OVERVIEW

In this lesson, students participate in lab activity designed to help them define qualities that result in reliable and meaningful scientific research. Students are asked to develop a protocol for extracting DNA from whole strawberries. By having students create a protocol, 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. After each group tests their initial protocol, students will present their findings in a lab meeting styled class discussion in order to collectively “make sense” of their findings. During the lab meeting, students will use the class’s “norms of discourse” to skeptically and collaboratively develop a new protocol. Teams will then repeat the lab activity using the class-developed protocol.

KEY CONCEPTS

- Social interactions are a key part of the process of sense-making in 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.
- Skepticism is valued in science; scientists actively question the methods and findings of others and do not accept claims that do not have strong evidence and support behind them.

PURPOSE

Students will know:

- An organism’s DNA is sequestered within the nuclei of its cells.
- DNA can be extracted from cells using mechanical and chemical means. Knowledge of the properties of cell components as well as the composition of materials used in the extraction can help in developing an effective procedure.
- 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 class approaches.
- Make claims and support them with evidence and reasoning.
- Critically and respectfully evaluate the claims of others.
- Revise methods in light of group discussion.

LAB TIMELINE

<table>
<thead>
<tr>
<th>PART</th>
<th>DAY</th>
<th>TIME</th>
<th>TASKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engage &amp; Explore</td>
<td>1 &amp; 2</td>
<td>100 min</td>
<td>Introduction, Conduct a collaborative lab investigation, Communication / Collaboration Check-In</td>
</tr>
<tr>
<td>Explain &amp; Elaborate</td>
<td>3 &amp; 4</td>
<td>100 min</td>
<td>Lab meeting / seminar, Redesign protocol / protocol testing</td>
</tr>
</tbody>
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TEACHER PREPARATION

- Make copies as described in the Materials section.
- Set up an area in the classroom that students can access the different resources and measuring tools for DNA extraction.
- Make the “Bag-In-A-Bag” cell model.
- Perform a strawberry DNA extraction to use as the investigative phenomenon for the class.

“BAG-IN-A-BAG” CELL MODEL

During Days One & Two, you will present different analogies for extracting DNA from a cell. Abstract analogies such as breaking into a bank and opening complex packaging help students think about how to approach this activity. The “Bag-In-A-Bag” model, provides a direct and physical representation of cell structure.

**Materials:**
- Cardboard box = plant cell wall
- Large paper bag = cell membrane
- Shredded plastic bags (filler) = cytoplasm
- Smaller paper bag = nucleus
- Yarn = DNA

INVESTIGATIVE PHENOMENON: EXTRACTED STRAWBERRY DNA

During Days One & Two, you will present some strawberry DNA that has already been extracted. This will help generate questions. It will also serve as an example of what the final product should look like.

1. Make the DNA Extraction Buffer by mixing the following ingredients:
   - 10 ml dishwashing soap
   - 90 ml water
   - 1.5 g salt
   - Pinch meat tenderizer

2. Place one strawberry in a plastic baggie and mash it into a pulp.

3. Add 10 ml DNA Extraction Buffer to the bag. Carefully mix the contents. Avoid bubbles.

4. Place a gauze-lined funnel on top of a 15 ml collection tube and pour the contents of the bag through the filter. Try to collect 3 ml of the strawberry mixture.

5. Slowly add 5 ml of cold ethanol to the liquid along the side of the tube to create a layer of ethanol on top of the strawberry mixture.

6. The strawberry DNA should precipitate out of solution into the ethanol.
Procedure

In this lesson, students are tasked with creating a protocol for extracting DNA from strawberries. The students will have to collaborate within their teams for the initial design. Resource Cards show the materials available and their properties. Some materials are decoys like baking soda and vinegar, while others are commonly found in DIY DNA extraction protocols. Students will need to create steps using their collective knowledge about cells and DNA.

DAYS ONE & TWO – EXTRACTING DNA

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 aspect 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. Ask students: “Why is it important that scientists communicate with each other and with society about their discoveries?”
4. With student input, create working definitions of communication, collaboration, and skepticism:
   - **Communication**: Sharing information with others.
   - **Collaboration**: Working together with others towards a goal.
   - **Skepticism**: Evaluating information critically and looking for evidence and reasoning behind claims.
5. Discuss any norms of discourse that may have already been established in your class.
6. Tell the students that they will be working in groups to extract DNA from cells. Unlike typical lab activities, the students will need to figure out the logical steps needed to accomplish this goal. Each group will need to use their collective understanding of the cell and DNA in order to inform their design. As a group, they will need to agree on order of events, amounts, time, temperature, and materials.

