Ben Geller
PERG/Sci.Ed Meeting, 3/31/14

Gavin Clip #1 (Interview date: 05.31.13)

G: This class was very good about telling us about thermodynamics and entropy's role in the universe and why reactions proceed the way they do. And I think diffusion was when everything started to click; when we talked about how molecules go from higher concentration to lower concentration because they're bumping into each other so much, and so these Newtonian interactions were able to move particles away from one another because the less they interact with each other the more stable their environment really was; there was less collisions and stuff like that. And pressure decreased. And so I felt like that's when things started to click [snaps fingers]... I was like that's why molecules go from higher concentration to lower concentration...

I: So you already knew that it happened?

G: I knew that it happened but then I was like how the hell do they know where the lower concentration is, and in biology we never explain that [brushes arm across]. And I think that biology had done obviously very brilliant things and I love biology, but as far as the professors, they're very knowledgeable but they have to go over so much stuff that they don't really take time to explain why things happen. And I'm a very "why" kind of person; I want to understand why does this happen. And that's why I struggle with Orgo so much, because it's like memorize the mechanisms and take the test... [throws up his hands] well how the hell do I know why the mechanism is happening in the first place...

I: How do the molecules know what to do...

G: Exactly. And why do they do this bouncing thing [moves hands back and forth] and it was never explained to me very well, and then when I take this class and understand, oh, this is why molecules interact the way they do, this is why you are going to have this expansion of particles over space.

Gavin Clip #2 (Interview date: 12.11.13)

G: But going to back to how biologists and physicists [think] differently and where I fit...

I think I am pretty well in the middle. Now actually, I would probably say I think more like a physicist. I feel like biology is the what's happening, and physics is the why and the how. And why is kind of overlapped between the two. You can think with biology, with evolution and ecology, you know it happens because there's more fitness or greater benefit or survival. And then with physics you would say why it's happening is integrated in the way that the molecules bounce off each other in order to expand.

But then the how is extremely useful and I remember when I was taking Orgo um and I took too long before I was ready to study I was sitting there for like my second test in Orgo 1 and I was asking my friends who'd studied for like an extra day, 'guys like how does this mechanism work? I understand that there is this mechanism and I have to memorize these stupid shapes, but like what is happening, why is it happening this way, what is the logic behind it?'

And for the life of me I never understood. I never understood it. I was told, I saw these little shapes and these pictures and follow the arrows and then change a couple letters and you are good, and everything is still wrong.

I: Uh huh.

G: But then when I got to physics, I felt very comfortable compared to chemistry - I was never good at chemistry - I felt very comfortable with physics because I got to see, I got to visualize the why and the how.

And biology was useful because I knew what was happening and I got a little bit of the why but then in physics I really was able to investigate the how. And for instance I told you that we were always told that oil separates from water but we were never told how it happens. And in physics we were told how it happens, and uh so I would say I think more like a physicist now.

I: I was going to say you started by saying you place yourself in the middle but I am hearing you say.

G: I am leaning in a certain direction.

Elena Clip #1 (Interview date: 02.27.13)

I: Yeah. You said that the longer hydrocarbon than the water molecules means that maybe the interaction between two hydrocarbons is larger than the interaction between A hydrocarbon and A water molecule... but what about if you had a line of water molecules?

E: Yeah (smiles having anticipated the question)... I don't know, I would have to look at the numbers.

I: Sure, ok. Yeah, I agree. And if the numbers came out that the water line was more attracted to the hydrocarbon line than two hydrocarbon lines were, would that bother you?

E: That would bother me.

I: Why would that bother you?

E: Because then to me it would just seem like, well, why wouldn't water completely surround each individual hydrocarbon, if it overall has the stronger interaction than the hydrocarbon with the hydrocarbon?

I: So in terms of this (points to deltaG = deltaH - TdeltaS equation on whiteboard), what would the story be if the line of water is attracted more to the line of hydrocarbons (than are two hydrocarbon lines)?

E: Ok, so, now this is where I kind of have two separate thoughts (uses both of her hands to indicate two different places in space). Here (points toward the page showing phospholipid and water molecules interacting with each other) we are talking about like electrostatic interactions...

I: Where do those live (looking toward the board)?

E: (Animated) Those, I just don't feel like they're involved in there at all (circuling the equation with her hand)! So that's why I'm kind of having trouble like piecing the two together in my mind (uses her hands to show the two different pieces coming together in space).

I: OK, gotcha.

E: And I think that's also why that (quiz) question really confused me when Prof. Losert and Redish brought up electrostatic interactions. Like I'm thinking entropy (points toward G = H - TS equation on whiteboard) and you're thinking electrostatic interactions. How do those come together?

