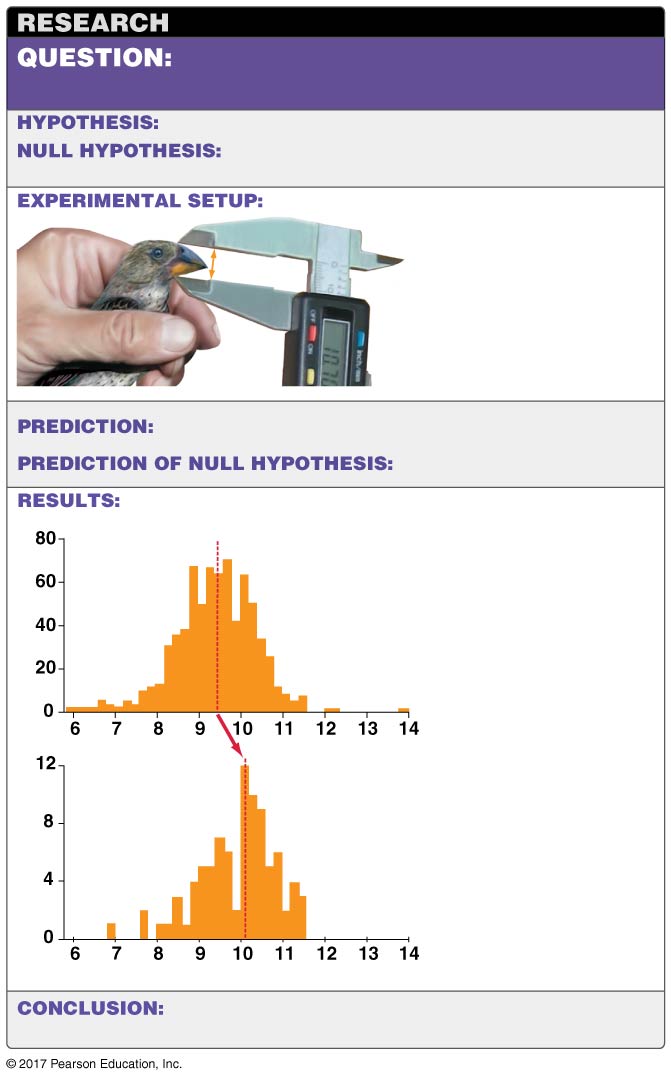
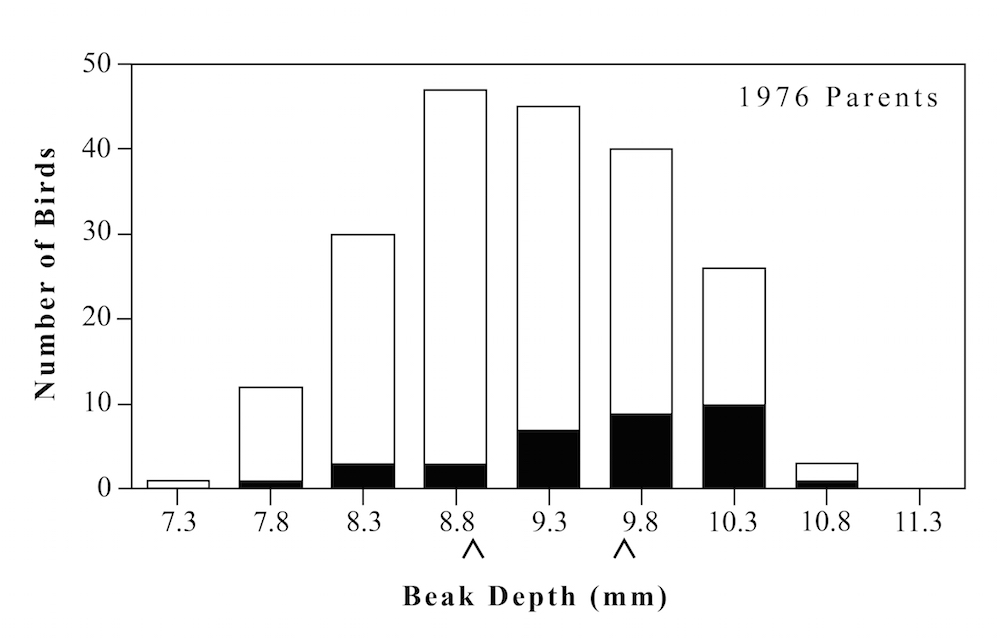
**Natural Selection and Galápagos Finches**

