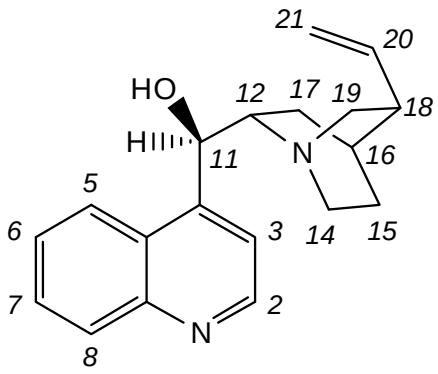
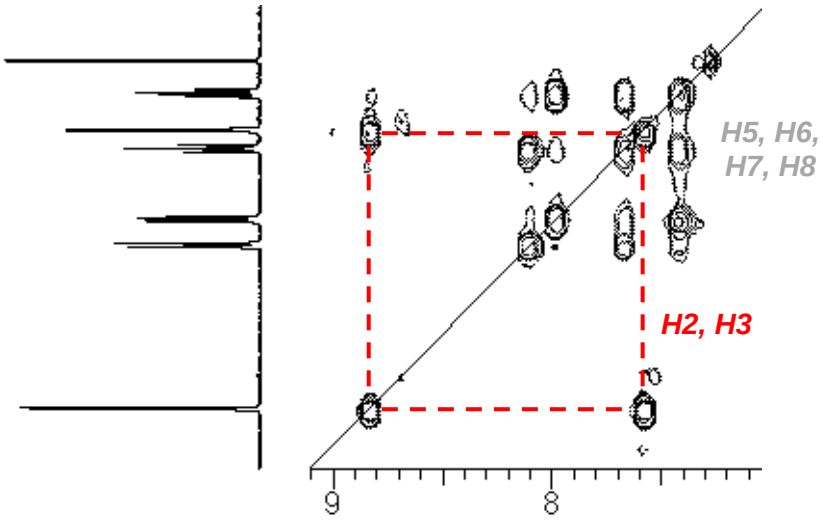
Chemistry 4361/8361 Tuesday, October 16

Discussion Section Exercise:
2-Dimensional NMR Spectroscopy



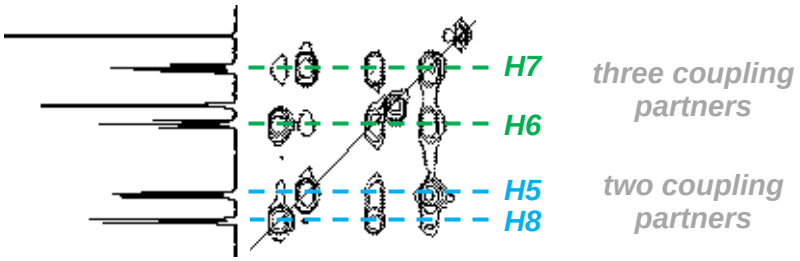
I think there were some resonances that were obvious here, and some that were not so obvious. There is 22H worth of proton intensity in the ^{1}H NMR, which means that every single proton in the molecule—including the -OH proton, often absent from typical spectra—is observed here.

The alkenyl protons (H20, H21a, and H21b) are in a pretty distinct region (δ = 4.5 to 6.5 ppm) of the ^{1}H NMR spectrum, and they have lots of splitting, so they are pretty easy to distinguish; the more substituted H20 should be downfield of the less substituted H21 protons. These are coupled to one another in the COSY spectrum, which confirms their identity. Interestingly, they do share space with a simple, broadened doublet, which I assume to be H11. (I'm guessing this is downfield of a typical α-alcohol proton because of the adjacent, aromatic quinoline.) The broad peak at δ = 3.9 ppm looks pretty featureless, so I'm guessing this is the -OH proton.

