Teaching Biology Through Inquiry

INVESTIGATING YEAST

In this chapter, we will examine a 10th-grade biology class carrying out laboratory investigations involving yeast. The investigations in this case study lead students from teacher-initiated inquiries into student-initiated inquiries. In addition, the case study will further our understanding of how teachers can use a constructivist lesson format, the 5E Learning Cycle, to sequence instruction.

This lesson correlates to the National Science Education Standards (NRC, 1996) for both inquiry and content standards, which are quoted below.

Science as Inquiry Standard

Students will

- Identify questions and concepts that guide a scientific investigation. (p. 175)
- Design and conduct a scientific investigation. (p. 175)
- Formulate scientific explanations and models using logic and evidence. (p. 175)
- Recognize and analyze alternative explanations and models. (p. 175)
- Communicate and defend a scientific argument. (p. 176)

Life Science Content Standard

As a result of their activities in grades 9–12, all students should develop (an) understandings that

- Cells have particular structures that underlie their functions. Every cell is surrounded by a membrane that separates it from the outside world. Inside the cell is a concentrated mixture of thousands of molecules which form a variety of specialized structures that carry out such cell functions as energy production, transport of molecules, waste disposal, synthesis of new molecules, and storage of genetic material. (p. 184)
A Day at the Life Sciences Learning Center

Sara McClane has been teaching general and college preparatory biology at Penport High School for 8 years. This past July, she participated in a 2-week summer professional development workshop sponsored by the Life Sciences Learning Center (LSLC), located in the University of Rochester in Rochester, New York, to engage secondary school science teachers in inquiry-based instruction. As a follow-up to that workshop, participating teachers are encouraged to bring their biology classes back to the LSLC for a full day of laboratory investigations. The LSLC is a unique hands-on science inquiry center serving middle, high school, and Advanced Placement students and teachers throughout central-western New York State. The LSLC is devoted entirely to precollege science education and providing hands-on, inquiry-based, and laboratory-based investigations for students aligned to the state’s science learning standards. The LSLC also provides ongoing professional development, such as the workshop Sara attended, on laboratory-based life science instruction and biotechnology for secondary school teachers. For more information on the LSLC, visit http://lifesciences.envmed.rochester.edu/.

Dr. Dina Markowitz, LSLC director, and Ms. Jana Penders, LSLC science educator, lead the lessons for students attending the center. Dina is an associate professor and Director of Community Outreach and Education Programs at the University of Rochester’s Department of Environmental Medicine. With a background in molecular biology from Columbia University, Dina also is a research geneticist at the university. Jana is a former high school biology and chemistry teacher with research experience in microbiology and molecular biology. She is presently fulfilling requirements for a master’s degree in secondary science education.

The day’s agenda for the yeast investigation follows the 5E Learning Cycle format. The morning session includes the Engagement and Exploration stages. Following lunch, students return for the Explanation and Extension stages. The Evaluation stage will be completed by Sara the next day, when the class returns to school.

Engagement Stage: What Is Life?

Sara and her students arrive by bus at the center at 8:30 A.M. They are greeted at the door by Dina and Jana, then are led upstairs to the laboratory. As the students put on their white lab coats and settle onto the stools at their assigned lab tables, the lesson opens with a 20-minute introduction by Jana. She initiates a discussion to assess the students’ prior understanding of the characteristics of living things. “What do you know about living things?” she asks. “Do you think this is living?,” she asks as she points to a potted geranium near the window. Nora, a student in the class, tells Jana that living things carry out certain functions such as respiration and reproduction, and also respond to external stimuli. “Since the geranium performs these functions,” Nora says, “it is a living organism.” Jana then shows the class a picture on the television monitor and continues. “How about these bacteria? Are they alive? How do you know?” Several students provide responses to indicate that bacteria, like the geranium, are living organisms.

“Today we are going to act like scientists and detectives,” Jana says. “In a sense, they both do the same kind of work. They both make observations and draw inferences based on their observations.” She then holds up two identical-looking vials, one labeled “A” and the other labeled “B.” The vials contain equal amounts of tan-colored granules.
“We have a mystery to solve,” Jana continues. “I have two vials, but I don’t know what is in them. I’ll need your help in finding out which of the granules in the vials are living organisms or nonliving.” Although the contents look nearly identical, vial A contains sand and vial B contains common baker’s yeast. The students are told that their task is to perform several laboratory techniques to determine which vial contains living organisms, be able to substantiate their evidence, and be able to provide a logical explanation. “You will be making both qualitative and quantitative observations,” Jana tells the students. “All your data should be accurately recorded in your science journals.” The students then pair up and move on to the Exploration stage, during which they begin to test the samples in the vials.

