolates form, then they're going to react with one of the aldehydes; again, the aldehydes are not going to be that different in reactivity, in fact they are likely more similar in reactivity than acidity. That means there'd be a roughly 50/0 chance of either of the enolates attacking either of the aldehydes. We're going to get four distinct products. In the case of propanal having been the enolate, that carbonyl will reform, so it's essentially like doing a substituted propanal; since this is an aldol condensation, that means we have a new alpha,beta unsaturation. It's reacting with either a two- or a three-carbon aldehyde, so there'll be three carbons total added or two carbons total added. Similar types of products would come from the other enolate. Since that was ethanal that had made the enolate, these will be effectively substituted ethanals. We again add three carbons total with unsaturation at the alpha,beta positions, or we add just two carbons. We have a four-, five-, or si-carbon product, and they're got different substitution patters: two that have a methyl group at the alpha position, two that don't. In this case, roughly equal proportions of each of these will be formed – which means it's not an ideal situation, unless you wanted that kind of mixture.

Let's go back and see why particular aldol condensation was an idea one: ideal meaning you can control it and end up with only product. Our two starting materials were p-anisaldehyde [and] acetophenone. What is one of the two main reasons that this is an ideal condensation? How many different types of alpha protons are there between these two compounds? Only one, cause if we look at the p-anisaldehyde, where it's attacked to the benzene ring, that carbon has already got four bonds, so there's no hydrogen there. The hydrogen that's part of the carbonyl, that's not an alpha proton, so there's no alpha-protons on the anisaodehyde. Acetophenone, where it connecst the benzene ring, that's already got four bonds to it, no hydrogen there. There's only one type of alpha hydrogen, wich means there's only enolate that's going to be made. Let's say that we had two ketones up above that we were producing. Aside from the fact that you had two different compounds that could each form an elotae, if those ketones, then you could form the enolate one direction from the carbonyl or the other, which means you actually get four enolates, which can combine with the two ketones – you get eight different products. The is very directed, because there's only one enolate that can form. That's one of the reasons [it's an ideal mixed aldol condensation].

[second reason]
Which of the compound is more likely to be attacked by an enolate? Aldehydes are more reactive that ketones; why? Hyperconjugation: because you have, in a ketone, two alkyl groups that could have bonds that would hyperconjugate with the pi bond, wherein an aldehyde, one side or the other automatically you have a hydrogen, which is perpendicular to that pi bond, so they're no orbital interaction. Automatically, the aldehyde has got less electron density in that carbonyl, which means the carbonyl's more reactive, which means the one and only one enolate that forms is going to attack only the p-anisaldehyde, which means you only get one product. That's why it's ideal. [delta G] Just a small different in energy can have a huge effect on equilibrium constants. If there's enough difference in reactivity here, then at least we could 99 time out of 100, the aldehyde'll get attacked, even by just a small energy difference. Aldehydes are more reactive than ketones, so the enolate will only react with one reagent. We can jump to the product by remembering the compound that forms the enolate essentially is still in the product's structure, so acetophenone with that methyl group, that part is retained. Of course, we make the new alpha,beta unsaturation. It's p-anisaldehyde that reacted with it; it only has the one carbon that's on the carbonyl there, so next comes the benzene right, and then the methoxy group.

[IR spectrum – single carbonyl conjugated compounds, product has even more conjugation, affects absorbance frequency – shift in carbonyl, lack of those carbonyls from the starting materials, formation of new alkene][Robinson annulation]

A Dean-Stark trap is something like this, where you have your reaction flask at the bottom. Your mixture is being heated to reflux, which means evaporating and recondensing up and down the glassware. Eventually as it's condensing, though, some of it's automatically going to flow down the sides and flow into the sidearm. Since we used toluene as the co-solvent, and we have water that's being removed, the two of them will come over together. They'll both end up in this sidearm, but they're going to phase-separate. We'll end up with the organic layer up top since toluene is less dense; we'll end up with water on the bottom. They come over together because water and toluene form an azeotrope. [eugenol] An azeotrope is a gaseous mixture of compounds that, in the liquid phase, are immiscible.

If we had a large-scale reaction, which is where this piece of glassware's normally, the organic phase would just keep building up, building up, and building up as more condensation's occur, and of course the water level keeps building up. At some point, the organic phase will spill back over into the reaction flash, which [is] exactly what you want, for it to be able to evaporate more to pull more water out. The water, you could empty out if you wanted to make sure that it somehow wasn't spilling back over. At the same time, many of these traps are designed such that they have markings, volumetric settings on those sidearms, so you know how much water came off, so you could do a rough calculation of how complete the reaction.