**Part 1: The 1976 Drought and Beak Depth**

Rosemary and Peter Grant performed a series of long-term studies on the finches on the island of Daphne Major in the Galápagos Islands. With its short, blunt beak, the medium ground finch is adapted to picking up seeds from the ground (Figure 1). In 1976, seeds on the island were diverse and plentiful. However, during a drought in 1977, seeds became more scarce. Once the finches had eaten all the small and medium-sized seeds, they had to turn to larger, spiny seeds that are hard to crack open. The graph below shows the distribution of beak depths of the finch population before the drought (white bars) and after the drought (black bars) (Figure 2).

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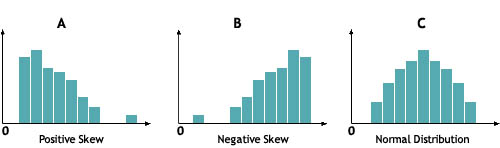
**Figure 1.** The medium ground finch (*Geospiza fortis*) is one of the finch species that lives on Daphne Major. Beak depth is one of the measures of a finch’s beak – this measurement is shown in the figure. *Biological Science, Freeman, 6th edition.*

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**Figure 2.** Distribution of beak depths in the breeding population of medium ground finches (*Geospiza fortis*) on the island of Daphne Major in 1976 (white bars) and of the survivors of the 1977 drought (black bars). The means of the two populations are indicated by the carets (^).

Examine Figure 2 on the previous page and use it to answer the following questions:

1. The three graphs below show different amounts of skew in a histogram. Which of these does the initial population look most like? Which of these does the surviving population look most like?



2a. What is the mean beak depth of the initial population?

2b. What is the mean beak depth of the surviving population?

2c. Describe, in your own words, the process that caused there to be a difference in beak depth in the population over time:

How selective pressures, such as the 1976 drought, affect a population can be characterized in several different ways. The first is to calculate a **selection differential** – a measure of the intensity of the selection pressure. The selection differential is calculated by finding the difference between the mean phenotypic state in the population before and after a specific selective event. In this case, it is calculated by taking the mean beak depth in the breeding population before the drought and subtracting it from the mean beak depth in the population that survived the drought:

**selection differential = µsurvivors - µinitial**

The sign and magnitude of the selection differential give information about the direction and strength of selection. For example, if the mean beak depth of the initial population was larger than the mean beak depth of the survivors, the selection differential would be negative. The negative sign of the selection differential would indicate that beak depth became smaller as a result of this selective pressure. The larger the value of the selection differential, the larger the difference in beak depth between the two populations.

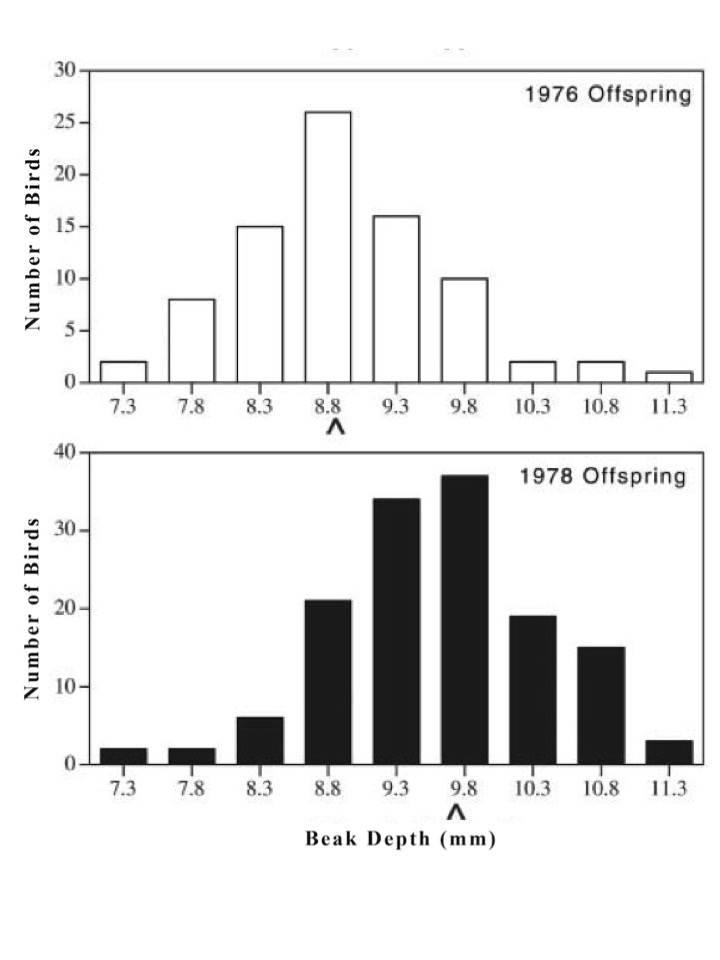
3. Using the means of each population shown in Figure 2 (and recorded in Question 2a and 2b), calculate the selection differential for beak depth.

