BIRDS AND THEIR BEAKS PART 1

Students experience first-hand how different characteristics can provide an advantage to individuals by "eating" with distinct "beaks," graph and analyze this data, and apply their results to explain the effects of adaptations on changes in the ecosystem or environment.

SC STATE STANDARD **Birds and their Beaks Part 1 works towards this standard. It introduces the idea of variation within a population and survival within the environment.* **If you also do Birds and their Beaks Part 2, the standard will be fully addressed.* **Birds and their Beaks Part 2 can be done without Birds and their Beaks Part 1.*	8-LS4-4 Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individual's probability of surviving and reproducing in a specific environment.
NEXT GEN STANDARD **Birds and their Beaks Part 1 works towards this standard. It introduces the idea of variation within a population and survival within the environment.* **If you also do Birds and their Beaks Part 2, the standard will be fully addressed.* **Birds and their Beaks Part 2 can be done without Birds and their Beaks Part 1.*	MS-LS4-4 Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individual's probability of surviving and reproducing in a specific environment.
LEARNING OBJECTIVE(S)	- Students will be able to recognize and explain the interaction between the environment and an organism's traits. - Students will be able to explain how some traits increase some individuals probability of surviving - Students will graph data and recognize patterns across multiple repetitions.
ESTIMATED TIME	Two 45 minute class periods

WHAT YOU'LL NEED:

All of the items can be purchased from a local craft store, big box store, or online. Example products from Amazon are provided as links. The box provides the materials for 30 students, with a single bag per student containing the below:

1. 5 soft pom poms. The box includes 0.75 to 1 inch pom poms as we found this to be the most useful size (example product).
2. 15 pony beads (example product).
3. Approximately 15 rice grains (a generous pinch). *We find arborio rice to work the best* (example product). *White rice and other thin grains are not able to be picked up with binder clips.*

4. Any container (“stomach”) to collect pom poms, beads, and rice. For example, this can be a lunch size paper bag (example product), plastic cup ~7oz or larger (example product), or a sandwich size reclosable bag (example product).
5. One small 0.75” binder clip (example product) and one large 1.25” binder clip (example product). *Alternatively, using their fingers or clothespins may be more accessible for students with mobility limitations: mini clothespin* (example product) *and large clothespin* (example product).
6. You may also want paper plates or lunch trays to help students keep their materials contained or separated.

WHAT YOUR STUDENTS SHOULD KNOW BEFORE:

Some general knowledge of how certain characteristics serve a certain function may be helpful, but not necessary since this activity is designed for students to hypothesize and experiment with this concept.

WHAT TO DO BEFORE YOUR CLASS:

Here is an example of a student’s materials including pom poms, beads, and rice, and two “beaks.” Not pictured is a bag or cup.

HOW TO SET UP YOUR CLASS:

This activity can be completed by students working individually or in pairs to collect the data.

WHAT YOU NEED TO KNOW FOR YOUR SAFETY:

Small beads could be a choking hazard.
Binder clips can pinch skin.

This lesson has been designed to follow three dimensional learning, as described in NGSS standards. In this teacher version, we annotate the associated Science and Engineering Practices and Cross-Cutting Concepts using icons (from these NGSS Planning Cards) before the relevant student question and blue and green text, respectively, within the student instructions. Additionally, content and questions that specifically address the Disciplinary Core Idea is represented in orange text. Sample student responses, classroom recommendations, and other hints are in *red italicized text*. See https://scienceweb.clemson.edu/beakerbox/ for additional files such as non-annotated student versions, Spanish versions of student materials, and slides.

BIRDS AND THEIR BEAKS PART 1

Student Activity Instructions:

Phenomenon:

Green anole lizards are common in South Carolina. Recently, scientists have observed that the green anole lizards in Florida have larger toepads and more scales than previous generations of lizards.

Image: "Strawberry" redux- wild green anole, Vicki DeLoach, https://www.flickr.com/photos/vickisnature/6481619097

Another scientist was interested in guppies. He moved a population of guppies into a predator-free stream to see what happened. The guppies grew larger, matured later, and reproduced slower. However, the guppies in the stream with predators matured earlier and reproduced faster.

Image: Trinidadian guppy (Poecilia reticulata) male and female.png
https://commons.wikimedia.org/wiki/File:Trinidadian_guppy_%28Poecilia_reticulata%29_male_and_female.png#/media/File:Trinidadian_guppy_(Poecilia_reticulata)_male_and_female.png

Bedbugs are pesky animals. When DDT (a powerful pesticide) was introduced after WWI, bedbugs seemed to go away for a while. Now, they are back and more resistant to (unaffected by) pesticides.

Image: bedbugs, Charles LeBlanc, https://www.flickr.com/photos/httpoldmaisonblogspotcom/4244054615

From these examples, it is evident that sometimes populations change. The driving question for this lesson, which you will work to answer throughout the activity is, how do populations change and why?

Note for teachers: We are emphasizing that populations change over time. Individuals themselves do not change.

In 1977 and 1978, Rosemary and Peter Grant noticed a change in the population of medium ground finches (*Geospiza fortis*) on the Galapagos Islands. They had been collecting data and studying these famous birds for a number of years when they noticed a dramatic shift in the size of bird beaks within the population of medium ground finches.

Additional questions to think about and add to the driving question board:
What caused this sudden change in the population of medium ground finches? How can we explain this change in the medium ground finch population and use what we learn to understand how other populations of other animals change?

You can have students generate additional questions for the driving question board or work together as a class to generate additional questions.