Why is it, though, that we were doing this process? Why were we trying to do this trick of removing water? Cause if you look back at the reaction, water is a product. This reaction, in principle, is fully reversible because it's a cationic reaction. If it's reversible, then if you had water present still with the acid, this means this could go backwards. Remember that Le Châtelier's principle says that if you remove products, more products are going to want to form. That's because this is trying to be at equilibrium, but if you keep removing products, there's no reverse reaction to balance out, so the forwards reaction keeps happening to try to make more products, but those products keep getting taken out, so the reaction just gets pulled to completion. Since we're removing water physically this way, it's not a reversible process, cause there's no water left; that's how this drives the reaction to completion.

[benzocaine]
[Answers to exam 1]

First problem was taking acetic acid, reacting with a large excess – that means a whole bunch of it – of isotopically-labeled water. Both oxygens will react in a carboxylic acid [because of tetrahedral intermediate], which means that, given enough time, you'll get the double-substituted acetic acid.

Next one. [must use correct reducing agent] For acyl halides, the correct reagent is the alkoxide derivative of lithium aluminum hydride – lithium aluminum tris([tert-butoxy]) hydride. You can't use plain lithium aluminum hydride, because you can't stop the reduction; it's going to go all the way to the alcohol.

Next one. We had a Grignard reaction, using two equivalents of the Grigard reagent, followed by dilute sulfuric acid work-up. Gave us a tertiary alcohol. The fact that two equivalents were used would mean it could have been either an acyl halide or an ester, because carboxylic acids wouldn't give you alcohols; they'd give you a ketone instead. Analyzing the carbon structure, we could see: here's one ethyl group, here's the other. That meant that whatever we started with, with a four-carbon compound. The two functional groups that react with Grignard reagents twice to give this kind of alcohol would be four-carbon acyl halide or a four-carbon ester (it doesn't particularly matter what your R group was).

Next question was acetic acid reacting with this compound, which is diazomethane, which is the one basic compound that can convert and acid into an ester – specifically a methyl ester.

Next one: we had acetone reacting with something to form alpha-bromoacetone. That's alpha halogenation, which we know two sets of conditions for: one set of conditions causes the haloform reaction – that's the basic one; this is monosubstitution, so it's the acidic form – bromine and some form of acid.

Next one: something reacts with the thiol equivalent of an alkoxide to make what's called a thioester. Oxygen and sulfur are in the same column of the periodic table; they have similar reactivity. If this was an alkoxide instead, what could it react with to make an ester? Any anhydride or an acyl halide. It can't be an acid, cause that would just be neutralized, and it can't be an ester, because even if you worry about transesterification, in this case, we do worry about the fact that alkoxides are more basic, so it would be more likely that the oxygen would stay stuck on there than the sulfur, so it needs to be an anhydride or an acyl halide.

Reduction of an amide is a way to make an amine. When lactams are reduced, the ring does not open, whereas in a lactone, the ring does open. Since deuterium was the reducing agent, then yes, we're going to have a deuterated product.

Last three. The eneamine reacts with something to make a ketone. Notice that it's an alpha,beta-unsaturated ketone, which means this was an aldol condensation; since we stared with an enamine, this was like the Stork enamine synthesis. There are two answers you could have given: one would hvae been ethanal, because in a regular, old aldol condensation, that's what we would have used. [acyl halide used as well, instead?] Technically, you a need a second step, because after the reaction, you'd still have an enamine, an to get rid of an enamine, you'd have to hydrolyzed.

Last two. If you look at this product, what I hope you would notice is that it could have been made by a Dieckmann condensation, which is nothing more than a cyclic Claisen condensation. The answer I was looking for would have been the dicarboxylic acid, which if you count carbons would be a seven-carbon diacid. Both ends would need to have the same kind of ester to prevent any transesterification. If you put this down instead, the acyl halide, that's a correct answer.

Last of the fill-in-the-blanks: combination ketone/ester, reduced by sodium borohydride. Esters cannot be reduced by sodium borohydride, but ketones can and will.