**Exploration Stage**

During the next 2.5 hours, students design their investigations through prompting and guidance by Jana and Dina. The students are provided with the following materials and equipment to help them collect evidence and draw their conclusions:

- One vial of sand (labeled Sample A)
- One vial of baker’s yeast (labeled Sample B)
- One transfer pipette
- One small beaker containing 100 mL of warm water
- Two test tubes
- Two large ziplock bags
- One plastic teaspoon
- One permanent marker
- One ruler
- One 100-mL graduated cylinder
- Two packets of sugar and artificial sweeteners (Equal, Sweet’N Low, Sugar Twin)
- Microscope slides
- Microscope cover slips
- One container of methylene blue
- One magnifying lens
- Paper towels
- One dissecting microscope
- One compound microscope (with oil immersion)
- Oil for immersion objective
- One incubator (set at 37°C)

“Because all good scientists and detectives start with observations,” Jana explains, “your first step is to use your senses, with the exception of taste, to observe the two samples. Although they are both safe, it’s recommended not to taste anything in a laboratory. You can observe the samples first with your naked eye and then by using a magnifying lens.”

“Later,” Dina adds, “you can put the samples under the microscope and see if there is a difference in the samples. I suggest you start with the dissecting scope first, and then use the compound microscope later. This way, you are always increasing in magnification.” The groups take the next 15 minutes to observe both vials and record observations in their science journals.
In one group, Ann records that Sample B looks like fish food. Michael adds that Sample B looks like little capsules and smells like pizza dough. In another group, Michelle says, “Sample A doesn’t smell at all, and B smells like yeast.” As the students are busy making their preliminary observations, Jana encourages students to use a two-column chart, similar to Figure 9.2, to record their observations and questions.

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<tr>
<th>Observations</th>
<th>Questions</th>
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Once the groups have made their initial observations, they are ready to move on to Step 2. Jana begins the discussion by asking “What can we do next to further our investigation?”

A student suggests, “I think we should put each sample in some water and see if it dissolves, floats or sinks, or changes color.” With minimal guidance, each group now takes a small sample of the unknown granules, places each in a separate test tube, and adds equal amounts of water. The students then observe the test tubes with a magnifying lens and note that Sample A rests at the bottom of the test tube and water, while Sample B forms a suspension. One group asks if they can prepare a wet mount of each sample, and Dina encourages the entire class to do so. The students observe the two samples under both low and high magnification. For the first time, the groups distinguish significant differences between the two samples microscopically, using both flat and depression slides. Students now include in their journals illustrations of granules for Sample A and cell-like objects for Sample B.

Figure 9.3

As Dina continues to circulate among the groups, Jana places slides of Samples A and B, similar to what the students prepared, in the micro-viewer for the entire class to see. She uses the samples in the micro-viewer to compare and contrast the two samples and what the students have in their own microscopes. She suggests the students construct a Venn diagram in their notebooks, similar to Figure 9.4, to record the similarities and differences of Samples A and B.
By the end of Step 2, most of the groups conclude that the samples are sand and yeast. Although many of the groups come to this conclusion, they are reminded that they need substantial data to prove their case and that their observations alone are not sufficient. They need more evidence!

Jana now leads the class into a discussion about the staining techniques for Step 3 of the investigation. She tells the class that when they add methylene blue to each slide sample, the stain will indicate the presence of a cell membrane. "How, then, does the methylene help you to answer the question—is it alive?" she asks.

Maria answers, "If the methylene blue stain is absorbed by the sample and the cell membrane is highlighted, we have additional proof that the sample is a living organism." Jana now demonstrates how to add a drop of methylene blue to the slide. By placing a drop of stain at one end of the cover slip and by placing a piece of paper towel at the opposite end, the stain is drawn across the slide, through the sample, and into the paper towel. After students perform the technique on both slides, they view the samples under 100X magnification with oil immersion and soon discover that the sand, Sample A, does not absorb the indicator, whereas the yeast in Sample B does, highlighting the cell membrane. They conclude that Sample B consists of living cells.