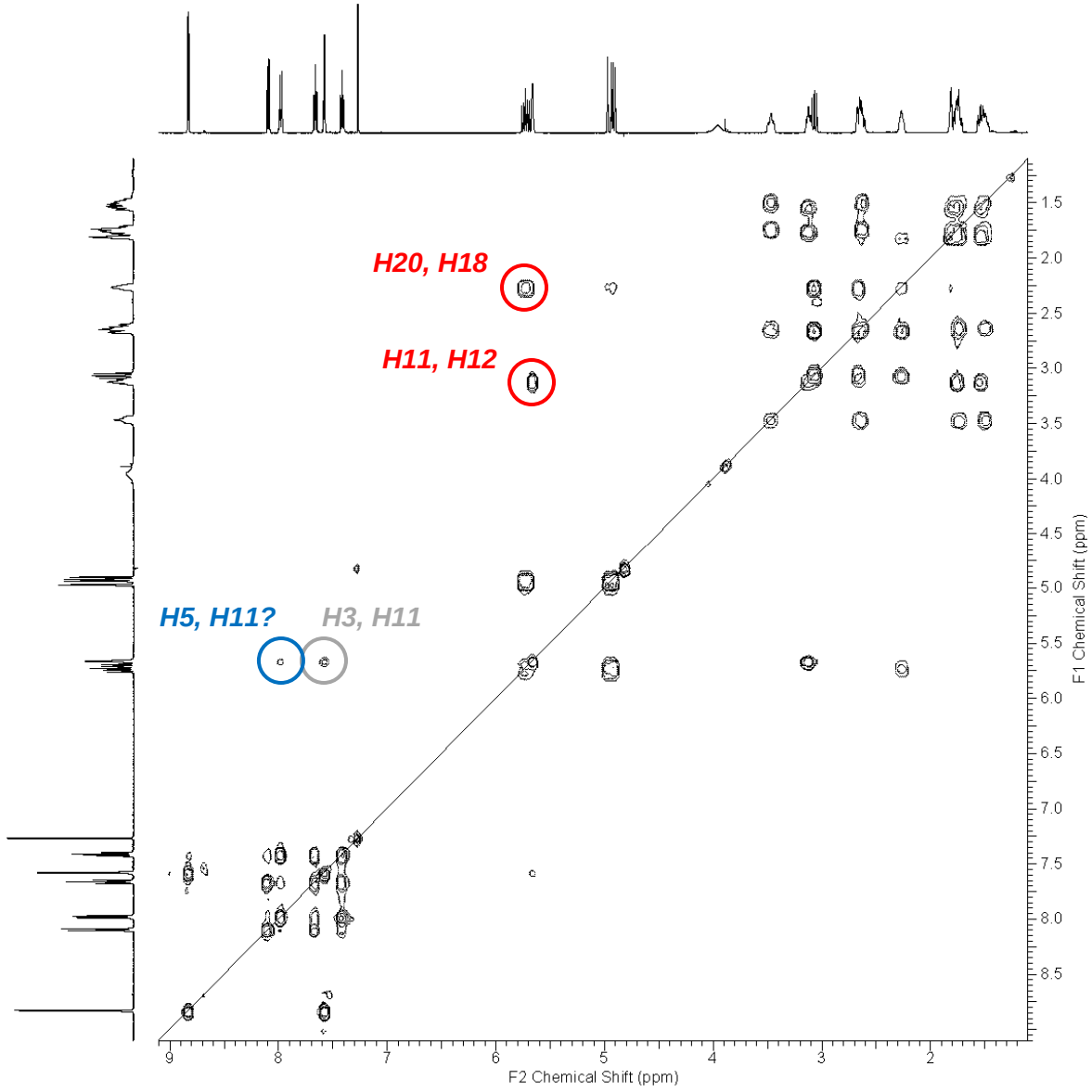


In the aromatic region, there are two doublets that couple only to each other in the COSY, and then four complex multiplets that couple to each other. These correspond to the two sets of coupled protons on the quinoline ring (H2/H3, and H5/H6/H7/H8). The quinoline nitrogen is pretty electron-withdrawing, and shifts nearby protons downfield; this puts H2 downfield of H3, and H8 downfield of H5. (This is confirmed by Pretsch's numbers for unsubstituted quinoline.) Looking at that COSY closeup, H5 and H8 should only be coupled to one, or possibly two (via ^4J) partners, while H6 and H7 should be coupled to two or three partners. I've made preliminary assignments on the COSY cutout on the next page based on Pretsch, but I'm not sure about H6 & H7 yet; the intensity of the

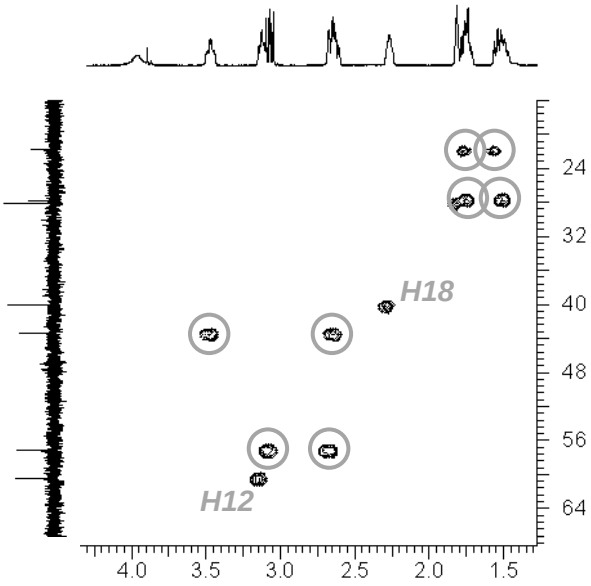
COSY peak usually matches the size of the *J* value, and my assignments put ^{3}J crosspeaks as less intense than ^{4}J crosspeaks, which doesn't make sense.



