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P.O. Box 219 • Batavia, IL 60510
(800) 452-1261 • Fax (866) 452-1436
www.flinnsci.com • E-mail: flinn@flinnsci.com

Catalog No. FB2130

Publication No. 11303

Beaks

Flinn STEM Design Challenge™

Introduction

Natural selection is the theory that explains how slight differences among members of a population can be advantageous to survival and reproduction of that population. Those differences are passed on to offspring, with the most beneficial traits increasing in frequency within the population. Over time, changes become noticeable among the population.

Until recently, scientists thought these changes would take more time than could be observed in a lifetime. Recent observation and experimentation show this is not the case. For example, the bacteria *Staphylococcus aureus* has demonstrated evolution on multiple occasions. This bacteria lives on the skin and can cause infection if it enters through a wound. Doctors initially treated the bacterial infection with penicillin and within two years it evolved a resistance to this treatment. As a result, doctors began to treat patients with methicillin, a very powerful antibiotic. Within two years, cases of methicillin-resistant *Staphylococcus aureus* (MRSA) began to emerge. From 1993 to 2005, reported hospitalizations increased from less than 10,000 to over 350,000 showing the evolution of resistance to methicillin.

Concepts

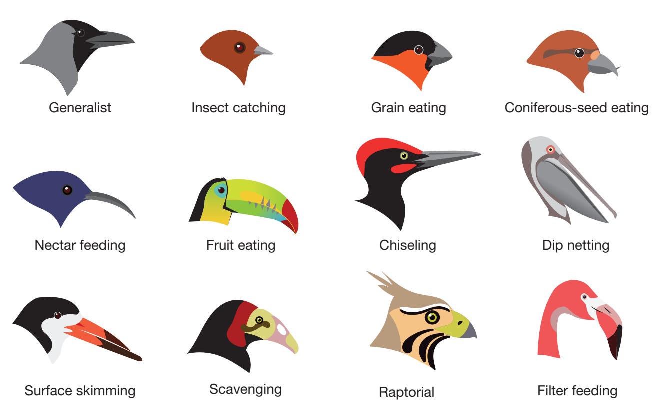
- Alleles
- Gene Pool
- Microevolution
- Natural selection

Background

Evolution on the smallest scale is called *microevolution*. It is the change of allele frequency from generation to generation within a population. A *population* is a local group of individuals of the same *species* with the potential to mate and produce viable offspring. The individuals that reproduce successfully pass their unique genetic material to the next generation. Those that do not reproduce die prior to passing on their genetic material.

Alleles are alternative forms of a gene. All the genes within a population are known as the *gene pool*. The gene pool is where the genetic variation is stored and pulled from for future generations. The gene pool varies based on how environmental factors impact natural selection. For example, if the environment "selects" for traits, and the conditions increase the ability to survive and reproduce, then those traits become more common, indicating a change in the gene pool.

Changes to the gene pool sometimes occur by chance. *Genetic drift* occurs most dramatically in small populations due to low genetic variation within the gene pool. Two examples of genetic drift are the bottleneck effect and the founder effect. The *bottleneck effect* is the reduction in the gene pool due to natural disasters, such as floods. The *founder effect* alters the gene pool when a few individuals colonize an isolated habitat. The small population offers fewer alleles and a small gene pool leading to a reduction in genetic variation.



A terrific example of microevolution occurs regularly on the Galapagos Islands. This is the same set of islands where Charles Darwin studied. The data he collected helped form his ideas of evolution through natural selection. Currently, there are 13 different species of finches that call the Galapagos Islands home. They are distinguished primarily by their beaks, each suited for a different food source. The medium ground finch, *Geopiza fortis* is a medium-sized bird with a blunt beak suited for crushing small seeds. All the finches will dine on small, soft seeds, but some—those with slightly bigger beaks—can eat larger, tougher seeds as well. In this activity, you will be given a finch "beak" and

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participate in a simulation to show how variation within the gene pool can be caused by environmental changes from generation to generation. You will then design and construct a finch beak to see if it can survive generationally and through environmental changes.

