- This is a sample of only 100 birds, but we know from the film that the Grants collected data on almost the entire population of medium ground finches on Daphne Major. Most researchers typically collect data from samples rather than the entire population. Why do you think that is? What are some advantages and disadvantages of using samples in research?

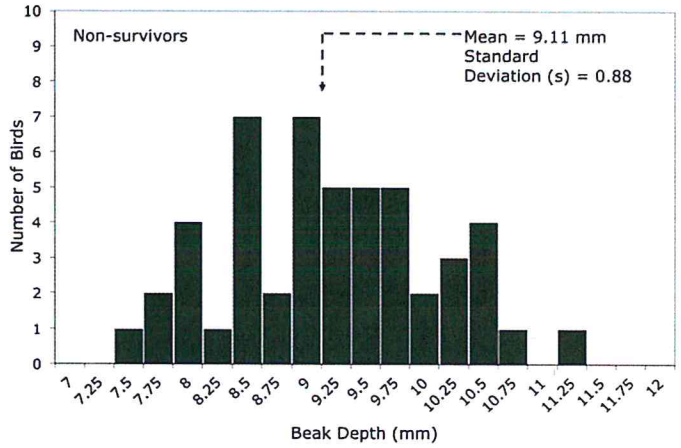
Note: The birds in this sample data set consist of a mix of males, females, and birds of undetermined sex.

Once students have had a chance to explore the data set and ask questions about it, have them answer the questions in the Student Handout. Answers to those questions are provided below.

ANSWER KEY

PART B: Analyzing Graphical Data

Beak Depths of 50 Medium Ground Finches That Did Not Survive the Drought



Beak Depths of 50 Medium Ground Finches That Survived the Drought

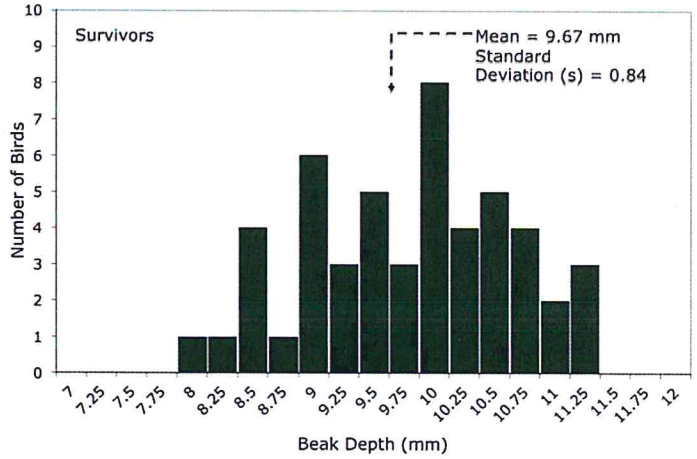


Figure 1. The two graphs above show the beak depths, measured in mm, of 100 medium ground finches from Daphne Major. Fifty birds did not survive the drought of 1977 (top graph). The other 50 birds survived the drought and were still alive in 1978 (bottom graph).

1. a. What observations can you make about the overall shape of each graph?
(Imagine that you are drawing a line that connects the tops of the horizontal bars.)

Students should indicate that the shapes of the distributions look like bell curves or hills. Some students may also know that this is a normal distribution.

b. What do the shapes of the two graphs indicate about the distribution of beak depth measurements in these two groups of medium ground finches?
The shapes of the graphs reveal that there is variability in the beak depth trait among the birds and that most birds have beak depth measurements that cluster around the mean.

2. Compare the distribution of beak depths between survivors and non-survivors. In your answer, include the shape of the distributions, the range of the data, and the most common measurements.
Both survivors and non-survivors have similar shapes of distributions for the beak depth measurements; however, the distributions are "shifted" in the two graphs. The range of beak depths for the non-surviving birds was between 7.25 mm and 11.25 mm, and more than half of the non-surviving birds had beak depths between 8.5 mm and 9.5 mm. The most common beak depths for the non-surviving birds were 8.5 mm and 9 mm. By contrast, beak depths of the birds that survived the drought ranged from 8.0 mm to 11.25 mm, more than half the birds had beak depths between 9.5 mm and 10.5 mm, and the most common beak depth in the 1978 population was 10 mm.

3. Based on what you saw in the film, think about how changes in the environment may have affected which birds survived the drought. Propose a hypothesis to explain differences in the distribution of beak depths between survivors and non-survivors.
Answers may vary, but expect students to remember enough of the film to explain that the change in food source for the birds during the drought—from small, soft seeds to large, hard seeds—may have selected for birds with larger beak depths. Birds with larger beaks were better able to use these large seeds as food (i.e., they were better adapted) than were birds with smaller beaks.