The students are now ready to begin Step 4. Dina begins this section of the investigation by asking, "Do you think the yeasts will grow in water alone?"

"No," one student suggests. "You'll need a food supply."

Dina then asks, "What food supply would you add to the water to help the yeast grow?" Some students suggest sugar; others suggest molasses or corn syrup. "All of you are right," she says. "Now let's design a way to determine the effect of sugar, or any another sweetener, on the samples." During this part of the lesson, students are
led through a teacher-initiated inquiry: Are yeasts living things, and do they need a food supply, like sugar, to grow? Students are given two ziplock plastic bags, and they place a teaspoon of yeast in each bag. A packet of sugar is added to one of the bags and labeled “Sugar.” The second bag, to which no sugar is added, is labeled “Control.” One hundred milliliters of warm water is added to each bag. (Some students decide they want do the identical procedure with the sand sample just to compare.)

Figure 9.5

The students squeeze all the air out of the bags, seal the tops, and roll the bags tightly. They now place their paired bags in an incubator set at 37°C for 15 minutes.

After 15 minutes, the students remove their bags from the incubator, measure any vertical rise in the bags, and return the bags to the incubator for another 15 minutes.

After 30 minutes and again at 45 minutes, the students repeat the procedure, removing the bags from the incubator and measuring any change in height. The students continue to make observations and record their measurements in their science journals. One student makes a notation in her journal with the following results:

When I add sugar to the yeast and then place the bag in an incubator for 30 minutes, fermentation occurs and a gas, probably carbon dioxide, is produced. The bag inflates because the gas being produced is trapped within the bag. The yeast metabolizes the sugar and produces the gas (carbon dioxide) as a by-product.
Table:

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<tr>
<th>Time (in minutes)</th>
<th>Control</th>
<th>Sugar</th>
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<td>15</td>
<td>0</td>
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**Explanation Stage**

After the groups record their data from the yeast exploration, Jana brings the class together for a teacher-led discussion. A handout accompanies her comments. “Yeast,” she explains, “are unicellular and belong to a group of microorganisms called the ascomycotes, or *sac fungi.* Their scientific name is *Saccharomyces cerevisiae,* meaning sugar-loving. They are quite common and can be found naturally in the soil, in animals, including humans, on locker room floors, or just about anywhere there is moisture. Yeasts are especially noted for their ability to ferment carbohydrates, like sugar, and produce alcohol and carbon dioxide. This makes them important in the production of beer, wines, and bread. Yeasts usually reproduce by budding. That means that they reproduce asexually by producing small budlike outgrowths from the parent cell. Yeasts, however, can also reproduce sexually by producing spores called *ascospores.*"
As the students take notes for their presentations, Jana shows yeast cells and their rigid cell walls on the monitor using the micro-viewer. She continues her presentation by explaining that yeasts, although living, are neither plants nor animals. “They belong to a separate phylum of fungus,” she adds. “And since mycology is study of fungi, today you have been working as mycologists!” She goes on to explain why yeasts are eukaryotic and describes both the fermentation process and the life cycle of yeasts.

At the end of the Explanation stage, the class concludes that yeasts are indeed living organisms because they reproduce, use respiration, and repair and grow new cells. The class also concludes that Sample A is sand and Sample B is yeast. After a full morning of laboratory work, the class breaks for lunch.

**Elaboration Stage: What Do Yeast Live On?**

When the students return from lunch, they are ready to begin the Elaboration stage, in which they design their own student-initiated investigations. Jana tells the students to work in their groups to brainstorm questions to investigate. She suggests they refer to their two-column charts from the Engagement section and their data from the Exploration section to consider questions for further investigation.

After a few minutes of brainstorming, Tim and Carrie decide to test regular sugar versus artificial sweeteners. They want to see if the amount of carbon dioxide produced during fermentation varies among natural and artificial sweeteners such
as table sugar, Equal, Sweet’N Low, and Sugar Twin. They design their investigation so that equal amounts of each sugar or sweetener are placed in a plastic bag with yeast and warm water.

Brian and Brandon want to find out how the amount of sugar affects the rate of fermentation and production of carbon dioxide. To do this, they propose adding varying amounts of sugar (10, 20, 30, and 40 grams) to the plastic bags. They also hope to determine how the amounts of food available affect the growth of the yeast cells.