Elena Clip #2 (Interview date: 02.27.13)

I: OK, but like what factors helped you to think about whether it [deltaH] was positive or negative, like what were you thinking about to determine deltaH for the process of oil and water (separating)?

E: Internal energy.

I: And what did that, how did you figure out what that was, or (rather) what sign that had?

E: We were thinking, well is the internal energy changing? (thinks about it...) I honestly don't remember what we said... I feel like it was... poooosssiiiitiiive?

Well, OK, so if you have interactions, if you have bonds and you're breaking bonds and reforming them... I think that's where we got it from.

I: ok.

E: So actually I guess the interactions, they're electrostatic interactions, so now it makes sense. (Laughs).

[00:19:03.18]

I: Ok, so I could see how the electrostatic stuff where you're thinking about charges exerting forces doesn't feel the same as bonds necessarily?

E: Yeah...

I: But you were thinking about bonds probably when you were thinking about deltaU...

E: We were definitely thinking about it (now I just wasn't thinking about it) .... that (points to board) will help be for my exam on Friday (laughs).

I: I think you raise a really good point that needs to be clarified. Electrostatics and all the other forces and energies associated with [?] show up in that U which is buried inside the H.

E: Yeah.

I: So, going back to... if we somehow looked up the numbers and found that a chain of waters was more attracted to a hydrocarbon chain than two hydrocarbon chains were (to each other), could you still tell the oil and water story?

E: I think so, because you would have a positive deltaH here (for oil and water separating), but as long as the entropy (points to deltaS term on board) was higher and this (points to deltaS term) kind of overwhelms this (points to deltaH term), as long as it wasn't too much of a (positive deltaH), you would still have a negative deltaG.... I feel like I can explain this so much better than I could last semester (laughs).

Tammy Clip (Free Energy Recitation, Spring 2013)

T: Am I wrong in being overly frustrated?

I: (with mouth full) I'm really frustrated.

T: Ok. So I'm not like the only one who is just like crazy because two things contradict (pointing toward dU = Q - W and dU = kT)?... Literally this is what happened last week and I went home to do my thermodynamics HW for MCAT (prep) and it was totally backwards. And I can't be doing that. I can't go back and forth.

S: What was backwards?

T: We did the thermodynamics (lipid bilayer recitaiton) last week, right? So I did the thermodynamics worksheet and it like kind of made sense what the TA was talking about... I went home to do my MCAT

practice notebook and I happened to be doing thermodynamics. I answered the question. It was completely backwards to the answer.

S: Which one?

T: The question in the textbook was like 'ink dissovles in water vs oil separates... why?' And it was wrong! And like everything that I'd done in class that day was completely backwards when I went home to do my homework.

S: What's the actual answer for that?

T: I don't know! I don't know! Nobody is giving me a right answer and I worked through it and it's right, and then it's not. And that's what I'm doing here. And like two things can't be the same and be different at the same time. I mean they just can't! So why are they different? 'Well I can't give you that answer because you have to work through it.' But I'm working through it and I can't understand it. Like it doesn't make sense to me.

?: Let's just keep going. Let's just show her that we worked through it.

?: I'm so frustrated with this class right now.

Hollis Clip (Bilayer Formation Recitation, Spring 2012)

TRYING TO UNDERSTAND WHY A MONOLAYER CANNOT FORM SPONTANEOUSLY, BUT A BILAYER DOES....

H: I mean, in terms of like bio and biochem, the reason why it forms a bilayer is because polar molecules need to get from the outside to the inside, so you need a polar environment inside the cell. But I don't know how that makes sense in terms of physics. So...

C: So like what I'm saying is, you have to have, like if it (the lipid tail) is hydrophobic and interacting with water, then it's going to create a positive Gibb's free energy, so it won't be spontaneous. So, in this case (the monolayer case), you have the hydrophobic tails interacting with whatever's on the inside of the cell, which is mostly water, right? It's been a long time since...

H: Or other polar molecules.

C: Yeah, other polar molecules. It's going to have, and that's bad.

H: And that's why...OK.

C: That's a positive Gibb's free energy.

H: Yes. See, you explained it perfectly.

{C laughs}

[00:36:17.17]

{writing on their worksheets for a full minute}

[00:37:17.22]

H: So that made perfect sense, the way you said it.

C: OK (laughing).

H: Cause I was thinking that, but I wasn't thinking it in terms of physics. And you said it in terms of physics, so, it matched with bio.

C: Good.

{H: fist pump}