4. Let's look in more detail at the mean beak depths in the two groups of birds to understand the meaning of standard deviation.
   a. How do the mean beak depths and standard deviations of the mean beak depths compare?
   The mean beak depth for the non-surviving birds was 9.11 mm, whereas the mean beak depth for the surviving birds was 9.67 mm, an increase of approximately 6%. The standard deviations for the two groups were nearly the same: 0.88 and 0.84 for the non-surviving birds and surviving birds, respectively.

   b. If the standard deviations of the two samples were vastly different, what would you conclude about the two groups?
   If two data sets have similar standard deviations, it means that the two data sets have the same amount of variability compared to the mean of each data set. In other words, the data are equally spread out. If the standard deviations are different, the data set with the larger standard deviation has more variability compared to its mean. In other words, the data points in the data set with the larger standard deviation are more spread out than the data points in the data set with the smaller standard deviation; each measurement agrees more closely with the mean for the data set.

PART C: Examining the Importance of Sample Size

Table 1. Beak Depths in Two Samples of Finches That Did Not Survive the Drought and Two Samples That Did

Non-survivors				Survivors			
5-finch sample		15-finch sample		5-finch sample		15-finch sample	
Bird ID #	Beak Depth (mm)	Bird ID #	Beak Depth (mm)	Bird ID #	Beak Depth (mm)	Bird ID #	Beak Depth (mm)
12	7.52	283	11.20	943	9.10	623	8.80
347	9.31	288	9.10	1643	8.80	673	10.10
413	8.20	294	10.50	1884	9.15	891	8.00
522	8.39	315	8.80	2244	11.01	1477	10.10
609	10.50	321	8.48	8191	10.86	1528	8.55
		352	7.70			1850	10.40
		413	8.20			1884	9.15
		468	9.02			2242	9.45
		503	9.10			2939	8.31
		507	8.85			678	9.70
		561	10.20			2249	10.68
		610	9.00			1019	11.21
		619	9.25			1797	9.31
		621	7.60			2378	9.86
		676	9.70			316	9.85
Mean	***8.78***	Mean	***9.11***	Mean	***9.78***	Mean	***9.56***
s	***1.15***	s	***0.98***	s	***1.06***	s	***0.90***

5. For each sample, calculate the mean beak depth and standard deviation (s) and add those numbers to the tables.

6. Record the means and standard deviations for each sample of survivors and non-survivors in Figure 1 from Part B (50 birds) and Table 1 in Part C (5 and 15 birds) in Table 2 below.

Table 2. Mean Beak Depths for 50-, 15-, and 5-Finch Samples of Birds That Survived and Did Not Survive the Drought

	Mean			Standard deviation		
	50-finch sample	15-finch sample	5-finch sample	50-finch sample	15-finch sample	5-finch sample
Non-survivors	***9.11 mm***	***9.11 mm***	***8.78 mm***	***0.88 mm***	***0.98 mm***	***1.15 mm***
Survivors	***9.67 mm***	***9.56 mm***	***9.78 mm***	***0.84 mm***	***0.90 mm***	***1.06 mm***

7. Compare the mean and standard deviation for each sample size (5 birds, 15 birds, and 50 birds) within each group of survivors and non-survivors.
   a. Are the means in smaller samples different from the means in larger samples? Explain your answer.

Except for the non-survivor sample size of 15, none of the means match the mean beak depths of the 50-bird samples. The means are different because each set of birds was randomly selected from the larger group, and since there is significant variation in beak depth in the population it is unlikely that the mean of any smaller sample will match the mean of the larger group.

b. Are the standard deviations in smaller samples different from the standard deviations in larger samples? Explain your answer.
In this example, the standard deviations of both groups of birds decrease with increased sample size. Students' explanations will vary and may reveal a misunderstanding of how standard deviation responds to sample size. Standard deviation is a measure of the amount of variation in a population. Some students may say that standard deviation increases with a smaller sample size, but standard deviation can increase or decrease with a smaller sample size because of sampling—the chance of having a sample that does not accurately represent the entire population. (Standard error, on the other hand, tends to increase with smaller sample sizes.)

