LESSON 1:
Gummy Bear Lab Meeting:
Social Practices in a Scientific Community

Vocabulary words used in each lesson are in **bold**. Definitions can be found at the end of each lesson and in the *Master Glossary* in the *Appendix*.

INTRODUCTION

In this lesson, students participate in a scenario-based lab activity designed to help them define qualities that result in reliable and meaningful scientific research. By having students conduct an investigation that gives highly variable results within and between lab teams, students learn the importance of making ***strong arguments*** in science as they use evidence and reasoning to support their claims. They also **communicate**, **collaborate**, and **skeptically evaluate** each other's claims. Other aspects of scientific practice that the lesson illustrates include the importance of **repeatable trials**, replicable methods, and **integrity** and honesty in data collection. After a class discussion of the checks and balances in place to ensure good science, teams repeat the lab activity with a protocol that they decide upon collaboratively. Lastly, students prepare to "submit their results for publication" and learn about the **peer review** process.

CLASS TIME

Five class periods of 55 minutes each allows students to complete the lab and engage in the collaborative process (see ***Suggested Timing*** section for more information).

KEY CONCEPTS

- Social interactions are a key part of the process of science. Scientists often discuss and refine their methods in **collaboration** with others; they also communicate their results to the research community for evaluation through the peer review process.
- The peer review process helps make science more "objective" as scientists critique and/or try to repeat the findings of others. These checks and balances within the scientific research process help lead to quality research and confidence in results.
- **Skepticism** is valued in science; scientists actively question the methods and findings of others and do not accept claims that are not backed with strong evidence and support.
- Engaging in scientific research can be a messy endeavor, requiring personal characteristics such as persistence and a tolerance for ambiguity.

LEARNING OBJECTIVES

Student will know:

- **Communication**, collaboration, and skepticism are essential to the scientific research process.
- It is important to back claims with evidence and reasoning, and to use evidence and reasoning to evaluate the claims of others.

Students will be able to:

- Actively participate in a class discussion evaluating the varied methods and results of approaches used by class members.
- Make claims and support them with evidence and reasoning.
- Critically and respectfully evaluate the claims of others.
- Revise methods in light of group discussion.

MATERIALS

Materials	Quantity
Student Handout 1.1—*Gummy Bear Lab Protocol*	1 per student
Student Handout 1.2—*Lab Meeting Data Sheet*	1 per student
Student Handout 1.3—*Lesson Assessment*	1 per student
Teacher Resource 1.1—*Class Frequency Distribution Table*. Two copies are needed for recording class data from each of the two protocols.	2
Teacher Resource 1.2—*Journal of Applied Polymer Confections Acceptance Letter*	1
Access to water and paper towels, plus an assortment of lab materials such as metric rulers, scales, graduated cylinders, beakers, scalpels, and clamp stands	1 set per student group
Gummy bears [**Note:** Our field test teachers had success with Black Forest brand bears, as they tend to retain their shape better when left in water]	Minimum of 2 per student

SUGGESTED TIMING

Day	Activities
Day One	Introduce lab. Students develop and carry out protocol. Bears soak in water overnight.
Day Two	Students analyze data. Students prepare to present.
Day Three	Lab meeting, including presentations. May include discussion of new protocol.
Day Four	Determination of new protocol. Students carry out new protocol. Bears soak in water overnight.
Day Five	Students analyze and share new data. Discussion of peer review. Closure.

NOTE TO THE TEACHER

The wide range of results between and among lab teams may lead to student frustration and a sense of confusion during the lab. This is an expected part of scientific research when there is no "answer in the back of the book." Asking students to develop their own protocol may also be uncomfortable for students. Help students work through their frustration by communicating with each other and working together to come up with the best plan for improving their lab protocol.

You know your students best. If students will likely be uncomfortable with the open-ended nature of the lab and the idea of critiquing their classmates, we recommend beginning the unit with *Lesson Two: "Stupidity" in Science: A Text-based Discussion*. This lesson speaks to the importance of not having all the answers in science, and sets up a discussion method based on evidence that students might find helpful during the lab meeting. This discussion strategy also provides students with practice making evidence-based claims.

