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Bad Hair Day

"My hair is falling out and I'm going to sue you for it!" So begins the Bad Hair Day lab in my Molecular Biology class. Natalie Georgette, a fictional model, has tried the new line of shampoos from Ecco Hair Design — the company the students now work for. Alas, Ms. Georgette's hair is now falling out by the handful. She is canceling photo shoots and threatening lawsuits. The Ecco Hair Design Team is having a bad day.

I believe in Problem Based Learning. I believe in teamwork, cooperation, and collaboration. I believe my students can succeed at the highest levels and do extraordinary work. Bad Hair Day is their first chance of the New Year to prove me correct. When I began teaching Molecular Biology ten years ago, I made a conscious decision to teach in a different fashion. Science to me has always been about doing and not listening. I do not lecture for more than fifteen minutes at a time. The rest of our meeting periods are spent at the lab bench. From my years in the research laboratory, I understood that the best employees, the best scientists, and the best leaders all shared a common vision of teamwork that allowed them to accomplish remarkable feats. I wanted my students to experience and learn these skills in a high-level science environment.

In "Bad Hair Day," the students play the role of technicians in the Quality Control Department of Ecco Hair Design. Something has clearly gone wrong with a batch of the new shampoo, and Ms. Georgette's histrionics are threatening to bring down the company (there is a local TV crew parked outside the building as we speak). Assembled together as a Crisis Response Team by their lovable and effective boss, Willy, the students begin a Problem Based Learning exercise in which they initially know very little, and must seek out, via brainstorming, the right questions to ask, in order to reveal the crucial information they need to resolve the company wide crisis. While the legal team handles Ms. Georgette's letter (and the TV crew), the QC Technicians quickly ascertain that their new shampoo contains a rich luster protein that was created by recombinant DNA technology and produced in larger fermentation tanks. Could the luster protein be causing an allergic reaction? The test data says otherwise, but a clue emerges when the students discover an SDS-PAGE protein gel that shows a contaminant protein has snuck through their purification processes and might be causing the allergic reactions. The QC team is tasked with discovering a way to eliminate this rogue protein from the shampoo. Willy suggests they try a size exclusion column that separates on the basis of molecular weight, and an ion-exchange column that separates proteins by charge.

That's pretty much it for instructions. Now the students must come through with a plan to save their company, their jobs, and their reputations. (Their grades too!)

The next week in class is spent making chromatography columns, prepping samples, running SDS-PAGE gels, and checking, checking, always checking their work, and recording the results. All solutions are made from scratch, nothing is pre-prepared for them. Students follow industry Standard Operating Procedures (SOP's) and must adhere to Good Laboratory Practice (GLP) guidelines. In short, they are as close to being practicing biotechnology scientists as I can get them to be at this point in the year.

I have not given a test or quiz in Molecular Biology in ten years. When students initially hear that statement there is, as you might imagine, a great deal of smirking and anticipation of a class where the only assignments are take home, and cooperation and collaboration are encouraged, nay required. "This will be easy," some of my students think. Others know better because their older siblings took the same course a few years ago, and thus they have some idea of what is to come.

I believe that unless you apply knowledge to a situation or problem you cannot really be said to have learned the material. In my class, we seek to break the memorize-regurgitate cycle of education, and replace it with a team-driven, problem-solving model that emphasizes critical-thinking skills and teamwork. A typical question on a Molecular Biology problem set runs for three pages of experimental data and detailed protocol steps. Somewhere at the end will be a show stopper of a question like: "So based on this data, does your protein bind ferrodoxin under low pH conditions? If so, how could you validate your conclusion using a different methodology?" As one of my students commented last year, "I have never worked so long and so hard, just to understand what the question is asking of us."

But I do not teach in this fashion just to demonstrate that molecular biology is fiendishly difficult, or that I can make my students invest hours of sweat equity in order to earn an "A" grade. My goals are to transform their thinking, to bring them together as a group, and to prepare them for a life of science. Approximately half of the seniors in class will work in a research laboratory next year, having impressed a college professor with their background knowledge and unusual (for a freshman) skill set. The other half will be in college, but not perhaps pursuing a science major. It is those students I actually focus on the most. I want them to understand how science works, how it is tentative at first, gradually growing stronger in the strength of its conclusions, but never reaching certainty. For the rest of their lives, I want them to read a general science article and have some idea of the struggle and effort behind a simple sentence such as, "The protein binds to ferrodoxin at high pH only."

So students collaborate in my classes. Indeed, they must if they are to survive and prosper. Rare indeed is the student who can process three pages of protocols and understand both the experimental design and all the background biology. We meet then, in small groups and large groups, after class, and into the evening, to work on these problem sets. Students are unrestricted in their access to outside resources and encouraged to share their answers with each other. The only stipulation is that they write their own answers in the privacy of their rooms. I use an online anti-plagiarism site to screen their writing for "excessive" collaboration. The trick in crafting the problem set questions is to avoid the simple and emphasize the complex. If answers require two or three paragraphs to explain, expand, and elucidate, then you are unlikely to find that answer on a website. Nor will two students produce identical answers. Students will, however, become better writers and stronger scientists as the year progresses.

I have always believed that if you want to truly understand something, you should teach it to someone else. To listen in on a student-student conversation as one teenager tries to convince the other that her explanation is correct and his answer is incorrect is to observe a moment of pure joy for educators everywhere. The students also know that next week the situation is likely to be reversed and he will be explaining his answer to her. Teamwork rules the day.

Back in the lab, a place we spend more than eighty percent of our time, the students have run their columns and then their gels. It appears that one column does separate the luster and rogue proteins from each other. But which column was it? Back to the careful notes and observations they took to confirm their suspicions. With an answer to the problem, the Crisis Team must now document their findings in a report to Willy. And Willy is in a hurry. (Remember those TV crews?) An adapted and revised SOP must be devised to remove the rogue protein and the important findings must be rushed to the legal department where the non-science trained lawyers must understand what the QC scientists are telling them.

Finally, Willy passes out congratulatory awards, pay raises, and promotions to the successful team, before dropping a bombshell that they must now find a way to positively identify the luster protein on their gels by a direct method rather than by a process of elimination, as the team used in their initial findings. He suggests a Western blot would work well. Ah yes, but that is an experiment for next week.