## Workshop 3 Solutions
Interpreting 2D COSY Spectra

To interpret a COSY spectrum, it is always a good idea to find one resonance or crosspeak that you can definitively assign, and the work from there. For me, the easiest resonance to assign was the C_{14} methyl group at $\delta = 1.22$ ppm. This group gives a doublet due to its coupling with H_{14}. From here, we can "walk" through the COSY spectrum, from diagonal to crosspeak and then back to the diagonal again, assigning each subsequent resonance to a proton in the chain.
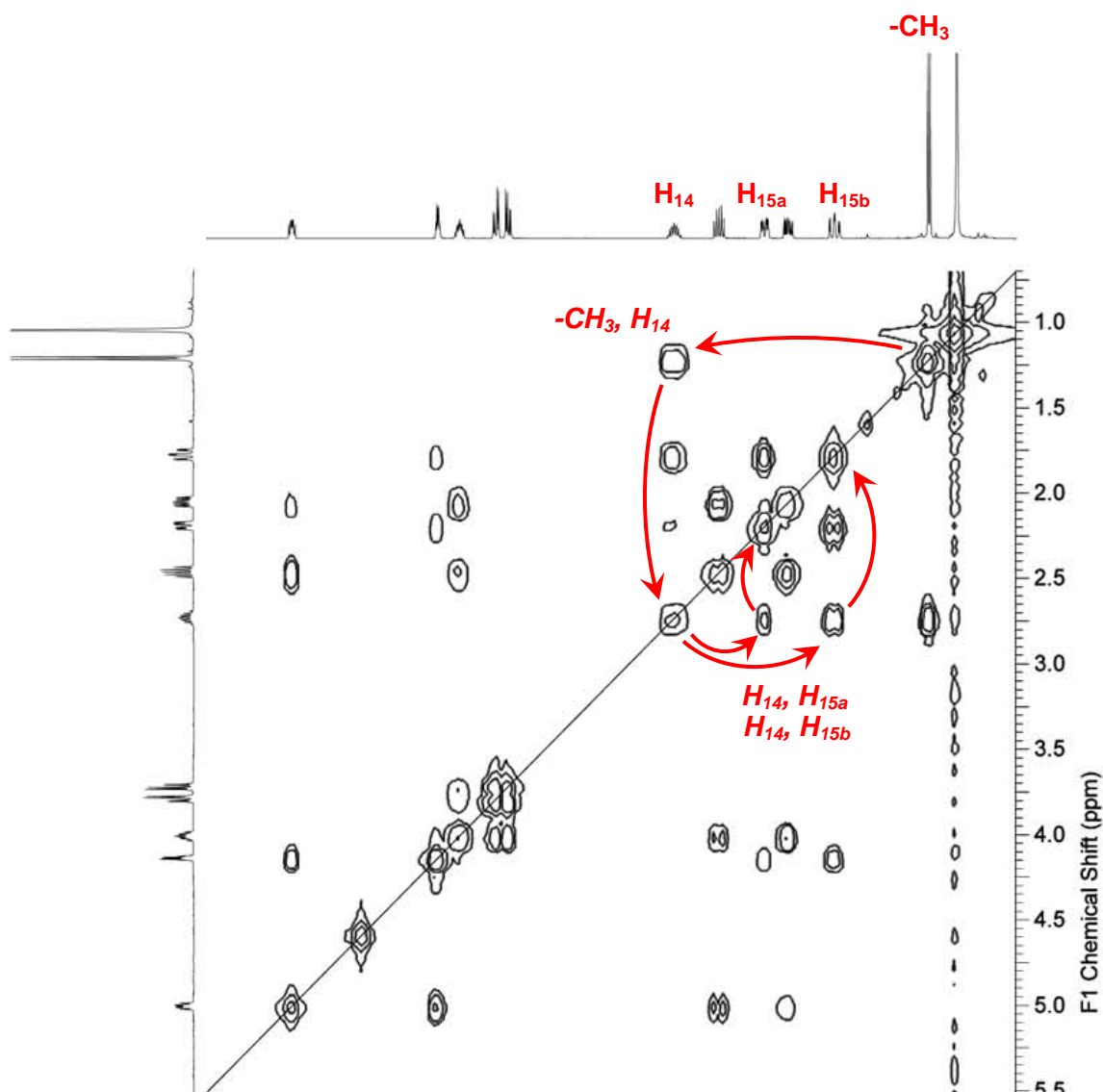
