Name: _____ Date: _____

Student Exploration: Genetic Engineering

Vocabulary: callus, exon, genetic engineering, genetically modified organism, genome, green fluorescent protein (GFP), herbicide, insecticide, intron, promoter, transcription, transformation

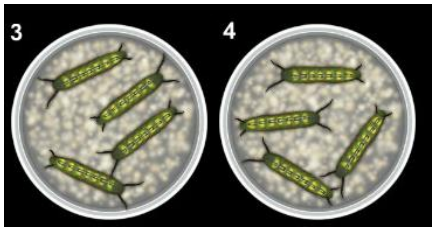
Prior Knowledge Questions (Do these BEFORE using the Gizmo.)

1. What are some things that can damage a farmer's crops? _____

2. What can farmers do to protect their crops? _____

Gizmo Warm-up

Many farmers use chemical **herbicides** to kill weeds and **insecticides** to kill insects. Using **genetic engineering**, scientists have developed ways to resist harmful crop pests. In the *Genetic Engineering* Gizmo, you will use genetic engineering techniques to create **genetically modified** corn.



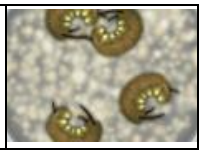
Check that **Task 1** is selected. The Gizmo shows petri dishes that contain different strains of bacteria (white dots) and caterpillars (Lepidoptera sp. larvae). In the first challenge, your goal is to find bacteria that produce toxins that kill the caterpillars. Click **Play** ( ).

1. What do you observe? _____

2. Which strains of bacteria were able to kill Lepidoptera sp. larvae? _____

   Were some more effective than others? Explain. _____

   Some bacteria are able to produce a toxin that kills Lepidoptera sp. larvae. Find out which gene is responsible for this toxin in the next step.

Activity A: **Caterpillar-resistant corn**	Get the Gizmo ready: • Click **Reset** ( ) and check that **Task 1** is selected in the dropdown menu.	

Introduction: Lepidoptera sp. larvae (caterpillars) eat corn kernels, leaves, and stalks. In this activity, use genetic engineering techniques to create a corn plant that is resistant to caterpillars.

Question: How can we produce corn that is resistant to Lepidoptera sp. larvae?

1. Observe: Click **Play**. Select one of the strains of bacteria harmful to larvae (by clicking on the plate).

   Which strain did you select? _____

2. Investigate: Click **Continue**. The screen now shows the **genome**, or set of genes, of the selected bacteria. One of these genes produces the protein that kills the caterpillars. You will test each gene by adding it to the genome of a bacteria that does not kill caterpillars. This process is called **transformation**.

   Drag three genes into the Petri dishes at lower right. These genes are now inserted into the genomes of the sensitive bacteria in the plates. Press **Play**. If none of those genes help to kill the caterpillars, click **Reset** and try three other genes. When you find a gene that kills the caterpillars, click on the Petri dish to select the gene that confers resistance.

   Which gene did you select? _____

   In reality, finding a gene with a desired trait is much less common. Scientists search through many more bacterial strains and potential genes to find the traits they are looking for.

3. Observe: Click **Continue**. **Promoters** are regions of DNA that initiate the **transcription** of a gene. Some promoters only work in specific types of cells, such as leaf cells or root cells.

   To determine which cells of a corn plant a promoter works in, four promoters have been attached to the **Green Fluorescent Protein** (GFP) gene. Each promoter-GFP gene has been inserted into a corn plant. Select **Lights off** to see the parts of each plant glow green and fill in the table below.

Promoter	Glowing plant part(s)	Promoter	Glowing plant part(s)
1		3	
2		4	

   Which promoter is active in only the leaves? _____ In the whole plant? _____

   Select the promoter you would like to use by clicking on a plant, and then click **Continue**.

(Activity A continued on next page)

Activity A (continued from previous page)

4. Choose: The resistance gene that was chosen in step 2 was attached to the promoter chosen in step 3, and the new DNA was inserted into five **calluses**. A callus is a group of cells that will incorporate the new gene into their genome and grow into a mature corn plant.

   In each genome, genes are shown as green bars. Each gene contains light green **exons**, or sections that code for proteins, and medium green **introns**, which do not code for proteins. The dark green bars represent promoters and the red bars represent gene termination sites.

   Use the left and right arrow buttons to observe where the new gene (blue bar) was inserted into each of the corn calluses genomes. Problems can occur if the new gene is inserted into the middle of an existing corn gene (green bar).

   In which calluses did the new gene insert inside an existing corn gene? _____

   Select one of the corn calluses that *do not* disrupt an existing corn gene and click **Continue**.

5. Experiment: On the left is a control plant that does not contain any new genes. On the right is the transformed plant you created. Click **Play**. When the plant has finished growing, click on each of the circles to observe the leaves, cobs, and roots of each plant.

   A. Did the transformed plant grow into a healthy mature plant? _____

      If not, you may have chosen a bad callus. (Click **Back** to try a different callus.)