Mechanisms

First mechanism: pentane-2,4-diol reacting with propenal in sodium hydroxide and heat; the hint was: is there a reason that there was exces sodiim hydroxide? The answer's no, because this is a base-promoted reaction, so technically, we never use up the sodium hydroxide. Making sure that we do have a concentrated solution does help the reaction move forward. Let's see what ends up resulting. What is the pKa of that hydrogen that I just wrote down? 9 or 10, so this is a stronger acid than other alpha compounds would be. That mean when we deprotonate this, this is a weaker base, which is heavily conjugated, and you have an unsaturated, squishy aldehyde. Soft squishy ions [like] to react with other soft, squishy ions; more dense or hard ions [react] with other hard ions. The point here is that this enolate will do a Michael additions, because it's a conjugated substrate it would attack.

First deprotonate [showing resonance optional] to make an enolate. It is a Michael addition, so it adds in a conjugated fashion. That's an enolate, which is not favorable, it's going to want to tautomerize. Since we started out with hydroxide, that means we're going to have some water, which could be used to provide the proton. We end up with this combination ketone-aldehyde, that then gets deprotonated, because if equilibrium can happen, it will happen. We have this nice reactive aldehyde that's at just the right position to be attacked intramolecularly, which means yes, it's really a Robinson annulation. After protonation, we end up with the beta-hydroxy carbonyl compound. That hint of excess base is the hint that further deprotonation occurs, and we have E1cb elimination to make a cyclic, alpha,beta-unsaturated ketone.

The second mechanism: an ester that was exposed to acid, water, heat, and time. What's the point of this time element? We'll see. With an ester, acid, and water, it's going to be hydrolysis, deesterification, so two rounds of protonate, open, attack, deprotonate. [combining resonance] First, protonate and open; we have water in solution, so that attacks, and then deprotonation. We're halfway there. What used to be the ester portion, the methanol here, gets protonated; it leaves [combined with resonance]. We have a protonated carbonyl, which gets deprotonated. So we end up with a carboxylic acid – a beta-ketoacid. With heat and time, this carboxylation occurs. That will generate an enol that's not stable, so it tautomerizes to give us this ketone.

Malonic ester synthesis

We view this as a substituted acetic acid, which means we're going to have a three-carbon alkyl halide that we use at the alkylation point of the synthesis. The malonic ester, it didn't actually matter which R group that you used; it is diethyl malonate that's the more common one, but if you used any R group, that would have been fine. Deprotonating this – the pKa of this compound's about 13, the pKa of water is closer to 16, so if you carefully add hydroxide to this – not a concentrated solution, but just a like a titration you added hydroxide – you would be able to deprotonate this but avoid saponification. If sodium hydroxide [is used in] this kind of situation, you also have to know what method of addition you have. If you don't want to worry about any of that, then this is the safest base [to use], because the worst thing that happens, it reacts with the ester to make the same ester. [no mechanism] We deprotonate to make the enolate. We have a three-carbony alkyl halide or tosylate; this is aspargyl bromide. The safest thing to do at this point would be saponification; however, if you put acid an water in at this point, triple bonds are actually tougher to hydrolyze than double bonds; you need a lead catalyst or some other kind of Lewis acid to help encourage the process. Under harsh enough conditions, it would hydrate. If you had a double bond, you definitely would want to saponify first to avoid possibly hydrating that double bond. The recommended approach would be to saponify to get the disalt. And then, [acid is used] to protonate it, and heat it a bit to decarboxylate; that gives us the product.

The last question was the set of reverse syntheses. You had these four different targets, favorite one of which was this one: adamantanedione. We're given how many molecules and, in some instances, what type of molecule that you were supposed to start with.

The first one: alpha,beta-unsaturated ketone – aldol condensation. To go backwards, we chop at the alpha,beta-position; where the carbonyl already was, you just erase the double bond there cause that was the alpha-proton that got removed there. On the other side, that's where the other carbonyl was. If you count carbons carefully, you'll find that this was the starting material, which is nearly identical to what we did in lab, just one carbonyl one carbon over.

The next one: a compound in which one carbonyl is delta to the other – that's a Michael addition. Again, we break the compound apart by breaking at the alpha,beta position, but there we have a single bond instead of a double bond. SInce we have two carbonyls, there's two ways we could have done it; I'll show you both. One, we coul have used acetophenone and propenal; since only one compound starts with alpha protons, that might we the way that I approach it in real life. The other way is to use ethanal [still only one compound with alpha-protons]. It would react with this conjugated ketone.

The next one: it wasn't a pure Claisen condensation. You probably saw that and thought alpha and you saw ester [and said]: ok, Claisen, but where's the other ester? If you take two esters and condense them you get an ester. If I told you there was an ester, though, then it looks like an ester somehow got kicked out during whatever condensation occurred. If we chopped this bond, for example, and pulled the molecule apart, you can see that we've got a ketone that's got an alpha proton that could be removed that then could attack the ester that's right next door and cause exactly this product to form. It's a mixed Claisen condensation.