Note: Students may be tempted to find a protocol online. There are several possible approaches. You could say nothing (field testing has shown students are unlikely to look for protocols if the issue is not raised). Or, you can emphasize that the purpose of this lab is communication and collaboration and that online methods may not necessarily be better than theirs.

7. **Tell students the essential question:** “How can we figure out how to get DNA out of cells?” Ask to think/pair/share about, “What do we need to know to answer this question?”
8. Possible answers include: Information about the properties of the cell, DNA, types of tissue. Information about tools, chemicals, and methods. Identify possible constraints.
9. As a class have students activate their background knowledge by discussing what they know as a class.
   - What do we know about DNA and cells?
   - What do we know about the physical features of DNA?
   - Is there anything on our list that would explain why scientists would be interested in getting DNA out of the cell? (This is called “extracting” it.)
10. Relate DNA extraction to breaking into a bank or opening a complex package. Use the “bag-in-a-bag” cell model to have students think about the structure of a cell. Discuss how to think about different reagents as chemical tools they might use to break into a cell.
11. **Present the DNA: a test tube with DNA that has already been extracted.**
12. Emphasize that this DNA was extracted with one possible protocol but that there are MANY ways to extract DNA and that they might design a way that is better than existing ways. Emphasize that scientists are actively researching ways to extract DNA easily and efficiently. Ask students if they have additional questions.
13. Organize students into teams of four. Each team should meet at a lab station, to begin to develop their protocol.

Protocol Development

14. Hand out copies of the Tech Guide and Resource Cards to each student. Have teams read and discuss the resources available by reading through the cards.
15. Each team will collaborate on their protocol. The final procedure must be agreed upon by all team members before it can be presented to the teacher.
16. After the teacher signs off on the initial protocol, each student will complete the Communication/Collaboration Check-In.
Initial Testing

17. Lab teams can spend the rest of the class time testing their protocol. During testing, students will need to make notes on any change, observations, or clarifications they need to make in their lab notebooks.

18. Lab results will be stored in the refrigerator for discussion next class.

19. For homework, have students consider changes they would make to their protocol and give reasoning for each change.

Days Three & Four: Lab Meeting

1. Tell students that they need to prepare for a “lab meeting”, where they will discuss their initial results as a class. Ask students what the goal of a “lab meeting” might be. Possible answers might include:
   a. To compare findings.
   b. To analyze each other’s work.
   c. To figure out what to do next.

2. Students have been collaborating in their teams so far, and now they are preparing to collaborate with the larger lab group (whole class).

3. Tell students that during the discussion, teams take turns presenting their protocol and their results. 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 made from the team’s data.

Lab Teams Prep for Lab Meeting

4. To prepare for the lab meeting, each group should prepare to communicate to other groups a summary of their protocol and how well their method of extraction worked out. Student should work with their group to write the answer to the following questions in their lab notebooks:
   a. What was your protocol?
   b. What can you conclude about the effectiveness of your method? (claim)
   c. How do your results support your conclusion and why? (evidence and reasoning)
   d. What worked with your protocol? What did not?

5. Ask students to share the responsibility of presenting among their group members.

Review Norm for Discourse

6. Before the lab meeting, revisit any class norms developed earlier related to respectful listening and critique.

   a. 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.
      • Appropriate: “Why did you choose that method of measurement?”
      • Inappropriate: “Why did you do it in such an obviously wrong way?”

   b. 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.

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

Lab Meeting

(Optional: Students can also share physical copies of their protocol or summarize it on whiteboards or large post-its.)

8. Have the first team present their work. Choose a confident and resilient team that is comfortable serving as a model for the lab meeting, which entails having their results questioned and challenged by the group.

9. Have students consider whether the group used a “scientific” approach to developing their protocol. Was their design informed by their understanding of the cell? Is their protocol replicable?

(Note: To allow enough time for everyone to participate, you may decide to limit the number of comments or questions each student can give.)

10. Open the class up to other questions from students. If spontaneous questions from the group do not address the following topics, you may need to provide some facilitation. For example, you can ask each lab team to collaboratively come up with a question for the first presenters.
11. As students ask questions, it may be helpful to write them up on the board as they are asked, grouped by topic. Then, leave these questions up on the board during the rest of the presentations. Alternatively, you may wish to have students brainstorm the type of questions they could ask in each category before starting the lab meeting.

