Lesson 5. How is a Population of Radish Plants Likely to Change when Hungry Caterpillars Arrive?

The *"Big Idea"*	The same process of natural selection that occurs with animals also occurs with plants. Data show how the distribution of trait variants in a population changes over time.
Investigation Question	How is a population of radish plants likely to change when hungry caterpillars arrive?
Summary	Students predict what will happen to the distribution of the hairiness trait when caterpillars prey on a population of radish plants. They apply reasoning with the mechanism of natural selection to order graphs of the hairiness characteristic in radish populations over 4 generations. Finally, they find out if their predictions align with evidence collected by a scientist.
Materials	For the class ● Photographs of a hairy and a smooth radish plant ● Slide deck for this lesson ● Optional: Plant life cycle video *https://www.youtube.com/watch?v=DKk61gemIW8* For each group ● Sets of laminated graphs For each student ● Notebook pages 20-21

Lesson Description and Rationale

By now students are familiar with the idea that trait variants exist in populations of organisms. In Lesson 3 (radish seedlings) they learned that graphing measurements of a trait variant is a useful tool for describing variation in a population. At the end of Lesson 3, they thought about whether caterpillars will prefer to eat plants with many hairs or plants with no or few hairs.

Today they continue to think about caterpillars and radish plants. First, they predict whether having more or less hair might be beneficial to individual plants when caterpillars invade their environment. Then, they apply their understanding of change over time by deciding how to order graphs that depict different distributions of hairiness in radish plants. The graphs they'll use in this lesson show how the distribution of the hairiness trait changes over four generations after a population of radishes is invaded by caterpillars that prefer to eat plants that are hairless or have very few hairs. Finally they compare their initial ideas about what a sequence of graphs might look like with data collected by a scientist. The scientist's data were adapted for this lesson.

Note: Plants, like animals, also experience natural selection. A reminder: feel free to use the term "natural selection" with students.

Learning Targets in this Lesson

- Individual plants with beneficial trait variants (e.g., lots of hairs) are more likely to survive and have more offspring.
- Graphs of trait variants can show how the number of individuals with beneficial trait variants increases from generation to generation.

Sequence of Experiences		
1. Introduction	All class	5 Minutes
2. Interpreting a Scientist's Graphs	All class	10 Minutes
3. Ordering Data	Small groups	10 Minutes
4. Make Meaning of Data	All class	15 Minutes
5. Wrap Up	All class	5 Minutes

Preparation

- Review the 4 graphs showing 4 generations of data. Review the order that shows that the proportion of plants with many hairs increases over the generations (blue=1st generation, orange=2nd, green=3rd, purple=4th).
- Ensure that each student group will have a set of the 4 laminated radish generations graphs.
- Decide whether or not you think the class needs to review the plant life cycle so students understand that plants have "offspring" in the form of seeds. (See link to video with this information below).

The Lesson

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1. Introduction (3 min)

Remember when we made a graph of plant hairs together, with the sticky notes? Today we are going to use the same reasoning that we did about changes over time in the case of the piloses to make sense of some graphs. At the end of the lesson, we will compare our ideas with a scientist's data.

Note: Some students may wonder about plants having offspring. You may want to review plant life cycles briefly - that seeds from plants grow into new plants that tend to look like the original (parent) plants. Here is a video to review the plant life cycle. https://www.youtube.com/watch?v=DKk61gemIW8 (1:22)

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2. Interpreting a Scientist's Graphs (10 min)

Remind students that they predicted whether caterpillars preferred to eat plants with many hairs or plants with no or few hairs. Based on those ideas, ask students to predict what would happen in a population of radishes if hungry caterpillars arrived. Ask for a show of hands:

Who thinks the number or proportion of hairier plants in the next generation would…

Increase?
Decrease?
Stay the same?

Note: You can expect that most students will predict that the proportion of hairier plants will increase.

Explain that a scientist wondered about the same question.