The last problem: to make a carboxylic acid from a ketone – that's the haloform reaction. We start with a methyl ketone.

I want to discuss the five things that we're going to worry about as far as the structure of carbohydrates. We have learned so far the hexoses [number of carbons]. All of these have been ones that have aldehydes. We have how many carbons there are, and we have the type of functional group. These are all aldoses that we've done so far; they have aldehydes. Then, there's the d and l configurations. When we make the ring, we have whether it's an alpha or beta another. [Then], you could make a six-membered ring, like we've already done, which is called the pyranose form of a molecule, or we could make a five-membered ring, which is the furanose form.

Let me talk about two of these terms. First one we'll cover is the type of functional group that's on the sugar. Glucose, since it has an aldehyde, this is known as an aldose. Close-related molecule: notice that the bottom three stereocenters are the same for both of these molecules. This other molecule I just drew is d-fructose. It's called a ketose, since it has a ketone as a functional group. Let's see what the relationship would be in terms of isomers between these two compounds. They're not diastereomers, cause they're not stereoisomers; they have similar stereocenters, but the top, the functionality's swapped around. We've essentially swapped a single bond for a double bond; where else have we done something like that before? What about enols and ketones – aren't those just swapping single and double bonds around? What do we called those? Tautomers. If we took these top two carbons, and we were to protonate and open the carbonyl, and then eliminate and make a double bond, we would a double bond, an alkene, that has two -OH groups on it. That, of course, could reverse, but what if the second -OH group became the carbonyl instead, when we did everything in reverse? That's exactly what occurs – these are double tautomers of each other. These are chemically related to each other, but they're distinct in that one is an aldehyde, so it's an aldose; the other's a ketone so it's a ketose.

What about other terms? We have the number of carbons. The four most common types are the hexoses like glucose, the pentose – which have five carbons and include things like ribose – tetraoses, and then our lone triose. [names of sugars]

[The arrangement of sugars in naming] is purely a matter of geometry. It was determined that it is mainly just the d forms of sugars that are biologically active; that's why we default to talking about the d sugars so much. The d sugars are the ones where the bottom stereocenter is written on the righthand side. We have three other stereocenters, which means we have 2 to the 3rd sets of molecules, cause each stereocenter, independently, could be left or right, R or S, so 2 x 2 x 2, that gives us 8 possibilities. What logical way do we have to arrange those eight possibilities? For example, why don't we start with everything on the left? If we read from left to right, we might have this natural tendency to order things from left to right. Why don't we start with a molecule where all of the -OH groups are on the left and then arrange them on that order? [Because] Presumedly because we're dealing with d sugars where we start automatically with one of the groups on the right. If we start with that – we have one stereocenter on the right here, the next stereocenter on the right here, and the third stereocenter on the right here, then what are the combinations? This one can be either here or there, this one can be either here or there, and this one could be here or there. [demo] I wanted some way to show you geometrically what's going on. [demo – half and quater pace] That's binary counting; I just counted the numbers 0 through 7 in binary – it's the same thing, and that's the only reason I'm using the binary system – so that if we follow [tradition] and arrange the molecules in this way, they're arranged in binary pattern, why not acknowledge that and use that as our way to memorize them.

The way that I'm using this is I'm defining ... since the first thing is to have it on the right, in binary, we have either one or zero, we'll call it zero, cause that's the first thing. Then, I read from bottom to top, so I could put that one that changes the most in the listing of the sugars, make that the last digit of a binary number. Once you know the names, what you could do is say: ok, that's 1st, 2nd, 3rd, 4th, 5th, 6th, 7th, 8th, if we're just talking about listing them; if we're counting, then there's eight of them, the first, the second, third, fourth, fifth, sixth, seventh, eighth. But the first one, if we're doing a binary interpretation, we're calling this [0000], it's actually the number 0 that we start with. If I represent these in binary, they're [0000], [0001], [0010], [0011], [0100], [0101], [0110], [0111]. [futurama] Which sugars are there? Allose, altrose, glucose, mannose, gulose, idose, galactose, talose. You count the number. if you can remember that sequence, then let's say it's idose – [it's the] sixth one – 5, [0101], [left, right, left, right]. So if you look at idose, it's going to be configurations [left, right, left, right], if you read from bottom to top. Of course, this requires remembering the names. [demo][we can conceptualize time and we have speech][practice in time][humans are programmed to respond in time][techno] These are the hexoses.