Experiment Overview

In this simulation, an environmental change will cause microevolution. You will determine how the frequencies of three beak types is affected by the conditions over several generations. Once you have modeled these changes, your challenge is to design a beak that is advantageous in a variety of conditions, leading to evolution by natural selection.

Pre-Lab Questions

1. Evaluate the differences between natural selection and microevolution.

2. Read "Part A" of the procedure and predict which "beak" will be most successful through six generations. Explain your reasoning.

3. Explain genetic drift and how it affects a population. Which type of genetic drift would have occurred to a population that experienced a drought?

Materials

Calculator	Fork
Food items	Skewer, bamboo
Forceps	Weighing dish

Safety Precautions

Wash hands thoroughly with soap and water before leaving the laboratory. Please follow all laboratory safety guidelines. Students must walk to and from their nests and walk with their beaks down.

Procedure

Part A. Predetermined Beaks

Feeding Rules:

a. You may not use your hands except to hold the "beak."

b. You may not push other "birds," knock the food out of the other "birds' beaks," or steal food from other "birds' nests."

c. You may not move your nest to another location once you have selected your location.

d. When time is called, you must stop where you are. If you have food in your "beak," you may place it in your nest.

e. Do NOT eat any of the food items.

f. You can use your fingers to remove "food" from your "beak" to your nest.

Generations 1–3

1. Obtain one of the “beaks” from the designated beak area.
2. At each lab station, there is one weighing dish for each student. This is your nest. All food items must be placed inside your nest.
3. Find a location in the room to place your nest. Alternately, you may be assigned a nesting site.
4. In Generation 1, only one “beak” of each type will participate (three students total to start). Anyone not participating is required to assist with data collection, clean up and replenish food.
5. Once time has started, walk from your nest to the feeding site and obtain food. Once the food item(s) is secure in your beak, walk back to your nest and place it inside your nest. *Note:* The beak is used to obtain and carry food, no hands.
6. Continuing adding food to your nest until time is called.
7. After food has been collected, as a class, fill in the data table for Generations 1, 2 and 3.
8. Using the Beak Survival table, determine the number of “beaks” that will participate in Generation 2.
9. Return food to the feeding site—this simulates nutrient cycling. Birds that do not survive will not return their food, rather they will put the food in a designated container.
10. Repeat steps 1–9 for Generations 2 and 3.

Generations 4–6

11. For the next three generations, the food source has changed due to environmental conditions.
12. All the “beaks” from Generation 3 will participate in Generation 4.
13. Follow steps 1–9 for generations 4, 5 and 6.
14. Follow the same rules as generations 1, 2 and 3.

Part B. Beak Design Challenge

Utilizing what you learned from Part A, design a bird beak that you believe will allow for the greatest survival chances. Remember, with natural selection if you increase your chance of survival, you live long enough to reproduce and therefore allow your traits to be passed on to your offspring. Here are a few rules and hints for you to consider while designing:

1. Different food items will be used during the design challenge.
2. You want a beak that can withstand changes to environmental conditions.
3. The beak you design must be “beak-like.” For example, there needs to be a hinged jaw and it must open and close like a beak.
4. You can use any materials you want however, it must be a modified or original design. For example, you cannot bring in a kitchen spoon unless it was modified to behave like a beak.
5. The size of the beak needs to fit within the following parameters (unless otherwise given by your instructor):
   a. length—under 10 cm
   b. width—under 3 cm
   c. height—under 5 cm
6. Because each beak will be unique, changes in the number of birds with a particular beak type cannot be modeled. Therefore, the “best beak” will be determined by process of elimination.

