Natural Selection and the Evolution of Darwin's Finches

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Activity
Educator Materials

OVERVIEW

This activity provides students with opportunities to make predictions, create mathematical models of data, and use multiple sources and types of evidence in developing arguments for the adaptation and natural selection of Darwin's finches. Students watch segments of and use information from the short film *The Origin of Species: The Beak of the Finch*, which can be downloaded or streamed at http://www.hhmi.org/biointeractive/origin-species-beak-finch. In addition to the curriculum connections listed below, this activity is aligned with the NGSS science and engineering practices (SEPs) of (1) engaging in argument from evidence using mathematical and computational thinking and (2) analyzing and interpreting data.

KEY CONCEPTS

- An adaptation is a structure or function that confers on an organism a greater ability to survive and reproduce in a particular environment.
- When two groups within one population become geographically isolated, genetic changes in one group will not be shared with members of the other group, and vice versa. Over many generations, the two groups can diverge into distinct populations with measurable differences, as their traits change in different ways.
- If there is enough genetic variation among individuals in a population, and if the natural selection acting on this variation is strong, then evolutionary change can occur rapidly and in only a few generations. However, major change, such as the origin of new species, often takes many thousands of generations.

STUDENT LEARNING TARGETS

- Make claims and construct arguments using evidence from class discussion and from a short film on the evolution of the Galápagos finches.
- Use data to make predictions about the effects of natural selection in a finch population.
- Construct mathematical models (i.e., bar graphs) to illustrate predicted results and compare them to actual results.

CURRICULUM CONNECTIONS

Standards	Curriculum Connection
NGSS (2013)	HS-LS2-8, HS-LS4-2, HS-LS4-4
AP Bio (2015)	1.A.1, 1.A.2, 4.C.2, SP1, SP3, SP5, SP6
IB Bio (2016)	5.1, 5.2
AP Env Sci (2013)	II.C
IB Env Systems and Societies (2017)	2.1
Common Core (2010)	ELA.RST.6-12.7, WHST.6-12.1, MP2, MP4, MP8
Vision and Change (2009)	CC2, CC5, DP1, DP2

KEY TERMS

adaptation, evolution, mutation, natural selection, rationale, trait

TIME REQUIREMENTS

Two 50-minute class periods but may take longer depending on the amount of class discussion; Parts 1 and 2, and some of Part 3, can be covered in one day. The remainder of Part 3 and Part 4 can be covered on a second day. Part 5 can be done at home as homework or in class on a third day (see Figure 1).