This lesson requires an investment of time. Though it may be tempting to merge two days into one, the discussion ***processes*** take time and should not be rushed. Allowing students enough time to work together through a common problem at their own pace with minimal teacher input is key to the success of the lesson.

TEACHER PREPARATION

- Make copies as described in the *Materials* section.
- Set up each lab station with an assortment of lab equipment and a number of gummy bears to choose from. Make sure there is a minimum of eight gummy bears per lab station.

PROCEDURE

In this lesson, students are given a scenario in which they are scientists working for a principal investigator (PI) on a research problem involving **diffusion** of water into gummy bears. Gummy bears are made of gelatin and sugar. Gelatin is a **polymer** that forms large three-dimensional matrices that give structural support to jellies and jams. Students conduct the lab twice with a classroom discussion in between.

Day One: Introduction to the Lab—Collaboration

1. Begin the lesson by asking students: "Have you ever had a problem that when you talked to several other people about it, you came up with a better solution than if you just thought about it yourself?"
2. After discussing some student examples, note that collaboration and communication are key aspects of the social part of science. Explain that students will be doing a lab activity that highlights these concepts. The lab will also demonstrate how skepticism is important in science.
3. With student input, create working definitions of communication, collaboration, and skepticism:
   - **Communication:** Sharing information with others.
   - **Collaboration:** Working together with others toward a goal.
   - **Skepticism:** Evaluating information critically and looking for evidence and reasoning behind claims.
4. Tell students that over the next five days, their classroom is going to become a scientific community, and they are going to become "polymer scientists." Share with them that there is currently a lot of controversy in the polymer research community about the type of polymer and how much it increases in volume when left in water.

[**Note:** You may want to expand on the definition and chemical characteristics of polymers if appropriate. For this lab, students only need to know that a polymer is a large thread-like molecule made of repeating units.]

5. Relate the expanding of polymers in water to important research on creating absorbent materials that might soak up chemical spills or hold water in soil. Liquid-absorbing polymers may also be used in soft contact lenses, dressings for burns, or in tissue engineering. New research is also being done on polymers as a potential drug-delivery molecule.
6. Explain that one way scientists communicate is by sharing their findings with others in journals. If the class obtains good, careful results, their findings will be "published" in the *Journal of Applied Polymer Confections* (a make-believe journal). Publishing in a journal allows a scientist's work to be viewed skeptically by other scientists which can advance the field of polymer science. If scientific ideas withstand repeated scrutiny and testing, they become increasingly accepted within the community.
7. Tell students that you are the "Principal Investigator" (PI) in charge of the lab group (class) investigating the characteristics of polymers. They are scientists studying polymer science. They will be working in teams conducting basic research to be used as the foundation for future research.
8. Explain to students that past research with gummy bears has shown that the size of a gummy bear increases when soaked in water. Building on this prior knowledge, our hypothesis is that gummy bears will increase in size by between 200 and 600 percent due to water molecules entering the polymer matrix.
9. Tell students that the class will need to obtain a precise answer to the question:

   How much does the volume of a gummy bear increase after soaking in water?

   To answer the question, students will need to focus on the ***best method*** of obtaining the most consistent data. During the upcoming lab meeting, when students share and discuss their results, students will need to make a strong argument for the measurement method they used based on their evidence (the percent change in volume of their gummy bears).

[**Optional:** If your students need extra motivation, suggest that the whole class get extra participation points if class results are carefully obtained and their work is "published." Results have to be accurate and consistent to be published.]

10. Organize students into teams of four. Each team should meet at a lab station, where an assortment of gummy bears and laboratory equipment will be available to them.
11. Tell students that each team will work independently without input from the teacher or other lab teams.
12. Hand out copies of Student Handout 1.1—*Gummy Bear Lab Protocol*, one per student. Allow time for students to record observations, discuss method of measurement, and complete the protocol.