Name: ________________________________

Beaks Worksheet

Flinn STEM Design Challenge™

Part A. Predetermined Beaks

Beak Survival

Food Items Collected	Outcome
Fewer than 10	Does not survive
10–20	Survives but does not reproduce
21–30	Survives and produces 1 offspring
31–40	Survives and produces 2 offspring
41–50+	Survives and produces 3 offspring

Generations 1, 2 and 3

Beak Variation	Generation 1		Generation 2		Generation 3	
	Number of Individuals	Phenotype Frequency (%)	Number of Individuals	Phenotype Frequency (%)	Number of Individuals	Phenotype Frequency (%)
Forceps	1					
Fork	1					
Skewer	1					
Total	3					

Change in Frequency

Beak Variation	Phenotype Frequency (%) in Generation 3 (A)	Phenotype Frequency (%) in Generation 1 (B)	Change in Phenotype Frequency (%) (A–B)
Forceps			
Fork			
Skewer			

Environmental Change: ________________________________

Beak Variation	Generation 4		Generation 5		Generation 6	
	Number of Individuals	Phenotype Frequency (%)	Number of Individuals	Phenotype Frequency (%)	Number of Individuals	Phenotype Frequency (%)
Forceps						
Fork						
Skewer						
Total						

Change in Frequency due to Environmental Change

Beak Variation	Phenotype Frequency (%) in Generation 6 (A)	Phenotype Frequency (%) in Generation 4 (B)	Change in Phenotype Frequency (%) (A–B)
Forceps			
Fork			
Skewer			

Name: ____________________________________

Post-Lab Questions

1. Using the data from Generations 1–3, determine which beak was the most successful and explain why.

2. When the food supply changed, was there a shift in the frequency of alleles? Explain your answer.

3. Using the grid below, create a line graph showing the success of each beak variation over all six generations. Be sure to include a title, labeled axes and an appropriate scale.

4. Describe the pattern of change for *each* beak and suggest reasons for the change.

Name: ______________________________

5. Besides variation in the types of beak, what other factors contributed to the success or failure of the "bird's," ability to survive and reproduce in this simulation?

6. After reflecting on this activity and the parameters for Part B, describe the beak you believe will be the most successful in the most environments.

Part B. Beak Design Challenge

Survival Rules

Generation	Food Items collected to Survive
1	More than 20
2	More than 40
3	More than 60
All students return to the ecosystem before generation 4 due to migration.	
4	More than 20
5	More than 40
6	More than 60

Beak Data

Generation	Population Size (No. of students participating)	No. of Survivors	% Survival
1			
2			
3			
4			
5			
6			

Post-Lab Questions

1. Describe the design of your beak and explain why you chose this design.

2. How well did your beak perform in the first three generations?

3. How would you alter your beak for better performance?

4. Did microevolution occur throughout the six generations? Describe what you observed.

5. Suggest one change to this activity that would more closely simulate the natural world.

Teacher's Notes

Beaks—Flinn STEM Design Challenge™

Materials Included in Kit

Aquarium gravel, 500 g
Bingo chips, 300
Corks, Size 00, 200
Fishing lures, 75
Foam peanuts, 300
Forks, clear plastic, 30
Forceps, 30
Kidney beans, 1 lb
Marbles, glass, 150
Pom poms, 300
Skewers, bamboo, 30
Straws, plastic, 100
Toothpicks, plastic, 300
Weighing dishes, 5.5 g, 30

Additional Materials Required

If desired, other or extra items can be used for food.

Large demonstration trays are useful to hold food in the feeding site(s).

Pre-Lab Preparation

1. Cut plastic straws into approximately 1-inch pieces.
2. Prior to student arrival, create feeding site(s). Depending on lab/classroom layout and the size of your trays, you may need multiple feeding sites. Plan on about three students per square foot of feeding space to start. Cover up the feeding sites so the students cannot see the food items.
3. During Part A, use all the following soft foods: foam peanuts, lures and straws for generations 1–3 and hard foods: toothpicks, kidney beans and marbles for generations 4–6.
4. During Part B, use all the following soft foods: corks, pom poms and teacher's choice (one of the three soft items from Part A) and the following hard foods: bingo chips, aquarium gravel and teacher's choice (one of the three hard items from Part A).