4a. If the finches that survived the drought reproduced, make a prediction about the size of the beak depths in their offspring (e.g. would they be larger, smaller, the same size?).

4b. How might the beak size of the offspring you predicted in Question 4a compare to the beak depths of any offspring that were hatched before the drought?

**Part 2: The Offspring of the Drought and Beak Depth**

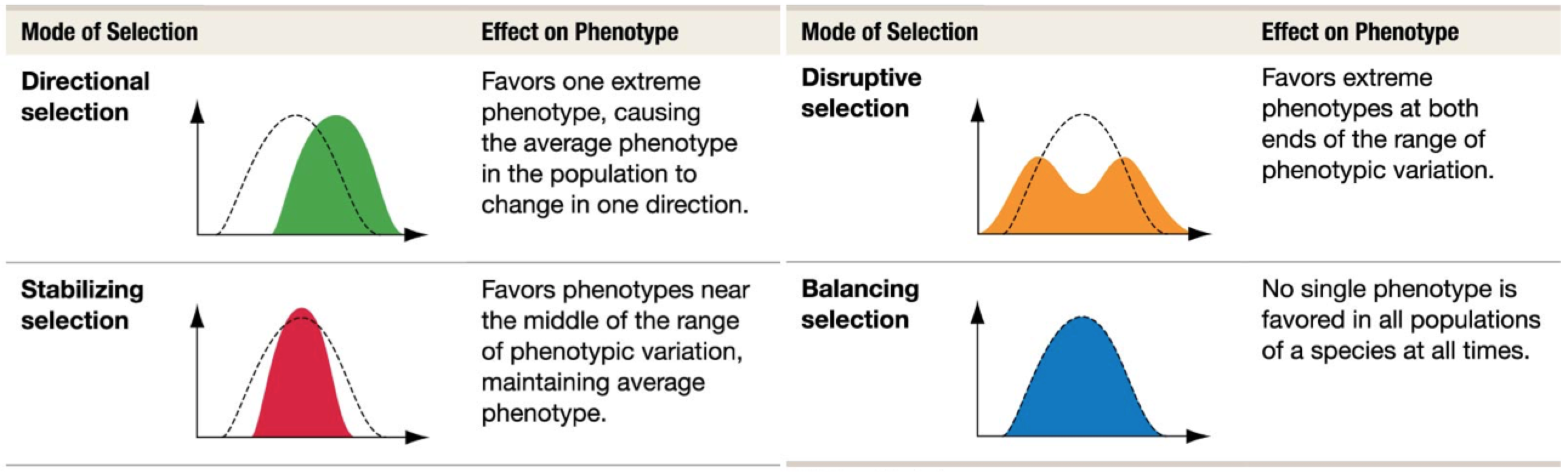
The figure below shows the distributions of beak depths of fully grown offspring hatched in 1976 (before the drought) and 1978 (after the drought) (Figure 3).



**Figure 3.** Distribution of beak depths of fully grown offspring hatched in 1976 and 1978 on the island of Daphne Major. The means of the two populations are indicated by the carets (^).