Nikola, a scientist who studies radish plants, was curious about the effect that the arrival of caterpillars would have on the radish plants she was studying. She began to collect data. Here is the graph that shows the variation in the number of hairs she counted in the first generation of radish plants – the plants that were there when the caterpillars arrived.

<u>The first generation (blue graph)</u>
Show the bar graph from the teacher slide deck for all the individuals in the *first generation (blue)*. Help students interpret the information from this graph.
Ask:

- *What does this graph tell us about the hairiness trait in this population of plants?*

Note: 1. Students may remember they looked for the mode and the range in their Lesson 3 data. Students don't need to memorize these handy descriptors, but you can remind them that two important features of population graphs are ***the value that has the most plants*** *(mode) and the* ***smallest and largest values*** *(range).*
2. If you feel your students may need to be reminded how to look at the data, recall these questions from L3:

- *Which stack of sticky notes is the tallest?*
- *What is the lowest number of hairs? The highest number?*

Listen for ideas:

- There are more plants with 2 hairs than any other number/variant (the mode is 2)
- There are very few plants that have lots of hairs
- The hairiest plant has 20 hairs
- The range is 0-20 hairs.

Ask students to turn and talk about this question

- *Now that caterpillars will be attacking this first generation of radish plants, what do you think the 2nd generation (the offspring) will be like if you look for hairs?*

Further prompts if students seem stuck:

Do you think there will be the same number of plants with no hairs? The same number of plants that are hairy? A few more that are hairy?

After a few minutes, ask for a volunteer to share his/her ideas.

Do others agree? Does someone have a different idea?

Check to see if the class agrees that caterpillars prefer to eat leaves with no or few hairs.

<u>The 2nd generation (orange graph)</u>

Now show the scientist's data on the 2nd generation graph (orange).
Project the slide showing the two graphs directly aligned so the 1st generation (blue) is positioned above the 2nd generation (orange).
Ask:

- *Is the 2nd generation (orange) more hairy, less hairy, or the same as the parent generation? What is the evidence from the graph: did the mode change or stay the same? The range?*

Listen for ideas

- There are more plants with more hairs
- Evidence: The mode (the largest stack, bar, bump) is higher; the range (both lowest and highest number of hairs) is bigger.

Note: A student may ask how offspring can have more hairs than their parent plant given that they tend to look like their parents. You might explain by analogy - if a mom and dad are both tall, they will probably have kids who are tall, but not all the siblings will be exactly the same height.

Ask students to explain why the second generation has more plants with many hairs.
Listen for ideas

- Plants that have more hairs will be more healthy because fewer of their leaves will be eaten. This means that they will have more offspring (make more seeds).

- Since offspring generally resemble their parents, the number of plants with the advantageous trait variant (more hairs) will increase in the population.

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3. Ordering Data (10 min)

<u>The 3rd and 4th generations (green and purple graphs)</u>
Explain that in small groups, students will take 5 minutes to

1. Look at 2 more laminated graphs from the scientist's investigation.
2. Decide on the order of the remaining 2 graphs (green and purple), which show the populations of the remaining 2 generations.
3. Be ready to explain the group's reasoning.

Project or post the directions (above).
Hand out a set of laminated graphs to each group and ask them to begin.

Note: Students who originally predicted that caterpillars would eat hairier plants will find that none of the 2nd, 3rd, and 4th generations has a smaller number of hairy individuals and a greater number of less hairy individuals, as would be expected if natural selection works the way they have learned so far. In the face of the evidence, they will come to realize that their prediction was incorrect.

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4. Make Meaning of Data (15 Min)

Form a discussion circle.

<u>The **purpose** of this discussion</u> is for students to (i) interpret the evidence from a scientist's investigation of the hairiness trait in 4 generations of radish plants, (ii) explain these findings in terms of natural selection, and (iii) recognize that there will be more and more individuals with a beneficial trait variant over time.

Now we can see all of Nikola's data for 4 generations of radish plants attacked by caterpillars! By looking at the scientist's data, we can learn whether our predictions and reasoning about change over time in the hairiness trait of radishes is sound or not.

Project the slide showing the correct order of the graphs (blue, orange, green, purple).

