Name: _____   Date: _____

Student Exploration: GMOs and the Environment

[Note to teachers and students: This lesson was designed as a follow-up to the Genetic Engineering *lesson. We recommend doing that activity before trying this one.]*

Vocabulary: herbicide, insecticide, genetically modified organism, pesticide, refuge field, resistance

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

1. How might genetic engineering help farmers create more robust crops? _____

   _____

   _____

2. How might GM crops affect the environment? _____
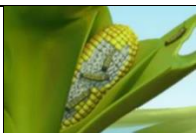
   _____

   _____

Gizmo Warm-up
In the *Genetic Engineering* Gizmo™, **genetically modified** (GM) corn was created that was **resistant** to insect pests and tolerant of **herbicides**. In the *GMOs and the Environment* Gizmo, you will use these strains of corn to maximize corn yields while seeing how these techniques affect the environment.
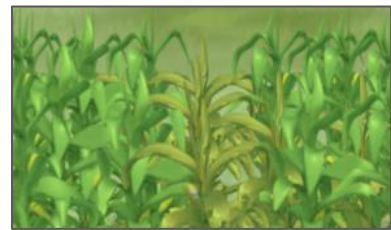
On the Controls tab, make sure **One-year** is selected for the Mode and **None** is selected for the **Resistance type**. Make sure both sliders are set to zero. Click **Play** (▶).

1. Describe the corn field shown in the SIMULATION tab on the left. _____

   _____

2. Click **Reset** (↺). Drag the **Herbicide** and **Insecticide** sliders all the way to the right. Click

   Play. Describe the corn field treated with these **pesticides**. _____

   _____

| Activity A:
One-year analysis | <u>Get the Gizmo ready</u>:

• Click **Reset** and drag the **Herbicide** and
  Insecticide sliders back to zero. | |

Introduction: In a corn field, about 75,000 plants are grown per hectare (2.47 acres) of land. In this simulation, a small sample of test plants are grown on about 0.0005 hectares of land.

Question: How can we maximize corn yield using different strains of corn?

1. <u>Observe</u>: When the Resistance type is **None**, the corn isn't resistant to insects or herbicide.

   A. Click **Play**. Click on a few different corn plants to see a close-up. What do you

   observe? _____

   _____

   B. What is the corn yield at the top right of the SIMULATION tab? _____

   Yield is the amount of crops harvested, and can be sold, per area of land.

   C. Select the TABLE tab. Based on the recorded data, what factors do you think have reduced the corn yield from its maximum amount of close to 15 tons/ha? (Note: Spiders eat harmful insects but do not damage corn.)

   _____

   _____

2. <u>Hypothesize</u>: What Gizmo settings do you think would maximize crop yield? _____

   _____

3. <u>Investigate</u>: Click **Reset**. On the TABLE tab, click **Clear** to delete the current data. With the resistance type **None** still selected, adjust the **Insecticide** and **Herbicide** sliders until you get the best yield. (Note: Yields within 1.0 tons/ha are not significantly different.)

   A. What is the maximum yield? _____

   B. How much **insecticide** did you use? _____

   C. How much herbicide did you use? _____

   D. Why didn't it help to add more herbicide to the corn? _____

   _____

(Activity A continued on next page)

Activity A (continued from previous page)

4. Experiment: For each of the remaining resistance types, try to maximize corn yield by adjusting the amount of herbicide and insecticide used. Then, fill out the table below.

Resistance type	Herbicide Amount	Insecticide Amount	Yield
Herbicide			
Caterpillars			
Caterpillars and herbicide			

5. Explore: When using caterpillar-resistant corn, does it help to add insecticide? _____

    Explain. _____

6. Challenge: Try to maximize corn yield without using any chemicals at all. Which resistance type did you choose, and what was the yield?

    Resistance type: _____   Yield: _____

7. Observe: Clear any data in the table. Select the herbicide resistant corn. Set the **Herbicide** slider to 300 L/ha. Starting with no insecticide, run several simulations, adding an additional 20 L/ha insecticide after each simulation until the maximum is reached.

    Switch to the GRAPH tab. Change the dropdown menu on the right to **Insecticide**.

