BioPharmaceutical Technology Center
I N S T I T U T E

Biotechnology Teaching Online: Maintaining Experiments While Virtual

Peter Kritsch

Teaching online during the pandemic has reminded me that figuring out WHAT to teach is as important as HOW to teach it. In fact, given that the HOW is driven by the limitations of being online, the WHAT becomes even more critical. While going over the wonders of the respiratory system or the details of genetic engineering can be explained in any recorded lecture or online reading, the important part of teaching science takes place in the experiments.

It is within these experiments that students learn how to observe, how to predict, how to design, and how to analyze. These science skills are significantly more important than science facts. Don't get me wrong. - you cannot be a good scientist without knowing science facts, but knowing how to think will serve all people much better than knowing that anaphase follows metaphase during mitosis. But how do you do this online when students do not have lab equipment at home?

To address this issue in my Biotechnology class, I modified one of my lab experiments. The DNA extraction lab I do with my students uses solutions of soap, salt, and protease to extract DNA from strawberries. We then precipitate the DNA with ethanol. Along the way, they learn the purpose of each solution in the DNA extraction process. We then use those ideas later in the semester when we more carefully purify DNA - using Wizard Mini-prep materials, of course! It's a straightforward demonstration, however, and not really an experiment.

I realized that students probably have access to lots of these materials at home. Strawberries and resealable plastic bags are fairly easy to track down. So are detergents such as dish soap, hand soap, and shampoo. Salt water? No problem. Protease? Meat tenderizer, contact lens solution, and pineapple juice all have proteases in them. Ethanol? Remember, I'm dealing with high school students so the liquor cabinet was not an option, but rubbing alcohol would suffice. To be fair, these were not new ideas and are typically how we do this in the classroom, too. Doing the demo online was not going to be a problem, but how could this be converted to an experiment?

I decided that I would provide directions which would give a baseline for what and how much to use. Aside from adding ethanol as the last step, the order is not critical. Actually, the volumes and exact examples of detergents, salts, and proteases are not optimized either. You will notice this as you look for DNA Extraction Labs online that each teacher seems to have their own set of directions.

Students were asked to select one variable and alter it. They could choose to alter the type or the volume. For example, they could choose to do a second experiment using bananas instead of

strawberries or to compare shampoo to dish soap. Alternatively, they could use more salt. Anything is possible as long as they only change one variable. They also made a prediction of what they anticipated seeing. Would their variable lead to the extraction of more DNA, less DNA, or even the same amount of DNA?

Importantly, students were also asked to explain their prediction. WHY would they anticipate more, less, or the same amount of DNA? This is an important part of their hypothesis. Without it, their prediction is just a random guess. With an explanation, they have an experiment. Also importantly, they did not have to be correct. Their explanation should make sense, but the results did NOT need to match the prediction.

Science is not about being right or wrong as much as it is about testing an idea. If the prediction matched their results, then their idea was supported (at least with the way they tested it and with a sample size of one). If the prediction and results did not match, then they should revisit their prediction and revise it. Careful, revision and erasing are two very different things. Erasing would be pretending that the original idea did not exist. Revision would mean accepting that the original idea is not true.

In science, that means that our experiment still gave us an idea of how the world around us works. It might work differently than we thought, but science does not care if your original idea was right or wrong. In this way, students could be encouraged to learn some background information, develop a prediction based on those insights, run an experiment, and revisit and maybe even revise their prediction based on those results.

This approach has worked really well. Aside from feeling badly about an expensive table cloth stained by strawberries, this is a lab activity that I will continue to use in the future when we are finally back to live, in-person teaching. Students learned HOW to do science - they learned HOW to think. And that is significantly more important than teaching WHAT to think.

BTCI, in partnership with Embi Tec, will be sharing this and other lessons learned during an online teaching for teachers on January 12, 2021. (Details coming soon!)