**Unit Essential Question:** *Why do organisms change over time and should we intervene?*

**Introduction**

Throughout this unit, students have learned how organisms have naturally changed over time, looking at evidence in the fossil record and exploring the actual process behind these changes in simulations and case studies. However, these changes are not always completely natural. For thousands of years, humans have been influencing the changes of some organisms in the form of selective breeding—a practice that is still common today. Students will learn that selective breeding was only the beginning of human intervention. In the last 50 years, we have entered a new era of genetic technology in which scientists can actually insert desired genes into the genomes of the organisms themselves. To investigate these technologies, students practice critical reading skills to gather information, which will serve as the foundation to the question in their culminating project.

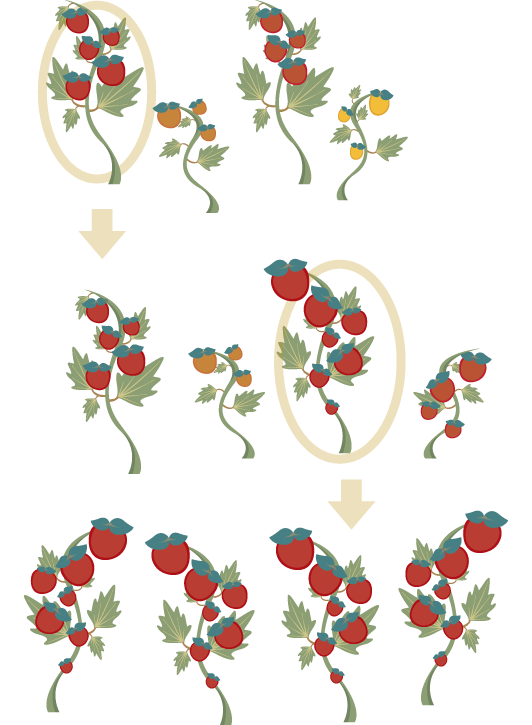
**Alignment Table**

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| --- | --- | --- | --- |
| **Performance Expectations** | **Science and Engineering Practices** | **Disciplinary Core Ideas** | **Crosscutting Concepts** |
| **MS-LS4-5. Gather and synthesize information about the technologies that have changed the way humans influence the inheritance of desired traits in organisms.** [Clarification Statement: Emphasis is on synthesizing information from reliable sources about the influence of humans on genetic outcomes in artificial selection (such as genetic modification, animal husbandry, gene therapy); and, on the impacts these technologies have on society as well as the technologies leading to these scientific discoveries.] | **Obtaining, Evaluating, and Communicating Information**   * Critically read scientific texts adapted for classroom use to determine the central ideas and/or obtain scientific and/or technical information to describe patterns in and/or evidence about the natural and designed world(s). | **LS4.B. Natural Selection**   * In *artificial* selection, humans have the capacity to influence certain characteristics of organisms by selective breeding. One can choose desired parental traits determined by genes, which are then passed on to offspring. | **Cause and Effect**   * Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability. |
| **MS-LS3-1. Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism.** [Clarification Statement: Emphasis is on conceptual understanding that changes in genetic material may result in making different proteins.] [*Assessment Boundary: Assessment does not include specific changes at the molecular level, mechanisms for protein synthesis, or specific types of mutations.*] | **Developing and Using Models**   * Develop and use a model to describe phenomena. | **LS3.A Inheritance of Traits**   * Genes are located in the chromosomes of cells. Each distinct gene chiefly controls the production of specific proteins, which in turn affects the traits of the individual. Changes (mutations) to genes can result in changes to proteins, which can affect the structures and functions of the organism and thereby change traits.   **LS3.B: Variation of Traits**   * In addition to variations that arise from sexual reproduction, genetic information can be altered because of mutations. Though rare, mutations may result in changes to the structure and function of proteins. Some changes are beneficial, others harmful, and some neutral to the organism. | **Structure and Function**   * Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the shapes, composition, and relationships among its parts; therefore, complex natural and designed structures/systems can be analyzed to determine how they function. |
| **Equity and Groupwork**   * Co-develop two models * Co-construct a flowchart | | | |
| **Language**   * Read and annotate a scientific article * Write conclusions * Depict relationships in a flowchart | | | |

