DRIVING QUESTION: WHERE IS BIOTECHNOLOGY HEADED?

LENGTH: 1 hour

OBJECTIVES: Students will be able to:

- Compare and contrast gene editing and genetic engineering

Standards

Next Generation Science Standards Addressed

Disciplinary Core Ideas

LS3.A Inheritance of Traits

LS3.B Variation of Traits

Practices

Obtaining, Evaluating and Communicating Information

Cross-Cutting Concepts

Patterns: Observed patterns of forms and events guide organization and classification, and they prompt questions about relationships and the factors that influence them.

Common Core ELA Standards

Writing Standards 6-12, Text Types and Purposes (2) Write informative/explanatory texts to examine a topic and convey ideas, concepts and information through selection, organization and analysis of relevant content.

Materials

- Biotechnology Venn Diagram handout

Suggested Video

"CRISPR-Cas for Healthy Seed Development" by Pioneer Seeds

https://www.youtube.com/watch?v=KUApt4RIU1M (3:25)

Lesson Context

Students understand the role that genes play in determining the unique characteristics of different organisms. In previous lessons, students have learned how genes can be isolated and then replicated using bacteria. In lesson 7, students learned that desired genes can be inserted into organisms to produce genetically modified crops by transgenics. They have defined selective breeding, biotechnology and GMOs. Now, in lesson 8, students will learn about one of the newest advancements in biotechnology — gene editing — and compare and contrast this technology to genetic engineering. While both gene editing and genetic engineering are techniques used in biotechnology, gene editing takes less time and allows for improved efficiency when compared to genetic engineering. Gene editing is much more precise because it allows scientists to make changes to a specific sequence of DNA within a gene. It's also relatively cost-effective compared to other methods[xxviii], meaning more scientists could gain access to it. In looking at the similarities, gene editing and genetic engineering are both tools that enable plants to produce higher yields, become better tolerant to drought or resistant to disease, or even provide more nutrition for humans who consume these plants.

KEY CONCEPTS: Gene editing allows scientists to make changes to a specific target sequence of DNA within a gene. It modifies the gene in a precise and predictable manner.[xxix] One of the newer gene editing technologies is CRISPR-Cas technology which stands for Clustered Regularly Interspaced Short Palindromic Repeats. With CRISPR-Cas, the most widely used gene editing technology, scientists can program genetic guides to target a location along the plant's DNA where the Cas9 enzyme cuts the DNA. The cells change the DNA sequence as the cut is repaired.[xxx]

SETUP: Preview video listed above. Print Biotechnology Venn Diagram handout.

Outline

1. Ask students to share the definition of plant biotechnology and genetic engineering from previous lessons. Emphasize that biotechnology is the umbrella that covers many different technologies. Genetic engineering falls under this umbrella of plant biotechnology.
2. Share that there are always new technologies evolving to help feed the world, and today students will be learning about one of the newer technologies, gene editing.
3. Recall the discussion students had in lesson 4 about the concerns they may have had before learning more about plant biotechnology and GMOs. Explain that scientists

continually work to find technologies that will be widely accepted in today's society. This has led to a different kind of plant biotechnology called gene editing.

4. Define gene editing: *Gene editing allows scientists to make changes to a specific target sequence of DNA within a gene. It modifies the gene in a precise and predictable manner.*[xxxi] *One of the newer gene-editing technologies is CRISPR-Cas technology.*
5. Write CRISPR on the board vertically to allow for the acronym to be explained. Write what each letter stands for as you share with the students.

