Bananas! Fungi and a Changing Environment

Unit: **STRAND: BIO.4:** **Evolutionary Change**	**Utah SEEd Standard / NGSS Performance Expectation:** **BIO 4.5 -** Evaluate design solutions that can best solve a real-world problem caused by natural selection and adaptation of populations. Define the problem, identify criteria and constraints, analyze available data on proposed solutions, and determine an optimal solution. Examples of real-world problems could include bacterial resistance to drugs, plant resistance to herbicides, or the effect of changes in climate on food sources and pollinators. (LS4.C, ETS1.A, ETS1.B, ETS1.C)	**Time:** **70 minutes**

Link to all lesson resources and materials: https://byu.box.com/s/xvu9a60k418kunm61ylt57afj8c82x6z

Anchor Phenomenon	'Trouble with Fungus' activity: Class gets hit with a fungus – who survives? Can fungi be devastating? See "'Zombie' Parasite Cordyceps Fungus" Video
Driving Question(s)	Can students evaluate a real-world problem involving a species adapting to or failing to adapt to a changing environment?
Performance Task	Evaluate possible solutions already being explored. Students read articles that utilize different methods to combat plant disease (transgenic, artificial selection, etc.)

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Lesson Summary: A real-world problem involving a species either adapting or failing to adapt to a changing environment.			
	Time	**Guiding Question / Learning Objective** Evaluate design solutions to a real-world problem involving a species adapting or failing to adapt to a changing environment.	**How are students answering the guiding question or meeting the learning objective?**
 **Engage**	10min	**Determine** who has the "Scary Fungus." **Visit** which students have the trait that the fungus attacks and those who don't. "'Zombie' Parasite Cordyceps Fungus" Video	Students participate and make connections to how fungus affects their life.
 **Explore**	10min	**Watch** "Will Bananas go extinct?" video, which provides background on bananas. **Taste** the banana candy and real bananas—compare. **Answer** phenomenon questions on the student handout	The effects of the fungus on bananas and how organisms change over time are compared.
 **Explain**	20min	**Answer** 'After Video questions' on the student handout. **Discuss** the cause and effect of fungus and solutions (criteria and constraint).	Cause and effect of the fungal disease and bananas are discussed.
 **Elaborate**	25min	**Student debate** on the "best" solution for making an organism disease-free.	Students evaluate the cause and effect of different solutions for stopping the fungus from spreading.
 **Evaluate**	5min	**Evaluate** student responses and summarize the best solution for saving bananas from the Panama disease fungus.	Students will choose which of the above solutions for which they would pick according to the criteria and constrains chart created. They will recognize the resources needed for saving food sources for human use.

Three Dimensions Focused on in This Lesson

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Disciplinary Core Idea: **NGSS Appendix E** LS4.C - Evolution results primarily from genetic variation of individuals in a species, competition for resources, and proliferation of organisms better able to survive and reproduce. Adaptation means that the distribution of traits in a population, as well as species expansion, emergence or extinction, can change when conditions change.	**Science and Engineering Practices:** **NGSS Appendix F** **Designing Solutions (Evaluating)**: Students evaluate solutions to a problem involving the effects of natural selection and adaptation of populations, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations.	**Crosscutting Concept:** **NGSS Appendix G** Cause and Effect: Changes in systems may have various causes that may not have equal effects. Cause and effect relationships can be predicted by examining what is known about the system.
Learning Objectives 1. Evaluate design solutions to a real-world problem involving a species adapting or failing to adapt to a changing environment.		
Related Knowledge and Skills from Prior Grades		
Disciplinary Core Idea: **NGSS Appendix E** Species can change over time in response to changes in environmental conditions through adaptation by natural selection acting over generations. Traits that support successful survival and reproduction in the new environment become more common.	**Science and Engineering Practices:** **NGSS Appendix F** **Students do and use the Science and Engineering Practice by:** • Designing, evaluating, and/or refining a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations.	**Crosscutting Concept:** **NGSS Appendix G** **Students think and connect through the Crosscutting Concept to reason that:** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. • Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. • Changes in systems may have various causes that may not have equal effects.
Connections to Mathematics and ELA/Literacy Standards		

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ELA/Literacy Standards:	Mathematics Standards:
• **RST.11-12.1:** Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. • **WHST.9-12.2:** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. • **WHST.9-12.9:** Draw evidence from informational texts to support analysis, reflection, and research.	• **MP.2**: Reason abstractly and quantitatively