**Learning Goals**

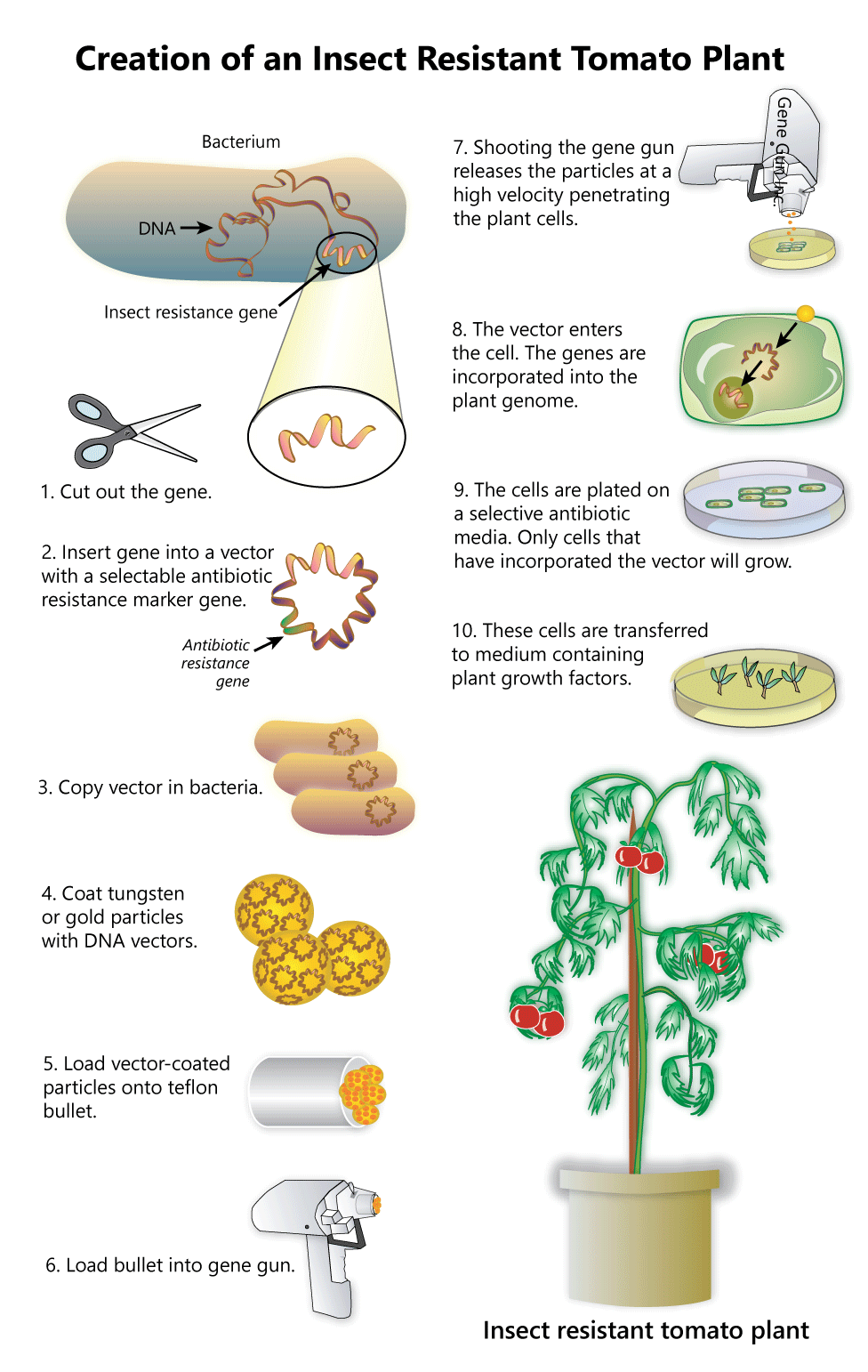
This learning task explores how humans are able to influence certain characteristics of organisms. More specifically, the purpose is to:

* Make a prediction about why organisms may change.
* Read and annotate an article on how humans can enhance desirable traits in living things.
* Develop two models showing selective breeding and genetic engineering and use the models to compare and contrast the two processes.
* Draw a flowchart depicting one process in relation to a specific example.
* Apply knowledge of selective breeding and genetic engineering to develop a potential solution for a climate-threatened organism.