   Clustered
   Regularly
   Interspaced
   Short
   Palindromic
   Repeats

6. Explain CRISPR-Cas: *CRISPR stands for Clustered Regularly Interspaced Short Palindromic Repeats. With CRISPR-Cas, the most widely used gene editing technology, scientists can program genetic guides to target a location along DNA, where the Cas9 enzyme cuts the DNA. The cells change the DNA sequence as the cut is repaired.*[xxxii]
7. *Continue to share further information about gene editing with students: Gene editing tools provide a great deal of flexibility in the kinds of genetic changes that can be made. Changes that can be made include simple edits to, or deletions of, one or a few targeted letters in the genetic code. The tools can also be used to insert much longer genetic sequences from the same species or another one — similar to what can be done with older transgenic technologies. The key difference is that these edits and insertions can be made at very precise locations in the plant's genome.*
8. Divide students into groups of three to four. Hand out the Biotechnology Venn Diagram handout.
9. Set context for activity: *We know that genetic engineering and gene editing are both examples of plant biotechnology, but they do have their differences. Using what we've learned about genetic engineering and what we are going to be learning about gene editing, we will be comparing and contrasting these two technologies.*
10. Instruct groups to write down what they remember about genetic engineering in the "Genetic Engineering" circle of their handout. Give them five minutes to do this.
11. Ask for each group to share one characteristic of genetic engineering until all characteristics have been shared.
12. Have students watch "CRISPR-Cas for Healthy Seed Development" found at https://www.youtube.com/watch?v=KUApt4RlU1M. Instruct them to take notes in the "Gene Editing" circle. If there are similarities between genetic engineering and gene editing, have them write those characteristics where the circles overlap.
13. Explain that gene editing has an advantage over genetic engineering for several reasons. It's more precise than genetic engineering, and technology keeps getting more reliable.[xxxiii] It's also relatively cost-effective compared to other methods, meaning more scientists could gain access to it. All of these advantages mean more potential innovation.[xxxiv]
14. Give students 10 minutes to complete their Venn diagrams in their groups. Walk around the room and answer questions.
15. Have student groups find a partner group to share their Biotechnology Venn diagrams with and discuss what they've learned. Walk around the room and answer questions.
16. Based on what has been learned about the similarities and differences between genetic engineering and gene editing, have a class discussion on students' thoughts on the acceptance of gene editing.

Additional Content Support:

Pre-/Post-Assessment:

What is the definition of plant biotechnology?

- Plant biotechnology is a set of techniques used to adapt plants for specific needs or opportunities.[xxxv]

True or False: Genetic engineering is a type of plant biotechnology.

- True

How does gene editing differ from genetic engineering?

- Gene editing allows scientists to make changes to a specific target sequence of DNA within a gene. Because of this, it is much more precise than genetic engineering. Gene editing takes less time and allows for improved efficiency when compared to genetic engineering.[xxxvi]

Suggested Accommodations:

For students struggling to meet performance expectations:

- Remind students of the structure of a Venn diagram before asking students to complete the diagram with content.
- Discussing knowledge students acquired from previous lessons about genetic engineering will be important to help students compare and contrast genetic engineering and gene editing.
- The "CRISPR-Cas for Healthy Seed Development" video may need to be played more than once for the students to capture all the details around gene editing. Ask students to share observations. As students share, others in the class will write down any information any that they missed.

For students who have already met performance expectations and have high interest:

- Have students investigate applications of gene editing in fields other than agriculture. Consider the following examples:
  - Health/Medical
  - Environmental

For students who are English language learners (ELL), have special needs or are reading below grade level:

- The video modifications suggested for all students will assist ELL students. The videos are picture/graphic rich which will help with some comprehension.
- Translation of the key terms for this lesson will benefit the student. Plant biotechnology, genetic engineering and gene editing are all key terms.
- Partnering the ELL student with a bilingual student may assist as information from the videos is critical.

For engaging ways to connect learning to students' homes and communities:

- Have students hypothesize what the benefits of more precise, reliable and cost-effective technologies used to adapt plants for specific needs or opportunities would mean for the agriculture industry. How would these benefits for agriculture benefit their community?

NAME: _____ DATE: _____ CLASS PERIOD: _____

RUBRIC

		ADVANCED	PROFICIENT	NOVICE
DISCIPLINARY CORE IDEAS	Inheritance of Traits	Student can explain the impact that gene editing continues to have on the precision, reliability and cost of technologies used to adapt plants for specific needs or opportunities.	Student can explain some of the impacts that gene editing continues to have on the precision, reliability and cost of technologies used to adapt plants for specific needs or opportunities.	Student can explain the impact that gene editing continues to have on the precision, reliability or cost of technologies used to adapt plants for specific needs or opportunities.
	Variation of Traits			
PRACTICES	Obtaining, Evaluating and Communicating Information	Student can gather information about gene editing and genetic engineering and evaluate information to compare and contrast gene editing and genetic engineering. Based on that information, student can communicate their thoughts on the acceptance of gene editing.	Student can gather information about gene editing and genetic engineering and evaluate information to compare and contrast gene editing and genetic engineering.	Student can gather information about gene editing and genetic engineering.
CROSS-CUTTING CONCEPTS	Patterns	Student can explain the similarities and differences of gene editing and genetic engineering. Student can elaborate on what they believe public perception of gene editing could be in the context of current public perception of GMOs.	Student can explain the similarities and differences of gene editing and genetic engineering.	Student can explain the similarities or differences of gene editing and genetic engineering.

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

BIOTECHNOLOGY VENN DIAGRAM