Ask A Biologist activity for classroom and home

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Table of Contents

About the Authors

When this activity was first designed, **Robin Greene**, **Karla Moeller**, and **Megan Rowton** were all graduate students in Arizona State University's School of Life Sciences. They designed the activity for a Scientific Teaching course.

Learn more

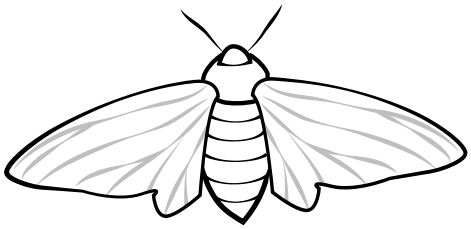
This is a companion PDF for this online article:

Sooty Selection
askabiologist.asu.edu/experiments/sooty-selection

Experiment Overview

A female giraffe walks up to a tree with leaves just out of reach. She lifts her head and stretches her long neck, barely reaching the green leaves of the tree. As she eats more and more leaves off of tall trees, her neck seems to have grown a little bit longer. This giraffes is pregnant with a baby giraffe. When the baby grows to be full size, will it have a longer neck because the mother giraffe stretched so much?

Let's picture a different scene now. Think about a forest filled with trees that have light-colored bark. The air pollution in the area gets bad over time, and the color of the tree bark starts changing from light to dark. Suddenly, light moths that were previously camouflaged are now easily found by birds. Will light moths be common in the next generation?



These examples all focus all relate to the same main questions: How is a trait passed to an organism's offspring and how does it spread through a population?

This week, you will discuss ideas of natural selection with your class, play a selection-based game, and take a trip through time to see how scientists of the past figured out just how a trait is passed from a parent to its offspring.

What you need

- PowerPoint presentation (your teacher has this)
- One pre-lesson quiz
- Post-lesson quiz
- In-class worksheet
- Pen or pencil

If you are completing the moth hunting activity, you will also need:

- Access to a computer

If you are completing the rice activity, you will also need:

- Light and dark bark (or crumpled light and dark construction paper)
- Small bag of wild rice
- Small empty bag
- Forceps (like tweezers)
- Timer or stopwatch

Before you begin

The very first thing you should do is answer all the questions on the pre-lesson quiz. This one has PRE written in the top corner. Don't worry, this first one is not for points! When you've completed the quiz, make sure your name is on it and turn it into your teacher

Procedure

ENGAGE: Giraffe Example

1. Look and listen closely to the pictures and presentation shown by your teacher. Follow along with the presentation, thinking about the pictures and questions presented and discussing them with your classmates.

2. After you and your class have finished talking about the giraffe's traits and how they developed, discuss this hypothetical situation: Imagine two pairs of giraffes: one pair with a male and female that eat only from the tops of tall trees, and one pair that eats from the lower branches of trees.

Experiment Overview *(continued)*

3. Listen to the rest of the teacher's presentation. Then, pick one of the following questions and write the question and your answer on your classroom worksheet. This is individual work, do not work in groups.

    - How did giraffes as a species get such a long neck?
    - Will giraffe babies be similar or different than their parents? Why?
    - How are traits, such as a long neck, passed down from parents to offspring?

4. Discuss your answers as a group and explore how these ideas might apply to birds with different sized beaks.

EXPLORE: Computer Simulation OR Rice Activity

If using the computer simulation, follow these directions:

5. Open the game and click on the bird icon (farthest to the right) to play "bird's eye view" of selection. Read the instructions and play a game in the light forest. Record your results on the classroom worksheet.

6. Revisit the bird icon and play a game in the dark forest. Record your results on the classroom worksheet.

7. After you've played in both the light and dark forest, click on the power plant icon to learn about the background for the game you just played.

8. Click on the scientist icon to visit an explanation of Dr. Kettlewell's experiments. Read through the explanation of his experiments and predictions.

9. Skip down to step number 13, below.

If using the rice activity, follow these directions:

5. Teachers will assign small groups of 2 to 3 students. Each group should get a piece of light bark (or construction paper), a pair of forceps, and a bag of wild rice. Make sure to crumple and then reflatten the construction paper.

6. Student #1 will set up the activity by counting out 15 white grains of rice and 15 dark grains of rice and spreading them out on the crumpled paper.

7. Student #2 will get out the stopwatch to time rice hunting. Student #3 should have the forceps and be ready to start "catching" rice with the forceps during a 10-second time interval. Make sure to only grab one piece of rice with each peck of the forceps. Collect the captured rice in the empty bag.

8. Clear off the remaining rice from the paper and count how many white grains and dark grains are left. Record this information in the table in the row for Generation 1.