[**Note:** The protocol for this lab provides guidelines so that students will be able to share data gathered in a uniform way. Make sure students know that there is no one "scientific method" that all scientists use to discover new information. Scientists use a number of practices and approaches to explore and find meaning in the natural world. Other approaches include observational and descriptive studies, epidemiological studies, correlational studies—even serendipity plays a part in scientific discovery.]

13. Let beakers sit undisturbed overnight.

Day Two: Communication

14. **Communication:** Tell students that they need to prepare for a "lab meeting," where they will discuss their results as a class. Ask students what the goal of a "lab meeting" might be. Possible answers might include:
    - To compare findings.
    - To analyze each other's work.
    - To figure out what to do next.
15. Tell students that they have been collaborating in their teams so far, and now they are preparing to collaborate with the larger lab group. It is also time to communicate to each other what they've found.
16. Each lab group will need to collect the beakers containing the gummy bears that soaked overnight. Next, challenge students to complete the ***Day Two Protocol*** on Student Handout 1.1—*Gummy Bear Lab Protocol*.
17. To prepare for the lab meeting, each group should prepare to communicate to other groups what happened to their gummy bears and how well their method of measurement worked. Students should work with their group members to write the answers to the following questions in their lab notebooks:
    - What was your method?
    - What can you conclude about the effectiveness of your method of measurement? (***Claim***)
    - What did you find to be the percentage increase of gummy bears soaked in water?
    - How do the data and your experiences support your conclusion and why? (***Evidence*** and ***reasoning***)
    - What worked with your method? What did not?
18. One person from each group should record the group data on one copy of Teacher Resource 1.1—*Class Frequency Distribution Table*. Percentage changes for each bear should be rounded to the nearest 50 before recording.

[**Note:** It is helpful to give each team a different colored marker to enter their data on the class data table. The colors will show concentrations of data.]

19. As students are preparing to share their data in the lab meeting, teachers may wish to model ways to communicate about data and methods. For example, "Our method was to measure the volume before and after by measuring length x width x height, using the highest point on the bear as the height. From the results of our trial, we think bears increase 30%. In our graph you can see that one bear increased 50%, but all our other bears were closer to 30%. One source of error is that a chunk of our yellow bear broke off when we tried to measure it."
20. Ask students to share responsibility for presenting among their group members. Each student should share one or more of the points outlined in *Step #17*.

Day Three: The Lab Meeting—Collaboration and Skepticism

21. **Collaboration:** In your role as PI, explain that today you will be convening a ***lab meeting*** for the scientists to share their initial data, review the methods of other teams, and give critical feedback to improve the overall quality of science coming from the lab. Tell students there will be a short question and answer period following each informal presentation so that the other teams can assess the quality and validity of the conclusions drawn from the team's data.
22. Revisit any class norms developed earlier about respectful listening and critiquing ideas rather than people.
23. **Skepticism:** Explain that students should be skeptical of each team's work and ask for clarification or explanations in a civil way. Emphasize that the point is not to accuse one another of shoddy work, but to challenge them to think critically about methods that result in the most reliable data. Model for students what would be an appropriate critical, skeptical question ("Why did you choose that method of measurement?") and an inappropriate one ("Why did you do it in such an obviously wrong way?")

> "Skepticism is the agent of reason against organized irrationalism—and is therefore one of the keys to human social and civic decency."
>
> ~Stephen Jay Gould

24. **Courage:** Tell students that full and honest participation in a lab meeting may also require courage on their part. It takes courage to:

- Put out their ideas for criticism.
- Critique the views of others and speak up.
- Give up a cherished idea and not take it personally.

25. Distribute copies of Student Handout 1.2—*Lab Meeting Data Sheet*, one per student, for students to take notes on during the lab meeting, or ask them to take notes in their notebooks.

