BIOTECHNOLOGY (HS)

DNA extraction

Focus questions	How might we see the raw material of life, DNA?
Vocabulary	Protocol, extraction, communication, collaboration, skepticism
Learning target	Students develop a protocol (uniform accepted method) to extract DNA from corn.

This activity is adapted from Chowning, J. T., Wu, R., Brinkema, C., Crocker, W. D., Bass, K., & Lazerte, D. (2019, February). A new twist on DNA extraction. *The Science Teacher.* **libguides.fredhutch.org/SEP/sep/dna**

HS-LS1: From Molecules to Organisms: Structures and Processes

Performance expectation HS-LS1-1	**Classroom connection:** This activity is one step toward the accomplishment of this performance expectation. Making DNA visible helps students to begin to *construct the explanation.*

Science and engineering practices

Constructing Explanations and Designing Solutions	**Classroom connection:** Students design their own solutions to address the problem of how to extract DNA from cells. They then plan and carry out an investigation based on their experimental designs. Afterwards, they construct claims for the results they observe based on evidence from their results. They communicate information about their findings with other teams in a classroom "lab meeting" discussion where students respectfully question and critique each other's designs. Finally, students collaboratively argue for how the protocol could best be redesigned, based on evidence from class data.

Disciplinary core ideas

LS1.A: Structure and Function	**Classroom connection:** This activity reinforces that DNA is located in cells and is sequestered/protected within the nucleus.

Cross-cutting concepts

Structure and Function	**Classroom connection:** Students base their solutions to the problem posed in the activity on the properties of different materials made available for use in their protocols and their potential effects on the structures and functions of cellular components.

Background

This activity allows students to practice creating a protocol to extract DNA from corn. A protocol, or established procedure, is important to assure replication and high-quality results. Protocols consist of detailed step-by-step instructions. A current protocol may be revised if and when new technology or materials become available. Different labs researching the same thing may use different protocols based on the equipment and resources available.

In this lesson, students are tasked with creating a protocol for extracting DNA from corn. 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.

Prior knowledge

In order to successfully complete this activity, students should know:

- An organism's DNA is 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.

Teacher preparation

Step-by-step guidelines are included on the student sheet to allow students some structure for the development of their protocols within their groups.

1. Make copies as described in the Materials section.
2. Set up an area in the classroom where students can access the different resources and measuring tools for DNA extraction.
3. Make the "Bag-In-A-Bag" cell model.
4. Perform a DNA extraction from corn to use as the investigative phenomenon for the class using the procedure below.
5. Make the DNA Extraction Buffer by mixing the following ingredients:
    a. 10 ml dishwashing soap
    b. 90 ml water
    c. 1.5 g salt
    d. Pinch meat tenderizer
6. Place a cup of canned or frozen whole corn in a plastic baggie and mash it into a pulp.
7. Add 10 ml DNA extraction buffer to the bag. Carefully mix the contents. Avoid bubbles.
8. 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 corn mixture.
9. 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 corn mixture.
10. The corn DNA should precipitate out of solution into the ethanol.

For additional details and day by day instructions, specifically how to facilitate the protocol development and discussion sessions see: `libguides.fredhutch.org/SEP/sep/dna`

- Allow 2 periods for students to determine protocol for their own lab group and to carry it out.
- Allow 1 period to run lab meeting.
- Allow 1 period to redesign protocol.
- Allow 1 period for evaluation/assessment.

Materials

- Resource cards - 1 set per group printed front to back so descriptions are on the back of each card
- Student handout
- Communication/Collaboration check-In
- Lab meeting data sheet post-assessment
- “Bag-In-A-Bag” cell model - 1 for the class
- Cardboard box = plant cell wall
- Large paper bag = cell membrane
- Shredded plastic bags (filler) = cytoplasm
- Smaller paper bag = nucleus
- Yarn = DNA
- Test tube of extracted corn DNA

For protocol testing:

- gauze (filter)
- funnels
- 15 ml test tubes
- plastic bags
- corn (fresh or frozen)
- vegetable oil
- baking soda
- salt
- vinegar
- water
- sugar
- ethanol (refrigerated)
- beakers
- graduated cylinder
- meat tenderizer

Differentiation

Other ways to connect with students with various needs:

1. **Local community:** Students may visit a local plant pathology or university lab, or invite a technician from the lab, to discover how they do diagnostic or specific lab tests and how the method they use was decided.
2. **Students with special needs (language/reading/auditory/visual):** Students may participate in the activity in a number of ways: choosing the reagents to use, determining the quantity and the temperature requirements, gathering materials once decided upon, measuring the amounts, preparing the DNA by crushing the corn, etc.
3. **Extra support:** If students are struggling, they may watch Fantastic DNA! Extraction Steps at `youtu.be/vpXsWaUrcJs`
4. **Extensions:** Students can try to extract DNA from other fruits or vegetables or try to extract more DNA by increasing the amounts of selected materials.