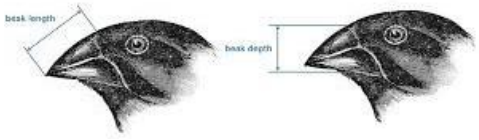


Figure 1: Beak Measurements Diagram
Image: retrieved from: http://bebi103.caltech.edu.s3-website-us-east-1.amazonaws.com/2019a/content/homework/hw3/hw3.2.html

In this activity, you will simulate a population of finches to explore the mechanisms that drive population change.

1. Make some initial predictions about why you think the birds' beaks may have changed.

Answers will vary.

Procedure Instructions:

1. Look at the materials provided by your teacher. You should have the following at your station to carry out your investigation:
    a. Three types of "food" (15 beads, 5 pom poms, 15 grains of rice)
    b. Two types of "beak" (large and small binder clips)
    c. One "stomach" (paper bag, plastic cup, or sandwich bag)

    You may want to have students put the "foods" on a paper plate or lunch tray.
2. You will use your "beak" to collect food, <u>one item at a time</u>, for 20 seconds. On your teacher's cue, begin collecting food using your beak, putting what you pick up in your "stomach."
    If you have a competitive class, consider reducing the time to 15 seconds. For a less competitive class, consider increasing the time to 30 seconds.
3. You can only use the "beak," black part of the binder clip to pick up the "food"
4. Once time is up, put down your "beak." Count and record how many beads, pom poms, and rice you collected during your investigation.
5. Repeat this process (steps 3 and 4) using the second type of beak.
    Conduct a practice round for 20 seconds to allow students to practice using the "beaks" before timing the "official" rounds.

Data Table: Record your data here

Small Binder Clip			Large Binder Clip		
Pom Poms	Beads	Rice	Pom Poms	Beads	Rice
2	3	5	3	9	2

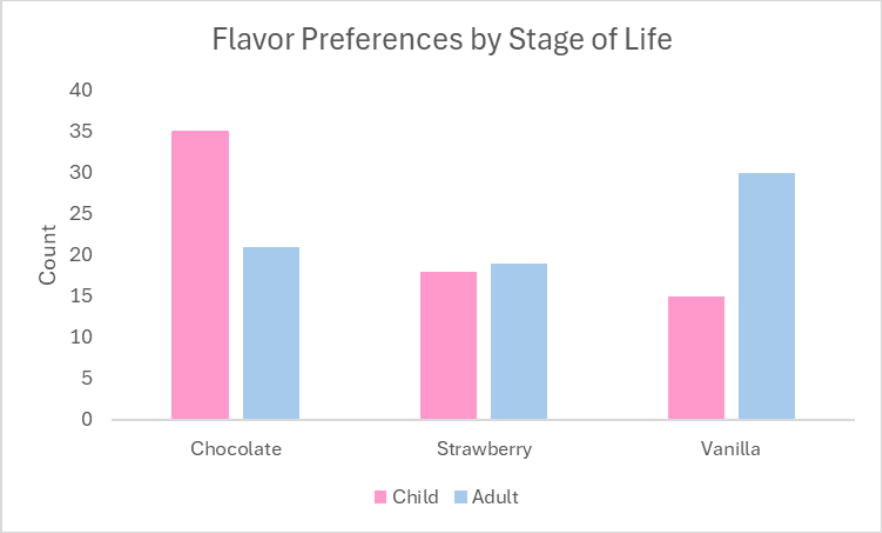
2. Determine your independent and dependent variables.

Use this to scaffold information about variables if needed

An **Independent variable** is the variable being changed or manipulated in an experiment. A **Dependent variable** is the variable that could change in response to changes in the independent variable.

Example: The number of people who like a flavor of ice cream (dependent variable) depends on the age of person asked (independent variable)

You may also have more than one independent variable. Here is a sample bar graph with multiple independent variables.



When graphing, your independent variable goes on the x-axis and the dependent variable goes on the y-axis.

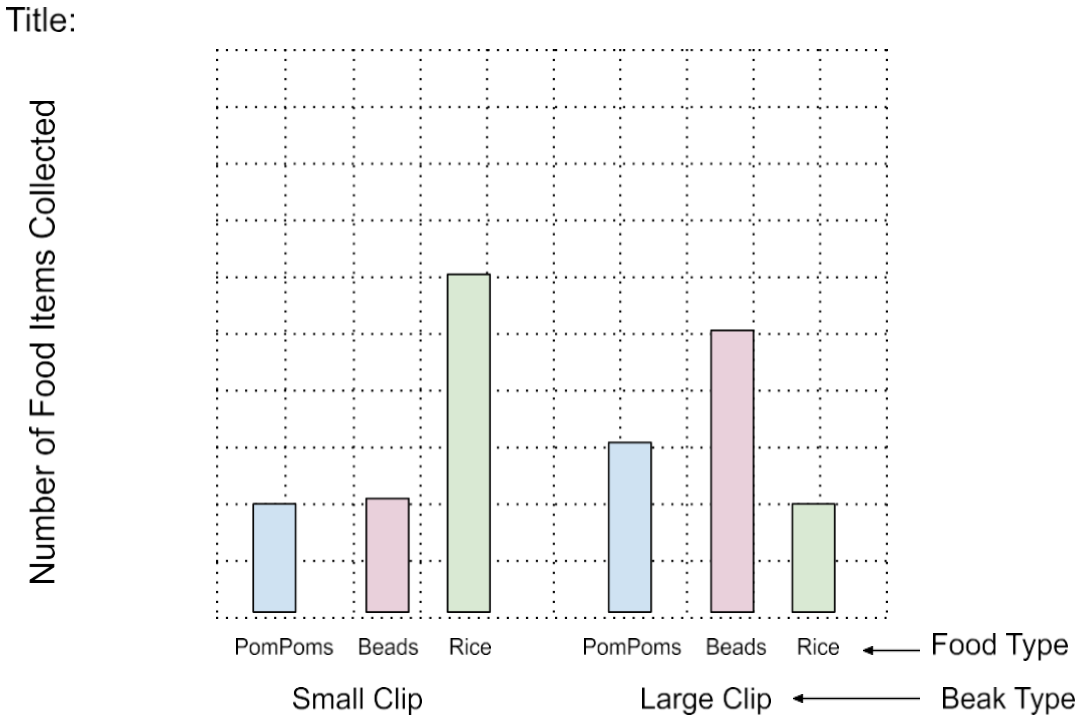
In this investigation, your 3 variables are the type of beak, type of food, and the amount of food gathered. Using this information, determine which 2 variables are independent and which 1 variable is dependent.