26. Have the first team present their work. Choose a confident and resilient team that is comfortable serving as a model for the lab meeting, where their results will be questioned and challenged by the class.

27. After the first team presents, have students consider whether the team used a "scientific" approach. Derive the ideas that scientific approaches are precise (not vague) and have a solid design (for example, confounding variables are controlled), and that scientific answers are well-supported with evidence.

28. Open the class up to other questions from students. If spontaneous questions from the class do not address the topics below, you may need to provide some facilitation. For example, you can ask each lab team to come up with a question for the first presenting team.

29. As students ask questions, it may be helpful to write them on the board, grouped by topic. Leave these questions up on the board during the rest of the presentations.

Measurement method
How did you measure? How did you make sure each member of your team measured the same way? Did you check each other's measurements to make sure you were consistent?

Claims, Evidence, Reasoning
What did you conclude about your method of measurement? Can you explain how your data or experiences support your claim?

Overall Approach
What would you do differently next time? What were possible sources of error? Should the whole class use your approach if we were to do this again? Why or why not?

Data
What do your data show? Did you check each other's math when calculating percent size change?

30. Repeat this process for the remaining teams, allowing questions to be student-driven. Teachers can facilitate the lab meeting by helping students recognize areas in which questioning may be productive.

[**Note:** It is natural that the focus of a presentation is on the presenters. A good lab meeting, however, relies heavily on good questions from the student listeners. As a challenge to the class, have them write down the ***best question posed*** at the end of Student Handout 1.2—*Lab Meeting Data Sheet*.]

31. Once all teams have presented, lead the class in a discussion about the overall quality of the investigation.

   a. Do you feel you can confidently determine the percent change in volume that occurs in gummy bears soaked in water using the conclusions presented? Why or why not? (*Challenge them if they say yes!*)

   b. Which measurement method appeared to give the most consistent results? Does this mean it results in the most valid data? How would you be able to test the validity of the data? (*Replication*)

32. *Questions #c-e* are optional, if time allows.

   c. Which team appears to have the most consistent data? Does this mean they have the most valid data? How would you be able to test the validity of their conclusions? (*Replication*)

   d. What characteristics of good scientific design might be missing from the protocols? What changes need to be made?

   e. What variables were controlled for? (*Amount of water, size of beaker, etc.*) What was the treatment?

33. Explain to students that scientists commonly engage in these types of discussions to improve techniques and solve problems. The problem they should be able to discover with this initial investigation is that the irregular shape of the gummy bear makes it difficult to measure accurately and consistently across trials.

34. Ask students to think about possible ***sources of error*** in this trial and how to remedy those. They may also point out the small ***sample size*** makes variability in the data more significant. Lead them to the idea that in the next trial, the class could pool all its data to make a larger sample size.

Day Four: Collaborative Redesign

35. Facilitate a student-led brainstorming session about ways to modify the existing protocol to get better measurements. Allow for a variety of creative solutions. Tell students that as their PI, you would like to see them improve the protocol for this investigation to get more accurate and consistent results across all teams to publish your lab's findings. Stress that in authentic scientific research (unlike experiments often done in schools), procedures and/or experiments are often repeated.

36. Record students' suggested methods on the board or ask a student to do so. Facilitate a discussion of their pros and cons. Ask for clarification when necessary, but allow students to control the overall research design as much as possible.

37. Have the class agree on one method that all teams will use for a second round of the investigation. Guide them through this by recording their ideas on the board for all to see. Make sure to allow adequate time for this discussion; a high tolerance for long pauses and plenty of "think time" is helpful.

38. Students should record the new protocol they will use in their journals or on a sheet of paper they can attach to Student Handout 1.1—*Gummy Bear Lab Protocol*.

39. Give students time to complete the new protocol.

40. Provide closure by asking students: How did the lab meeting tie back to the ideas of communication, collaboration, and skepticism? What about courage?