    A. Describe the shape of the graph. _____

    _____

    B. What does the shape of the graph indicate about the amount of insecticide needed

    to be effective? _____

    _____

8. Apply: What is the minimum amount of chemicals (herbicide and insecticide) required to get a yield above 13 tons per hectare? You can use any resistance type. Fill in the table below.

Resistance type	Herbicide Amount	Insecticide Amount	Yield

Activity B: Long-term yield	Get the Gizmo ready: • Select **Multi-year** for the Mode. • Set **Resistance type** to **None**. • Set **Insecticide** and **Herbicide** to 0 L/ha	

Question: What are the long-term effects of GMOs on the corn field?

1. Review: In Activity A, you determined how to maximize yield for each type of resistance. List the settings you used and the resulting yields in the table below.

| Resistance type	Herbicide Amount	Insecticide Amount	Yield
None			
Herbicide			
Caterpillars			
Caterpillars and herbicide			

   A. How do you think the yields might change over a long period of time? _____

   _____

   B. Which method do you think will cause the least amount of harm to the environment?

   Explain. _____

   _____

2. Observe: Run a simulation for each resistance type using the settings in the table above. (For the caterpillars and caterpillars and herbicide resistant corn, use 0 L/ha insecticide.)

   Select the GRAPH tab. Below, roughly sketch the **Corn yield** graph for each resistance type. Fill in the final yield after 30 years below.

   None   Herbicide   Caterpillars   Both

   Yield: _____   _____   _____   _____
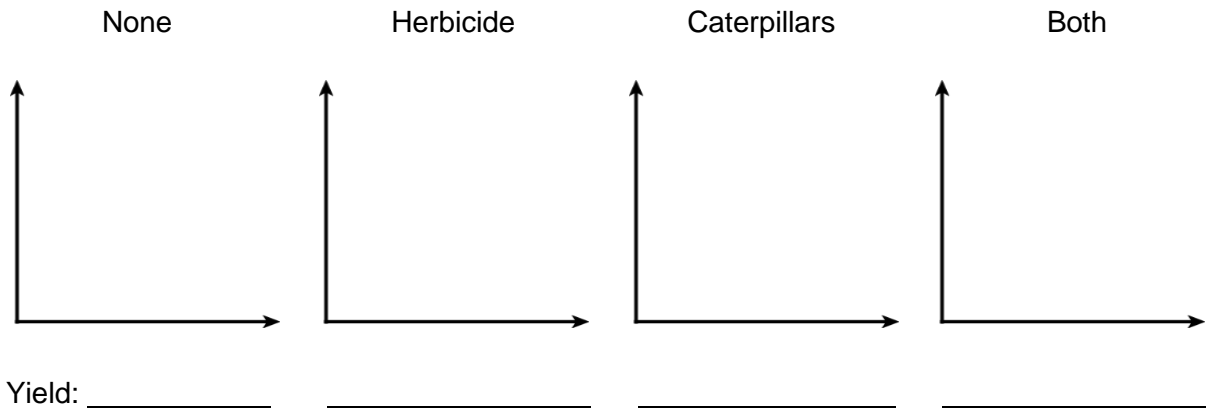
**(Activity B continued on next page)**

Activity B (continued from previous page)

3. <u>Observe</u>: Click **Reset**. Select the **Caterpillars and herbicide** corn. Set **Herbicide** to 300 L/ha and **Insecticide** to 0 L/ha. Run the simulation for 30 years.

    A. Describe the corn field. _____

    B. Switch to the GRAPH tab. You can change the data the graph displays using the dropdown menu. Roughly sketch the following graphs below.