Independent Variable(s):	
Dependent Variable:	

3. Create a bar graph representing the number of each type of food you collected for each type of "beak."
    a. Your axes are already labeled, and you can begin by adding numerical values for your count of food types on the y-axis.
    b. Now you're ready to begin graphing! Create bars that go up to the amount of food you collected.

An example graph is shown below.

To graph data with two independent variables, pretend you are making two separate graphs. Start with your small clip data. Label the x-axis with the type of food and color in the bars. Repeat this process but now with data for the large clip. Write a title for your graph at the top.

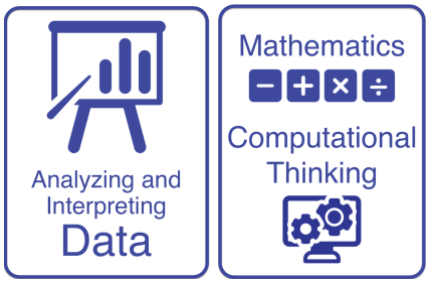


4. Which type of food was the small clip best able to collect according to your data? Which type of food was the large clip best able to collect according to your data?

If the student has the small clip, they will likely have more rice grains. If the student has the large clip, they will likely have more beads. Both clips were able to pick up the pom poms.

5. How did the size of your "beak" impact the function? Did it make it easier or harder to pick up certain types of food? Discuss your results with your classmates.

The small clip was best able to pick up the rice grains and the pom poms. It was difficult for the small clips to pick up and put down the beads. The large clip was best able to pick up the beads and the pom poms. However, it was difficult for the large clip to pick up the rice grains relative to the small clip.



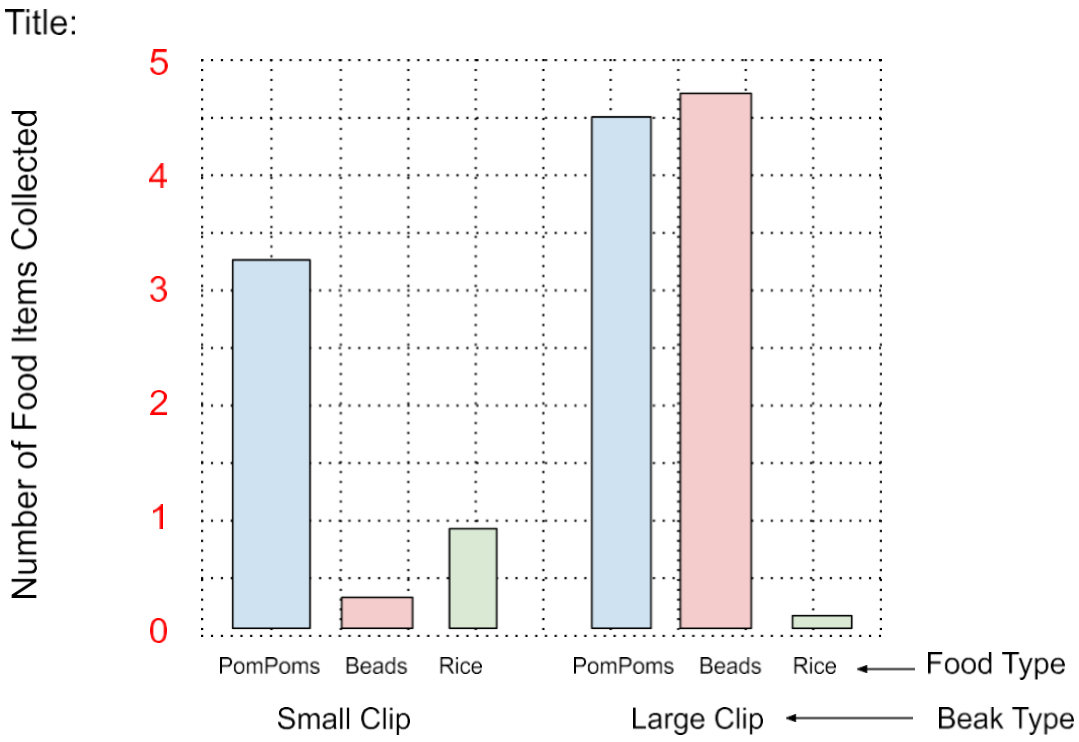
6. Now that you have some practice graphing, you will analyze the data collected by the whole class. Collect the data from each group and record the data in the table below. Calculate the average number of pom poms, beads, and rice collected by each individual for each beak type.

Class Data Table

Group	Small Binder Clips			Large Binder Clips		
	PomPoms	Beads	Rice	PomPoms	Beads	Rice
1	1	2	2	4	7	0
2	2	0	0	5	3	0
3	4	0	1	5	5	0
4	4	0	0	3	7	0
5	5	0	1	4	7	0
6	5	0	1	5	4	0
7	5	0	1	5	2	0
8	3	0	1	5	2	1
9						
10						
11						
12						
13						
14						
15						
Average	3.125	0.25	0.875	4.5	4.63	0.125

The independent and dependent variables will be the same as your individual graphs. Following the same procedure, create a graph for your class data graphing the averages.