Donnell and Willis want to know if baker’s yeast metabolizes differently in varying types of sugars. To do this, they design an investigation to test sucrose, dextrose, glucose, and fructose. They inform Dina that their manipulating variable in the investigation is the type of sugar used and the responding variable is the amount of carbon dioxide produced as measured by the height of the bag after fermentation.

Sandy and Sharon’s question is “What is the optimal temperature for yeast growth?” They decide to investigate the ideal conditions for yeast growth and metabolism by growing yeasts at three different temperatures: 27°C, 37°C, and 47°C.

When Carol and Ron placed the methylene blue stain in the slide from the morning investigation, that stirred three new questions: What would happen if we place a sugar solution under the slide of yeasts? Will gas bubbles form under the cover slip? Will the carbon dioxide bubbles look different from air bubbles?

For each investigation, Jana and Dina encourage the students to identify the manipulated (or independent) variable, the responding (or dependent) variable, and the controlling (or constant) variables. Once the students design their experiments, they bring their plans to Dina or Jana for approval. After an hour of investigation, each group has 10 minutes to share with the class the question they investigated and communicate their findings.

Before they know it, it is time for the class to board the bus and return to school. As the students make final notations in their journals and clean up their lab stations, they all agree that the day was worthwhile and rewarding. Many of the students comment that they felt they were actually doing real science!

**Evaluation Stage**

In class the next day, Sara uses the data collected at the Life Sciences Learning Center to introduce a genetics lesson on haploid and diploid life cycles. The purpose of the lesson is to extend the Elaboration stage and apply what the students learned at the LSLC to the district’s science standards and curriculum. At the completion of the Elaboration stage, Sara gives the students a unit test. The unit test includes multiple-choice questions, several short answer response questions, and a performance task to assess their progress in meeting the learning standards. Here is the task the students are given:

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**The task:** A student wants to demonstrate how the rate at which a balloon inflates is proportional to the growth rate of the yeast cells. Use the materials listed below to:

1. Design an investigation to solve the problem.
2. Provide an appropriate table to record your data.
3. Carry out your investigation.
4. Fill in the data table.
5. Make a graph of your results.
6. Draw a conclusion from the data collected.

Materials:
- 100 mL of warm water
- Sugar cubes (or packets)
- A package of yeast
- One medium-size plastic bottle or flask
- One balloon
- One metric measuring tape

A sample procedure may look this:
1. Place the three sugar cubes (or packets) in the plastic bottle and pour in 100 mL of warm tap water.
2. Swirl the bottle until the sugar has dissolved.
3. Pour the entire contents from the package of yeast into the bottle.
4. Squeeze all the air from the balloon and stretch the balloon over the top of the bottle.
5. Observe what happens. Every 5 minutes, use the measuring tape to measure the circumference of the balloon.

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<th>Time (in minutes)</th>
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To assess the students’ progress on the performance task, Sara develops her own analytical rubric, similar to others she found posted on the Internet at the following sites:

www.col-ed.org/smcnws/scientific.html
http://resources.yesican.yorku.ca/trek/assessment/r8_inq.html
In this case study, we see how teachers can use the 5E Learning Cycle to design investigations and units of study. We also see how a teacher-initiated inquiry can lead to a student-initiated inquiry. (Note: For references on artificial sweeteners, see www.sweetnlow.com or www.equal.com.)

AN INTERVIEW WITH DINA MARKOWITZ AND JANA PENDERS

From the perspective of a university researcher and a science educator, what is your definition of inquiry? Is inquiry any different for the researcher than it is for the high school science teacher?

Dina: I think inquiry has multiple meanings. It can be both similar and different things for the researcher and the science teacher. In both cases, inquiry centers on asking questions, which leads to some answers and which lead to more questions. There are, however, limited numbers and types of inquiries that can actually be completed in a secondary school lab. Teachers are often limited by time, whereas research is often limited only by money. Researchers often need many months or years to come up with the answers, whereas science teachers need to be sure that students complete most or all of the inquiry activity in the time allowed by a classroom period. Teachers may also be constrained by the resources and equipment available to them, whereas in the research laboratory, that is usually a smaller concern. At the Life Sciences Learning Center, we need to make sure that students work on a question or problem that is answerable and that they are able to complete all or most of the investigation in the time they are here. We also need to be sure that all students meet a level of success while they are here and that they leave with very positive attitudes about science.