Starting from that -CH3 group, we can walk off-diagonal to H_{14}, back to the diagonal, and then to both H_{15a} and H_{15b}. (We don't know which of these is above the plane of the molecule and which is below, but we can assign them.) There is also a crosspeak for coupling between H_{15a} and H_{15b}. From there we can march to H_{16}, H_{17}, and the two H_{18} protons:
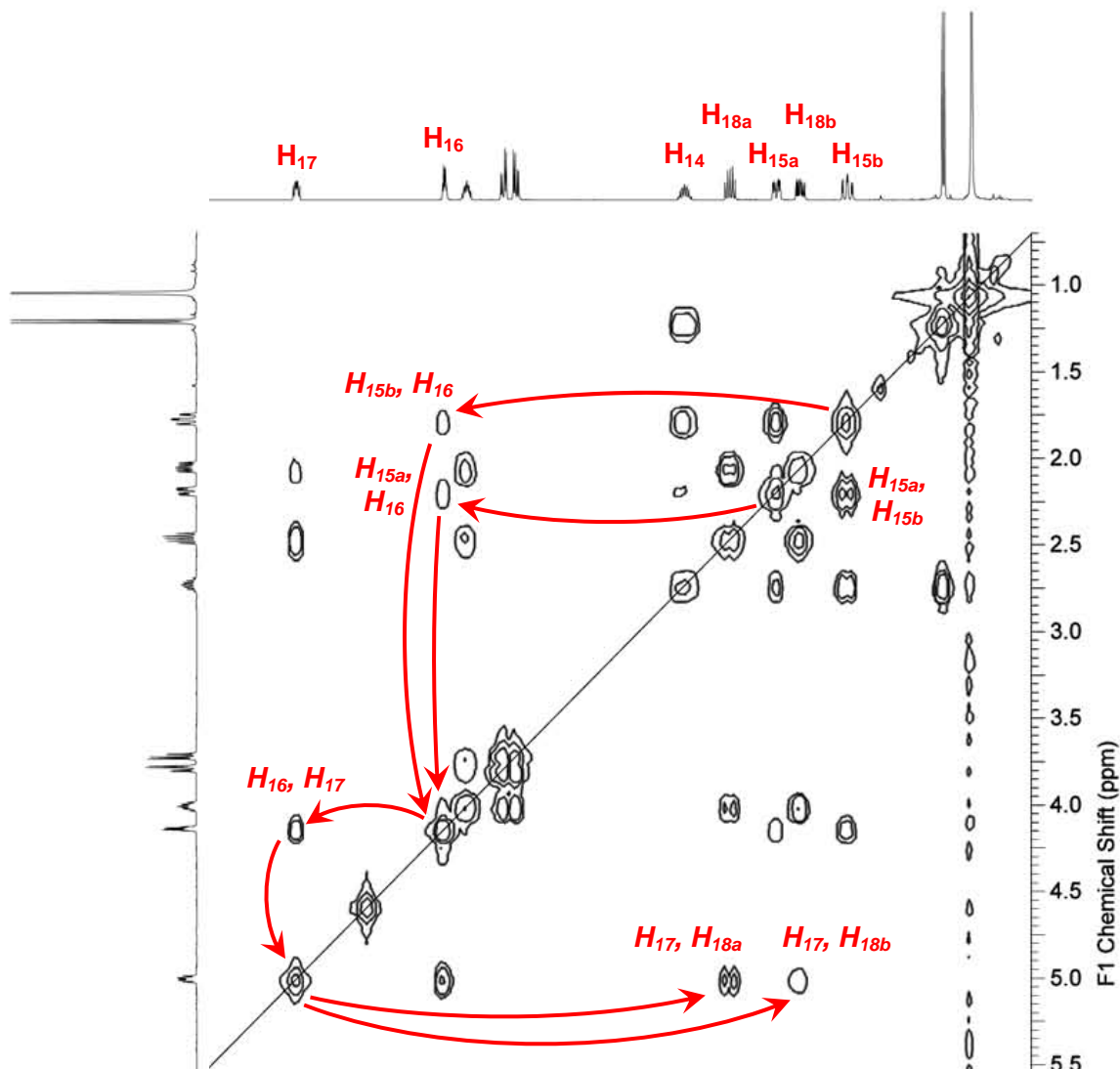
The two H_{18} protons then couple to H_{19}, and then the two (very close) H_{20} protons. So overall, we can finish the chart of coupling constants (next page):

