DRIVING QUESTION: HOW CAN WE EXAMINE DNA?

LENGTH: 1 hour

OBJECTIVES: Students will be able to:

- extract DNA from common fruits/vegetables

Standards:

Next Generation Science Standards Addressed

Disciplinary Core Ideas

LS1.B Growth and Development of Organisms

LS3.A Inheritance of Traits

LS3.B Variation of Traits

Practices

Planning and Carrying Out Investigations

Cross-Cutting Concepts

Structure and Function: Complex and microscopic structures and systems can be visualized, modeled and used to describe how their function depends on the relationships among its parts, therefore complex natural structures/systems can be analyzed to determine how they function.

Materials:

- Copies of Lesson 2 Student Handout: Discovering DNA (1 per student)
- Pint/quart sized sealable plastic bag (i.e., Ziploc) (1 per student)
- Previously frozen strawberries (1 per student)
- DNA extraction buffer (10 mL) pre-mixed for class: 50 mL dish soap, 15g NaCl (2 tsp plain salt), 900 mL water
- Paper towels, filter paper or cheese cloth (1 per student)
- Ice cold 90% ethanol or isopropyl alcohol
- Test tube or plastic champagne flute (1 per student)
- Funnel (optional)
- Plastic coffee stir straw (1 per student)

Optional: tomato, banana, avocado, cucumber or other produce to replicate lab

Suggested Video:

"Genetic Engineering" by MIT K12 Videos

https://www.youtube.com/watch?v=nfC689ElUVk (7:20)

Lesson Context

This section provides guidance for teachers for how lessons build on each other.

Now that the students have made their own models of DNA during Lesson 1, it is time they see actual DNA. Lesson 2 provides the opportunity to extract DNA from common fruits and vegetables. The video link will provide the laboratory connection of genetic engineering and how we isolate specific genes in DNA. It also explains the process to clone a desired gene using restriction enzymes, bacterial plasmids, antibiotics and bacteria. This concludes with explaining how gel electrophoresis is used to separate different genes to isolate the desired genes. Gel electrophoresis will be extensively explained during Lesson 6. This is the same technique used to mass-produce insulin for diabetics.

KEY CONCEPTS: The process for discovering biotechnology begins with a strong foundation of understanding DNA. DNA is found in all living things. Sections of DNA are referred to as genes. These genes code for specific amino acids. Amino acids form together to make long chains which are called proteins. These proteins are expressed to give an organism its unique characteristics. In this lab, students will have a hands-on experience extracting DNA.

SETUP:

- Chill the alcohol in a freezer or ice bath for at least one half hour to make it as cold as possible.
- Freeze produce and then allow thawing prior to class. Freezing helps break down the plant material.
- Optional: You may wish to melt the end of a coffee stir straw with a flame to form a hook/knob for ease in catching the DNA.
- Optional: You may wish to place fruit in individual bags prior to the lab to save time in class.

Outline:

1. Distribute student handout Discovering DNA and have students preview the lab procedure.[ii] Answer questions before beginning lab.
   - Place one thawed strawberry in the plastic bag and squeeze until all lumps are turned into a uniform puree.
   - Add 10 mL of buffer solution. Zip the bag closed.
   - By squeezing the bag, mix the strawberry with the buffer solution completely.

- Fold the paper towel into a half circle, then a quarter circle, opening it to form a cone.
- Fill the test tube or champagne flute (approximately two inches) with ice-cold alcohol. Place the filter paper cone into the test tube/flute so that half of the cone is on the inside and half is on the outside of the test tube/flute.
- Fill the paper towel cone with the strawberry solution.
- As the strawberry mixture filters through the cone and comes in contact with the cold alcohol, the DNA will form ribbons and then coagulate at the top of the alcohol.
- Use the straw to scoop and retrieve the DNA.

2. Have the students compare their DNA sample with those of other classmates. Discuss their observations. Ask the students: *Did everyone's DNA look the same? Why did some people have more DNA? Why is isolating DNA an important process? What do you think scientists can learn from studying DNA?* Listen for students to recall that DNA contains genetic information. By studying DNA, scientists are able to identify the genes (genetic markers), which code for specific traits.
3. In the event that one or more students did not have any DNA, explore why not. Listen for students to evaluate if they followed the procedure correctly.
4. If desired, repeat the process with additional samples.
5. When observations have been made, have the students pour contents of the test tubes back into a plastic cup and dispose of the materials as directed.
6. Optional Extension Opportunities:
   - Have students weigh the strawberry prior to testing, and the DNA after separating. Create a class graph evaluating the relationship between weight and amount of DNA collected.
   - Increase the variables (e.g., hot vs. cold alcohol, 70% vs. 90% alcohol, type of soap used in buffer, different types of fruit/vegetables, frozen vs. unfrozen samples, etc.) and compare results.

Additional Content Support

Pre/Post Assessment

This section provides a suggested assessment tool that may be used before and after a lesson to assess student readiness. See the Pre/Post Assessment file for a ready-to-distribute copy for your students.

1. What are genes? A section of DNA that encodes certain traits.
2. What is genetic engineering? The direct manipulation of an organism's genome. For example, if a frog gene is inserted in bacteria, when the bacteria reproduce, the frog gene is multiplied also.
3. What is the role of bacterial plasmids in genetic engineering? They carry desired genes into bacteria to be duplicated by the bacterial growth.
4. What is the role of bacteria in genetic engineering? After the desired gene is inserted into the bacteria's DNA, the bacterial growth provides duplication of the desired gene.
5. What is used to separate the desired gene from the other genes after plating the bacteria? Gel electrophoresis.

Suggested Accommodations

This section provides optional tools to enrich learning and meet students where they are.