9. Time for rice to reproduce! Count out the same number of each rice color from the full bag of wild rice and add it to the population. This should double the population.

10. Repeat steps 6 - 8 for three generations. Once you are done and have recorded population changes, calculate the percentage of each rice color in the whole population. Remember that you started out with 50% of each color.

Experiment Overview *(continued)*

11. Repeat steps 4 - 9 on a dark piece of construction paper.

12. Once you've completed the activity, use the percentages to figure out what was going on in the population. Answer the following questions on your classroom worksheet: Which rice color became more common on each background? Why?

EXPLAIN

13. As a class, discuss the activity you've completed (either the computer simulation or the rice activity). What changes did you observe in your population? Why did this happen?

14. Discuss what would happen if we helped the rice blend in by coloring them to be more camouflaged. In the wild, would this cause the rice's offspring to change color as well?

15. Discuss Lamarck and Darwin's ideas. Which theory drives the appearance of adaptations?

16. Think about species as a whole. If no dark morph had existed in this species, what could have happened? If more changes affected one population of these moths, might they gather enough new traits to be considered a new species?

17. Listen and learn as the teacher presents Weismann's mouse tail experiment. What would you expect to find from this experiment?

18. Participate in the discussion of adaptations for each of the following questions:

    - How can a trait or characteristic benefit an individual?
    - What does "survival of the fittest" mean?
    - How does an adaptation begin?
    - How does a trait spread within a population?
    - What factors might cause some animals to survive while others don't?

ELABORATE

19. As a class and with the help of your teacher, decide on definitions for the following terms:

    Fitness:

    Adaptation:

    Natural selection:

    Heritability:

    Mutation:

20. Read The Peppered Moth: A Seasoned Survivor on Ask A Biologist: **askabiologist.asu.edu/peppered-moth**

21. Discuss how the ideas you've learned apply to some of the following examples of adaptations: bird feet, cacti, insects, and pesticide resistance.

22. Try to think of human adaptations and how they increase our reproductive success (fitness) in the context of our habitat.

Teaching Tips

This activity is designed according to a 5E model. It is recommended for high school students, in grades 9 or above.

For younger grades (3 or 4), we suggest focusing mainly on the Engage and Explore sections, with a brief version of the Explain section.

Tips for Classroom Implementation

Time required

The entire lesson, including extension, should take around 5 hours (only completing one of the two provided Explore activities). This can be split into one hour per day for four days, plus an hour of homework, or can be distributed evenly throughout a week in class. However, the first three hours are very important, so it is encouraged to have three hours on the first day, with two follow-up hours on subsequent days.

Classroom set-up

Two different activities can be used (either the computer simulation or the rice activity). For the rice activity, make sure adequate desk space is available for students to work in groups of two or three. Make sure all three worksheets (pre-lesson, classroom worksheet, post-lesson) are printed for each student. The extension worksheet should also be printed if it will be used in class or for homework.

If doing the rice activity, make sure to count all forceps and double check that all are returned at the end of the rice activity.

Tips

Make sure to review the PowerPoint and familiarize yourself with the key ideas of natural selection before leading your class through the lesson.

Here is a suggested rubric for grading the pre- and post-lesson quizzes:

RUBRIC: 10 points total

- Questions 1-3: worth 2 points each, for 6 points total
- Question 4: worth 4 points

Based on the following criteria, each section of the question will be worth 1 point total.

1. Did the student answer the questions correctly? (0.25 points)
2. Whether or not the answer was correct, did they use reasonable logic according to their new knowledge? (0.5 points)
3. Did their answer include references to the topics covered in class and/or defined concepts we discussed? (0.25 points)

If you are unsure of the answers, feel free to email **dr.biology@asu.edu**.

Extensions

In class or as a homework assignment (see Extension Worksheet), students can practice applying the concepts and terms they learned that are associated with adaptations. Assign students with a habitat and an organism from a particular guild (e.g., predators, herbivores, primary producers). They should sketch and describe this organism. Specifically, they should describe the adaptations this species has acquired (through natural selection) that make it successful in its environment. What would happen to this organism if the environment changed (less rainfall or more extreme temperatures, for example)?

They will also be asked to identify and describe one human adaptation (not discussed in class) and how it relates to our environment. Students will be asked to address the five vocabulary terms and how the terms relate to the human adaptation they chose to discuss.