Assessments

Rubric for assessment

Skill	Developing	Satisfactory	Exemplary
Construct an explanation extracting DNA	Student can describe the activity but does not make connections to the mechanics of extracting DNA.	Student can describe the activity and explain how materials used helped to extract the DNA.	Student can describe the activity and explain how materials used helped to extract DNA, and use the method on various organisms with success.
Communication using evidence	Student shared no ideas or few ideas with the group, providing little to no evidence for them, and had difficulty with the extraction protocol.	Student shared ideas with the group supported by evidence and contributed to the development of the protocol.	Student shared ideas supported by evidence, listened to shared ideas, and helped to evaluate to focus the actions of the group to develop the protocol.
Communication using evidence	Student was unable to construct an explanation connecting a geologic event(s) and soil texture.	Student constructed an explanation using one past geologic event to support the soil texture results.	Student constructed an explanation using more than one past geologic event to support the soil texture results.

Rubrics for self-assessment

Your current ability to communicate using evidence

1. My current ability to communicate using evidence when talking in my lab group. (Indicate by putting an *x* on the line.)

(1) - - - - - - - - - - - - - - (5) - - - - - - - - - - - - - - (10)

very low ... very high

2. My current ability to communicate using evidence when talking in large class “lab meeting”. (Indicate by putting an *x* on the line.)

(1) - - - - - - - - - - - - - - (5) - - - - - - - - - - - - - - (10)

very low ... very high

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

4. I would rate our collaboration as: ☐ Non-existent ☐ OK ☐ Very good
   The reason for my rating is:

   One improvement I would suggest in order to improve our communication and collaboration is:

Final assessment

Skill	**Yes**	**No**
Everyone had a chance to participate equally in our discussion.		
Everyone listened well to contributions.		
Someone in our group took over.		
I "kept up" and understood what our group was doing and why.		
We divided up the work fairly.		

BAKING SODA 	**DISHWASHING SOAP** 	**MEAT TENDERIZER** 
OIL 	**SALT** 	**SUGAR**
VINEGAR 	**WATER** 	**FILTER** 

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

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

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

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)

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

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

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

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

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

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PINEAPPPLE JUICE

ETHANOL

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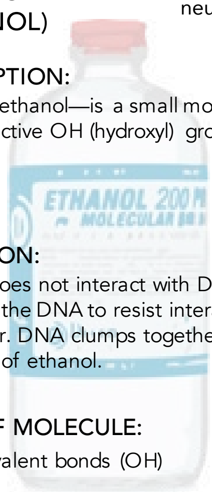


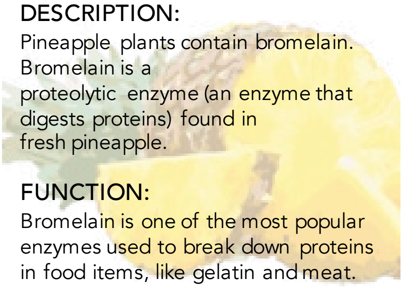
ALCOHOL (ETHANOL)

pH: 7.33 (mostly neutral)

DESCRIPTION:
Alcohol—ethanol—is a small molecule with a reactive OH (hydroxyl) group present.

FUNCTION:
Ethanol does not interact with DNA and will allow the DNA to resist interaction with water. DNA clumps together in the presence of ethanol.

TYPE OF MOLECULE:
polar, covalent bonds (OH)



PINEAPPLE JUICE (BROMELAIN)

pH: 3.5 (acidic)

DESCRIPTION:
Pineapple plants contain bromelain. Bromelain is a proteolytic enzyme (an enzyme that digests proteins) found in fresh pineapple.

FUNCTION:
Bromelain is one of the most popular enzymes used to break down proteins in food items, like gelatin and meat.

TYPE OF MOLECULE:
Protein, peptide