# Microbial Discovery Activity

## Natural Selection

### Author

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### Intended Audience

<table>
<thead>
<tr>
<th>Age Group</th>
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<td>9-12</td>
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### Activity Characteristics

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<tr>
<td>Classroom setting</td>
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<tr>
<td>Uses hands-on manipulatives</td>
<td>X</td>
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<tr>
<td>Inquiry</td>
<td>X</td>
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<tr>
<td>Can be performed individually</td>
<td>X</td>
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<tr>
<td>Appropriate for students with special needs</td>
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<td>Requires more than one class period</td>
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Introduction

Description
This lab is a hands-on activity in which students will uncover the science behind natural selection. It was originally developed as an activity for the Microbe World Activities Collaborative published by the National Association of Biology Teachers in 1999. The original writers/developed in addition to Ms. Thiel-Cobbey were Ms. Linda Brown (Carnegie Science Center), Ms. Charlotte Mulvihill (Community College of Allegheny County), and Dr. John Stolz (Duquesne University) all from Pittsburgh, PA. For additional activities, please visit Microbe World at http://www.microbeworld.org/resources/experiment.aspx

Abstract
Using a variety of beans, students will investigate how various microbes can survive and reproduce. They will explain the effects the environment has on the sustainability of a microbial community and the adaptations they need to make for survival.

Core Themes Addressed

<table>
<thead>
<tr>
<th>General Microscopy Concepts</th>
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<tr>
<td>Microbial Cell Biology</td>
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<td>Microbial Genetics</td>
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<td>Microorganisms and Humans</td>
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<td>Microorganisms and the Environment</td>
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<td>Microbial Evolution and Diversity</td>
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<td>Other -Common properties of life; Cellular components</td>
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Keywords
Adaptation, Selective Pressures, Natural Selection, Microbial Evolution

Learning Objectives
By completing this activity, the student will be able to:

- Describe the process of natural selection.
- Model the natural selection process
- Identify and explain the environmental aspects (selective pressures) that influence natural selection.
- Predict why certain species have the ability to adapt and survive selective pressures.
- Explain the importance of natural selection among microbial communities.
National Science Education Standards Addressed

All Levels of Learning:

1. **Unifying concepts and processes:**
   - Systems, order and organization
   - Evidence, models and explanations
   - Change, consistency and measurement
   - Form and function

2. **Science as Inquiry:**
   - Abilities necessary to do scientific inquiry
   - Understanding about scientific inquiry

3. **History and Nature of Science:**
   - Science as a human endeavor
   - Nature of Science

Science Content Standards 5-8:

1. **Life Science**
   - Reproduction and heredity
   - Regulation and behavior
   - Populations and ecosystems
   - Diversity and adaptations of organisms

2. **Science in Personal and Social Perspectives**
   - Populations, resources and environments

Science Content Standards 9-12:

1. **Life Science:**
   - The interdependence of organisms
   - Biological evolution
   - Behavior of organisms

2. **Science in Personal and Social Perspectives**
   - Population growth
Student Prior Knowledge
Students should have the following knowledge prior to completing this activity.

- Know how to conduct an experiment using the Scientific Method.
- Be able to gather and interpret information.
- Know how to make logical graphs to communicate scientific results.
- Have a basic understanding of natural selection.
- Be able to explain natural selection and its effects on living things.
- Be able to explain adaptations and why they occur.
- Be able to define and explain selective pressures.
- Have a basic understanding of what a microbe is and how they reproduce.

Teacher Background Information
If you look at the people around you, are they all the same? What would happen if we lived in a world where all the food was kept 8 feet off the ground and there was absolutely no way you could get it if you weren’t tall enough? Most likely, the short people would die off. The taller ones would multiply. And before long, instead of a population of people of all sizes, you would have a population of only tall people. Living things that are best-suited, or adapted, to their environment survive and multiply. Those that are not adapted don’t survive. This process is known as natural selection. Within a population of microbes, many environmental factors such as temperature, pH, nutrients, light, magnetism, radiation, and chemical agents can cause some individuals to die. Those that survive go on to produce hardier future generations. Those factors that determine which microbes survive or which do not, are called “selective pressures.”

Class Time
60 minutes.

Teacher Preparation Time
10 - 15 minutes.