41. Let the beakers sit undisturbed overnight.

Day Five: Peer Review and Integrity

42. Students should collect the beakers that soaked overnight and make/record their final measurements.

43. One person from each team should record their results (rounded to the nearest 50) on a second copy of Teacher Resource 1.1—*Class Frequency Distribution Table*. Again, it may be helpful for each lab group to use a unique pen color.

44. Display the *Class Frequency Distribution Table* for all to see. Have students ask questions of each other and discuss the quality of results. Make sure to address whether any teams ran into problems with the new protocol or deviated from the new protocol. It is not necessary to have each individual group present at this time; instead focus on the whole-class discussion.

45. Ask students if they think this data and their conclusions are strong enough to be published and read by other scientists. Explain to them that this is called peer review and is part of the checks and balances that make scientists accountable for the quality of their work. Explain that scientists submit papers (much like a lab report) to scientific journals. The editors and other scientists review the work to see if it is worthy of publication.

46. Tell students that peer review can happen on a number of levels. For example:
    - ***Small-scale peer review*** happens when members of a team or lab group question and critique each other's work internally. Students have just participated in this type of peer review during the lab meeting, and may be familiar with this from peer-review experiences in other classes.
    - ***Large-scale peer review*** happens when a team or lab group shares their ideas and findings with the broader scientific community. This provides a way for claims and evidence to be rigorously examined by others who are knowledgeable in a field. Scientific findings that have been accepted over time by the scientific community move knowledge forward and help make science more "objective." Submitting papers to a peer-reviewed journal is one example of this type of peer review. However, future findings might cause scientists to revisit their understandings, and thus scientific knowledge ultimately remains tentative even when a large body of evidence supports it.

47. Explain that while the practices of peer review and publication lead to a way of knowing about the world that can be very reliable, the pressure on scientists to publish in a peer-reviewed journal can be intense. Hence the saying, "*Publish or Perish*."

48. Ask the class, "Did any teams leave out information when you presented to the class?" For example, did teams report on bears that broke? Did teams report on whether or not they blotted the bears before measuring? Ask if, in general, there were places where data could be ignored, fabricated, or falsified. How would students feel if their careers depended on the publication of this data?

49. Ask students how integrity and honesty in data collection impact the classroom results. In a collaborative environment, one person's dishonesty can have an effect on everybody in the lab, especially if the group's work will be published with shared authorship. For many reasons, it is important that all information (like data, how it was analyzed, results, graphs, conclusions, and explanations of how the study was done) be made available to anyone wishing to see it. Making the steps and actions taken during the lab easily understood and clear to others is called **transparency**.

[**Note:** Of the more than 2,000 papers that were retracted from scientific journals between 1977 and 2010, two-thirds were retracted due to scientific misconduct, which includes plagiarism as well as knowingly and intentionally falsifying data.]

50. Tell students that scientific research can lead to data and facts that are reliable and durable, so many people consider "science" to be very objective, or leading towards "truth." The ***process*** of scientific research, however, is a human endeavor and open to subjectivity. For example, cultural elements influence how science is conducted, how science is communicated, and what science gets funded.

51. Collect the *Student Handouts* and/or lab notebooks and tell students that as the PI, you will use their work to write a (fictitious) paper for submission to the *Journal of Applied Polymer Confections*.

52. Before submitting the "paper" to the journal, ask the students, "Who should get credit for the work?" and "In what order should names be listed on the submitted paper?" Tell students that these are very important questions in the scientific community. In most publications, the order in which the authors are listed denotes the relative contribution of each person. In some cases, relative contribution is made apparent through font size, how the name is listed, or through side notes. Different scientific journals have different established norms for publication.

53. Tell students you have sent off their work in a paper called "The Effect of Hydration on a Gelatin Polymer Confection." You have (remarkably quickly) received a letter from the editors of the *Journal of Applied Polymer Confections*. (To maintain the imagined scenario, teachers may choose to wait a few days to "receive" the letter from the journal.) The editors have sent your paper to a number of other scientists in the field of polymer confections for peer review. Based on the peer review, the editors have accepted the work, but the reviewers request modifications. Their critique includes these issues:
    - Sample size is too small for data to be significant.
    - A stronger connection to the social impacts and applications to future research should be made.
    - Explore how different colors, brands, and formulations of gummy bears (gelatin vs. vegetarian pectin types) are affected by hydration.