Objectives

After the lesson, students should be able to:

1. Explain how the environment can affect the fitness of a population.
2. Describe how different traits can lead to increased or decreased fitness.
3. Predict how a population with a given trait will change over time due to environmental influences.
4. Analyze changes in allele frequencies over time and compare between populations.
5. Describe how traits are inherited.
6. Discriminate between Darwinian and Lamarckian evolutionary theories.
7. Explain why mutations occur, how they relate to the concept of alleles, and how they can change in frequency over time and within a given population.
8. Apply knowledge gained from the rice experiment or moth simulation to different situations they are presented with.
9. Evaluate the evidence for human adaptation and evolution via natural selection.

Science Standards

Arizona Science Standards

Grade 3. Strand 4: Life Science | Concept 4: Diversity, Adaptation and Behavior

- **PO 1.** Identify adaptations of plants and animals that allow them to live in specific environments.
- **PO 2.** Describe ways that species adapt when introduced to new environments.

Grade 4. Strand 4: Life Science | Concept 4: Diversity, Adaptation and Behavior

- **PO 1.** Recognize that successful characteristics of populations are inherited traits that are favorable in a particular environment.
- **PO 2.** Give examples of adaptations that allow plants and animals to survive: camouflage.

Grade 8. Strand 4: Life Science | Concept 4: Diversity, Adaptation and Behavior

- **PO 1.** Explain how an organism's behavior allows it to survive in an environment.
- **PO 2.** Describe how an organism can maintain a stable internal environment while living in a constantly changing external environment.
- **PO 3.** Determine characteristics of organisms that could change over several generations.
- **PO 6.** Describe the following factor that allows for survival of living organisms: protective coloration

High School. Strand 4: Life Science | Concept 4: Biological Evolution

- **PO 1.** Identify the following components of natural selection, which can lead to speciation: (1) potential for a species to increase its numbers, (2) finite supply of resources required for life, (3) selection by the environment for those offspring better able to survive and produce offspring.
- **PO 4.** Predict how a change in an environmental factor (e.g., rainfall, habitat loss, non-native species) can affect the number and diversity of species in an ecosystem.

Common Core Standards

- **CCSS.ELA-LITERACY.RST.6-8.1.** Cite specific textual evidence to support analysis of science and technical text.
- **CCSS.ELA-LITERACY.RST.6-8.2.** Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions.
- **CCSS.ELA-LITERACY-RST.6-8.4.** Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics.

Next Generation Science Standards

- **MS-LS4-4:** Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment.
- **HS-LS4-4:** Construct an explanation based on evidence for how natural selection leads to adaptation of populations.
- **HS-LS4-5:** Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.

Sooty Selection Pre-Assessment

Name: _____

Date: _____

1. Which of the following would be an example of adaptation through natural selection?

   a. Some honey badger populations overlap with king cobra populations. In these overlapping areas, honey badgers that had a venom-resistant mutation are able to catch and eat king cobras as an additional source of food, increasing their resources. This mutation has spread through the population over several generations.

   b. Two parents that are both World Weightlifting Champions are about to have a baby. They expect their newborn to be a muscle-bound girl.

   c. Gopher snakes and diamond back snakes both have a diamond pattern that makes them look similar. A female gopher snake noticed that the nearby rattler scared off predators with its loud rattle, so the gopher snake started using a similar tactic, by vibrating its tail in the leaves. Any offspring she has will vibrate their tails as well.

   d. A pesticide-resistant locust population lives in an agricultural field that is getting too hot. The population moves to a cooler, non-agricultural area. The next generation of offspring will not be pesticide-resistant because they have no need to be.

2. One grizzly bear population has moved to an area that has snow year-round. Which of these statements might you expect to occur if a mutation for coat color is going to spread through the population?

   a. The adults of the population that moved to the snowy area started growing lighter fur.

   b. Grizzlies with white hair have an advantage, so the next generation of grizzly bears will all be white.

   c. Grizzly bears that have a lighter fur mutation can catch prey more easily and so have more resources to have more offspring. Due to this, the trait starts to spread through the population.

   d. If any grizzly bears living in snow develop white fur and it is beneficial to them, then the entire population will soon have white fur and will never have brown fur again.

3. Which of the following statements is true regarding traits that are related to fitness?

   a. A trait that increases fitness in one environment will always be a beneficial trait.

   b. A trait that makes an animal stronger or faster will automatically increase the animal's fitness.

   c. All individuals in a population that share similar traits are of similar fitness.

   d. A trait that increases the number of offspring an animal has increases the animal's fitness.