Graph of Class Data



7. Most scientific investigations have many repetitions to confirm the accuracy of the results. Every person conducted one repetition, and when your data is put together you have done multiple repetitions.
    a. Do you notice a pattern in the data collected across the multiple repetitions? (Hint: *What happens to the dependent variable as the independent variable changes?*)

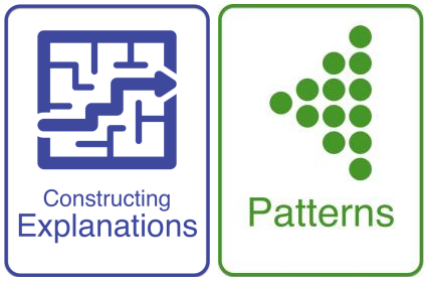
Answers will vary. An example answer is below.

A student using a small clip tends to pick up more rice than beads. A student using a large clip tends to pick up more beads than rice.

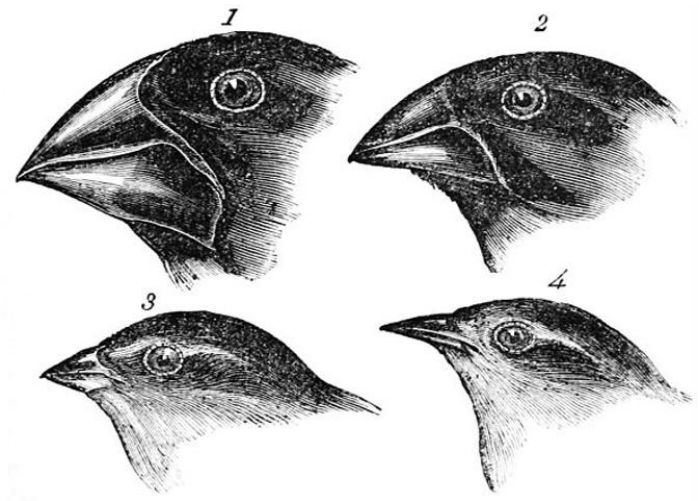
    b. Are the patterns the same from your personal data set and the class data set which contains repetitions, or did they change?

Answers will vary. An example answer is below.

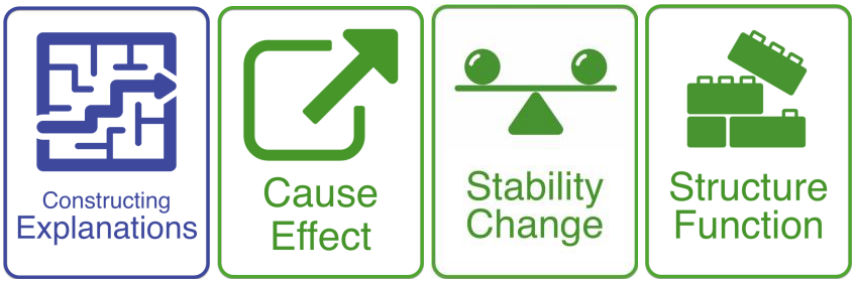
The small clip is the better "beak" for picking up the rice grains, and the large clip is the better "beak" for picking up the beads.



8. The following birds are a set of birds that live on the Galapagos Islands in South America and are called Darwin's finches after the scientist who studied them, Charles Darwin. On the islands, these birds can eat either large, hard nuts or small, soft seeds. Which of the birds below do you think are most likely to feed on the nuts and which do you think are most likely to feed on the seeds? Explain why using the patterns you observed in your data.



Birds 1 and 2 are more likely to feed on the nuts as they have larger beaks that can both fit these foods and are large enough to crush them. Birds 3 and 4 are more likely to feed on the small soft seeds, as they have beaks that are better at picking up these small objects.



9. In 2003, there was a drought in the Galapagos Islands. This low rainfall caused plants not to produce larger seeds, and the effect was that only small seeds were available to eat. When this environment changed, what do you think the effects of this would be for each of the birds in Question 8 and why? When answering 'Why' (e.g. your explanation), use your data from the experiment and be sure to address how the structure of the beak relates to the animal's ability to eat both the larger and smaller seeds.

Birds 1 and 2 are most likely to be impacted because their large beaks can't pick up the small seeds. This was simulated when the large binder clip struggled to pick up rice but the small binder clip could pick up rice.
In fact, the average beak size of all the finches became smaller due to this drought!

BIRDS AND THEIR BEAKS PART 2

Students experience first-hand how different characteristics can provide an advantage to individuals by "eating" with distinct "beaks," graph and analyze this data, and apply their results to explain the effects of adaptations on changes in the ecosystem or environment.

SC STATE STANDARD **Birds and their Beaks Part 2 can be done without Birds and their Beaks Part 1.*	8-LS4-4 Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individual's probability of surviving and reproducing in a specific environment. 8-LS4-6 Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time.
NEXT GEN STANDARD **Birds and their Beaks Part 2 can be done without Birds and their Beaks Part 1.*	MS-LS4-4 Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individual's probability of surviving and reproducing in a specific environment. MS-LS4-6 Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time.
LEARNING OBJECTIVE(S)	- Students will be able to recognize and explain the interaction between the environment and an organism's traits to produce variable amounts of fitness. - Students will be able to describe a phenotype (structure) that provides an advantage in function in a particular environment. - Students will be able to understand how phenotypic traits can impact survival. - Students will graph repeated class data and recognize patterns in the data. - Students will be able to apply concepts of structure and function to real-life examples.
ESTIMATED TIME	Two 45 minute class periods

WHAT YOU'LL NEED:

All of the items can be purchased from a local craft store, big box store, or online. Example products from Amazon are provided as links. The box provides the materials for 30 students, with a single bag per student containing the below:

1. 5 soft pom poms. The box includes 0.75 to 1 inch pom poms as we found this to be the most useful size (example product)
2. 15 pony beads (example product)
3. Approximately 15 rice grains (a generous pinch). *We find arborio rice to work the best* (example product). *White rice and other thin grains are not able to be picked up with binder clips.*
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5. One small 0.75" binder clip (example product) and one large 1.25" binder clip (example product). *Alternatively, using their fingers or clothespins may be more accessible for students with mobility limitations: mini clothespin* (example product) *and large clothespin* (example product).
6. You may also want paper plates or lunch trays to help students keep their materials contained or separated.