**Content Background for Teachers**

In this task, students learn about two ways humans can influence the traits of organisms—selective breeding and genetic engineering. Both of these processes rely on the fact that organisms have genetic variation and new genetic variations arise through the process of mutations. With a mutation, the number and/order of bases in a gene is changed. This structural change in genes results in a structural change in the protein created, thus resulting in some change in structure or function of the organism. With both selective breeding and genetic engineering, humans pick desired mutations in order to create organisms with the traits they desire. Thus, student understanding and knowledge of this process from gene to trait is essential to understanding these technologies.

http://b4fa.org/bioscience-in-brief/plantbreeding/



In selective breeding, humans are merely guiding the natural breeding process by selecting the organisms with the desired traits to breed together. By doing this repeatedly, they end up with more organisms with the desired trait (See diagram above). They might also choose to breed two organisms with two desired traits to create an organism with both desired traits. For more information, read the article in the Explore section of the student guide.

In genetic engineering, humans interfere on the genetic level by harvesting the desired gene from an organism and then transplanting it into the desired organism. This is a faster method to end up with organisms with the desired trait. The process is depicted with the example of an insect-resistant tomato plant in the diagram to the left. For more information, read the article in the Explore section of the student guide. http://learn.genetics.utah.edu/content/science/gmfoods/

**Academic Vocabulary**

* Selective breeding
* Genetic engineering
* Transplant
* Gene
* Protein
* Trait
* Mutation
* Resistance
* Generation

**Time Needed (Based on 45-Minute Periods)**

4-5 Days

* Engage and Explore: 1 period
* Explain: 1-2 periods
* Elaborate: 1 period
* Evaluate and Reflection: 1 period

**Materials**

* Unit 3, Task 4 Student Version

Explore

* Tablets, computers, or projector and speakers for video

Explain (Per Group)

* Markers or Colored Pencils
* Poster Paper

Evaluate

* Project Organizer Handout

**Instructions**

**Engage**

1. Introduce Task 4: In previous tasks, you have seen how species naturally change over time. Think about what you were still wondering about at the end of the last task (look back if you need to). What questions do you still have?
   * Before you pass out their student guide, give students time to reflect individually or with a partner about the questions they recorded at the end of the last task. Share a few of these out as a class, using facilitating questions to guide students toward questions that relate to this task.
2. Transition to Task 4: You have seen how species naturally change over time, but this is not the only way organisms can change over time. Because of new technology, humans are able to influence the traits of some organisms.

* Now pass out their Task 4 student guide.

1. In pairs, have students observe the image and answer the questions on their student guides. The image shows two tomatoes, one small and one large. Students predict what could have naturally caused these two tomatoes to be different and how humans may have intervened to create this difference. The purpose of this question is to engage whatever background knowledge students bring to this lesson.
   * For the first question, students will likely come up with a natural difference in genes or a difference in environmental conditions (soil nutrients, sunlight, water, etc).
   * For the second question, some students may guess that the larger one is genetically modified. Others may have never heard this term.
   * These predictions emphasize the crosscutting concept of **Cause and Effect**, as students begin to consider how this case of the different-sized tomatoes, like many other phenomena, can have more than one cause.
2. Optional: Share out a few predictions and explanations. The use of equity sticks is encouraged for more equitable participation and to get the conversation started (See “How To Use This Curriculum” for more details).

* Keep in mind that while many students may know the term “GMO”, they may not truly understand what it means for an organism to be genetically modified. Many students, without knowing much about GMOs, come with a bias that GMOs are bad.