Materials

Handouts	Lab Supplies	Other Resources
Student Handout Student Extension: Transgenic Bananas Graphs Student articles (linked in handout) 1. Transgenics 1 2. Transgenics 2 3. Fungicides 4. Bio-Control 1 5. Bio Control 2 6. Artificial Selection 1 7. Artificial Selection 2 Folder with PDF versions of articles	Required Banana Taffy Candy Optional Supplies Several different banana varieties (if available) Paper Plates Plastic Knives to cut bananas	**Phenomenon Videos:** National Geographic: "Zombie" Parasite Cordyceps Fungus Beautiful Science: Will Bananas go extinct? **Alternative Articles:** Genetic modifications and solutions Fungicides Natural ways to help with Fungus Domestication of the banana Teacher Rubric for student handout

ENGAGE

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What is a real-world problem involving a species adapting or failing to adapt to a changing environment?	
Note: Before this lesson, students should have a basic understanding of natural selection, genes, and DNA→RNA→Protein→Trait 1. While handing out student worksheets, ask what fungal examples students know. (ex. Yeast, fungus on bread, ringworm, athletes' foot, mushrooms, etc.) 2. Teacher starts the lesson by saying that a 'new crazy scary fungus' is infecting humans. 3. Teacher asks who has a specific trait in the classroom (ex., Brown eyes or taller than 5'2, etc.). The teacher says that students with the chosen trait represent an individual in your class population that the fungus has killed. If students do not have the trait, they are ok and survive the fungus. Ask the following questions: a. What percentage of students died? (Math cross-disciplinary opportunity) b. Is it plausible for a fungal disease to do something like this? c. How could you survive if you have the traits that result in death? 4. The teacher shows the video clip of "zombie" fungus growing from an ant's head. 5. Discuss ant fungus. Then discuss classroom death fungus again. a. What if everyone had the specified trait (i.e., tall) and the fungus? b. How do we ensure that students with specified traits have offspring that won't die from this fungus? (Discussion could focus on alleles & if parents are carriers of recessive traits, could also introduce the idea of human interventions like fungal sprays and artificial selection). 6. Discuss any questions that students have about the phenomenon video. What is the issue and how would this issue effect us?	**Possible Bell Ringer**: "What are some examples of a species failing to adapt to a changing environment?" Video: National Geographic: "Zombie" Parasite Cordyceps Fungus

EXPLORE

What is a real-world problem involving a species adapting or failing to adapt to a changing environment?	
1. Teacher to students: "Let's talk about another real-world example of this." 2. Look at the student handout. Read through the first questions together. a. Ask a few of the following: What happened to the bananas? What is causing banana death? What will the likely effects be if things don't change? How are scientists trying to cause a change to solve the problem? 3. Watch the banana video all the way through 4. Help students answer questions on the student handout. Have conversations with students about	Video: Beautiful Science: Will bananas go extinct?

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the fungus and the traits of bananas that were detrimental or beneficial. 5. Discuss as a class any questions they have about a fungus with the banana or any other fungus that they know of involving food. Hopefully they connect that this is not just a banana issue but one that effects all types of food options we have on earth. **Banana/Candy Taste Test** 6. (Optional) Pass out a banana-flavored candy and let them compare it to the flavor of a piece of banana. Discuss: "Why is the banana candy flavor different than the flavor of store bananas?" Guide students to make the connection that the candy is based on the Gros Michael banana that is no longer sold in stores. Will you someday need to describe the flavor of bananas to your grandkids? 7. **Refer to Video:** Teacher asks students: Does anyone here work on a farm, or has anyone ever sprayed plants/crops with something? How often did you have to spray during a season? (Bananas are sprayed 50+ times!) 8. Continuing with a class discussion, talk about the **after-video questions** from the "Student Handout." 9. Do you think disease problems like this are only happening in bananas?	

EXPLAIN

What is a real-world problem involving a species adapting or failing to adapt to a changing environment?

Analyzing real-world problems and evaluating best solutions:

1. Q. What would a solution to this banana disease problem look like? (Criteria & Constraints table in the worksheet)
   a. Help students envision what an "ideal" solution to the fungal/disease problem in bananas looks like---what it needs to do (criteria) and what will constrain us in creating a solution.
   b. Teacher: "You are responsible for saving the bananas from extinction. Your job is to come up with the best possible way to get the outcome or effect of saving bananas without harming other important things."
      i. **Example optimal criteria**: All bananas are saved (fungus eliminated, affordable, available, good tasting.)
      ii. **Example constraints**: Solution causes minimal health effects to humans and the environment, money available for research or to spend making the solution, timeframe, human resources, governmental regulations (GMO, species availability), technology availability.