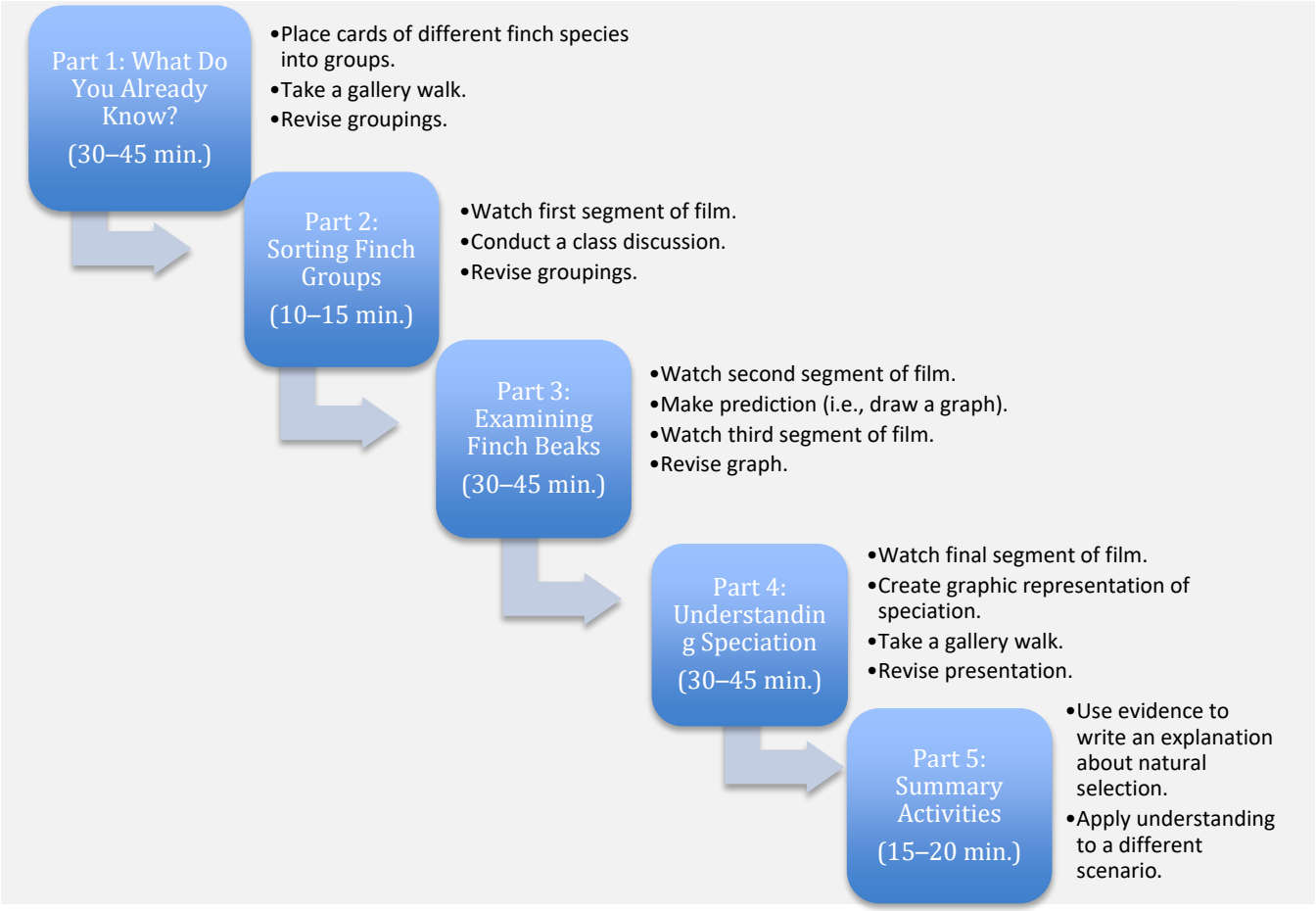

Figure 1. Lesson Overview.

SUGGESTED AUDIENCE

- Middle School: Life Science
- High School: all levels of Biology, including AP and IB

PRIOR KNOWLEDGE

Students should

- know that traits are inherited, and that some traits provide organisms with a greater chance to survive and reproduce in a particular environment.
- be able to construct basic graphs, as well as interpret a bar graph or a line graph.

MATERIALS

- Finch cards (13 cards per student team)
- Scissors
- Student handout (one per student team, with Part 5 separated in order to hand out later)
- Large, white poster board or butcher paper
- Blue painter's tape for attaching cards to poster board or butcher paper
- Access to a camera (optional)
- Sticky notes or index cards
- Graph paper
- Science notebooks or paper for writing
- Different-colored pens (optional)

TEACHING TIPS

- Cut out the finch cards ahead of time or have students cut them out.
- Students can work in teams of three or four for most of the activities; each team needs 13 finch cards and one student handout.
- Make sure students understand that each card represents a different finch species, not different individuals of the same species. The species are the large (card no. 2), medium (12), and small (8) ground finches; the sharp-beaked ground finch (5); the cactus (13) and large cactus (9) finches; the vegetarian tree finch (6); the large (11), medium (3), and small (10) tree finches; the woodpecker finch (1); the mangrove finch (4); and the warbler finch (7).
- Students can attach finch cards to poster board or butcher paper with blue painter's tape, which allows them to easily remove and rearrange the cards. Alternatively, they can arrange the cards on a flat surface and take pictures or make another kind of record of their groupings.
- Students can write observations and answers to the questions in their science notebooks, on separate paper, or in an online document. The student handout also can be used for capturing this information.
- Some activities require viewing specific segments of the film before proceeding.
- When students view other teams' work, they should provide written feedback in the form of questions and always add their initials so that they are accountable for their work.
- Students may revise their work at different points in the activities. It may be useful to have them use different ink colors to indicate revisions.

PROCEDURE

Hand out one pack of 13 finch cards and one handout to each student team. (Note: Hand out the entire handout except for the last pages with Part 5. These pages should be handed out at the very end.)

PART 1: What do you already know?