**Protocol Design**
Why did you decide on that sequence? Why did your group choose to use those materials? Are the amounts specified?

**Claims, Evidence, Reasoning**
What do your results show? What did you conclude about your protocol? Does it seem like your team successfully extracted DNA? What evidence do you have for your claim? Can you explain how your data support your claim?

**Overall Approach**
What would you do differently next time? Should the whole class use your approach if we were to do this again? Why or why not? Was there anything you learned from the other team presentations that could help with your protocol?

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

13. Explain to students that scientists commonly engage in these types of sense-making discussions in order to improve techniques, understand results, and solve problems.

**Protocol Re-write**
14. As a class, brainstorm ways to improve the protocol. On the whiteboard, write the different steps, allowing students to revise or interject ideas or questions in the process.

15. Once the class has completed and agreed on a class protocol, have students to return to their groups to conduct the experiment. Each group should use the protocol that was developed as a class.

16. Store lab results in the refrigerator for discussion next class.

**DAY FIVE: EVALUATE**

17. Lab groups compare the success of their initial protocol against the class-developed protocol. The outcome of their experiment is not the criteria for success.

18. Students complete the Post-Assessment to evaluate how their thinking about communication and collaboration in scientific investigation has changed, if at all.

19. Ask students, “What are the actions or behaviors of scientists that lead to reliable results in research?” Students should brainstorm and write down phrases such as:
   - Working collaboratively.
   - Communicating with each other and wider scientific community.
   - Having skepticism.
   - Performing multiple, repeatable trials.
   - Process of peer review and publishing.
   - Having persistence despite setbacks.
   - Working and reporting with integrity.
   - Having the courage to share results.
   - Being open to suggestions for improvement.
   - Being comfortable with ambiguity.

20. Debrief the question as a large group.

21. Give each student the Post-Assessment.

22. Instruct students to choose one characteristic of scientific research the class explored during this lab (i.e. communication, collaboration, skepticism, integrity, courage). 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 this lab or in another activity).
   d. Give an example of what it looks like in the greater scientific community.

23. Have students share this their example with a partner who was not in their lab group.
CREDITS

Based on materials developed by:

- Wendy Crocker, Shoreline High School, WA
- Krystal Bass, Kentridge High School, WA
- Northwest Association for Biomedical Research

### MEAT TENDERIZER

**pH:** 6-8 (slightly alkaline)

**Description:**
Meat tenderizer is a solid, seasoning like compound added to meat to make it more tender. The active ingredient is papain.

**Function:**
Meat tenderizer interacts with the proteins, breaking them down so the meat becomes softer and easier to chew/digest.

**Type of Molecule:**
papain—an enzyme derived from papaya functionally digests proteins

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### DISHWASHING SOAP

**pH:** 6-8 (slightly alkaline)

**Description:**
Dishwashing soap is often a liquid that is added to water to aid in washing dishes or other materials.

**Function:**
Removes grease (lipids) and disrupts the connections (bonds) between fat molecules.

**Type of Molecule:**
surfactant—allows hydrophobic (water hating) molecules to be broken apart

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### BAKING SODA

**pH:** 9 (alkaline)

**Description:**
Baking soda is a salt composed of sodium ions and bicarbonate ions. It is a white solid that is usually a fine powder. It has a slightly salty, alkaline taste.

**Function:**
Baking soda is a well-known cooking ingredient used to raise soda breads, cookies and cakes. In addition, it has wide range of applications, including cleaning, deodorizing, maintaining pH, and fire extinguishing.

**Type of Molecule:**
ionic, a chemical salt

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### SUGAR

**pH:** neutral

**Description:**
Sucrose is a disaccharide, meaning it is made of simple sugars joined together. It is 50% glucose and 50% fructose.

**Function:**
Sucrose is a naturally occurring sugar (carbohydrate). It is found primarily in plants, where it serves as a way to store energy. It is usually found in roots, fruits and nectars. Animals obtain sucrose by feeding on plants.

**Type of Molecule:**
polar, covalent bonds, carbohydrate (disaccharide)

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### SALT

**pH:** 7-8 (mostly neutral)

**Description:**
Salt water is water containing salt (NaCl). The salt dissociates into charged sodium (Na+) and chlorine (Cl-) ions.

