The Nature of Science and the Study of Biological Evolution

Variation: The Raw Material for Evolution

Teacher's Guide for Activity 9

Biological Sciences Curriculum Study
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Activity at a Glance

The purpose of this activity is to develop students' ability to conduct scientific inquiry by having them (1) make observations, (2) establish consistent criteria for data collection, (3) represent data graphically, (4) interpret graphs, (5) draw conclusions and inferences based on a limited data set, (6) effectively communicate results to peers, and (6) learn about the nature of science. The activity employs five instructional strategies: teacher-guided discussion, hands-on data collection, collaborative learning, graphing-to-learn, and oral explanation.

Students begin the activity by looking at a photograph of horses to observe individual variation. They then examine commercially grown sugar snap peas (store bought peas-in-a-pod) and participate in a teacher-led discussion about the variation among the pods. Students then break into groups to design a scientific investigation that answers the question, "Do sugar snap pea pods differ with respect to seed number?" They report their proposed counting criteria, measure seed number in a sample of pods, and pool their data. Finally, they graph their data for homework and compare it with data collected from a large population of wild peas.

Students demonstrate their enhanced understanding of scientific inquiry by (1) communicating their results to other students, (2) creating a histogram from a new set of variation data and interpreting it, (3) providing alternative interpretations and explanations for the data, (4) distinguishing between estimation and counting, and (5) justifying their methods to their classmates and teacher.

National Science Education Standards and Activity-Specific Concepts

This activity addresses the following *National Science Education Standards* (*NSES*) content standards:

- Science distinguishes itself from other ways of knowing and from other bodies of knowledge through the use of empirical standards, logical arguments, and skepticism, as scientists strive for the best possible explanations about the natural world.

- Scientists have ethical traditions. Scientists value peer review, are truthful about the methods and outcomes of investigations, and making public the results of work. Violations of such norms do occur, but scientists responsible for such violations are censured by their peers.

- Individuals and teams have contributed and will continue to contribute to the scientific enterprise. Doing science or engineering can be as simple as an individual conducting field studies or as complex as hundreds of people working on a major scientific question or technological problem.

- Scientific explanations must meet certain criteria. First and foremost, they must be consistent with experimental and observational evidence about nature, and must make accurate predictions, when appropriate, about systems being studied. They should be logical, respect the rules of evidence, be open to criticism, report methods and procedures, and make knowledge public.

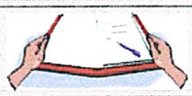
This activity addresses the following *NSES* "Science as Inquiry" standards:

- Identify questions and concepts that guide scientific investigations.
- Design and conduct scientific investigations.
- Use mathematics to improve investigations and communications.
- Formulate and revise scientific explanations and models using logic and evidence.
- Recognize and analyze alternative explorations and models.
- Communicate and defend a scientific argument.

This activity teaches students the following activity-specific concepts:

- Observations are limited by the care and precision with which they are made. Observations are subject to verification.
- All quantitative observations are to some degree imprecise and vary with measurement criteria.
- Graphs are tools that help make analysis possible.
- Several logical interpretations of the same data are possible.
- Sugar snap pea pods vary in seed number.

In Advance



1. Set aside two class periods for this activity. 45 minutes in class period 1; 20 minutes in class period 2.

2. Purchase enough fresh sugar snap peas to give 24 pods to each team of four students. *Note:* One pound of sugar snap peas costs $1.00–$3.00. There are approximately 120 pods in a pound.

3. Gather dissecting equipment (scalpels, single-edged razor blades, or dissecting needles).

4. Photocopy *Class Seed Data Worksheet* (1 per student).

5. Make a color copy of Transparency 1.

6. Make a copy of Transparency 2.

7. Photocopy the *Seed Data from a Population of Wild Strawberries Worksheet* (1 per student).

8. Read the background information on intraspecific variation in this guide.

9. Photocopy the *Assessment Worksheet* (1 per student).

Procedure

<u>**Class Period 1**</u> (45 minutes)

1. **Engage** (5 minutes)**:** Show your class Transparency 1 (a population of galloping horses).

   Instruct students to study the horses then call on them to answer the following questions. Accept all valid observations.
   - **How many "types" of animals do you think you see?**
   - **How are the individual animals similar?**
   - **How are the individual animals different?**

2. Call on students to answer one more question, **What did you have to do to answer the three questions I asked you about these animals?** (Answer: Students had to make observations.)