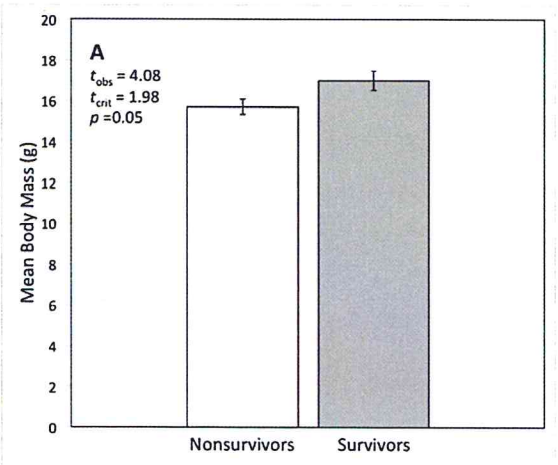
8. Which results (i.e., from 5, 15, or 50 birds) do you think are closer to the means and standard deviations of the entire population of medium ground finches on the whole island? Explain your answer.
Students should indicate that in general, the larger samples should provide means and standard deviation values that are closer to those of the population as a whole.

9. What is one advantage and one disadvantage of calculating the mean from a sample of a population rather than the entire population?
Advantages may include lower cost and less time; it is usually not feasible to collect data on an entire population if the population is large and spread out. One disadvantage is that the data obtained from a sample may not be reflective of the population as a whole.

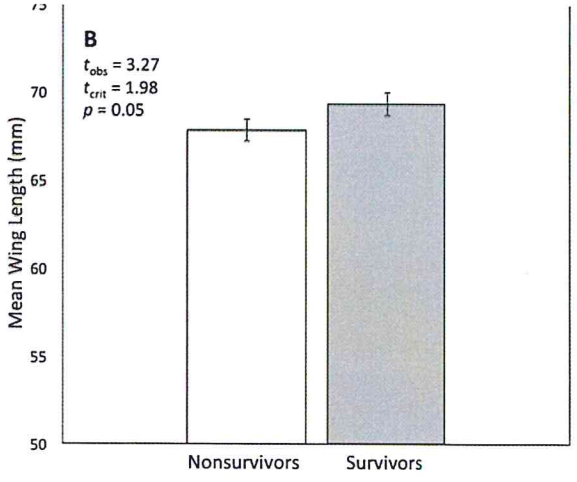
PART D: Adaptive Traits and Constructing Graphs

10. In the space below, construct two bar graphs showing the mean values for wing length for the two groups of birds on one graph and mean values for body mass for the two groups of birds on the other. Title your two graphs and label your axes.

Mean body mass for medium ground finches that did not survive the 1977 drought (non-survivors) and those that did survive the drought (survivors)



Mean wing length for medium ground finches that did not survive the 1977 drought (non-survivors) and those that did survive the drought (survivors)



11. Based on the graphs you have drawn, how does wing length compare between survivors and non-survivors? What about body mass?
The surviving medium ground finches had slightly longer wings and slightly larger body masses than medium ground finches that did not survive the drought of 1977.

12. What do the results illustrated by your graphs indicate about the effects of the drought on birds with particular wing lengths and body masses?
The results suggest that it may have been an advantage during the drought to have a larger body mass and longer wings. Students may also point out that larger birds probably also have larger wings and larger beaks, and are thus more likely to survive.

13. The Grants say in the film that a key trait that made the difference in survival for the birds during the drought was beak depth. Is that conclusion consistent with the data presented in this activity (including Part B)? Explain your answer.
Beak depth was larger for the surviving birds compared to the birds that did not survive. However, body mass and wing length were also larger among survivors. It could be that larger beaked birds simply have larger body masses and longer wings. All three traits could be important in survival.

14. Explain why the Grants concluded that beak depth may have played a more important role in survival during the drought than wing length or body mass. Correctly use the terms natural selection, adaptation, and fitness in your answer.
The major environmental change caused by the drought was a change in food source. The larger beaks of some medium ground finches became advantageous when the small, soft seeds disappeared and only large, hard seeds remained. Birds with larger beaks were able to use large, hard seeds as a food source and were therefore more likely to survive the drought and reproduce than were birds with smaller beaks. Therefore, large-beaked birds were more fit than small-beaked birds. Because the survival challenge posed by the 1977 drought had to do with a change in the food supply, natural selection probably acted primarily on beak depth, not wing length or body mass. An explanation for why wing length and body mass were also greater for surviving birds may be that birds with larger beaks were also larger overall—they had longer wings and were heavier than birds with smaller beaks.

Students may also indicate that having a larger body mass may have helped birds withstand lack of food better than birds with smaller body mass.

15. Explain the role of variation in important traits (like beak depth) in a population for the survival of a species.
Students should indicate in their own words that variation among individuals in important traits like beak depth makes it more likely that at least one form of the trait will be good enough for individuals to successfully survive a change in their environment.

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