54. Explain that this type of critique is common and that science is always expanding and questioning what is known. Explain that the process of having one's work published in a highly-regarded journal is very competitive. For example, the journal *Science* accepts less than 8% of the articles submitted.

55. Review with the class the process they completed and how this models the same process that scientists complete: collaboration within investigations, repeatable procedures, multiple trials, peer review, revision of procedures, and publication of results. This provides a segue to *Lesson Two*, in which students explore the qualities that make a successful scientist using a text-based discussion.

56. Lastly, show students the simulated letter, Teacher Resource 1.2—*Journal of Applied Polymer Confections Acceptance Letter*, stating that their paper has been accepted with revisions.

Closure

57. Ask students, "Was this lab really about gummy bears? Why or why not?" Lead students to the idea that the processes they took part in are important in all fields of science, from physics to bioengineering. In school, students are often asked to ***master*** prior knowledge. In this lab, they were involved in the process of ***creating*** new claims and discussing/critiquing the claims of others, which are essential parts of the scientific process. Tell students that not all scientific activities are "experiments"; there are many types of scientific practices such as observation/measurement that are also important.

58. Ask students whether the lab meeting is like any other types of discussions they have had.

59. Have students retrieve their *Unit Graphic Organizer* handouts and look at the first column titled "Research Process." Ask students, "What are the structures, systems, or ways of thought that lead to reliable results in research?" Students should brainstorm and write down phrases such as:
    - Working collaboratively.
    - Communicating with each other and the wider scientific community.
    - Demonstrating skepticism.
    - Performing multiple, repeatable trials.
    - Process of peer review and publishing.
    - Being persistent despite setbacks.
    - Working and reporting with integrity.
    - Being comfortable with ambiguity.

60. In addition, draw students' attention to the last column, "*Being a Scientifically Literate Citizen*." Ask students how their understanding of the research process impacts them as students. Discuss their responsibility to be scientifically literate in their role as a ***student*** and add that word to the graphic organizer.

Assessment

61. Instruct students to choose two characteristics of scientific research the class explored during this lab (i.e., communication, collaboration, skepticism, integrity, courage, peer review). For each one:
    a. ***Define*** the concept (what does the word mean?)
    b. ***Identify*** its importance (how and why is it necessary?)
    c. ***Give an example*** of what it looks like in the science classroom (for example, in the gummy bear lab or in another activity).
    d. ***Give an example*** of what it looks like in the greater scientific community.

    This assessment is similar to the end-of-unit *Summative Assessment* and will familiarize students with the process. A rubric for this is also included at the end of this lesson. In addition, teachers may choose to have students complete a formal lab write up for this lesson, or write a brief paper outlining their methods and results to submit for publication in the *Journal of Applied Polymer Confections*. These may be assigned as homework.

62. If time permits, also revisit the Formative Assessment—*Statements about the Social Nature of Scientific Research* and discuss how students' ideas about science have changed—or not. Ask students to provide examples and reasons for their answers, referring to specific activities that took place throughout the lesson.

HOMEWORK

Students can choose one of the short stories found in *The Scientist* magazine's "Top Science Scandals of 2011" and "Top Science Scandals of 2012" and explain how the story illustrates a ***lack*** of integrity, collaboration, skepticism, peer review, or other foundations of good scientific research. The stories can be found here:

- http://the-scientist.com/2011/12/19/top-science-scandals-of-2011/#disqus_thread
- http://www.the-scientist.com/?articles.view/articleNo/33695/title/Top-Science-Scandals-of-2012/

EXTENSION

Students can conduct additional research online related to water retention in polymers. This research is connected to "ecospheres" and other products that improve the capacity of soil to hold water.