   B. Click **Reset** and select **Add Lepidoptera sp. larvae** for each plant. Click **Play**. What do you observe? _____

      _____

   C. Compare the up-close views. How do the roots, leaves, and cobs compare? _____

      _____

      _____

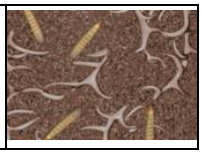
      _____

   D. Select **Show statistics**. How did the results for the transformed plant differ from the control plant? _____

      _____

   E. Click **Submit for review**. Was your plant resistant to Lepidoptera? _____

      If not, click **Back** or **Start again**. Be sure to choose genes that kill bacteria and a promoter that protects the corn cobs, leaves, and stalks.

Activity B: **Beetle grub-resistant corn**	Get the Gizmo ready: • Click **Start again** to reset the Gizmo. • Select **Task 2** in the dropdown menu.	

Introduction: Coleoptera sp. larvae are immature beetles. They feed on corn plant roots. Your goal in this challenge is to create corn that is resistant to Coleoptera sp. larvae.

Question: How can we produce corn that is resistant to Coleoptera sp. larvae?

1. Investigate: Using the Gizmo, select a bacterial strain that kills Coleoptera and determine the gene that will be used to develop resistance in the corn. Which choices did you make?

   Bacterial strain: _____ Gene: _____

   Click **Continue** to move on to the "Choose promoter" step.

2. Hypothesize: Turn the room lights off. Beetle larvae attack the roots of corn plants. Based on this, which promoters do you think would be effective against beetles? _____

   Explain your reasoning. _____

   _____

3. Apply: Knowing that the new corn strain will be eaten by humans, which promoter might be safer to use, and why? _____

   _____

   Select this promoter and click **Continue**.

4. Observe: Select a corn callus that you think will work and click **Continue**. On the next screen, add Coleoptera sp. larvae to each plant and click **Play**.

   A. Describe the control plant and the transformed plant. _____

   _____

   _____

   B. Select **Show statistics** and **Submit for review**. Is the experimental plant resistant to Coleoptera sp. larvae? _____

(Activity B continued on next page)

Activity B (continued from previous page)

5. Explore: Click **Back** and select a corn callus in which the new gene (blue bar) is inserted in the middle of an existing gene (green bar).

   A. Click **Continue**. Grow the experimental plant with and without larvae. What do you observe? _____

   B. Click **Back** and choose another callus in which an existing gene is disrupted. What do you observe? _____

   Note that these are dramatic examples of mutations. Complex organisms often have many genes that can perform similar functions, so disrupting one gene may not cause a noticeable change to the phenotype of the plant.

6. Explore: Click the **Back** button twice until the **Choose promoter** step is shown. Use the Gizmo to test the effectiveness of each promoter.

   Which promoters were effective in creating beetle-resistant corn, and why? _____

7. Explore: Click **Start again**. This time, choose a bacterial strain in step 1 that only kills some of the larvae. Grow the experimental plant in the presence and absence of larvae.

   How does this plant compare to the plant you created in part 4 of this activity? _____

8. Think and discuss: What are some of the possible benefits of creating insect-resistant corn, and what are some of the possible drawbacks? If possible, discuss your answer with your classmates and teacher.

Activity C: **Herbicide-resistant corn**	Get the Gizmo ready: • Click **Start again** to reset the Gizmo. • Select **Task 3** in the dropdown menu.	

Introduction: Weeds are wild plants that compete with crops for resources. Farmers kill weeds using herbicides, but corn plants may also be damaged by herbicides. Herbicides affect the roots, stalks, leaves, and cobs of corn plants.

Question: How can we produce a corn plant resistant to herbicide?

1. Observe: Bacterial colonies are being grown in Petri dishes. The white disks on each dish have been soaked in an herbicide.

   Click **Play**. Describe what happens to the bacteria in the Petri dishes. _____

   _____

   Which strains of bacteria are *not* affected by the herbicide? _____

2. Observe: Choose a bacterial strain that is resistant to herbicide, find the gene that is responsible for the resistance, choose a promoter, and transform a corn plant. Observe the control and experimental plants in the presence and absence of herbicide.

   When you have created an herbicide-resistant plant, fill in your choices below. (Note: you may need to try a few promoters before finding the correct one.)

   A. Which bacterial strain did you choose? _____

      Which gene did you choose? _____

      Which promoter did you choose? _____

      Which callus did you choose? _____

   B. Describe the control and experimental plants. _____

      _____

      _____

   C. Select **Show statistics**. How do the results from the transformed plant differ from the control plant? Explain. _____

      _____

      _____

(Activity C continued on next page)

Activity C (continued from previous page)

3. Experiment: Go back two steps and experiment with different promoters. Can any of the other promoters be used to create a resistant corn plant? _____

   Why or why not? _____

4. Analyze: What are some of the benefits of growing herbicide-resistant corn? _____

5. Analyze: Are there any possible drawbacks to having an herbicide-resistant corn plant? _____

6. Think and discuss: Herbicides and insecticides can be bad for the environment. Insecticides could harm beneficial insects like bees, and both herbicides and insecticides can contaminate nearby rivers and streams.

   A. What are some of the possible environmental benefits of GM crops? _____

   B. What are some of the possible environmental problems that can be caused by GM crops? _____

   C. What are some of the potential risks to humans and animals that eat GM crops?