Note: In light of the data, you may find that some students' prediction does not match the outcome. If this does happen, the class needs the opportunity to negotiate and revise ideas. It will be important to support a class discussion so that students can explain their reasoning.

Return to the investigation question: How is a population of radish plants likely to change when hungry caterpillars arrive? Ask

- *Can you describe the change that occurred in the population of plants over time?*

Listen for these ideas about the graphs:

- I can see that the generations included more and more hairy plants because the mode (of number of hairs) got bigger in each generation/there were no offspring with no hairs
- I know that the generations included more and more hairy plants because the range changed – the number of hairs that the least hairy plants had increased from generation to generation and the number of hairs that the most hairy plants had increased /there were no offspring with no hairs after the first generation
- I know that there was still variation in all the generations because there was a range in every generation.

Discuss with students:

- *Did the graphs help you see the change after the caterpillars arrived? Why?*
- *What parts of the graphs helped you?*

Time permitting, ask

- *If we were to write a storybook like the piloses but this would be about radish plants and caterpillars…*
    - *How would it begin?*
    - *What would happen next?*
    - *What would happen after that?*

Listen for these ideas about natural selection:

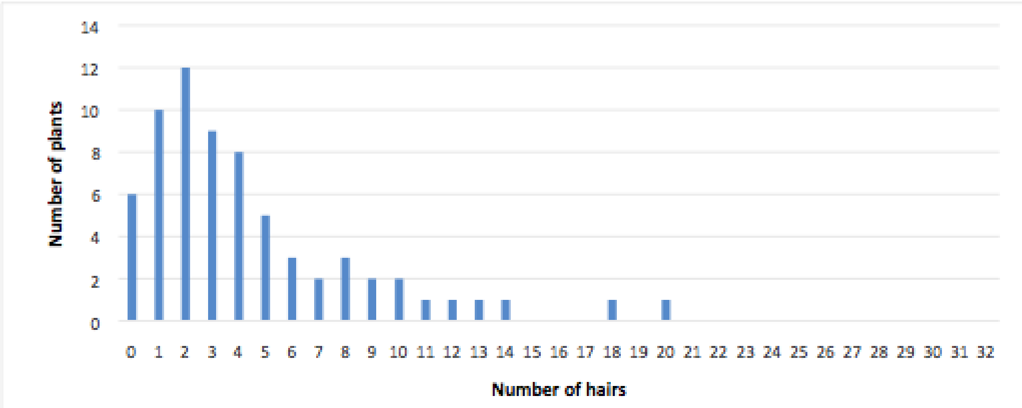
- First, there was a population of radish plants that had mostly leaves with no hairs but some more hairs – up to 20.
- Caterpillars arrived; they preferred to eat plants with fewer hairs
- Caterpillars ate all the plants with no hairs so there were none left to have offspring with no hairs.
- Some leaves were eaten from many of the plants that had few hairs; this made them less healthy so they had fewer offspring.
- The numbers of the more hairy plants increased; they were more healthy and so they had more offspring.
- Since offspring generally resemble their parents, the number of plants with the advantageous trait variant (more hairs) increased in the population.
- This went on for 4 generations.

Note: If there are still students who predicted that caterpillars would eat hairier plants and have not come to realize that their prediction was incorrect, give them a chance to rethink their prediction. Ask them what they think of their prediction now.