Jana: Here at the LSLC, I often say that every day is like the first day of school. That means that each day, we face the challenge of getting to know the kids as quickly as possible so they trust us in guiding them through their inquiry, thus leading to achieving success. Part of the approach we use here tries to make students feel confident in their own inquiry abilities and have ownership in the questions they pose.

Recently, I was at a high school and asked students who they felt was the best inquirer of all times. One student said it was Galileo. Another thought it was Isaac Newton. Then, when I suggested that newborn babies are perhaps the best inquirers, the kids agreed. We discussed how, with no means of communicating (except screaming or crying), babies have to figure out what they need, what they want, and how to get it. Babies have to figure out their whole new world, devoid of any preconceived notions. The infant discovers by putting objects in her mouth and touching and grasping things with her hand. So I suggested that all the students in the class have already been the best inquirers ever, just by experiencing life.
Are all your programs inquiry-based?

Dina: Most are inquiry-based. There are, however, some science activities that don’t lend themselves to an inquiry orientation. Some are what I would term “directed inquiry” because the procedure, like in the case of most of our biotechnology programs, such as “DNA Fingerprinting,” must be sequenced in a particular order. There is no other way to do it. In other cases, where students are mixing reagents, we don’t have enough time for them to discover this on their own, so the question, materials to use, and procedures of the technique are provided to the students. With wanting to have all students be successful when coming to the center and given the limited amount of time we have with the students, it becomes necessary to provide the structure that will lead to their success. I’m sure this is as true in the high school lab as it is here at the Life Sciences Learning Center.

Jana: In the case of the yeast investigation, there isn’t much that can go wrong. Even with some errors in the procedure, the yeast is probably going to grow and metabolize. But with the biotechnology activities, it’s different. There are the sequenced procedures that Dina mentioned. As engaging as inquiry is, you just can’t do it all of the time. Some activities and labs require structure. Others do not. It’s the teacher’s challenge to analyze the lab and determine when and where more decision making and student ownership can be placed.

You mentioned the importance of “trust” in an inquiry-based classroom. How do teachers build trust with their students?

Jana: First of all, you have to communicate that everyone in the room has something to contribute and that no one will be teased, ridiculed, or laughed at for anything that’s said. We remark that every comment that students make is valuable and adds to our discussion. Also, by practicing “wait-time” strategies, we tell students that they will have ample time to completely think out their responses. I often borrow the phrase “lifelines” from the show Who Wants to Be a Millionaire, by giving students an opportunity to “phone a friend” when they need help answering a question.

Dina: When students come to the center for the first time, they often have no previous relationship with us. We have found that by visiting their classroom one or two times before students come to the center, we introduce ourselves on “their turf,” and that makes the transition to the LSLC and the level of trust more comfortable. These skill-building, previsititation lessons help us to prepare the students for their investigations at the center and to introduce specific laboratory techniques, like using a pipette or gel electrophoresis equipment, which students will be using at the center.

What are some of the skills you find students need to have in order to be successful in completing an inquiry investigation?

Jana: Surprisingly, some of them are not science related at all. I find that life skills are just as essential as science process skills. Self-confidence and self-esteem are very crucial to success in inquiry-based classrooms. Once you develop the life skills, they lead to success for the manipulative skills. I once heard a teacher say his students
may not be able to do the investigation because they don’t have the necessary organizational skills. I posed the question, “How will students ever learn and develop organizational skills if teachers don’t first give them the opportunity to do inquiry?”

*The yeast investigation provides a means for students to learn through scientific inquiry. How difficult is it having students come into the lab with varying prior experiences with hands-on and inquiry-based science?*

**Jana:** Before a science class actually visits the center, I make one or two classroom visits to the high school to meet the teacher and students and communicate the purpose of the visit. Communication is essential. During the previsits, the teacher and I discuss the individual needs of students and tailor a program specifically to that class. This way, I can anticipate what each class’s needs will be. There are some prerequisite skills students need before coming to the center. For example, in our “DNA Fingerprinting” lesson, students need to know how to use certain equipment. I can preteach those certain skills during the previsits, thus increasing the chances of success for every student.