We have pentoses we have to learn. We have aldopentoses. Notice how I just combined the two terms. [tuvan throat singing] Aldopentoses – they have five carbons, which means they have three stereocenters, which since the bottom stereocenter is automatically the same for all of the d sugars, that means that they differ by only two stereocenters, which means there's only four of them, unique ones. First one, ribose – yes, if you take an oxygen off of it, we get deoxyribose, as in deoxyribonucleic acid. [arabinose, xylose {wood?}, lyxose {reverse?}] Those are the aldopentoses. There's only two distinct aldotetroses, cause there's only two stereocenters, but one of them is that d/l stereocenter. These names are related to stereochemical terms [polymer chemistry]. These are called erythrose and threose. [red blood cell?] Then there's the one aldotriose – glyceraldehyde.

Let's review this d/l designation. [was a guess] That d/l designation has to do with that last stereocenter. This is d-galactose. Just so that I had done it once, let's draw the full structure of an l sugar, l-galactose. How you know that it's d or l is you get that last stereocenter. But remember that the relationship between the sugars is that they are enantiomers; we just use this last stereocenter to say which of the two sugars it is. It's not just that last position that's inverted between the two of these; it's all of the stereocenters. It is a common mistake to flip just the bottom stereocenter around; that's a diastereomer, not an enantiomer, and the d and l sugars are enantiomers.

[There are] two classifications that only happen when sugars cyclize – we have the alpha and beta anomers, then we also have ring size. Let's do ring size. [furan, THF, pyran, DHP] What do these have to do with sugars? Let's take l-galactose. If we take that l-galactose, we could observe that's an aldehyde with a whole bunch of -OH groups on it. If we count position numbers from the carbonyl, we could find that at postion 5 from the carbonyl (if one is including the carbonyl), there's an -OH group that could cyclize to make a five-membered ring; one more carbon away, that means the oxygen attached to it would be position 6. Five-membered rings and six-membered rings are favorable, so depending on what reaction occurs or how the reaction occurs, we were getting a five-membered or six-membered ring. [R/S practice] Is that first stereocenter is R or S? We actually don't have to write the rest of the molecular structure to answer this question, cause if we look at that stereocenter, we could identify that the hydrogen is priority number 4; it's the lowest atomic number of what's attached. We can tell that the oxygen is priority number one, cause it's the highest [atomic number] of what's attached to that stereocenter. At the top and the bottom, we have carbons, so we can't make the decision there, so we have to go one more stereocenter out, one more position away. That also means that we need to rewrite this using phantom atoms. The way to do phantom atoms is – in this case, since we have a carbon-oxygen double bond, on the carbon, we'd put an oxygen; on the oxygen, we'd put a carbon. Now we could see that at the top carbon, we have attached to it [O, O, H]; on the other carbon, we have attached [O, C, H]. Since one has oxygen at the same point of comparison, whereas the other one has carbon, the top group is more important. The -OH group on the left, the more important group on top, the less important group down at the bottom; so which way does it look like I'm rotating? Clockwise, so it should be R – but it's not, because by [the] definition [of a] Fischer projection, anything on the side is pointed out at you; the hydrogen is pointed out at you, which means, even though looks like R, it's the reverse of it. It is in fact S.

Back to the ring size. You have five-membered rings and six-membered rings, so the terms that we use are furanose, for a five-membered ring, and pyranose, for the six-membered ring.

alpha versus beta

I want to draw a version of galactose: I want to do l-galactose – in its l form, in its six-membered ring form – so what I want to now draw is beta-l-galactopyranose. Notice how I combined terms here: galactose is the base name of the sugar, galactopyranose means when it's cyclized into a six-membered ring. The l form is [connected to] the configuration of that last stereocenter, and beta we're going to find out once we cyclize. l-Galactose means it's going to be [left, right, right, left]; pyranose means I'm going to make the ring from that next-to-last -OH group. When I make the ring, I'll now have five stereocenters. Does the oxygen, when it makes the ring, attack from the top or the bottom? The answer is yes. The carbonyl is planar. If you had the group attack from the bottom, that's going to push the -OH group up, the -OH group that's going to form; if you attack from the top, it's going to push it down. Then, you twist it put it on the left or the right. We have a planar, non-stereogenic carbon that becomes tetrahedral. When it becomes tetrahedral, that means there's two possibilities, because it could attack form the bottom or the top. Whether the top means it's left or right or the bottom means left or right doesn't matter; it's the fact that you have two possibilities, which is why it is left or right, which is why you have alpha or beta.

