STATE SCIENCE STANDARDS:

6th, 7th, 8th Grade Skills and Processes:
1.0.A.1.h Use mathematics to interpret and communicate data.
1.0.B.1 Review data from a simple experiment, summarize the data, and construct a logical argument about the cause-and-effect relationships in the experiment.
1.0.C.1.a Organize and present data in tables and graphs and identify relationships they reveal.

6th Grade Science:
3.0.D.1.c Describe ways in which changes in environmental conditions can affect the survival of individual organisms and entire species.
6.0.A.1.c Identify and describe how the natural change processes may be affected by human activities.
3.0.D.1.e Describe ways in which changes in environmental conditions can affect the survival of individual organisms and entire species.

8th Grade Science:
3.0.D.1.b Recognize that adaptations may include variations in structures, behaviors, or physiology, such as spiny leaves on a cactus, birdcalls, and antibiotic resistant bacteria.

GOAL STATEMENT:
Students will simulate the effects of pesticides on an insect population and observe how the population changes over time.

OBJECTIVES:
- Students will collect, graph, and analyze data.
- Students will explain how pesticide resistance can change the makeup of an insect population over time.

REQUIRED MATERIALS:
- Photographs of insect damage to agricultural plants (you may find photos online and print them or project them for the lesson or use the attached photos)
- Copies of activity data sheets (1 per student)
- Cup of light-colored dry beans (1 cup per group)
- Cup of dark-colored dry beans (1 cup per group)
- Small plastic container or paper lunch bag for each group of 2 to 4 students
- Colored pencils (optional) and straight edges for creating bar graphs

AMOUNT OF TIME TO ALLOW:
60 minutes. Extension activities will take additional time.
Many things can affect crop yield, the amount of a crop that is produced in a growing season. Bad weather and pests are the two primary factors that can negatively affect a farmer’s season. While farmers cannot control the weather, they can use pesticides to control weeds, insects, and plant diseases on their farms. Pesticides are specially-formulated chemicals that suppress or kill plant pests that can damage crops.

There is a large variety of pesticide products available, and pesticides have been widely used by farmers over the past several decades. However, some pesticides have become less effective over time. This is due to the development of resistance to pesticide chemicals within the pest population. Let’s consider insect pests. Some insects are naturally susceptible to a pesticide, while others naturally possess some amount of genetic resistance. When a pesticide is applied, the susceptible insects are killed but the resistant insects are not. These resistant insects are then able to reproduce and pass down their resistance genes to their offspring. As this cycle continues, that insect population eventually becomes entirely resistant, and pesticides that were once effective have no further action on the insect population. In summary, over several generations natural selection can cause a population to evolve and become almost entirely resistant to a pesticide.

Because pesticide resistance can become a problem, farmers do not rely solely on chemical pesticides to control pests. Instead, farmers use an approach called Integrated Pest Management (IPM). Pesticides are only one tool within an IPM program; other techniques include use of non-chemical practices such as tilling, rotating crops, and releasing natural predators of the pest. The IPM approach is more effective than the use of chemical pesticides alone and also reduces the likelihood that pesticide resistance will develop.

Show several photographs of crops with insect damage to the class. Ask students what words come to mind as they look at the photographs. Allow students to share ideas. Lead the discussion to the concept that insects can reduce the amount of food harvested by Maryland farmers. Because farming is a business, Maryland farmers try to harvest and sell the maximum amount of food per acre. As a result, modern farming in the United States usually relies on pesticides – chemicals that kill insects or plant pests that could compete with or harm the crop. Specifically, herbicides target plants while insecticides target insects. Pesticide application helps kill insect pests such as stink bugs that can damage tomatoes and squash, but it can also harm beneficial insects such as ladybugs that are predators and eat pest insects. As a result, modern farming uses integrated pest management that relies on a variety of techniques for reducing the quantities of pesticides applied to farm fields.