WHAT YOUR STUDENTS SHOULD KNOW BEFORE:

Some general knowledge of how certain characteristics serve a certain function may be helpful, but not necessary since this activity is designed for students to hypothesize and experiment with this concept.

WHAT TO DO BEFORE YOUR CLASS:

Here is an example of a student's materials including pom poms, beads, and rice, and two "beaks." Not pictured is a bag or cup.

HOW TO SET UP YOUR CLASS:

This activity can be completed by students working individually or in pairs to collect the data.

WHAT YOU NEED TO KNOW FOR YOUR SAFETY:

Small beads could be a choking hazard.
Binder clips can pinch skin.

This lesson has been designed to follow three dimensional learning, as described in NGSS standards. In this teacher version, we annotate the associated Science and Engineering Practices and Cross-Cutting Concepts using icons (from these NGSS Planning Cards) before the relevant student question and blue and green text, respectively, within the student instructions. Additionally, content and questions that specifically address the Disciplinary Core Idea is represented in orange text. Sample student responses, classroom recommendations, and other hints are in *red italicized text*. See https://scienceweb.clemson.edu/beakerbox/ for additional files such as non-annotated student versions, Spanish versions of student materials, and slides.

BIRDS AND THEIR BEAKS PART 2

Student Activity Instructions:

In this activity, you will simulate a population of finches to explore the mechanisms that drive population change. In Part 1, you kept track of the amount of food that was eaten and graphed how much food each type of "beak" was able to collect. In Part 2, you will be keeping track of how well the "birds" survive from one generation to the next.

1. Make some initial predictions about why you think some birds of the same species may survive and reproduce better than other birds with different observable traits (phenotypes).

Answers will vary.

Procedure Instructions:

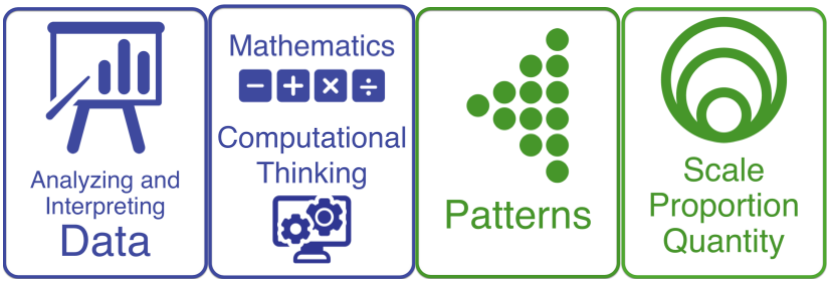
1. Work in groups of 2 with your own set of materials.
   Students can be allowed to compete with their partner for one set of materials, or each student can work to select their own materials from their own set. We found the data to work out either way.
2. Look at the materials provided by your teacher. You should have the following at your station to carry out your investigation:
   a. Three types of "food" (beads, pom poms, rice)
   b. Two types of "beak" (large and small binder clips)
   c. One "stomach" (paper bag, plastic cup, or sandwich bag)
3. Put the food into a pile in the center of your table, where both partners can reach it equally.
4. Each person will have one beak
5. You will use your "beak" to collect food, one item at a time, for 20 seconds. On your teacher's cue, begin collecting food using your beak, putting what you pick up in your "stomach."
   Note: If you have a competitive class, consider reducing the time to 15 seconds. For a less competitive class, consider increasing the time to 30 seconds.
6. You can only use the "beak," black part of the binder clip to pick up the "food"

7. Once time is up, put down your "beak." Count how many of each type of food you collected and record in the data table. Circle whether or not you survived.
    a. If you were able to collect 5 or more pieces of food, you survive and reproduce. Circle Yes
    b. If you did not collect 5 or more pieces of food, you do not survive and reproduce. Circle No
8. For each round, reset the food types in the center of the table according to what is available each round
    a. Round 1: all food types available
    b. Round 2: only Beads and Rice available
    c. Round 3: only Rice available
    d. Round 4: only Beads available
9. Repeat this process (steps 3 through 7) for each round AND each type of beak to complete the data collection.
   Conduct a practice round for 20 seconds to allow students to practice using the "beaks" before timing the "official" rounds.

Data Table: Record your data here

Individual data: Type of Food Eaten and Survival

Round	Type of Beak	Pom Poms	Beads	Rice	Total	Survived?
1	Small	*2*	*0*	*3*	*5*	*Yes* No
	Large	*3*	*6*	*0*	*9*	*Yes* No
2 The environment changed and no pom poms are available	Small	0	*0*	*3*	*3*	Yes *No*
	Large	0	*9*	*0*	*9*	*Yes* No
3 The environment changed and no pom poms or beads are available	Small	0	0	*5*	*5*	*Yes* No
	Large	0	0	*6*	*6*	*Yes* No
4 The environment changed and no pom poms or rice are available	Small	0	*1*	0	*1*	Yes *No*
	Large	0	*9*	0	*9*	*Yes* No



Class Data Table

Survival Data: Record the number of birds of each beak type that survived each round.