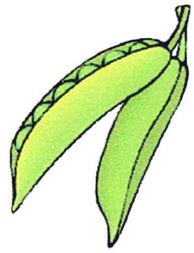
3. **Explore/Explain** (40 minutes)**:** Organize the students into **teams of four**.

4. Distribute **four pea pods** and **four dissecting instruments** to each team.

5. Pose the following question to the class, **How are the pea pods different from one another? Discuss this for a couple of minutes within your team.**

   Allow 3 minutes for team discussions. Circulate among the teams and monitor student discussions. Suggest that students can open the pods.

6. Call on teams to describe how the pea pods may vary. Reponses will likely include variations in length, mass, thickness, circumference, and number of seeds inside a pod. Introduce the idea that observations involving measurements are called *quantitative data*. Emphasize the value of quantitative comparisons.



7. Ask teams to design an investigation that answers the following question, **Do sugar snap pea pods vary in seed number?**

8. Tell teams they will have 5 minutes to examine the four pods and work out a method for collecting data on seed number per pod.

   Circulate and listen to the discussions. Some issues students need to address are
   - How will students open the pods? (For example, the pods can be cut open with a scalpel on the side opposite to where the seeds are attached to the pod.)
   - Will small, poorly developed peas count?
   - Will aborted seeds count? (A space where a seed could have developed.)
   - How many team members will count each pod?

   Resist the temptation to resolve these issues for the teams.

9. Call on several teams to describe their proposed counting method to the class.

   Ask students, **Why is it important that every team use the same counting method if we want to pool data from all the teams?** (Answer: It is important that all teams use the same counting method because the method chosen will influence the results.)

   IMPORTANT: Instruct the class to select one of the proposed counting methods.

10. Distribute 20 new pea pods to each team. Direct teams to count the number of seeds in each of the *new* pods.

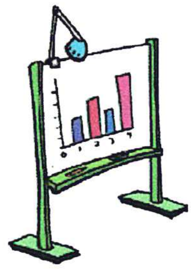
11. Call on several teams to report their data. Ask students, **Did your pea pods vary in seed number? If so, what kind of variation did you observe?** (Answer: Results will vary, but most students will find 6–8 seeds per pod.)

12. Display Transparency 2 (*Class Seed Data*). Direct teams to record their data directly on the transparency.

    Distribute the *Class Seed Data* worksheet. Tell students to copy the data from the transparency to this worksheet.

    Direct students to plot bar graphs for their team's data and the class data as homework. *Note:* Make sure your students understand how to plot a histogram.

<u>**Class Period 2**</u> (20 minutes)



13. **Elaborate:** Display the bar graph (histogram) for the pooled (class) data.

Call on students to answer the following questions **How was your team's graph similar to the class graph? How was it different?**

What is the value of measuring a larger sample of pea pods? (Answer: Responses will vary. The team histogram may not produce a bell-shaped curve, but the class histogram will likely be bell-shaped.)

What would be the benefit of having two people count the number of seeds in each pod? (Answer: The seed count data would probably be more accurate because there would be fewer miscounts.)

14. Display the *Seed Data from a Population of Wild Strawberries (Fragaria virginiana)* transparency.

    Call on students to answer the following questions, **How is the seed number data for wild strawberry similar to the data for sugar snap peas? How is it different?** (Answer: Seed number in both sugar-snap peas and wild strawberry varies in a bell-shaped manner. The range of variation is much greater in wild strawberry.)

    How might this variation be the raw material for evolution?
    (Answer: There must be individual variation in every population for natural selection to operate. This means that some individuals in a population will be better adapted to the environment than others. These better adapted individuals have chance combinations of heritable traits that give them a survival and reproductive advantage.)

<u>**Evaluate**</u> (conduct when appropriate)
Select one or more of the following assessment options:

- Assign students credit for participating in this collaborative learning activity.
- Collect and grade students' worksheets.
- Direct students to complete the *Assessment Worksheet* at home (highly recommended).