Safety Precautions

Remind students to wash their hands thoroughly with soap and water before leaving the laboratory. Students must walk to and from their nests and walk with their beaks down.

NGSS Alignment

This laboratory activity relates to the following Next Generation Science Standards (2013):

Disciplinary Core Ideas: Middle School

MS-LS1 From Molecules to Organisms: Structures and Processes
- LS1.B: Growth and Development of Organisms

MS-LS2 Ecosystems, Energy, And Dynamics
- LS2.A: Interdependent Relationships in Ecosystems

MS-LS3 Heredity: Inheritance and Variation of Traits
- LS3.A: Inheritance of Traits
- LS3.B: Variation of Traits

MS-LS4 Biological Evolution: Unity and Diversity
- LS4.A: Evidence of Common Ancestry and Diversity
- LS4.B: Natural Selection

MS-ETS1 Engineering Design
- ETS1.A: Defining and Delimiting Engineering Problems
- ETS1.B: Developing Possible Solutions
- ETS1.C: Optimizing the Design Solution

Disciplinary Core Ideas: High School

HS-LS3 Heredity: Inheritance and Variation of Traits
- LS3.B: Variation of Traits

HS-LS4 Biological Evolution: Unity and Diversity
- LS4.B: Natural Selection
- LS4.C: Adaption

Science and Engineering Practices

Developing and using models
Analyzing and interpreting data
Using mathematics and computational thinking

Crosscutting Concepts

Patterns
Cause and effect
Structure and function
Stability and change

Lab Hints

- Enough materials are provided in this kit for 30 students. Part A can be completed in one 50-minute class period. Students will need time, perhaps a weekend, to design and build their beaks before completing Part B, which also can be completed in one 50-minute class period.
- Explain to the students that the beaks they are using and creating are beaks for the same bird species, just with variations among them.
- Allow 45–60 seconds for feeding. However, the time can vary per the laboratory setting.
- Feeding sites can be a large area, like the teacher lab station, or there can be smaller areas within the laboratory. The supplies can easily be pushed off flat surfaces creating a mess and safety hazard. Placing food items onto large trays will minimize such issues.
- Start with soft foods (corks, pom poms, foam peanuts, lures, straws) at the feeding site(s) for the 1st, 2nd and 3rd generations and switch to hard foods (bingo chips, toothpicks, aquarium gravel, kidney beans, marbles) in the 4th, 5th and 6th generations. Use half of the items for Part A and the other half for Part B unless the teacher is supplying additional food items.
- During Part B, have all the students return for the 4th generation. Explain that since there are fewer birds competing for food, other birds would have the opportunity to migrate in. This will allow for maximum participation throughout the activity.

Teacher's Notes *continued*

Teaching Tips

- The switch to hard food is representative of a drought as an environmental change.
- Extensions and/or modification to this activity are many. For example, students could bring in different food items that challenge each other's beaks or as a class, group the beaks prior to Part B. Then the procedure from Part A could be followed to show variation while practicing or reviewing classification. Another extension could be to require each beak to obtain at least one particular food item in order to survive and reproduce. (For example, each beak must have a fishing lure in the nest; this could represent protein required during the breeding season for robin red breasts.) This could be required in both Part A and Part B.
- Focus on the idea of microevolution and changes within the same population over generations.

Answers to Pre-Lab Questions *(Student answers will vary.)*

1. Evaluate the differences between natural selection and microevolution.

   Microevolution is the change in allele frequency from generation to generation within a population. Natural selection is a mechanism for evolution that acts on individuals. The resulting evolution only becomes apparent as a population is tracked over time.

2. Read "Part A" of the procedure and predict which "beak" will be most successful through six generations. Explain your reasoning.

   Answers will vary. Accept all reasonable explanations. For example: The fork beak will be the most successful because it can stab or scoop food items. The skewer will only be able to stab items and the forceps will only be able to pinch food items.

3. Explain genetic drift and how it affects a population. Which type of genetic drift would have occurred to a population that experienced a drought?