    Corn yield   Weeds   Caterpillars
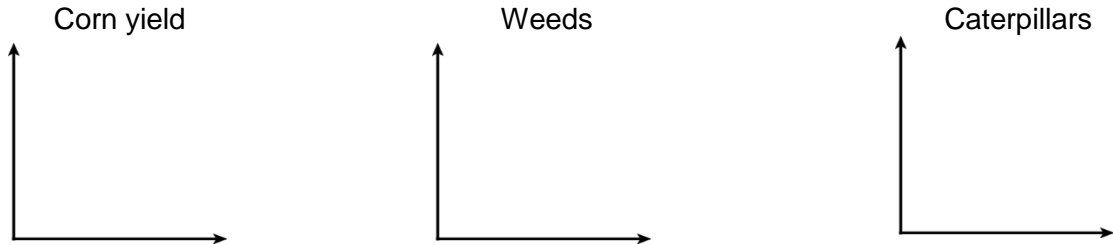
    C. Describe what happens to the population of caterpillars over time. _____

    _____

    D. How did this affect corn yield? _____

    E. Why do you think this is occurring? _____

    _____

    Caterpillars have evolved tolerance to the insect-resistant corn. This means they are no longer killed by the proteins the corn produces.

4. <u>Explore</u>: Click **Reset** and select the **Refuge field** box. A **refuge field** is a separate field that contains non-GMO corn. Click **Play**. What is the shape of the caterpillar graph now?

    _____

    _____

    A refuge field allows caterpillars that are not tolerant of the GMO corn to survive. This slows the spread of tolerance in the caterpillar population.

5. <u>Think and discuss</u>: Why is it necessary to continually produce new types of GMOs? _____

    _____

    _____

| Activity C:

Effects on the environment | Get the Gizmo ready:

• Click **Reset** to reset the Gizmo.
• Set **Resistance type** to **None**.
• Set **Insecticide** and **Herbicide** to 0 L/ha | |

Introduction: Chemical pesticides from farms can pollute nearby water supplies, negatively affecting the environment. Water pollution from pesticides can harm sensitive animals and plants living in nearby streams, reducing populations and decreasing the number of species.

Question: What effects do pesticides and GM corn have on the environment?

1. Hypothesis: How do you think GMO's affect the environment over the long term? _____

    _____

2. Observe: Click on the stream.

    A. What species do you observe? _____
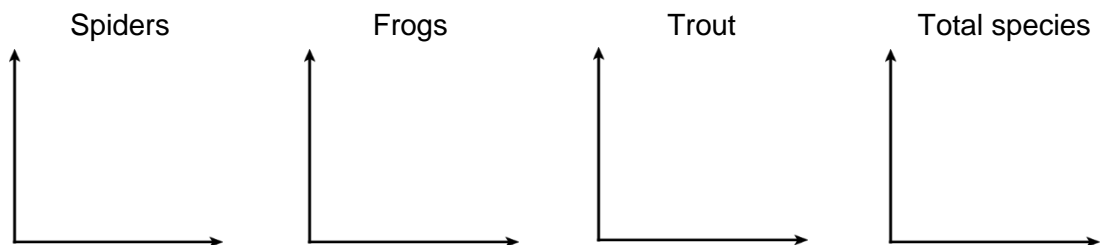
    _____

    B. How many total species are there? _____

    C. Run a simulation using 0 L/ha herbicide and 0 L/ha insecticide. Do you observe any

    changes in the stream over time? _____

3. Compare: Run a simulation with maximum herbicide and insecticide. Observe the stream.

    A. How does the stream change? _____

    _____

    B. Switch to the GRAPH tab. Roughly sketch the following graphs below.

| Spiders | Frogs | Trout | Total species |

    C. How do chemical pesticides affect the environment? _____

    _____

(Activity C continued on next page)

Activity C (continued from previous page)

4. <u>Challenge</u>: Using the Gizmo, try to maximize the 30th year corn yield while retaining 35 or more species in the stream. Then, try to maximize the yield with 50 or more species. Fill in the table below to show how you did it.

Resistance type	Refuge?	Herbicide	Insecticide	Total species	Yield
				35+	
				50+	

Why did you make the choices you did in the table above? _____

_____

_____

5. <u>Challenge</u>: Choose the non-resistant corn.

    A. What is the best yield you can get while still retaining 50 or more species? _____

    B. How does this compare to the GM corn? _____

       _____

6. <u>Think and discuss</u>: Use everything you've learned to answer the following questions.

    A. What are the benefits of GM corn to the farmer? _____

       _____

       _____

    B. What are the environmental benefits of using GM corn? _____

       _____

       _____

       _____

    C. How can GM corn be harmful to the environment? _____

       _____

       _____

       _____