Here is a link to a Discovery News™ video from fall 2010 video about local stink bug damage: <news.discovery.com/videos/animals-stink-bugs-invade-homes-damage-crops.html>
**Directions:**

1. Divide students into groups of 2, 3, or 4.
2. Hold up a plastic container or paper bag and tell students that it represents a farm field on which crops are being grown. The beans represent different colors of insects in a species that eats the crops. Explain that a pesticide sprayed on a farm field usually comes into contact with a portion of the insects on the crops. Because of genetic variation in a population, some insects tend to have a natural resistance to the pesticide and survive better than others.
3. Have each group count 100 light-colored beans and 100 dark-colored beans, place them in the container, and mix them. An option for limited time or for younger children is to reduce the number of beans to 50 white and 50 black.
4. Have someone in each group reach into the container and remove handfuls of bean “insects” until 100 have been removed. These beans represent insects that came into contact with the pesticide when it was sprayed. (We assume that 100 insects are sprayed each time the field is sprayed.) Students count the light and dark insects that came in contact with the spray and record the information on the data sheet.
5. All of the light-colored insects in the simulation die and should be put back into their original cup, but the dark-colored insects survive and reproduce.
6. Groups should put the surviving (dark) insects back into the “field” container and allow them to reproduce by doubling them. (For example, if 37 dark beans survived, 37 additional dark beans should be taken from the cup and added to the field container.)
7. Groups should simulate sprayings 2, 3, 4, and 5 by repeating steps 4-6.
8. All beans should be separated and placed into their original cups.
9. Students should use their data to plot bar graphs of the number of light and dark beans in each handful taken from the field following each spraying.

Note for classes of students with challenging behaviors: If the teacher is concerned about the possibility of students spilling or throwing beans, slips of colored paper or pictures of dark and light colored insects may be substituted in place of beans.

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**Explanation**

Allow students to answer the analysis/conclusion questions within their groups. Next, use the questions to guide a class discussion of why the population changed. Introduce the concept of natural selection. The natural resistance in the dark-colored insects gives them a selective advantage, meaning that they will survive and reproduce better than the light-colored insects. Over time, the proportion of dark-colored insects will continue to increase with repeated sprayings of the same pesticide that selects against light-colored insects. Change in a population over time is referred to as evolution.

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Ask students to suggest possible alternatives to repeated spraying of a pesticide on an agricultural field. Suggestions might include switching pesticides, rotating crops, organic farming with higher crop diversity, releasing beneficial predator organisms, etc. Share with students that farmers use many methods to control pests (i.e. biological, crop rotation, developing new pesticides and chemicals, developing plants resistant to pests, etc...). Many farmers use what is called an IPM (Integrated Pest Management) system that is developed to use the most effective technique which may control pests better than pesticide and actually limit the number and types of sprayings.

Allow students to research pests and pest management techniques using the University of Maryland Home and Garden Information website, <hgic.umd.edu> You might want to develop a list of agricultural pests that affect crops in your area and have students (or groups) research the pests as well as techniques that are used to reduce pest damage.

After students have researched pests and pest management techniques, you might want to ask each student or group to prepare a poster, fact sheet, or brief oral presentation to share the results of their findings with the class.

Pest management is an essential career field for the agricultural industry.

- **Pest management specialist** – This person may work in integrated pest management, which combines a wide variety of techniques intended to control pests while minimizing costs to farmers as well as the quantity of pesticides that are applied to crops.

- **Biotechnologist** – This person genetically engineers crops to make them resistant to pesticides.

- **Soil scientist** – This person monitors pesticide levels in the soil and make recommendations to farmers.

A pre/post test should be completed with this lesson plan. Student understanding of concepts can also be evaluated through class discussion as well as through evaluation of completed activity data sheets. Analysis/conclusion questions that are answered incorrectly by a large number of students should be addressed in a follow-up discussion.
Maryland Agricultural Education Foundation, Inc. <www.maefonline.com>
Educators can find a wide variety of agriculture support materials on this site.

University of Maryland Home and Garden Information Center. <hgic.umd.edu>
This website includes a searchable database that contains information about pests and beneficial insects in Maryland.

Photos of insect pest damage to be used in the “engage” section of the lesson were taken from the Home and Garden Information Center website. Additional information from the database can be used to supplement “Extension” section of the lesson.

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Stinkbug Damage

HGIC, U of MD

J.A. Davidson, U of MD
Tomato Horn Worm Damage

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Cucumber Beetle Damage
Goal:
Simulate the effects of pesticides on an insect population and observe how the population changes over time.

Materials:
– cup of light-colored dry beans
– cup of dark-colored dry beans
– plastic container or paper lunch bag
– colored pencils and rulers

Background:
Do you like to eat? Of course you do! Agriculture is a very important industry. Farmers work hard growing food that can be eaten by people and animals. Unfortunately, some insect “pests” eat many of the same crops people eat. Large numbers of insects eating the crops in a field can reduce the amount of food harvested by farmers. Because farming is a business, farmers try to harvest and sell the maximum amount of food per acre. As a result, modern farming in the United States usually relies on insecticides – chemicals that kill insects – to reduce insect populations and increase crop harvests.