4. [LONG ANSWER] Two groups of cloned seeds from a lima bean plant are grown under two conditions: 1) normal soil (NORM), 2) soil that is high in pollutants and low in nutrients (HI-LOW). The plants that grow from seeds in the HI-LOW soil grow shorter than the plant they came from and have lower seed production than plants grown in the NORM soil. Both groups of plants have offspring in the same soil type, and the new generation looks exactly the same as the previous generation, with HI-LOW plants being shorter than NORM plants.

   a. Is this an example of adaptation?

   b. What is causing the observed differences in appearance?

   c. Are these differences heritable?

   d. How might you test if this is heritable and/or if this is an adaptation?

Sooty Selection Post-Assessment

Name: _____

Date: _____

1. Which of the following would be an example of adaptation through natural selection?

   a. Some honey badger populations overlap with king cobra populations. In these overlapping areas, honey badgers that had a venom-resistant mutation are able to catch and eat king cobras as an additional source of food, increasing their resources. This mutation has spread through the population over several generations.

   b. Two parents that are both World Weightlifting Champions are about to have a baby. They expect their newborn to be a muscle-bound girl.

   c. Gopher snakes and diamond back snakes both have a diamond pattern that makes them look similar. A female gopher snake noticed that the nearby rattler scared off predators with its loud rattle, so the gopher snake started using a similar tactic, by vibrating its tail in the leaves. Any offspring she has will vibrate their tails as well.

   d. A pesticide-resistant locust population lives in an agricultural field that is getting too hot. The population moves to a cooler, non-agricultural area. The next generation of offspring will not be pesticide-resistant because they have no need to be.

2. One grizzly bear population has moved to an area that has snow year-round. Which of these statements might you expect to occur if a mutation for coat color is going to spread through the population?

   a. The adults of the population that moved to the snowy area started growing lighter fur.

   b. Grizzlies with white hair have an advantage, so the next generation of grizzly bears will all be white.

   c. Grizzly bears that have a lighter fur mutation can catch prey more easily and so have more resources to have more offspring. Due to this, the trait starts to spread through the population.

   d. If any grizzly bears living in snow develop white fur and it is beneficial to them, then the entire population will soon have white fur and will never have brown fur again.

3. Which of the following statements is true regarding traits that are related to fitness?

   a. A trait that increases fitness in one environment will always be a beneficial trait.

   b. A trait that makes an animal stronger or faster will automatically increase the animal's fitness.

   c. All individuals in a population that share similar traits are of similar fitness.

   d. A trait that increases the number of offspring an animal has increases the animal's fitness.

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   a. Is this an example of adaptation?

   b. What is causing the observed differences in appearance?

   c. Are these differences heritable?

   d. How might you test if this is heritable and/or if this is an adaptation?

Sooty Selection Worksheet

Name: _____

Group name: _____ Date: _____

Questions (answer one individually)

1. How did giraffes get such a long neck?
2. Will giraffe babies be similar to their parents? Why?
3. How are traits, such as a long neck, passed from parents to offspring?

Rice Activity: Record the number of rice grains after each round of "selection" in Table 1 then calculate the percent of the rice population that is white and dark.

TABLE 1	Experiment 1: WHITE BARK		Experiment 2: DARK BARK	
Generation	White grains remaining	Dark (Wild) grains remaining	White grains remaining	Dark (Wild) grains remaining
0 (Start)	15	15	15	15
1				
2				
3				

TABLE 2	Experiment 1: WHITE BARK		Experiment 2: DARK BARK	
Generation	% Population white grains	% Population dark grains	% Population white grains	% Population dark grains
0 (Start)	50	50	50	50
1				
2				
3				

Moth Hunting Game: Record the light and dark moth population percentages in Table 3 after hunting. Play ("select") in each forest twice and calculate the average for each box.

TABLE 3	Experiment 1: WHITE FOREST		Experiment 2: DARK FOREST	
Generation	% Population white moths	% Population dark moths	% Population white moths	% Population dark moths
0 (Start)	50	50	50	50
1				
2				
Average				

Sooty Selection Worksheet *(continued)*

Name: _____

Group name: _____ Date: _____

Questions (Discuss with your group and answer)

1. What changes did you observe in the rice/moth population? Why did this happen?

2. What would happen if we colored the rice/moths to be more camouflaged? In the wild, would the next generation change color too?

Weismann's Mouse Tail Experiment:

1. What do you think Weismann found?

2. Do results support Lamarck or Darwin's ideas?

Discuss and answer:

1. How can a trait benefit an individual?

2. What does "survival of the fittest" mean? What might a better phrase or term be?

3. How does an adaptation begin?

4. How does a trait spread within a population?

5. What factors might cause some animals to survive while others don't?

Define:

Fitness –

Adaptation –

Natural selection –

Heritability –

Mutation –