Materials and Equipment
Have the following for each group of 4:

- 5 cups of various sizes of beans or different colored beads
- 1 pencil
- 5 wooden dowels with assorted diameters
- 2 pieces of paper
- 2 Styrofoam bowls
Safety Precautions
Exercise care with a pencil when punching holes in the Styrofoam.

Teacher Preparation
Combine the packages of beans and distribute the mixed samples to each group of participants.

Methods
Introduction to activity:

1. Provide the participants with a mixture of beans and a Styrofoam bowl. *You can use lima beans as an example of a Yeast, pinto beans to represent Mycoplasma, kidney beans to represent E. coli, and lentils as small bacterial cells,*
2. Using a pencil, have them carefully punch a hole in the bottom of the Styrofoam bowl.
3. Have them place the mixed beans in the bowl and place the plate inside a second plate. Ask them to shake the bowl gently.
4. Have them note which beans passed through and which beans did not.
5. Have a class discussion about which beans passed through the hole and why. Also discuss why some of the beans do not pass through the hole. The Styrofoam plate can represent Penicillin, a selective pressure. If you used the topic of vaginal flora, ask the students what can happen to the flora after the use of antibiotics?
6. Introduce the topic of natural selection by asking the following questions.
   - What if the beans were a population of microbes and only the types that stay in the bowl survive to reproduce?
     
     *Possible Answer:* The microbes that pass through the bowl represent the species that cannot survive, and therefore will die out. The species that remain in the bowl have managed to adapt or survive the changes in their surrounding environment. They will go on to reproduce, but may produce an adapted form of themselves. They have manages to survive various “selective pressures” that the other bacteria could not adapt to, this demonstrating the process of natural selection.
   - Would the next generation look like those in the bowl?
     
     *Possible Answer:* The next generation may look the same, or may not look the same. This would depend on the adaptations that the microbes made to the changes in their environment.
   - What if the hole were larger than each bean?
     
     *Possible Answer:* If the hole were larger, then other species would fall through the hole, thus showing a loss in more species of microbes. There would be fewer microbes that have shown adaptations to the environmental changes.
   - What if the hole were smaller than each bean?
     
     *Possible Answer:* If the hole were smaller, then fewer species would fall through the hole, thus showing an increase in the species of microbes that were able to adapt to the environmental changes.
   - Which bean population would increase most significantly and why?
Possible Answer: The population that would increase most significantly would be the species that can survive and adapt to the changes in the environment. This would be dependent upon the various selective pressures that would be present within the environment.

- What changes might occur in the microbes that would cause selective pressure?

Possible Answer: Possible selective pressure that could occur due to microbial changes could be a difference in pH, possible temperature changes, introduction to new chemicals or microbial byproducts. These new changes could result in selective pressures for other microbial species, thus causing other microbes to die out.

Instructions for the participants:

1. Have one participant from each team of four gather needed materials.
2. Using a pencil or different-sized dowels, punch 6 different sized holes in the bottom of an unused Styrofoam bowl.
3. To create and initial “microbe” population, select five beans of each type, and place the population of 25 in the bowl.
4. Shake the bowl 15 times (side to side) and note which beans fall through the holes.
5. Record the number and type of beans that fall through, as well as the beans that do not fall through the holes in the bowl. The beans falling through the holes are considered to be dead, while the ones remaining in the bowl are still alive and considered to be the first generation microbes. The first generation microbes will be the “parents” of the next generation.
6. To simulate reproduction among the “parent microbes”, add another one of the same bean to the bowl for each bean that remained in the bowl.
7. Observe the beans/microbes that fell out of the bowl. Did all types fall out in the same number?
8. Observe the new population in the bowl, does it resemble the original, or are the proportions different?
9. Repeat the same procedure with the population created from the first generation.
10. Shake the bowl (side to side) 15 times.
11. Count and record the number of beans both in the bowl and those falling through the holes.
12. Duplicate the beans remaining in the bowl.
13. Observe the new population in the bowl. Note any changes that may have occurred in the population.
14. Complete the experiment until 5 generations have been produced.
15. Analyze data.

Inquiry based lab activity:

Participants will design an experiment to investigate natural selection. The 4-P method may be used to facilitate the experiment (4P's method = Posing, Predicting, Probing, and Persuasion). Students may follow the guided worksheet to complete it.