*The Life Sciences Learning Center is an excellent example of a university reaching out to the community and supporting middle and high school science teachers. How important is it for higher education institutions to form partnerships with secondary school teachers to ensure that all students meet rigorous national, state, and local standards in science?*

**Dina:** It’s essential that universities tap into local high school students who may in the near future be their own students. Universities today see the need to attract local students and keep them in the community to fill prominent positions in math, science, and technology. And with shrinking high school budgets, science teachers are looking to nearby community colleges and universities, as well as local businesses in science and technology, for additional support and resources. Coupled with the spiraling cost of laboratory equipment, more and more high school science teachers are turning to colleges and outreach centers to develop partnerships.

**What suggestions would you give to a high school science teacher seeking to form a partnership with a local college or university?**

**Dina:** First, look to a college or university with an undergraduate or graduate-level science education program and find out what resources it has to offer. Often, colleges have outreach grants and programs to support local and regional public schools; especially schools with high need and at-risk students. There are several federal grants available for higher education specifically to partner with public schools around needs in math, science, and technology. Many federal granting organizations, like NSF [the National Science Foundation] and NIH [the National Institutes of Health], now specify that up to 10% of the awarded amount must be set aside to support public educational programs. Although some partnerships are initiated by one science teacher approaching a college or university, the school should form a team ideally consisting of the principal, science department head or curriculum coordinator, and classroom teachers to identify their needs and explore possible avenues for assistance and resources.
What knowledge, skills, or attitudes do you expect students to walk away with after visiting the Life Sciences Learning Center?

Dina: Our goals are not different from the majority of high school science teachers. We want students to learn how scientists do their work and what it means to do a science investigation. Not everything scientists do is “Hey, wow!” exciting. And sometimes, science experiments don’t always work. We want them to discover that two scientists, working side by side, may not necessarily come up with the same answer. That's true too for any pair of students working together. Or even if they get the same data, they may interpret the evidence differently. That’s the nature of science.

Jana: It’s important for students to realize that most scientific investigations evolve over time.

Dina: We also want them to know that science is not a solitary, isolated process. When students act like scientists, they must work cooperatively together, discuss and share their results, and present their information. We want them to know that real science is not “cookbook” style.

Jana: Having students leave with a feeling of self-confidence is important to me. I want them to feel science is fun and not all scientists are stereotypic of the images they see on television or in cartoons. I want them to leave feeling that they are scientists and can pursue scientific, technical, and engineering careers in the years ahead.

Given the evolving nature of science investigations, is there some fallacy in the scientific method? It seems so many teachers and science textbooks place a high priority on introducing this.

Jana: When you leave it in the singular sense, yes, there is some fallacy. But in the plural form, scientific methods, it is not. That means there are many methods of doing science. So using the scientific method is different from using scientific methods.

Dina: The second fallacy lies in the “H” word. There are not always hypotheses in an investigation. Sometimes you go into an investigation and you have no clue what you are going to get. I’m sure this is true for some high school students. You are collecting data because you are interested in studying a phenomenon, but you really have no idea or preconceived notion about how it will work out. So those inquiries have no hypothesis. And yet the scientific method that teachers espouse often emphatically states that you must have a hypothesis and follow a linear, sequential format.

What knowledge, skills, or attitudes do you expect teachers to walk away with after visiting the Life Sciences Learning Center?

Jana: It’s important that science teachers return to their schools being excited and eager to transplant and follow up on any or all of these activities in their own classrooms and labs.
Dina: I would like teachers to understand that it’s okay to occasionally let students go off on the wrong path. Much of what we learn is from our own mistakes. I also would like them to realize the amount of time it takes to do a scientific inquiry properly.

Jana: Given the reality of the amount of content teachers need to cover (or should I say uncover) during the school year and the amount of instructional time available to teachers, the challenge lies in finding and scheduling longer periods to do engaging and extended inquiries. Most inquiries do not lend themselves to a 45-minute period. In a short 45-minute lab period, how can anything be accomplished that resembles real-life science? Inquiry-based labs usually take more time than traditional labs, which can often be completed in one period. That’s a very real challenge to high school science teachers.

QUESTIONS FOR REFLECTION

1. When having students design their own investigation, what precautions should the teacher take before allowing students to begin carrying out the procedures?

2. How can teachers anticipate the kinds of supplies, materials, and equipment that will be needed when students design their own inquiries?

3. If the teacher decides to use a rubric in this lesson, where would it be most appropriate?

4. What other examples of student-initiated inquiries can you suggest?

5. What other examples of assessments can you suggest for the evaluation phase of the lesson?