5. Interpret these graphs in light of the selection differential you calculated. Do the values match your prediction from Question 4?

The other way in which selective pressures can be characterized is to graph a **fitness function**. This type of graph shows how fitness changes as a result (or function) of phenotypic state in a particular population. The shapes of four fitness functions are typically characterized as one of four modes of selection, shown below (Figure 4).



**Figure 4**. Four modes of selection, and their general effect on phenotype. *Biological Science, Freeman, 6th edition.*

Fitness functions are generated by calculating the fitness for each phenotypic state, often by calculating the percent survival (because the number of reproducing offspring is often difficult to track). For example, the number of surviving finches at each beak depth is shown in the graph below.

**Figure 5**. Fitness function for beak depth comparing the initial population to survivors of the 1976 drought.

6. Which mode of selection is shown by the fitness function in Figure 5?

**Part 3: Natural Selection on Other Traits**

As part of their work, the Grants intensively studied the population of medium ground finches (*Geospiza fortis*) on the island of Daphne Major. Every year, the Grants measured the wing length, body mass, and beak size of hundreds of individual medium ground finches. They focused on these characteristics because they vary widely among individual birds within the same species –for example, some birds in a population will be larger than other birds or have bigger beaks, even though they all belong to the same species. It is normal for heritable traits to vary among individuals in a population because no two individuals, except for twins, are genetically identical. In some cases, individuals with one form of a trait, such as a larger beak, will have a survival advantage over individuals with a different form of the trait, such as a smaller beak. Those advantageous traits may make it more likely for some individuals to survive and produce more offspring, and therefore are more likely to be passed on to the next generation. This process is what Charles Darwin called **natural selection**.

You will be provided with a dataset that the Grants collected on medium ground finches between 1973 and 1982. They are divided into two groups – those that died in the 1977 drought, and those that survived past 1977 (survivors). You will choose one trait, and use it to do the following:

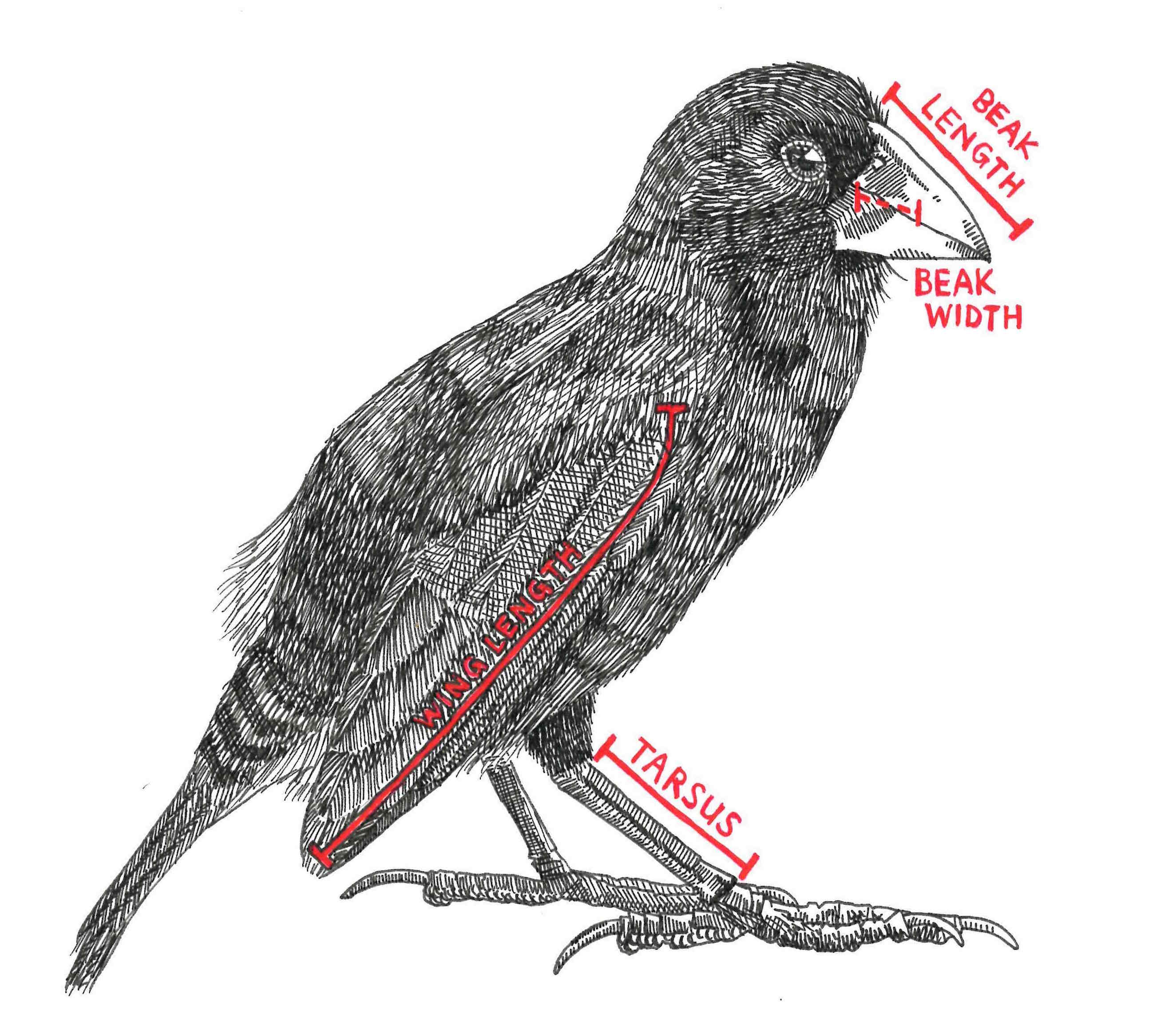
• calculate the **mean** for that trait for both the initial and surviving population