   Genetic drift is the change within a population due to chance. If a drought occurred, the bottleneck effect would most likely occur as it would be a natural disaster and effect the population. Those living through the drought would pass on their traits.

Sample Data Tables *(Student data will vary.)*

Part A. Predetermined Beaks

Generations 1, 2 and 3

Beak Variation	Generation 1		Generation 2		Generation 3	
	Number of Individuals	Phenotype Frequency (%)	Number of Individuals	Phenotype Frequency (%)	Number of Individuals	Phenotype Frequency (%)
Forceps	*1*	*33*	*1*	*17*	*1*	*9*
Fork	*1*	*33*	*2*	*33*	*3*	*27*
Skewer	*1*	*33*	*3*	*50*	*7*	*64*
Total	*3*		*6*		*11*	

Change in Frequency

Beak Variation	Phenotype Frequency (%) in Generation 3 (A)	Phenotype Frequency (%) in Generation 1 (B)	Change in Phenotype Frequency (%) (A–B)
Forceps	*9*	*33*	*–24*
Fork	*27*	*33*	*–6*
Skewer	*64*	*33*	*31*

Teacher's Notes *continued*

Environmental Change: *Drought occurred leaving only hard food items for finches to feed on.*

	Generation 4		Generation 5		Generation 6	
Beak Variation	**Number of Individuals**	**Phenotype Frequency (%)**	**Number of Individuals**	**Phenotype Frequency (%)**	**Number of Individuals**	**Phenotype Frequency (%)**
Forceps	*1*	*5*	*0*	*0*	*0*	*0*
Fork	*4*	*20*	*20*	*100*	*30+*	*100*
Skewer	*15*	*75*	*0*	*0*	*0*	*0*
Total	*20*		*20*		*30+*	

Change in Frequency due to Environmental Change

Beak Variation	Phenotype Frequency (%) in Generation 6 (A)	Phenotype Frequency (%) in Generation 4 (B)	Change in Phenotype Frequency (%) (A–B)
Forceps	*0*	*5*	*–5*
Fork	*100*	*20*	*80*
Skewer	*0*	*75*	*–75*

Part B. Beak Design Challenge

Beak Survival

Generation	Population Size (No. of students participating)	No. of Survivors	% Survival
1	*11**	*7*	*64*
2	*7*	*5*	*71*
3	*5*	*5*	*100*
4	*11*	*7*	*64*
5	*7*	*3*	*43*
6	*3*	*3*	*100*

**Data will vary based on beaks created by students. The sample data is from a simulated class size of 11.*

Answers to Post-Lab Questions *(Student answers will vary.)*

Part A. Predetermined Beaks

1. Look at the data from Generations 1–3. Which beak was the most successful and why?

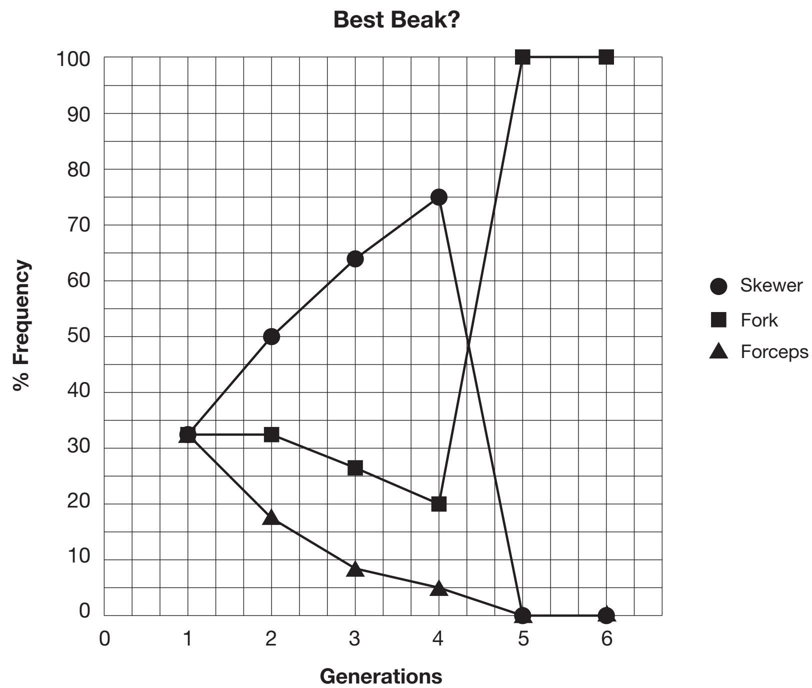
   Answers will vary. Based on sample data, the most successful beak was the skewer. It was able to stab multiple food items at each feeding opportunity within the allotted time.