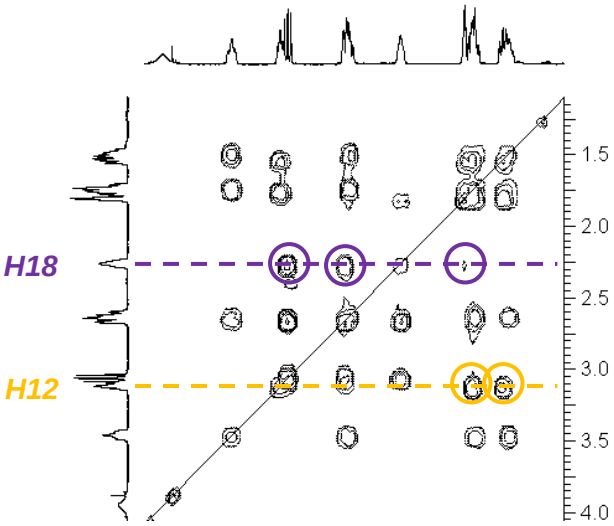
The azabicyclooctane part of the molecule is more complicated to assign. As always, the challenge here is to find an entry point into the system of coupled protons. None of the azabicyclooctane protons have obvious chemical shifts, but crosspeaks in the COSY connect some of these protons to ones that we already know.



We can identify H18 and H12 on the basis of crosspeaks with H20 and H11, respectively. Those two resonances can be used to identify other protons in the azabicyclooctane set. Before we do that though, I thought it would be useful to see which protons in this set were attached to the same carbon atoms, using the HSQC (shown at right). If we find any correlations to one of these protons, we can assign the other one in the pair too. And, conveniently, the only two crosspeaks in the cutout that aren't -CH_2- protons are H12 and H18, which we already assigned.



Back to the COSY. H12 is coupled to only two resonances, which the HMQC above says are attached to the same carbon; these must be H17a and H17b. H18 shows three crosspeaks. Two of these (the two on the left) are attached to the same carbon, and must be H19a and H19b. The other one has to be H16.



Okay, using all of this data, and using the HSQC to associate all of the ^{1}H resonances we've assigned to ^{13}C peaks, here's what we've got:

Name of hydrogen	δ (ppm)
H2	8.83
H3	7.58
H5	7.98
H6	7.66

Name of hydrogen	δ (ppm)
H15b	
H16	1.81
H17a	1.75
H17b	1.54

Name of carbon	δ (ppm)
C2	150.4
C3	118.4
C5	123.2
C6	129.2

Name of hydrogen	δ (ppm)
H7	7.41
H8	8.09
H11	5.66
H12	3.12
H14a	
H14b	
H15a	

Name of hydrogen	δ (ppm)
H18	2.27
H19a	3.07
H19b	2.62
H20	5.73
H21a	4.95
H21b	4.91

Name of carbon	δ (ppm)
C7	126.8
C8	130.5
C11	72.1
C12	60.5
C14	
C15	
C16	28.1

Name of carbon	δ (ppm)
C17	21.8
C18	40.1

Name of carbon	δ (ppm)
C19	57.1
C20	142.0

Name of carbon	δ (ppm)
C21	114.6

This assigns almost everything in the molecule, except the H's and C's at positions 14 and 15. We could do this by looking for correlations to H16 in the COSY, but I actually thought it was easier to see which pair of protons was farther downfield--that must be the pair closer to the bridgehead nitrogen atom. Sure enough, the unassigned pair at (3.47, 2.62) must be H14a/b, and the one at (1.73, 1.48) must be H15a/b. Filling in the empty spots in the table,

Name of hydrogen	δ (ppm)
H2	8.83
H3	7.58
H5	7.98
H6	7.66
H7	7.41
H8	8.09
H11	5.66
H12	3.12
H14a	3.47
H14b	2.62
H15a	1.73

Name of hydrogen	δ (ppm)
H15b	1.48
H16	1.81
H17a	1.75
H17b	1.54
H18	2.27
H19a	3.07
H19b	2.62
H20	5.73
H21a	4.95
H21b	4.91

Name of carbon	δ (ppm)
C2	150.4
C3	118.4
C5	123.2
C6	129.2
C7	126.8
C8	130.5
C11	72.1
C12	60.5
C14	43.4
C15	27.8
C16	28.1
C17	21.8
C18	40.1
C19	57.1
C20	142.0
C21	114.6