GLOSSARY

Collaboration: Working together to create something, solve a problem, or answer a question.

Communication: Sharing information with others.

Diffusion: The passive movement of molecules from an area of high concentration to an area of lower concentration.

Integrity: Honesty and truthfulness in one's research; avoiding cheating and plagiarism.

Peer review: The evaluation of scientific work or findings by others working in the same scientific field.

Polymer: A molecule or compound made up of several repeating units.

Repeatable trials: A feature of a valid scientific experiment, meaning it can be performed multiple times and produce the same or similar results.

Skepticism: A doubting or questioning attitude or state of mind.

Transparency: The quality of a scientific experiment or other process that allows others to easily see what actions have been performed.

SOURCES

University of California Museum of Paleontology. (2013). "Scrutinizing science: Peer review." *Understanding Science*. Retrieved from http://undsci.berkeley.edu/article/0_0_0/howscienceworks_16

Group of Gummy Bears Photograph. Thomas Rosenau/Wikimedia Commons.

Jelly Beans Photograph. Gcardinal from Norway/Wikimedia Commons.

Gummy Bear Lab Protocol

Name____ Date______________ Period______________

Communication, Collaboration, and Skepticism

GB Discovery Laboratory

Improving the quality of life with polymers

Welcome to your new job as a scientist for GB Discovery Laboratory. We are dedicated to designing polymer solutions to problems in biology and medicine. **Polymers** are large thread-like molecules made of smaller repeating chemical subunits. The specialty of your department is quantifying the effectiveness of liquid-absorbing polymers. Your department has previously studied and published their experimental findings on liquid-absorbing polymers used in soft contact lenses, dressings for burns, tissue engineering, and oil spill containment.

As members of the scientific community, we value and expect your full participation in our department lab meetings. Working with others is critical to improving the quality of science done by our group. Our lab meetings will focus on:

- **Communication** – sharing your information with others.
- **Collaboration** – working together with others toward a goal.
- **Skepticism** – evaluating information critically and looking for evidence and reasoning behind claims.

Your department has been divided into lab teams to investigate the ability of gummy bear polymers to hold water. Our goal is to determine the best procedure for measuring changes in gummy bear volume. Your team will design a plan, conduct an experiment, and then share your findings with the entire department during our next lab meeting. Following our own internal **peer review**, GB Discovery Laboratory plans to submit your findings for publication in the *Journal of Applied Polymer Confections* for broader peer review by the scientific community.

Day One Protocol

1. In your lab notebook, record your descriptive observations about the gummy bear, including color and shape.

2. Record the question: *How much does the volume of a gummy bear increase after soaking in water?*

3. Collaborate with your lab team to determine a way to measure the volume of the gummy bears. [**Note:** There are many ways possible.]

4. Once you have agreed on a method, record your planned procedure.

5. Construct a data table to record the volume data of each team member's gummy bear. Be sure to have a column for "Initial volume before soaking" and "Volume after 24 hours" (or however long you soaked your bears).

6. Measure your bear using the team method, record the measurement in your data table, and communicate your findings so each team member includes all bear volume data in their table.

7. Soak the bears overnight in a beaker of water.

Day Two Protocol

8. Gently remove gummy bears from the beakers and pat them dry. Be very careful because the candy is now extremely breakable.

9. Using the same method your team used before soaking, measure the volume of the bears and record the data in your table.

10. Calculate the percent change for each measurement for each bear using the formula provided below. Share your answer with your team members.

$$\textbf{Percent change} = \frac{\textbf{FINAL – INITIAL}}{\textbf{INITIAL}} \times 100$$

FINAL = VOLUME *after* 24 hrs
INITIAL = VOLUME *before* soaking

11. Your teacher will have a *Class Frequency Distribution Table*. Choose one member of your team to record your data on the table in the color assigned to your team. You will need to round the percentage change for each bear to the nearest 50 before recording your data.