**Function:**
Salt in water allows free Na and Cl ions to easily interact with polar molecules. In salt solutions, polar molecules can form clumps.

**Type of Molecule:**
Ionic compounds

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### OIL

**pH:** neutral

**Description:**
Triglycerides are the main component of most food fats and oils. A triglyceride is composed of glycerol and three fatty acids.

**Function:**
Assists in heat transfer in cooking. Add flavor and texture.

**Type of Molecule:**
non-polar, covalent bonds, lipid

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### FILTER

**pH:** N/A

**Description:**
A type of paper or cloth that often has very small pores (openings) or a fine mesh.

**Function:**
Filters are used to collect large piece of materials or debris that can be found in liquids—separating large pieces from small pieces—letting small pieces through the filter while large pieces stay on top of the filter.

**Type of Molecule:**
N/A

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### WATER

**pH:** 7 (ideal, neutral)

**Description:**
A polar molecule made of hydrogen and oxygen, participates in hydrogen bonding, important for all life

**Function:**
Water acts as a solvent, allow salts to dissolve and providing a pH buffer in chemical reactions.

**Type of Molecule:**
polar, covalent bonds, hydrogen bonds

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### VINEGAR

**pH:** ~2.4 (acidic)

**Description:**
Vinegar is a liquid that is produced from the fermentation of ethanol into acetic acid. The fermentation is carried out by bacteria. Vinegar consists of acetic acid (CH3COOH), water and trace amounts of other chemicals.

**Function:**
A cooking ingredient also used for pickling

**Type of Molecule:**
Polar, covalent bonds
PINEAPPLE JUICE

ETHANOL
<table>
<thead>
<tr>
<th>ALCOHOL (ETHANOL)</th>
<th>pH: 7.33 (mostly neutral)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DESCRIPTION:</td>
<td>Alcohol—ethanol—is a small molecule with a reactive OH (hydroxyl) group present.</td>
</tr>
<tr>
<td>FUNCTION:</td>
<td>Ethanol does not interact with DNA and will allow the DNA to resist interaction with water; DNA clumps together in the presence of ethanol.</td>
</tr>
<tr>
<td>TYPE OF MOLECULE:</td>
<td>polar, covalent bonds (OH)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PINEAPPLE JUICE (BROMELAIN)</th>
<th>pH: 3.5 (acidic)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DESCRIPTION:</td>
<td>Pineapple plants contain bromelain. Bromelain is a proteolytic enzyme (an enzyme that digests proteins) found in fresh pineapple.</td>
</tr>
<tr>
<td>FUNCTION:</td>
<td>Bromelain is one of the most popular enzymes used to break down proteins in food items, like gelatin and meat.</td>
</tr>
<tr>
<td>TYPE OF MOLECULE:</td>
<td>Protein, peptide</td>
</tr>
</tbody>
</table>
### Lab Meeting Data Sheet

<table>
<thead>
<tr>
<th>Name ___________________________</th>
<th>Date ___________</th>
<th>Period ___________</th>
</tr>
</thead>
</table>

#### Clarifying Questions, Responses, and Notes

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

#### Protocol Highlights

#### Lab Team
Communication / Collaboration Check-in

How's Our Group Communication and Collaboration Working?

1. Everyone has a chance to participate equally in our discussion.  Yes  No
2. Everyone is listening well to contributions.  Yes  No
3. Someone in our group is taking over.  Yes  No
4. I am “keeping up” and understanding what our group is doing and why.  Yes  No
5. We have divided up the work fairly.  Yes  No
6. I would rate our collaboration as:  Non-existent  OK  Very Good
7. I give this rating because:
8. One improvement I would suggest in order to improve our communication and collaboration is:

Post-Assessment

Post-Assessment
1) Your Current Knowledge of the Experiment
   a. What do you now know that you didn’t know before about how get DNA out of a cell?

2) Your Current Ability to Communicate Using Evidence – indicate by putting an X on the line
   a. Rating Scale: My current ability to communicate using evidence when talking in my lab group.

   1 .......................... $.......................... 10  
   1 = very low  
   10 = very high

   b. Rating Scale: My current ability to communicate using evidence when talking in large class “lab meeting”.

   1 .......................... $.......................... 10  
   1 = very low  
   10 = very high

   c. What is one way in which you grew in your ability to participate in a class discussion? Be specific. Give an example from the lab group work or meeting if possible.