Should that oxygen be there, or at the top of the molecule? What this turns into is a six-membered ring. The oxygen is between the top and the bottom. If you write it closer to one way or another, it doesn't change its connectivity. In other words, I can take this oxygen and put it [anywhere along the bond line]; it doesn't change the bonding pattern. This is also viewed as all of this being pointed away from us, which it's really like a roll, which means it comes back to us. Is my pen on the top or the bottom of the roll? Oxygen's here, whether I look at it this way or look at it that way, or spin it around any way I want to; I'm not changing its bonding pattern, I'm just changing the way way we look it. So, if I write the oxygen up here, instead of here, same molecule, same bond[s]. Let's finish this now. The rest of these stereocenters, they're exactly the same because none of them reacted. We have the new stereocenter at the top that we are going to make to the left or the right, depending on which anomer we want to represent; I want to represent the beta anomer. Beta and alpha refer to the configuration of that -OH group, relative this bottom CH2OH group.

At the moment, that's an issue, because the way that this is written currently, that is in our backbone, which means the left and the right – they both look trans or cis; we can't tell which one is when. Properly visualized, we have to know which end of the ring this is actually on, which is why we turn that ring to be in the backbone.

This is an l sugar. When we did the d sugar, we twisted the stereocenter a particular direction – don't memorized that direction, just remember, we want the ring in the backbone. For l sugars (the are aldohexoses), it's automatically backwards what you do, because l means that last stereocenter is on the opposite side from d, which means you're going to twist the stereocenter the opposite way. Don't remember which way you're doing it; remember why you're doing it. The why is because we need this ring to be in the backbone, because we won't know which on is alpha and beta [otherwise]. I do that twist; I rewrite it. I put the oxygen at the bottom, which is the same as the top. This last stereocenter does look a little different, but it's not changed. The other stereocenters remain as they were. We can now tell clearly which side of the ring the CH2OH group is on. Beta is when the anomer -OH group is cis to this last group, so I'm going to put my -OH group on the right – cis in terms of where on the ring is it. We could this like a cyclohexane ring [dashes and wedges]. Everything on one side of the FIscher projection, they're all wedges; everything on the other side of the Fischer projection, they're all dashes. It's arbitrary which one you do, depending on your perspective. That why, when two things are on the same side of the Fischer projection, they' cis, because they're on the same side of the ring; if they're on opposite sides, they're on opposite sides of the ring, which means one would be a wedge, one would be a dash, which means they're trans to each other.

The last step towards finishing the Haworth projection is to turn this into that hexagon pattern; if tilting 90° to the right confuses you, don't – jump straight to the projection, because if you follow standard convention, standard convention is to put the anomeric position on the righthand side. The anomeric position is this top carbon, so we have to tilt the Fischer projection one way or the other. If we tilted it the opposite way, that'd put the anomer position in the wrong place; that's the only reason why we're tilting to the right. If we always follow standard convention, then that's why that everything that's on the right is automatically on the bottom. This would be the structure of beta-d-galactopyranose.

There will be times where we don't write this exactly the standard. Sucrose, for example, is make up of two smaller sugars, both of which are in cyclic form. If you tried to do both sugars like this – written correctly with Haworth projections – we have to write a crinkly, twisted bond connect the two rings. We will be moving the viewpoint of these rings around a bit.

[5 classifications] which functional group a sugar is – this is an aldose; we have the number of carbons, galactose is a hexose; we have which enantiomer it is – this example is the l form. We have which ring size it is – this is the pyranose form; and, we have which anomer it is – which this is the beta form.

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1) Aldol condensation
Poor crossed-aldol condensation
Ideal crossed-aldol condensation
– Only one enolate can form, since only one compound ha alpha protons, and that compound only has alpha-protons on one side of the carbonyl.
– Aldehyde are more reactive than ketones, so the enolate will only react with one reagent.

2) Robinson annulation
Dean-Stark trap
Azeotrope – a gaseous mixture of compounds that, in the liquid phase, are immiscible.

3) Benzocaine

Carbohydrate classifications
– Functional group
– # of carbons: hexose, 6; pentose, 5; tetraose, 4; triose, 3
aldopentoses; aldotetraoses; aldotriose

– functional group (aldose)
– # of carbons (hexose)
– enantiomer (l)
– ring size (pyranose)
– anomer (beta)

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Structures – Identical to those from lab 7A (05/09/12)