Calculate the percent of birds of each size that survived *each round*.

Calculating percentages:

Take the number of survivors with mini beaks and divide by the total number of survivors. Multiply this number by 100.

$$\frac{\text{\# Small beak survivors}}{\text{Total \# of survivors}} \bullet 100$$

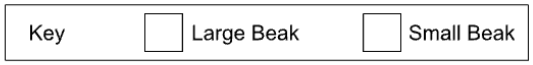
$$\frac{\text{\# Large beak survivors}}{\text{Total \# of survivors}} \bullet 100$$

To check your work: see that the percentage of mini beak survivors + the percentage of big beak survivors = 100 for each round.

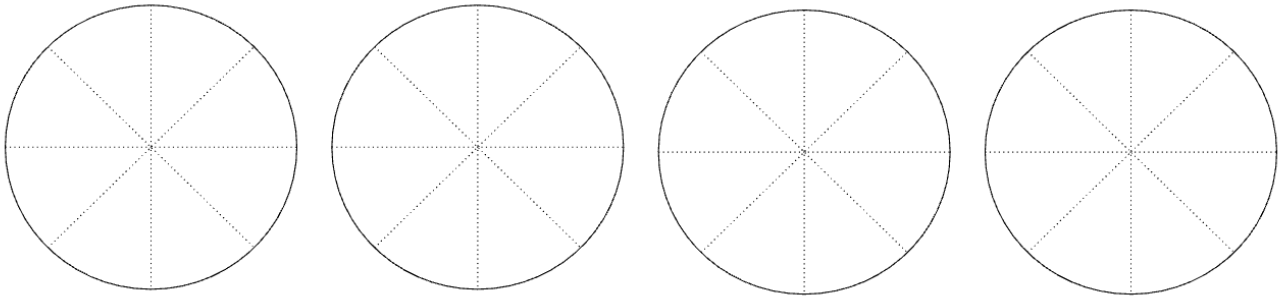
	Round 1			**Round 2**			**Round 3**			**Round 4**		
Type of Beak	Small	Large	Total	Small	Large	Total	Small	Large	Total	Small	Large	Total
Total	*15*	*15*	*30*	*6*	*15*	*21*	*14*	*15*	*29*	*2*	*15*	*17*
Percent Survival	*50%*	*50%*	100%	*29%*	*71%*	100%	*48%*	*52%*	100%	*12%*	*88%*	100%

Graph the Survival Data

In the circle graphs below, create a graph that represents the percentage of the surviving birds represented in the Class Data Table for each round. (*Hint: Use the lines provided in the circles to help you estimate the percentages*)

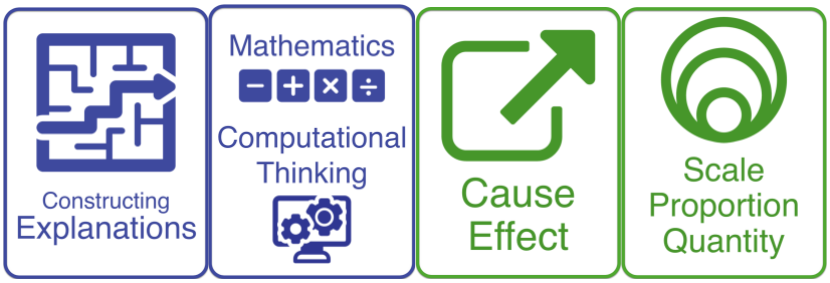


Round 1 **Round 2** **Round 3** **Round 4**



2. Describe what you notice about how the type of beak may or may not affect the survival of birds during each round?

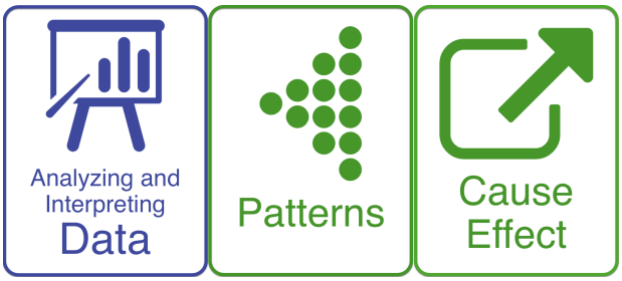
Potential outcome: During rounds 1 and 2, both types of beaks were equally able to survive. During round 3, birds with the little beaks were able to survive more than the birds with the bigger beaks. During round 4, birds with little beaks struggled to survive, but birds with big beaks survived more often.



3. How did the interaction between the "environment" (*Hint: available food*) and the bird's beak size affect their survival? Write a claim supported by evidence and reasoning from the activity regarding the proportion of birds with different sized beaks that survived.