• calculate the **selection differential**

• graph a **histogram** of both the initial and surviving population

• graph a **fitness function**

• identify the **type of selection**

The dataset is posted to Moodle as an Excel file, and contains identifying information for a total of 100 finches. The traits that you may select from are:

**weight**

**wing length**

**tarsus length**

**beak length**

**beak width**

Before beginning, select a trait and formulate a hypothesis and prediction about how this trait will vary in the initial and surviving population.

**Question: How did the distribution of the trait you selected change in the medium ground finch population in response to selective pressures during the 1976 drought?**

**Hypothesis**: *This should include a biological mechanism – a biological reason you think that the trait you chose might be similar or different in the finches that died during the drought versus finches that survived the drought.*

**Group (trait)**: *Identify the trait you will be using to test your hypothesis.*

**Prediction**: *This should predict how your data will look for your groups if your hypothesis is supported. You will be comparing the trait in both the initial population and the surviving population, and identifying the type of selection that occurred.*

**Calculating Selection Differentials**

You will first calculate two means, and use them to calculate one selection differential.

1. Use your spreadsheet program to calculate the average (mean, µ) of your trait of choice for the two populations: the initial population (all finches, regardless of “last year”), and the surviving population (all finches whose “last year” is not 1977).

2. Using these two mean values, calculate the selection differential caused by the drought on this trait:

**selection differential = µsurvivors - µinitial**

Take the mean phenotypic state of the entire population (µinitial), and subtract it from the mean phenotypic state of the survivors alone (µsurvivors).

\**Note: For cases of pure stabilizing or disruptive selection, the selection differential will be zero or very close to zero*.

**Graphing Multiple Frequency Distributions**

You will first “bin” your data, and then use the binned data to graph two histograms on the same axes.

1. For the X-axis, you will need to establish an appropriate number of bins in which to place the values for your trait. For example, the trait “beak depth” ranges from birds with a depth of 7.5 mm to birds with a depth of 11.21 mm. You might have 8 bins, each with a range of 0.5 mm:

|  |  |
| --- | --- |
| **Bin Number** | **Range** |
| 1 | 7.5 – 7.9 mm |
| 2 | 8.0 – 8.4 mm |
| 3 | 8.5 – 8.9 mm |
| 4 | 9.0 – 9.4 mm |
| 5 | 9.5 – 9.9 mm |
| 6 | 10.0 – 10.4 mm |
| 7 | 10.5 – 10.9 mm |
| 8 | 11.0 – 11.4 mm |

You may have to use trial and error to decide on the range of the bins, although you should aim for about 10 bins.