In the same way that people are genetically different from each other, insect populations have genetic differences (variation). Some insects are more resistant to certain pesticides and can survive better than other insects. This activity will let you model how pesticides can affect an insect population. In the activity, dark-colored insects have a gene that helps them survive being sprayed with a pesticide.

Directions:
1. Get into your lab group.
2. Listen carefully as the teacher explains the activity.
3. Count 100 light-colored beans and 100 dark-colored beans, place them in the container, and mix them together.
4. Someone should reach into the container and remove handfuls of bean “insects” that came into contact with the pesticide. Remove exactly 100 and put extras back in the “field” container. Count the dark beans and the light beans and write the information in the data table.
5. The light-colored insects you removed die and should be put back into their original supply cup.
6. The dark-colored insects are resistant to the pesticide: They survive and reproduce. Double the dark-colored insects by adding an equal number of dark insects from the supply cup. Put the dark insects and their “offspring” into the field container and mix them.
7. Simulate the effects of sprayings 2, 3, 4, and 5 by repeating steps 4-6 above.
8. Clean up: Separate the beans by color and place them into their original cups.
9. Use your data to make a bar graph of the number of light and dark insects taken from the field following sprayings 1-5.
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**Data Table**

<table>
<thead>
<tr>
<th>Pesticide Spraying Number</th>
<th>Number of Light Insects</th>
<th>Number of Dark Insects</th>
<th>Total Number of Insects Sprayed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td>100</td>
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<tr>
<td>2</td>
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<td>5</td>
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<td>100</td>
</tr>
</tbody>
</table>

**Graph:** Effect of pesticide spraying on color distribution in an insect population.

**KEY**

- Light-colored insects
- Dark-colored insects
Analysis:
1. Following the first spraying:
   A. How many light-colored insects were in the 100 you removed? ________
   B. How many dark-colored insects were in the 100 you removed? ________

2. For the last spraying:
   A. How many light-colored insects were in the 100 you removed? ________
   B. How many dark-colored insects were in the 100 you removed? ________

3. Describe how the populations of light and dark insects changed after repeated pesticide sprayings.

Conclusion:
1. Explain why each color of insect increased or decreased over time.

   ________________________________________________________________

   ________________________________________________________________

2. **Natural selection** says that there is genetic variation in populations. Some organisms will survive better than others and be able to reproduce at a higher rate. How does this activity demonstrate natural selection?

   ________________________________________________________________

   ________________________________________________________________

3. **Evolution** refers to changes in a population over time due to natural selection. Predict how the population will look if the farmer sprays the same pesticide five more times.

   ________________________________________________________________

   ________________________________________________________________

Extension:
1. Suggest some ideas the farmer might try to reduce insect pests without producing a pesticide-resistant population.

2. Research crops, insect pests, and pest management techniques and share your findings with the class.
PRE-Evaluation: Persistent Pests

1. How old are you? ______________
2. Are you....(Select one.)
   - A Boy
   - A Girl

3. Are you....(Select ALL that apply.)
   - African American/Black
   - Native American/Alaskan Native
   - White
   - Asian
   - Hispanic/Latino
   - Native Hawaiian/Other Pacific Islander

4. What type of school do you go to? (Select one.)
   - Public school
   - Private school
   - Religious school (Catholic, etc.)
   - Home school

Your Science and Agriculture Opinions and Knowledge

5. **BEFORE going through the AGsploration Program**, please **circle** the degree to which you agree or disagree with the following statements.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I like science.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>I feel that Maryland agriculture is a part of science.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Science is useful for solving everyday problems.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Maryland agriculture is beneficial to me, my family, and my community.</td>
<td>1</td>
<td>2</td>
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<tr>
<td>When I graduate from high school, I would like to have a job in agricultural science.</td>
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<td>2</td>
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<tr>
<td>I can name three jobs in the agriculture industry.</td>
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</table>

6. **BEFORE going through the AGsploration Program**, please **circle** your knowledge level about the topics listed below.

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POST-Evaluation: Persistent Pests

Your Science and Agriculture Opinions and Knowledge

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7. As a result of participating in this activity, tell one new thing you will try or one thing you will find information about.

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

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SUPPLEMENTAL - Evaluation: Persistent Pests

**Directions:** If you are teaching more than one lesson plan in one day, you may attach this to the pre/post evaluation form for the other lesson you are teaching. Please have the student fill out these during the pre and post evaluation times. In addition, only have the student fill out the post evaluation questions Q5 – Q7 at the completion of all lessons.

**PRE-Evaluation**

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**POST-Evaluation**

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