Posing Questions (Problem): Participants are to observe the beans and holes within each bowl and pose questions about which will survive and which will die off.

Predicting (Hypothesis): Participants reword the questions into hypotheses and make predictions.
**Probing (Experiment and Analysis):** Participants design an experiment to test the questions using appropriate controls. Observations can be recorded in a chart provided in the student worksheet. They should make careful notes about population numbers, bean types and characteristic changes in the population.

**Persuasion (Conclusion):** Participants should analyze the data and compare the results with their predictions.

### Suggestions for Assessment

- Have students complete and turn in the student worksheet.
- Students can compose an independent formal lab write up.
- Have students write up quiz questions pertaining to the lab and quiz other members of their class. The teacher may also use the student-generated questions to create a test or quiz.
- Journal
- Presentation (verbal or computer-based)
- Create a concept map that describes the lab and its results.
- Large or small group discussion
- Use a rubric to assess any of the suggestions above. See Appendix at the end of the manual for several sites on rubrics.

### Tips/Suggestions

- **Team logistics:** Ideally 2-4 participants work well together, and each group should have their own supplies.
- Lentils, pinto beans, kidney beans, navy beans, red beans, black beans, great northern beans, split-green peas, and black-eyed peas work well for this activity.
- Dry, multi-bean soup mixes also can be used.
- Lima and garbanzo beans are not advised. They tend to clog the holes in the bowl.
- Use the largest Styrofoam bowls available. Meat trays may be used in their place.
- Rather than students generating the procedure, the teacher may choose to give them the procedure outlined in the teacher guide.
- Teacher may post questions from the teacher guide to help students complete their conclusion.

### Additional Resources

**Links to obtain addition information:**

- Natural Selection: This is an on-line course from the PBS website for teachers [http://www.pbs.org/wgbh/evolution/educators/course/index.html](http://www.pbs.org/wgbh/evolution/educators/course/index.html)
- Natural Selection [http://emuseum.mnsu.edu/biology/evolution/genetics/naturalselection.html](http://emuseum.mnsu.edu/biology/evolution/genetics/naturalselection.html)
• Discovery Schools: Kathy Shrock’s guide: Assessment and Rubric Information
  http://school.discoveryeducation.com/schrockguide/assess.html

References and Acknowledgments
This activity was adapted from: “Natural Selection: Meet the Microbes through MicrobeWorld
Activities.” Microbial Literacy Collaborative. Copyright NABT.
Introduction
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Vocabulary
Natural Selection - Natural selection can be defined as a process in which some organisms live and reproduce and others die. Various forms of life may survive and reproduce because they are adapted to their environment and the environmental pressures within that environment.

Selective Pressures - Factors in the environment that determine if a population of organisms will survive or die. Some organisms will adapt and survive while others will not.

Adaptation - Changes in an organism's structure or habits that allow it to adjust to changes in its environment.

Bacterial Reproduction – Binary fission is the process in which microorganisms divide to create two new identical cells from one parent cell. This type of reproduction is asexual.

Materials
5 cups of various sizes of beans or different colored beads
1 pencil
5 wooden dowels with assorted diameters
2 pieces of paper
2 Styrofoam bowls

Safety Precautions
* Exercise care with a pencil when punching holes in the Styrofoam.
Posing Questions (Problem):

Write a question concerning an observation you have made about the bean population in the Styrofoam cup.

What is the effect of ____________________________

_____
on ____________________________

_____

Predicting (Hypothesis):

Write a hypothesis concerning the observation

Make a prediction based on the hypothesis:

If ____________________________

_____

then ____________________________

_____
Probing (Experiment):
Outline the method for the experiment below. Think carefully about the controls that are needed. Identify the independent and dependent variable(s).
Gather the Data (Analysis):

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Graphing (Analysis):

Produce a graph charting the generation totals for each bean “microbe.”

Bean Type: ___________________________  Bean Type: ___________________________

Bean Type: ___________________________  Bean Type: ___________________________

Bean Type: ___________________________  Bean Type: ___________________________
Persuasion (Conclusion):

Was your hypothesis supported?

What do you conclude from your experiment?

Describe the sources of error (if any).