2. When the food supply changed, was there a shift in the frequency of alleles? Explain your answer.

   Answers will vary. Based on the sample data, the skewer was able to thrive on the soft food, the frequency increased from 33% to 75% within three generation. The "skewer beak" was completely ineffective with hard food in the later generations. The frequency dropped from 75% to 0% between the 4th and 5th generation. The simulated drought devastated the allele for skewer beaks. The fork also showed a shift in frequency as it struggled to gather "soft food" in large quantities during the early generations, dropping from 33% to 20%, but the birds were capable of surviving and a few even reproduced. However, when the drought occurred, the fork excelled at food collection given the ability to scoop. The frequency rose from 20% to 100% of the population in one generation. The forceps did not fare well and showed little ability to survive or reproduce with soft or hard food.

3. Using the grid below, create a line graph showing the success of each beak variation over all six generations. Be sure to

include a title, labeled axes and an appropriate scale.



4. Describe the pattern of change for *each* beak and suggest reasons for the change.

   Answers will vary. Sample data showed that the skewer beak excelled during the "soft food" generations but was eliminated during the drought and "hard food" generations. The reason for this was during the "soft food" generations, the skewer beak was able to stab or slide through the food items. However, when the food items could not be stabbed, the beak was completely ineffective. The fork beak was able to maintain during the soft food generations, due to the ability to stab items. However, it could not stab as many as the skewer beak, which led to the difference in frequency. But, during the hard food generations, the fork beak was extremely successful as it could scoop up items that were unable to be stabbed. The forceps beak struggled during both food types. One reason could be that the forceps beak was only able to grab one food item, maybe two, at one time. The other beaks were capable of gathering more at one attempt.

5. Besides variation in the types of beak, what other factors contributed to the success or failure of the "bird's," ability to survive and reproduce in this simulation?

   Survival and reproduction were impacted by competition in later generations. As more beaks were added, there was less space at the feeding site(s) and less food per beak. Being able to accumulate enough food to reproduce became more difficult as the number of beaks increased. This illustrates another condition for natural selection: overproduction of offspring leads to competition. Students may also mention that motivation falls when it is very difficult to find food. This could be equated to competitive exclusion from a niche.

6. After reflecting on this activity and the parameters for Part B, describe the beak you believe will be the most successful in the most environments.

   Answers will vary.

Post-Lab Questions

Part B. Beak Design Challenge

1. Describe the design of your beak and explain why you chose this design.

   Answers will vary.

2. How well did your beak perform in the first three generations?

   Answers will vary.

3. How would you alter your beak for better performance?

   Answers will vary.

4. Did microevolution occur throughout the six generations? Describe what you observed.

   Answers will vary. Ideally, microevolution will occur and a certain beak design should prevail as the fittest beak. Most beaks will be very good at picking up a particular type of food item, either hard or soft, but not both.

5. Suggest one change to this activity that would more closely simulate the natural world.

   Answers will vary, but may include adding challenges like protecting your nest from predators, limiting the number of food items in one visit to the feeding site, having food spread throughout the lab rather than just at one feeding spot, or including predators at the feeding spot.

The *Beaks—Flinn STEM Design Challenge*™ is available from Flinn Scientific, Inc.

Catalog No.	Description
FB2130	Beaks—Flinn STEM Design Challenge™
AP5429	Demonstration Tray, Large

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