Teacher Tips:
Teachers may divide the class into groups to jigsaw the articles and then share them with the class.

Be specific with how many constraints and criteria (4 each).

The table should be drawn like this:

Criteria (What we want to happen)	Constraint (What barriers are in the way)
1. 2. 3. 4.	1. 2. 3. 4.

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ELABORATE

What is a real-world problem involving a species adapting or failing to adapt to a changing environment?

1. Students are divided into groups of 3 to 5 individuals.
    a. Students are provided various articles to read to evaluate multiple methods employed to give banana disease resistance.
        i. Students evaluate solutions from short articles using the table on the student handout on genetically modified crops, fungicides, biological control, and artificial selection.
        ii. Groups decide which method should now be pursued for bananas (why?)
        iii. Answer the "after research" questions as a group.
2. Group Debate **(optional/Recommended additional activity as time permits)**
    a. The teacher will assign groups to debate the cause and effect of a question together:
        i. "Who should foot the immediate costs of fighting a disease?"
        ii. "Should the government or a private company spend approximately $116 million to develop a genetically modified crop? Or should consumers pay a new higher price for bananas?
    b. Each student should be required to contribute at least two comments.
3. Change groups and have different students attempt to change their minds/share opinions about the issue of "who should foot the immediate cost of fighting a disease"

Teacher Tips

Articles can be modified for particular students or classes to simplify the material. (Ex. Students read the abstract or skim articles by looking at handout solutions.)

Additional modifications to help ESL learners: Paired reading or simple videos on topics. Several articles are already included for easier reading,

Note: debate may be a whole class debate or just in groups

EVALUATE

What is a real-world problem involving a species adapting or failing to adapt to a changing environment?

Evaluate the student responses as to the best solutions for saving bananas from the fungus.

Teacher Tips
Teachers check for student understanding in responses to the debate and discussions.

Teacher Rubric for student handout

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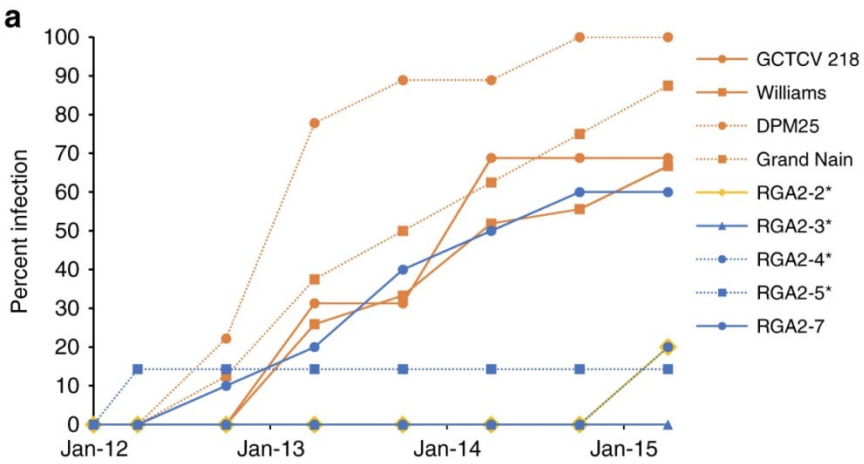
POSSIBLE EXTENSION / ALTERNATIVE ADAPTATIONS

~15-20 minutes

1. Students will research how another food is being impacted by disease and any possible solutions being researched. It may be helpful to let them pick from one of the four diseases below.
    a. **Examples**: Citrus greening of oranges, vanilla beans and black rot, apples and fire blight, tomato mosaic virus, cacao plant (chocolate) pod rot disease
2.

DATA Analysis for advanced students:
Look at the graph below. What does this graph tell you about solutions scientists have tried with other banana varieties? Rank the effectiveness of various solutions and provide the rationale for your ranking.



Description of the Graph Above:

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The graph shows the percentage of infected plants in two normal types of Cavendish bananas (“Williams” and “Grand Nain”) over three years. It also shows the percent of diseased bananas in different genetically modified banana varieties (RGA2-2*, RGA2-3*, RGA2-4*, RGA2-5*, RGA2-7) as well as two other types.
“GCTCV 218” is a banana created in Taiwan using plant breeding. It has a natural resistance to the disease. “DPM25” is a normal banana that has mutations caused by radiation. It is disease-resistant to a fungus similar to the fungus attaching Cavendish bananas.

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