Background Information, References, and Image Credits

Within Species Variation Three requirements are necessary for natural selection to move a population toward being better adapted to its environment. These requirements are (1) not all organisms that are born can survive (due to limited resources, competition, predation, and other environmental stresses), (2) heritable variation among individuals, and (3) some of these variations give individuals a survival/reproductive advantage. The outcome is natural selection—individuals with heritable advantages have more offspring (differential reproductive success), which will be similarly advantaged. Over many generations, the proportion of individuals having the inherited advantages will tend to increase in the population.

This activity focuses on the first requirement—*heritable variation*. Other activities investigate the remaining requirements. Heritable variation refers to genetically determined traits that vary among individuals within a species (intraspecific variation). For example, hair color varies among humans and is genetically determined. Therefore, human parents give their genes for hair color to their offspring. Variation in hair color among humans results from mutations that have occurred in hair color genes and the interaction of hair color genes provided by a father and mother.

The golden pea, *Thermopsis divaricarpa*

Seed number in many plants (including peas) has a heritable component too, although environmental factors influence seed number as well. Environmental factors include the amount of pollen delivered to a flower by pollinators and the amount of nutrients provided to the developing seed.

There must be a large amount of individual variation in every population for natural selection to operate. Biologists have discovered that this is true for all populations. This means that some individuals in a population will be better adapted to the environment than others. These better adapted individuals have chance combinations of heritable traits that give them a survival and reproductive advantage.

For example, under conditions of nutrient stress, plants that produce fewer high-quality seeds might contribute more offspring to the next generation than plants that produce many low-quality seeds because high-quality seeds have a higher germination rate. Under nutrient rich conditions, plants that produce more seeds might have selective advantage.

Because better adapted individuals are more likely to survive and reproduce (that is, be naturally selected), the traits of a population will change from generation to generation. Better adapted individuals contribute more offspring to the next generation which causes the frequency of advantageous heritable traits in the population to increase. This causes the population to become better and better adapted to its environment across time. Since environmental conditions are almost always changing, natural selection is constantly modifying populations. This is why the process of evolution by natural selection is often called *descent with modification*.

Charles Darwin's focus on the variation among individuals was a key insight into how natural selection operated. He was long impressed by the unusual varieties of orchids, pigeons, sheep, and dogs that breeders produced by selecting for mating only those individuals that had certain desired traits.

Darwin realized that selection by people and selection by nature were fundamentally similar processes. The difference was that in domestic breeding (or artificial selection), only those individuals with traits that were valued by people were allowed to breed. The adaptive value of these traits in nature did not matter. With natural selection, individuals who were better adapted to the environment would breed and leave offspring.

With natural selection as its driving mechanism, evolution can take many paths, depending on circumstances. The unpredictable influence of chance and history in the process, as well as the uncertain outcome of evolution, were contrary to finalism and its notion of a predetermined end.

Sugar Snap Peas Sugar snap peas (Leguminosae: *Pisum sativum*) were named "New Product of the Year" in 1997 by Universal Press Syndicate. They have been a consumer hit because of their sweet flavor, crunchy texture, nutritional value, and snack appeal. You can purchase them in most grocery stores.

Sugar snap peas can be eaten directly out of the bag or cooked. Both seeds and pods are edible. A 4 oz. serving (113 grams) of Mann's Stringless Sugar Snap Peas provides 50 calories, 9 grams of carbohydrates, 3 grams of dietary fiber, 4 grams of sugar, 3 grams of protein, and 0 grams of total fat, cholesterol, and sodium.

They also can be prepared fresh from the garden, or canned or frozen for later use. Horticulturalists at Ohio State University recommend the Sugar Daddy, Sugar Ann (dwarf), Sugar Snap, and Super Sugar Snap Mel cultivars for gardening. The pods grow on tall vines that require support.

References

Dave's Garden, Inc. (2002). Dave's Journal: Sugar Snap Peas (2000). Web site URL: *www.davesgarden.com/journal/viewentry/1215.html.*

Mann Packaging Co. Inc. (2000). Mann's fresh vegetables. Web site URL: *www.broccoli.com/snappeas.htm.*

Riofrio, M. (2002). Growing peas and snap beans in the home garden (HYG-1617-92). Ohio State University Extension Fact Sheet. Web site URL: *www.ohioline.osu.edu/hyg-fact/1000/1617.*

Image Credits

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Wild Strawberry (*Fragaria virginiana*) photo courtesy of Tia-Lynn Ashman, University of Pittsburgh.