Rising to the Top:
Promoting Deeper Learning in the Laboratory

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Part I – The Semester Begins

You are very excited to have just started teaching your first course! It's Introductory Molecular Biology and you have the task of teaching the students about the model organism, yeast *(S. cerevisiae),* in a class today. You decide that it will be much more engaging and fun to teach this subject by teaching "The Science of Baking Bread" where you can include an introduction to the yeast as well as review a little about proteins that they learned about earlier in the course. Even better, in their lab this afternoon, they can actually bake bread! You are sure your students will be able to connect the hands-on lab with the concepts from your lecture this way.

But you are soon to discover not all your students are as excited as you are…

Below are your lecture notes from part of today's class, followed by the lab manual. Read through this material to prepare yourself for the lab. You do not have to memorize it as you can use your notes when we get to the lab, but taking notes or making annotations may be helpful.

Lecture Notes

A key part of baking is to turn your rather dense dough into a light airy bread. How does this happen? Baking soda (bicarbonate) and baking powder work by creating a fast chemical reaction that produces carbon dioxide gas, but raised breads use yeast to do this.

Yeast are living, single-celled fungi. There are at least 1,500 species of yeast (Kurtzman *et al.*, 2011), but the one we are most familiar with is *Saccharomyces cerevisiae,* which has been made famous because it can be used in brewing and baking. Yeast eat (metabolize) sugar to produce carbon dioxide that makes bread rise, though this is typically much slower than the chemical reaction with baking soda. Yeast also can produce alcohol (though different strains are used), which is very handy in brewing beer! When we bake bread we usually start with dried or compressed yeast from the grocery store. This yeast is dormant until it comes into contact with warm water.

Producing carbon dioxide is not enough though. To make bread, we need to have a way to trap the carbon dioxide to make those lovely pockets in the bread and allow it to rise. This is why we use wheat flour. Wheat flour contains two proteins called glutenin and gliadin, which combine with water to form gluten. When you knead your dough, the gluten becomes more stretchy and elastic. As the yeast produce carbon dioxide the gas becomes trapped in the strands of gluten.

Wheat flour is made up of primarily starch and this is important too. Enzymes in the flour attack the starch and release sugars, which allow the yeast to grow and produce carbon dioxide. Starch also reinforces the gluten so that those pockets of gas remain stable.

As your bread bakes, the yeast continue to produce more gaseous carbon dioxide and the bread raises even more. As the temperature rises though, the yeast will die, the starch stiffens and the crust hardens. And you have freshly baked beautiful bread! *—Adapted from <http://www.exploratorium.edu/cooking/bread/bread_science.html>*

Excerpt from the Lab Manual

Supplies needed:

- 1 package active, dry yeast (7g)
- 2¼ cups (450 ml) warm water (110°F, 45°C)
- 3 tablespoons sugar
- 1 tablespoon salt
- 2 tablespoons vegetable oil
- 6 ½ cups (825 g) flour

Protocol:

In a large bowl, dissolve yeast in warm water. Add the sugar, salt, oil and half of the flour. Mix well until smooth. Continue stirring in flour a little at a time until you have a soft dough, keeping aside ½ cup (40 g).

Turn the dough onto a floured surface and knead the dough until smooth and elastic (about 10 minutes). Place the dough into an oiled bowl, cover and let rise in a warm place until doubled (about 1 and ½ hours)

Punch the dough down and turn onto a floured surface. Divide in half, form into loaf shapes and place into two greased loaf pans (9×5 in; 23×13 cm). Cover and let rise until doubled about 30–45 minutes.

Bake in preheated oven at 375°F (175°C) for 30–35 minutes or until it sounds hollow when tapped and is golden brown. Remove from pans to cool.

Reference

Kurtzman, C., J.W. Fell, and T. Boekhout. 2011. *The Yeasts: A Taxonomic Study*, 5th ed. Elsevier Science.

Part II – Role-Playing the Teacher

Your students are now in the lab following your "cookbook" lab manual. They have a lot of questions for you! You sadly notice that they don't seem to be connecting the lab to the lecture you just gave them this morning. How can you encourage them to do this? Try to answer their questions in such a way that your students will get a deeper understanding of the theory behind the lab. Often this will require answering their questions with another question.

Some ideas for types of answers/questions for your students are:

- Can you predict what will happen if …
- Can you explain why…
- What do you think you should do here?
- What will happen if you…
- How do you interpret this result?
- Have you heard of something similar?

Discussion

When you are finished with the role play discuss together in your group what your learned from this exercise. How could you use this approach to improve your lab teaching?

Part II – Role-Playing the Students

You are a student in this course and come to the lab having skimmed the material from the morning lecture and start following the directions. Unfortunately, you make a few mistakes and don't really understand why you are doing this lab.

Take turns asking the following questions to your lab assistant/teacher. Feel free to make up your own questions!

Questions

- The water I added was much too hot (200°F or 100°C). Will that matter?
- I forgot to add the sugar and I'm almost finished, can I add it now?
- I couldn't find regular flour so I used gluten-free flour. I thought that would be okay because I've seen gluten-free bread at the store.
- I put all the dough into one pan instead of two to rise, is that okay?
- I want to leave early so I turned the oven up to 500°F (300°C). It should be done in only 15 minutes then.
- Why does it sound hollow when I tap?
- What do I do with the ½ cup (40 g) of flour I don't mix into the dough?
- Why do I have to put it in a warm place to rise? Shouldn't it be in the refrigerator so it doesn't spoil?

Discussion

When you are finished with the role play discuss together in your group what your learned from this exercise. How could you use this approach to improve your students' learning in the laboratory?

Part III – Lab Manual Redesign

Now think back to the excerpt from the lab manual in Part I of this case study. It is the very definition of a cookbook lab. Does it require that the students understand anything about the topic in the lecture to succeed? Do the students learn the content better having done the lab?

- Discuss in your group how you could make small changes to this lab manual excerpt to reinforce the concepts and material presented in your lecture notes. Discuss also how you can reinforce the scientific method and a scientific approach to the laboratory.
- Discuss in your group how you could redesign this laboratory more significantly to make it an inquiry based laboratory. Could this be made into an experiment?

One member of the group can share your ideas with the rest of the class. Do you have any reservations or concerns about this approach? Are there any practicalities that need to be considered?