2. Count the total number of finches that fell within the range of each bin. For example, there are five finches in the initial population with a beak depth between 7.5 mm and 7.9 mm, so you would record a value of “5” for the first bin.

3. Make a table where you record the number of finches in each bin for both the initial and surviving populations. It should look something like this:

|  |  |  |
| --- | --- | --- |
| **Beak Depth** | **Initial** | **Survivors** |
| 7.5 – 7.9 mm | 5 | 0 |
| 8.0 – 8.4 mm | 12 | 4 |
| 8.5 – 8.9 mm | 18 | 9 |
| 9.0 – 9.4 mm | 19 | 8 |
| 9.5 – 9.9 mm | 17 | 9 |
| 10.0 – 10.4 mm | 14 | 10 |
| 10.5 – 10.9 mm | 11 | 7 |
| 11.0 – 11.4 mm | 4 | 3 |

4. Use this binned data to make a bar graph in your spreadsheet program. (See APPENDIX B – GRAPHING for more information.) Make a clustered bar graph that shows both the initial and surviving populations on the same axes.

*\*Note: Because there are two data sets represented in your graph, it should have a legend. Spreadsheet programs will often auto-generate a legend for you. If it does not, add a legend by clicking on the button labeled “Legend” under the “Chart Layout” tab (Excel) or by clicking on the drop-down menu labeled “Legend” under the “Customize” tab of the chart editor (Sheets).*

After removing Y-axis lines and adding axis labels and a legend, your graph should look similar to this:

**Graphing a Fitness Function**

You will first use your binned data (from “Graphing Multiple Frequency Distributions”) to calculate the percent survival, and then graph this as a line graph.

1. Use the same table of binned data that you used to graph your frequency distributions. Add a column for “percent survival.”

|  |  |  |  |
| --- | --- | --- | --- |
| **Beak Depth** | **Initial** | **Survivors** | **Percent Survival** |
| 7.5 – 7.9 mm | 5 | 0 |  |
| 8.0 – 8.4 mm | 12 | 4 |  |
| 8.5 – 8.9 mm | 18 | 9 |  |
| 9.0 – 9.4 mm | 19 | 8 |  |
| 9.5 – 9.9 mm | 17 | 9 |  |
| 10.0 – 10.4 mm | 14 | 10 |  |
| 10.5 – 10.9 mm | 11 | 7 |  |
| 11.0 – 11.4 mm | 4 | 3 |  |

2. Using these values, calculate the percent survivors for each bin:

**% survival = (# individuals in binsurvivors ÷ # individuals in bininitial) x 100**

Take the number of survivors for each bin (binsurvivors) and divide it by the number of finches for the same bin in the entire initial population (bininitial). Multiply this number by 100 to get a percentage (%).

4. Use just the bins and the percent survival to make a line graph in your spreadsheet program. (See APPENDIX B – GRAPHING for more information.)

|  |  |
| --- | --- |
| **Beak Depth** | **Percent Survival** |
| 7.5 – 7.9 mm | 0 |
| 8.0 – 8.4 mm | 33.3 |
| 8.5 – 8.9 mm | 50 |
| 9.0 – 9.4 mm | 42.1 |
| 9.5 – 9.9 mm | 52.9 |
| 10.0 – 10.4 mm | 71.4 |
| 10.5 – 10.9 mm | 63.6 |
| 11.0 – 11.4 mm | 75 |

After removing Y-axis lines and adding axis labels, your graph should look similar to this:

5. Using Figure 4 as a reference, determine which type of selection appears to have occurred.

Once you have calculated the selection differential and graphed the frequency distribution and fitness function for your trait, answer the following questions:

7. Do your data support your hypotheses? Explain why, or why not, citing specific evidence.

8. Based on your results, would the trait you chose to study be likely to evolve under natural selection? Briefly explain your reasoning, making sure to reference your selection differential and the type of selection that you observed.

9. If this population of medium ground finches was continually exposed to drought conditions similar to that of 1976, how would you expect the population to evolve over time? For example, describe what this population of finches might look like after 100 generations of this type of selection.