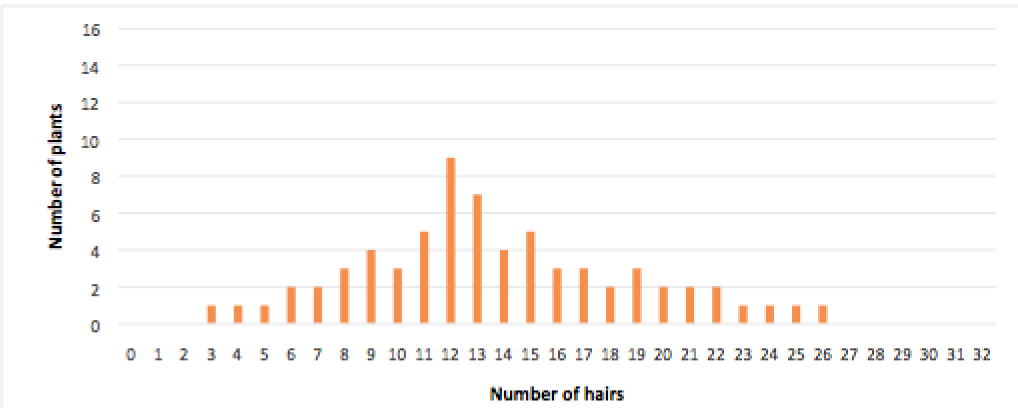
5. Wrap Up (5 Min)

The piloses story is a story of natural selection. We found that the same story can explain why, after caterpillars arrive, there are more and more hairier plants (and fewer plants with no or just a few hairs) in each generation. Natural selection happens to both animals (like the piloses) and plants (like the radishes)!

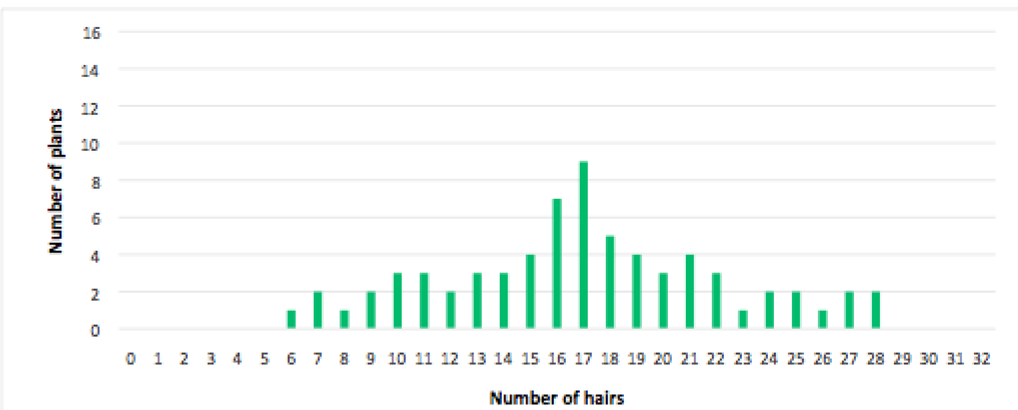
Next time, we'll meet some small lizards called anoles!



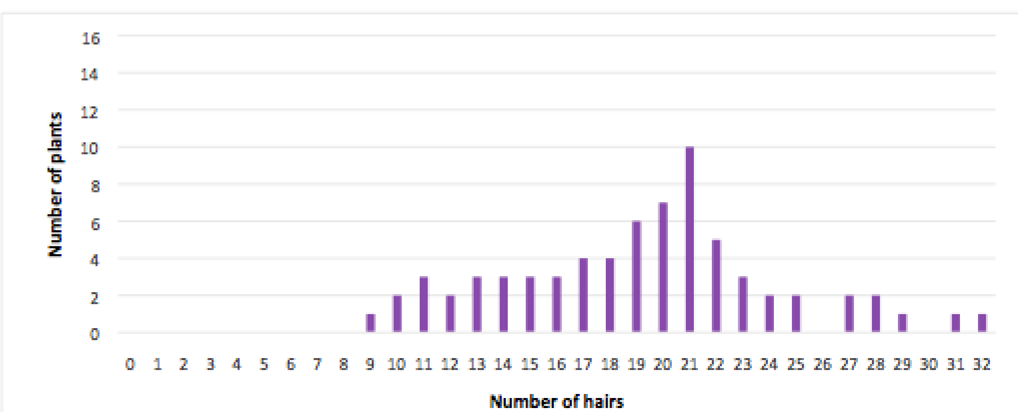
Number of plants
Number of hairs



Number of plants
Number of hairs



Number of plants
Number of hairs



Number of plants
Number of hairs