1. For students struggling to meet performance expectations:
   a. It is important for students to realize that DNA is a microscopic molecule. During their lab, students will see millions and millions of DNA molecules coagulate together like tangled string. As they become large enough bundles of DNA, they can be seen by the naked eye.
   b. This task is sensitive to the procedure. If any students do not get DNA results, have them observe from a student's sample that did extract DNA.
2. For students who have already met performance expectations and have high interest:
   a. Biotechnology is a growing science that utilizes what is known about plant science and genetics to improve the food we eat and how it is produced. Genetic engineering is a type of biotechnology. Have students choose to research how we are benefiting more and more each day in the fields of medicine and/or food science due to genetic engineering.
3. For students who are English Language Learners, have special needs or are reading below grade level:
   a. Before Lab: Identify and share each material being used in the lab. Model the procedures 1–7.
   b. During Lab: Partner ELL students with a non-ELL students and provide them an opportunity to perform their own DNA extraction watching the procedure from their partner.
4. For engaging ways to connect learning to students' home and community:
   a. Ask the students if they know of anyone with diabetes. Be sensitive to any students who may be diabetic themselves when you explain the seriousness of the illness.
   b. Your body breaks down the sugars and starches you eat into a simple sugar called glucose, which the body uses for energy. Insulin is a hormone that the body needs to get glucose from the bloodstream into the cells of the body. In type 1 diabetes, the body does not produce insulin. With the help of insulin therapy and other treatments, even young children can learn to manage their condition and live long, healthy lives.
   c. Where does the insulin come from that type 1 diabetics inject into themselves for this insulin therapy? Today's lesson will show you the process of genetic engineering that is utilized to produce this insulin.

Rubrics

We have created two optional tools for evaluating learning at the end of each lesson.

- **LESSON RUBRIC:** This can be provided to students and used by the teacher for evaluation.
- **STUDENT REFLECTION:** This can be provided to students to empower them to self-assess learning before turning in the rubric and completed work. The general Student Reflection sheet can be found at the end of this educator guide.

NAME: _____ **DATE:** _____ **CLASS PERIOD:** _____

DISCOVERING DNA

Lab Procedure:

1. Place one thawed strawberry in the plastic bag and squeeze until all lumps are turned into a uniform puree.
2. Add 10 mL of buffer solution. Zip the bag closed.
3. By squeezing the bag, mix the contents with the buffer solution completely.
4. Fold the paper towel into a half circle, then a quarter circle, opening it to form a cone.
5. Fill the test tube or champagne flute with (approximately two inches) ice-cold alcohol. Place the filter paper cone into the test tube/flute so that half of the cone is on the inside and half is on the outside of the test tube/flute.
6. Fill the paper towel cone with the strawberry solution.
7. As the strawberry mixture filters through the cone and comes in contact with the alcohol, the DNA will form ribbons and then appear supernatant (floating) at the top of the alcohol.
8. Use the straw to scoop and retrieve the DNA.
9. Compare your DNA with that of other classmates and complete questions below.
10. Repeat with other produce samples as directed by your teacher.
11. Clean up your lab area.

	Describe your DNA. What does it look like? How much is present?
Sample 1: Strawberry	
Sample 2:	
Sample 3:	

1. Compare your solution to your classmates' solutions. Does everyone's DNA look the same? Speculate why or why not.

2. Why is isolating DNA an important process?

3. What do you think scientists can learn from studying DNA?

GRADING RUBRIC – FOR TEACHER		
Student successfully completed lab according to written procedure. Score _____/_____	Lab responses indicate a working knowledge of the role of DNA in science. Score _____/_____	Sections are thoroughly completed on handout. Score _____/_____

NAME: _____ DATE: _____ CLASS PERIOD: _____

Pre/Post Learning Assessment

1. What are genes?

2. What is genetic engineering?

3. What is the role of bacterial plasmids in genetic engineering?

4. What is the role of bacteria in genetic engineering?

5. What is used to separate the desired gene from the other genes after plating the bacteria?

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LESSON HANDOUT 2

NAME: _____ DATE: _____ CLASS PERIOD: _____

Pre/Post Learning Assessment

1. What are genes?

2. What is genetic engineering?

3. What is the role of bacterial plasmids in genetic engineering?

4. What is the role of bacteria in genetic engineering?

5. What is used to separate the desired gene from the other genes after plating the bacteria?

NAME: _____ DATE: _____ CLASS PERIOD: _____

RUBRIC

		ADVANCED	PROFICIENT	NOVICE
DISCIPLINARY CORE IDEAS	Growth and Development of Organisms	Student can explain that desired genes can be inserted into bacteria to be replicated by a process called genetic engineering using restriction enzymes and bacterial plasmids.	Student can explain that desired genes can be inserted into bacteria to be replicated by a process called genetic engineering.	Student can explain that genes can be inserted into bacteria.
	Inheritance of Traits			
	Variation of Traits			
PRACTICES	Planning and Carrying Out Investigations	Student followed the DNA extraction procedures and isolated DNA with a scoop to retrieve from more than one sample.	Student followed the DNA extraction procedures and isolated DNA with a scoop to retrieve from one sample. Or the student was not able to extract DNA but analyzed the procedures and evaluated where an error in the procedures may have happened.	Student followed the DNA extraction procedures and was not able to extract DNA and did not analyze the procedures and evaluate where an error in the procedures may have happened.
CROSS-CUTTING CONCEPTS	Structure and Function	Student can explain the function of the restriction enzymes, bacterial plasmids, bacteria, antibiotics and gel electrophoresis during genetic engineering.	Student can explain the function of the restriction enzymes, bacterial plasmids, bacteria and antibiotics during genetic engineering.	Student can explain the function of restriction enzymes, bacterial plasmids and bacteria.