12. Answer the following questions in your lab notebook:
   - What was your method?
   - What can you conclude about the effectiveness of your method of measurement? (***Claim***)
   - What did you find to be the percentage increase of gummy bears soaked in water?
   - How do the data or your experiences support your conclusion and why? (***Evidence and reasoning***)
   - What worked with your method? What did not?

13. Collaborate with your team to divide the previous questions among your team members and be prepared to communicate the answers to the class.

14. Throw the bears away in the trash and clean out your beakers. Follow your teacher's instructions on putting away the lab equipment.

STUDENT HANDOUT 1.2

Lab Meeting Data Sheet

Name______________________________ Date______________ Period______________

Lab Team	Percent Change of Bear Volume(s)	Clarifying Questions, Responses, and Notes

Challenge: Write down the ***best question*** asked by a student listening to team presentations.

HANDOUT

Lesson Assessment

Name____ Date_______________ Period_______________

Gummy Bear Lab Meeting: Social Practices in a Scientific Community

Instructions:
Choose two characteristics of scientific research that we explored during this lab.
(i.e., communication, collaboration, skepticism, integrity, courage, peer review). For each one:

a. ***Define*** the concept (what does the word mean?)

b. ***Identify*** its importance (how and why is it necessary?)

c. ***Give an example*** of what it looks like in the science classroom.

d. ***Give an example*** of what it looks like in the greater scientific community.

Rubric:

Exemplary	Proficient	Partially Proficient	Developing
Student is able to ***define two concepts, identify their importance, and give examples of their applications***			
Student defines concepts and clearly articulates their meaning.	Student clearly defines concepts.	Student partially defines concept(s).	Student defines concept(s) poorly.
Student identifies the importance of each concept, addressing both how and why each is necessary.	Student identifies the importance of each concept.	Student only partially identifies the importance of each concept.	Student discusses the importance of each concept briefly or not at all.
Student demonstrates thoughtfulness and insight in connecting each concept both to the classroom and to the scientific community.	Student connects each concept both to the classroom and to the scientific community.	Student only partially connects each concept both to the classroom and to the scientific community.	Student connects each concept both to the classroom and to the scientific community briefly or not at all.
Student addresses more than one concept.	Student addresses more than one concept.	Student only addresses one concept.	Student only addresses one concept.
Student expertly uses vocabulary and examples to explain concepts and their applications.	Student uses vocabulary and examples to explain concepts and their applications.	Student uses vocabulary and examples to explain concepts and their applications but the examples may lack clarity and/or contain minor errors in understanding.	Student examples may lack clarity and/or contain major errors in understanding.

TEACHER RESOURCE 1.1
Class Frequency Distribution Table

RESOURCE

Instructions:
Round the percentage change in volume for each bear to the nearest 50. Place an X in the appropriate column, using your team's color, if instructed to do so. Make sure all of the X's are the same size.

Circle One: Protocol 1 Protocol 2

Number of Bears

200	250	300	350	400	450	500	550	600	650	700	750	800

Percent Change in Volume

Journal of Applied Polymer Confections Acceptance Letter

Journal of
Applied Polymer Confections

JAPC-C-12-033299
The effect of hydration on the volume of a gelatin polymer confection

Dear Authors,

Thank you for submitting your revised manuscript to the *Journal of Applied Polymer Confections* for review. After careful consideration and peer review, we feel that your manuscript is ***suitable for publication with revisions***.

Please address the following critiques from the reviewers:

From Reviewer #1:

- Sample size is too small for data to be significant.
- A stronger connection should be made to the social impacts and applications to future research.

From Reviewer #2:

- Explore how different colors, brands, and formulations of gummy bears (gelatin vs. vegetarian pectin types) are affected by hydration.

Please submit your modifications to the manuscript and responses to the critiques within 60 days.
If you choose not to proceed with publication, please notify us.

Yours sincerely,

Leena L. Pranikay, Ph.D.
Academic Editor

Journal of Applied Polymer Confections

HANDOUT