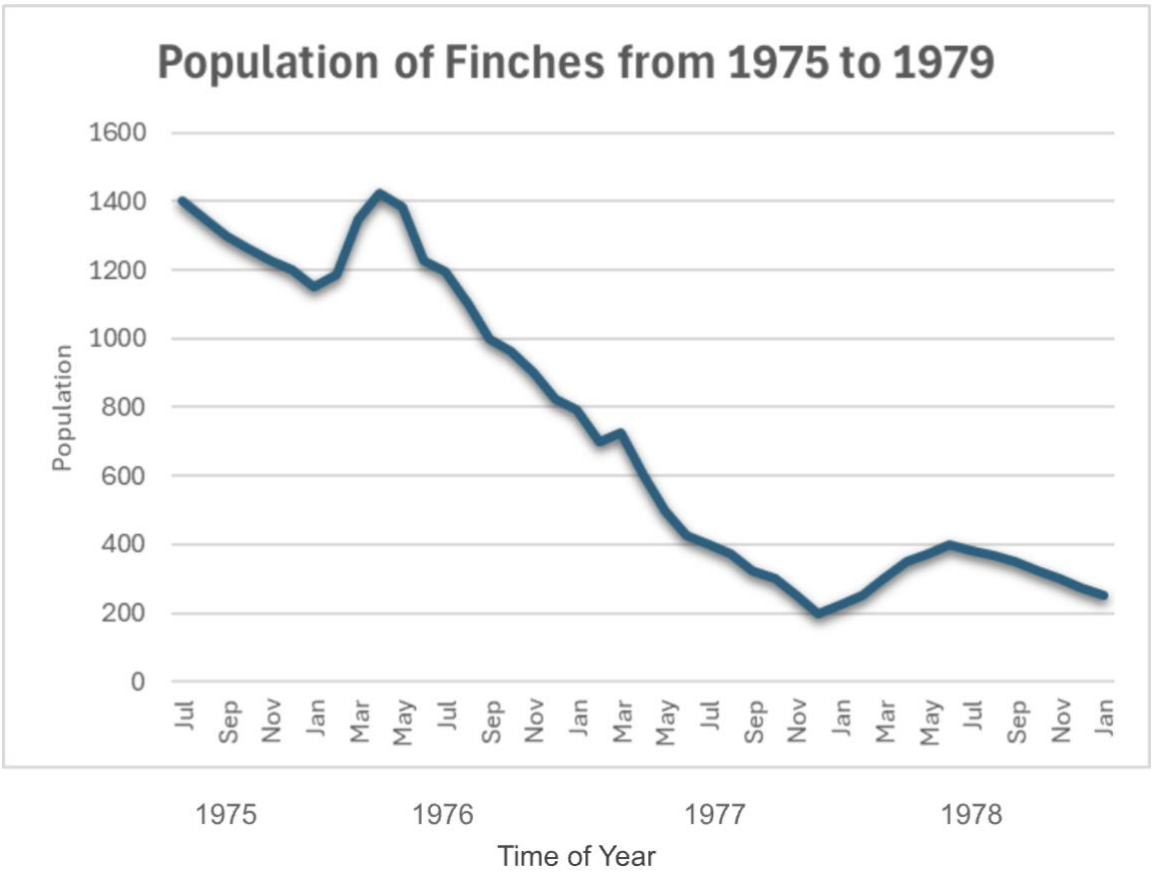
Student responses can vary:
Birds with the small beak were more likely to survive than birds with the large beak when only rice grains were available. During round 3, when only rice was available, % birds with the small beak survived while only % of birds with the large beak survived. Birds with the small beak were able to pick up the small grains of rice more efficiently than the birds with the big beak, and so when only the small food was available, they were better able to survive.

Conversely, birds with the large beak were more likely to survive than birds with the small beak when only beads were available. During round 4, when only beads were available, % birds with the large beak survived while only % of birds with the small beak survived. The birds with the small beak were less efficient at picking up the beads and could not collect enough food to survive.

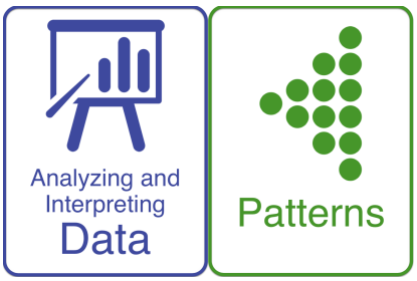


4. The graph below illustrates the finch population through the years 1975 to 1979. During this time, there was a severe drought leading to changes in the environment including the types of food available to the finches.
    a. What do you notice about the finch population from 1975-1979?
    b. What might have caused the change in the population of finches?