**Explore**

1. To learn more about the ways that humans have been able to influence certain characteristics of organisms, students will read and annotate a scientific article adapted from two sources: *GCSE Bitesize* and *Learn Genetics Utah*. They will also view a short video that will better help them understand the process that takes a gene to make a protein to result in a trait.

* The purpose of this is not only to provide them with the content, but also to give them practice at **Obtaining, Evaluating, and Communicating Information,** by critically reading two scientific texts adapted for classroom use to determine the central ideas related to genetic engineering and selective breeding.

1. This activity also gives students much-needed practice at reading scientific text and extracting information that they will need to build their models. We recommend you ask students to annotate the article, either using whatever strategy they are most familiar with in your classroom or the strategy detailed in their student guide.
2. Since all students read at a different pace, you may want students to move on to the Explain and begin planning their group models individually on their student guides.
3. This section includes a lot of new information and vocabulary. We recommend reviewing some of the main ideas of the article in a class-wide discussion before all students move on to the next segment.
   * Depending on the needs of your students, this may include a PowerPoint presentation, a class discussion, re-watching the video and pausing to diagram the different parts of the process, etc.

**Explain**

1. With the knowledge they have gathered through the article, students will make two models showing the processes of selective breeding and genetic engineering. In both models, they should emphasize how a change in genes results in a change in traits.

* This asks students to use the science and engineering practice of **Developing and Using Models** to describe twodifferent processes. By creating a model to describe how the function of traits depends on the composition of the gene and the shape of the protein, student are also engaging with the crosscutting concept of **Structure and Function**.
* We recommend this task be completed in groups since these are new and complex concepts.

1. You may wish to have students do some independent planning first in the student guides before discussing as a group.

* Then provide groups with poster paper and writing utensils to create their group models on poster paper.

1. Assign roles to each group. You may use whatever roles you prefer. We recommend the use of the Materials Manager, Facilitator, Reporter, Harmonizer.
   * Ask Facilitator to read the directions and to make sure everyone understands the task and what directions are asking.
   * Ask the Materials Manager to gather any materials needed to complete the task.
   * Ask the Harmonizer to make sure that everyone contributes their ideas and that everyone’s voice is heard.
   * Ask the Reporter to make sure everyone is contributing to the models on paper.
2. Optional gallery walk: You may want to conduct a brief gallery walk so students can see how their peers are modeling the same processes.

* Then give students time to revise and add to their posters based on exemplars they see around the classroom.

1. Students are then given a Venn diagram and reflection questions that are meant to both help them revise their models and clarify their understanding. Students use their models to compare the two processes and conclude how changes in structure lead to changes in function in both processes.

* Students will likely note that both processes entail a change in genes leading to a change in protein and thus a change in trait (a more desirable trait). However, the first few steps of the model to get to that change in gene varies. Selective breeding selects organisms with desired traits, while genetic engineering selects the desired gene itself.
* The last question asks students to notice that the structural change in DNA leads to a structural change in protein, which leads to a change in trait, either structure or function. This continues to help students emphasize the crosscutting concept of **Structure and Function**, as described above.
* Once complete, we recommend reviewing these questions as a class. One option is to hang a few exemplar posters at the front of the room to use as a reference during the discussion.

**Elaborate**

1. Students return to the original question from the Engage, equipped with their new knowledge of selective breeding and genetic engineering.
   * Previously they made predictions as to why the tomato on the right is larger. Now, they pick which process or processes they think are responsible for the larger tomato.
2. In pairs, students discuss the two processes and decide on one process—selective breeding or genetic engineering. Using the tomato as the context, students draw a flowchart describing how selective breeding or genetic engineering created the larger tomato.

* This brings students back to the crosscutting concept of **Cause and Effect** from the beginning of the task, as they consider the multiple causes that could be in play but use their knowledge to identify which process probably led to this difference in size.
* This flowchart may mimic many aspects of their models from the Explain, but will be specific to the tomato context, thus giving extra practice with these concepts and the practice of **Developing and Using Models.**
* Students may use pictures and/or words.