proton	δ (ppm)	multiplicity
-CH$_3$	1.22	d
H$_{14}$	2.74	crazy m
H$_{15a}$	2.20	ddd
H$_{15b}$	1.78	ddd (or dt)
H$_{16}$	4.14	dt
H$_{17}$	5.01	ddd

proton	δ (ppm)	multiplicity
H$_{18a}$	2.47	dt
H$_{18b}$	2.06	ddd
H$_{19}$	4.01	m
H$_{20a}$	3.79	dd
H$_{20b}$	3.72	dd

b. There were a number of ways to distinguish **2** from **3**. I think the easiest was to look at the relative chemical shifts of H$_{16}$, H$_{17}$, H$_{19}$ and H$_{20}$. In molecule **2**, H$_{16}$ is α to an ester oxygen, and H$_{17}$ is α to an ether oxygen. If the product had structure **2**, I would expect the more electron-withdrawing ester oxygen to shift H$_{16}$ downfield of H$_{17}$. This is not the case, however. In structure **3**, things are reversed; H$_{17}$ is the ester oxygen, and should be farther downfield. Sure enough, H$_{17}$ is the farthest proton downfield, indicating structure **3**.

The relationship between H$_{19}$ and H$_{20}$ is very similar—in **2**, the electropositive silicon atom is near H$_{19}$, whereas in **3**, the Si atom is near the H$_{20}$'s. Whichever H is farther upfield has the Si atom attached, meaning once again that molecule **3** must be the product.

Another way to try to answer this question was to do it with coupling constants. Although molecule **2** is free to rotate about the C$_{16}$-C$_{17}$ bond, it will have a preferred conformation that minimizes gauche interactions and that places H$_{16}$ and H$_{17}$ 180° from each other. On the other hand, the chair conformation of the *cis*-fused lactone in **3** will force H$_{16}$ and H$_{17}$ at an angle of ~30°.
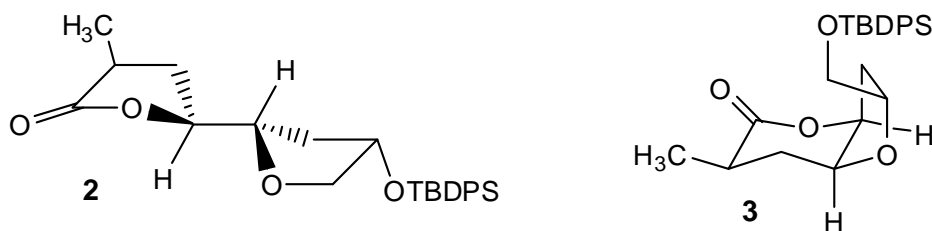
Because of these conformational preferences, I might guess that J(H$_{16}$,H$_{17}$) for **2** would be greater than 7 Hz (the value for random orientation), and that J(H$_{16}$,H$_{17}$) for **3** would be less than 7 Hz. The measured J is ~5 Hz, which is weak confirmation of structure **3**.

Although none of this data is conclusive, I think it all points towards **3** as the correct structure.

c. I think we explained all of the observed crosspeaks in terms of geminal and vicinal coupling; no long-range coupling was observed here.