Graph 1

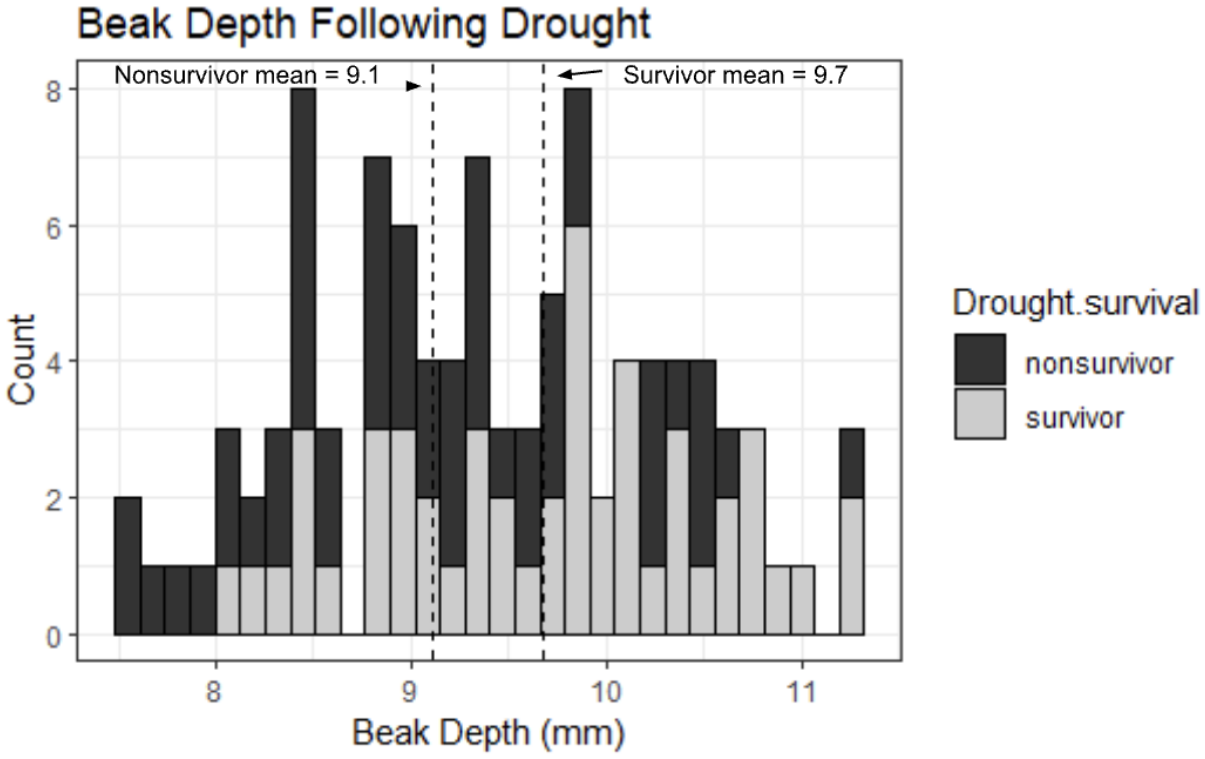


The finch population declined overall from 1975 to 1979. The entire population decreased from approximately 1400 birds in 1975 to just over 200 birds in January of 1979.

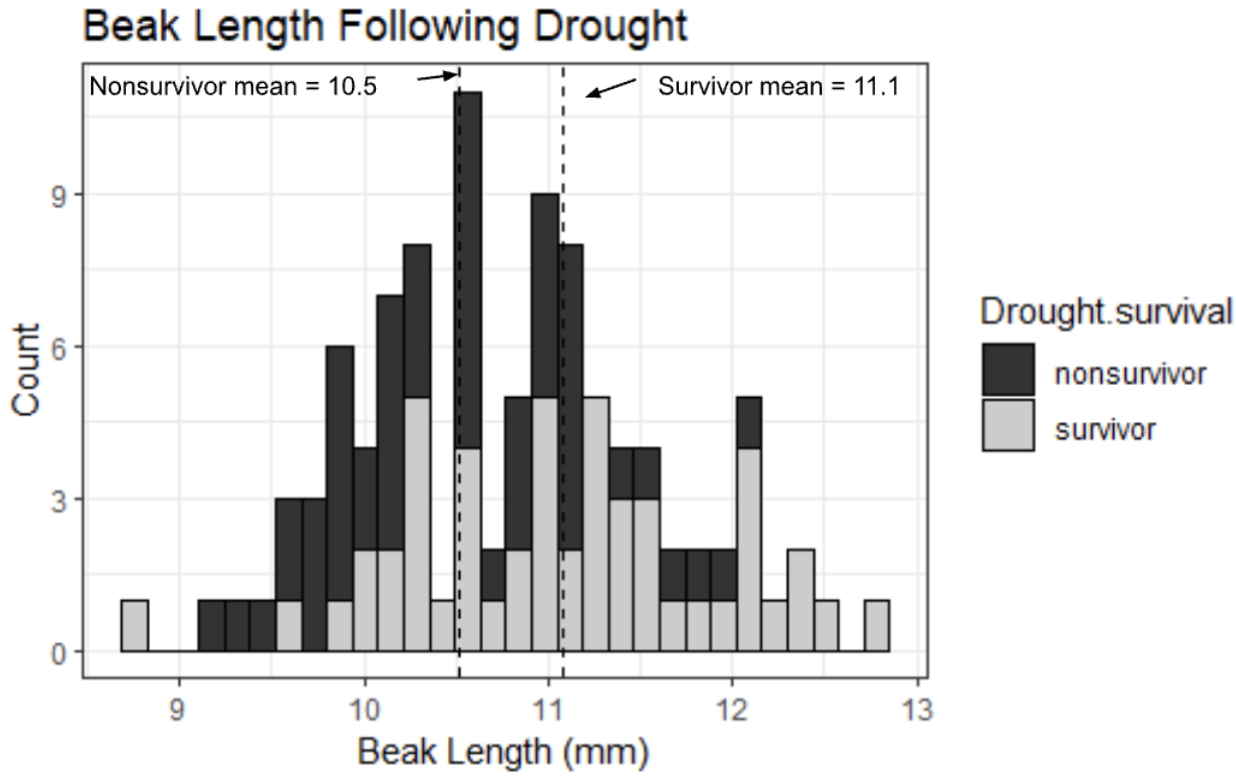


5. The following two graphs depict data collected about surviving and non-surviving finches after the severe drought in 1977. Interpret the two histograms (graphs) below and determine the pattern in beak traits (beak depth and beak length) that you notice between surviving and non-surviving finches.

Graph 2



Graph 3



It appears that birds that survived tend to have deeper, longer beaks relative to the birds that did not survive. The light gray bars are more to the right indicating a larger beak depth and a longer beak length relative to the non-surviving birds.

6. Based on the patterns in graphs 2 and 3, describe what you think the future generation of birds will look like.

Students may predict that the future generation of birds will have larger beaks, both in beak length and beak depth.

7. Construct an explanation in which you discuss how natural selection led to changes in the overall population of finches from 1975-1979. Include in your explanation how the characteristics of the surviving population of finches compared to those that did not survive citing evidence from the three graphs.

The finch population overall declined from 1975 to 1979 with hundreds of finches not surviving the change in the environment. This is evident in the pattern illustrated in the line graph and the decline in population from approximately 1400 birds in 1975 to just over 200 birds in 1979.

Examining the histograms of the beak depth and beak length, the surviving birds tend to have larger beaks than the non-surviving birds. This suggests that birds with smaller beaks were not able to survive.