1. Optional: Match each pair up with another pair who selected the other process. Have each pair present their own flowchart to the other pair and get feedback.
2. Return to the whole-class concept map from the Lift-Off Task.
   * In small groups, have students brainstorm new concepts and new connections that they have learned in this task, as well as any new questions that have come up for them. Then have groups share these aloud in a class-wide discussion and add to the class concept map. The use of equity sticks is encouraged for more equitable participation in class-wide discussions (See “How To Use This Curriculum” for more details).
     + Some facilitating questions to ask students are: What new ideas/concepts do you want to add to the map? What connections do you want to add or change? What is your reason for that addition/revision? What connections can we make between the questions/ideas already on the map? What new questions do you have about the phenomenon?
     + Draw circles around each question and boxes around each concept.
     + Write connector words to describe connections between the concept boxes.
     + For this task, students may begin to connect some of their previous question circles to concept boxes about the following: genetic engineering; selective breeding; mutation; and/or the structure-and-function relationship between genes, proteins, and traits.
   * Have students analyze the additions to the class concept map for as many examples of this task’s crosscutting concepts as they can find. Once a student has identified the crosscutting concept, you can trace the circle in the corresponding color (decided on in the Lift-Off task). We recommend asking students to share key words that helped them identify the crosscutting concept for that concept or question. Some identifying words students might look for are:
     + **Cause and Effect**: These could be phrases such as, “which results in,”   
       “which causes,” “that explain why,” “is due to,” etc.
     + **Structure and Function**: These could be phrases such as, “this shape affects \_\_\_\_,” “and “it can only function if,” “this structure leads to,” etc.
   * Once again, the purpose of this concept map is to facilitate generation of student questions, promote language development, and support understanding of the science content throughout the unit. Allowing students to ask their own questions and use their own words to make meaning of the concepts will not only help them make deep connections about science content, but will also help their oral and written language development.

**Evaluate: Connecting to the Culminating Project**

1. Students independently complete the Task 4 section of the Unit Project Organizer in class. Revisions can be done for homework, depending upon student’s needs and/or class scheduling.
2. For their project, students will be arguing whether humans should intervene on the behalf of climate-threatened organisms or let nature take its course. Their prompt is as follows: Think about how your species is being affected by an environmental change caused by humans.

* What change in trait might help the species survive this environmental change?
* Model the process of changing this trait, using what you have learned in this task.

**Reflection**

1. At the end of the task, ask students to reflect on what they have learned over the course of this task by answering the following three questions in their student guide:

* At the beginning of this task, you were asked to predict how humans might have intervened to create the larger tomato. Look back at your prediction: how does it differ from the process you outlined in the Elaborate? What have you learned over the course of this task?
* In this task, we focused on two crosscutting concepts:
  + **Cause and Effect:** Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.
  + **Structure and Function**: Models can be used to describe how function depends on the structure.

Where did you see examples of **Cause and Effect** and **Structure and Function** in this task?

* Now that you have learned more about the ways in which humans can influence the traits of some species, what questions do you still have?

1. There are no right answers, but encourage students to look back at their student guides and their class concept map. They should not change their initial responses, but rather use this reflection space to add ideas and questions based on what they have learned through this task. By generating more of their own questions, students continue to engage in sense-making of the phenomenon and gathering knowledge and skills for their final projects.

**Assessment**

1. You may collect the Project Organizer and assess using:
   * *Criteria of your choice.* We recommend using the Alignment Table at the beginning of this document to inform your criteria.
   * This can be a formative tool to periodically look for trends in student understanding after the completion of a task. You can then use this formative data to inform any re-teaching, as necessary.
2. You may also give students time to make revisions with one of the two options:

* Students may make changes to their Project Organizer according to your comments OR
* Ask students to exchange Project Organizers with a partner and give partners 5 minutes to give written feedback. Then allow students time to make changes to their work according to the feedback.