1. Have students work in teams of three or four to arrange the finch cards into groups based on characteristics. They can attach the cards to poster boards or butcher paper or arrange them on tables, making a record of their groupings (for example, by taking a photo of the groups or writing down the number of the finch cards in each group). Students might group the cards according to birds' sizes or colors, or the sizes or shapes of the beaks.

   There isn't a wrong answer for this part of the lesson, as long as students can justify their categories. The objective is for students to make observations about the different species and any characteristics that are more similar among some finch species than others. Certain shared characteristics may provide clues into how these different finch species evolved.

Figure 2. An Example of a Team's Grouping. The categories are (1) finch species on branches ([a] thin beak and [b] thick beak), and (2) finch species on the ground ([a] thin beak and [b] thick beak).

2. Students should prepare a key on sticky notes or index cards that describes their evidence for each group. In the example in Figure 2, the student team would claim, "We grouped these finches based on where the finches live and on their beak shape." Their evidence would be, "These finches either live on the ground or on branches; some have thin beaks and some have thick beaks."
3. Have students look at other teams' posters. Each student should provide constructive feedback by individually writing two questions and initialing them. Possible questions include these:
   - Why did you put this bird in this group?
   - What do the birds in this group have in common?
   - Is there another way you could group them?

   Allow about two minutes per group (so if you want students to provide feedback for three groups, it should take about six minutes).
4. Some students may not want to revise their posters. Have students document their rationale for revising (or not revising), including additional evidence, or additional questions, on their posters. Allow five to eight minutes for revision.

   Before moving on to Part 2, ask students these questions:
   - Why would a researcher group species of animals? What information can you obtain from these groupings?

Students should understand that researchers group animals by appearance to understand their evolutionary relationships. Similarities in certain traits among species may indicate that they are closely related or that they evolved in similar environments or eat similar foods.

PART 2: Sorting Finch Groups

5. Show the first segment of the film *The Origin of Species: The Beak of the Finch* from the beginning to 5:36 minutes. While they watch the first segment, have students take notes on the questions they are listening for.
6. Allow 15–20 minutes for a class discussion. First, clarify any questions students may have about what they saw in the film. Then, have students discuss the questions in their handouts with others on their team. Start the class discussion with students offering their answers to this question:
   - What do the different beaks tell us about the different finch species?

   Some possible student answers are included below:
   - **Different species of finches have different shapes and sizes of beaks because they have different versions of genes.**
   - **Individuals with particular beak shapes and sizes are better able to obtain and eat certain types of foods on the island. As a result, they are more likely to survive and reproduce, and their offspring will inherit the same genes.**
   - **Different beaks make different species of finches better adapted to eating different types of foods.**

   Listen for common misconceptions, such as that different beaks evolved because birds need them to eat a particular food. This kind of reasoning is called teleological reasoning. Indeed, traits do not evolve on demand or because a species needs them. Natural selection acts on existing variations in a population. Those traits that are more advantageous in a particular environment will become more common over many generations.

   Next, have students discuss their answers to this question:
   - What evidence did scientists use to determine that the 13 species of finches on the Galápagos arose from a single common ancestor?

To answer correctly, students may have to rewatch this portion of the film. Possible answers include the following:

- The evidence comes from DNA analysis showing that species on the islands are more closely related to one another than they are to any bird species on the mainland.
- The alternative hypothesis is that 13 different bird species migrated from the mainland and then populated the Galápagos. If this were the case, some of the finch species on the islands would be more closely related to birds on the mainland than to one another. If students are confused about these two explanations, having them draw a graphic representation of both might be helpful.
- The conclusion that all Galápagos finches evolved from a single ancestral population was important because it suggests that one population evolved into 13 different ones. Biologists Peter and Rosemary Grant, profiled in the film, could then try to study how this process occurs.

Students may have questions about how DNA evidence shows that different species of finches are more related to one another than to species on the mainland. Basically, researchers look for differences in DNA sequence—in general, the fewer the number of differences, the more closely related two species are. (This explanation is a simplification of the process but serves as a general illustration of the concept.) Based on the DNA data, researchers have also determined which species of Galápagos finches are more closely related to one another. The phylogenetic tree in Figure 3 illustrates these relationships. (For example, note that all the ground finches are more closely related to one another than to other finches.) These groupings may or may not match the groupings students came up with based on the finch characteristics, which is fine.

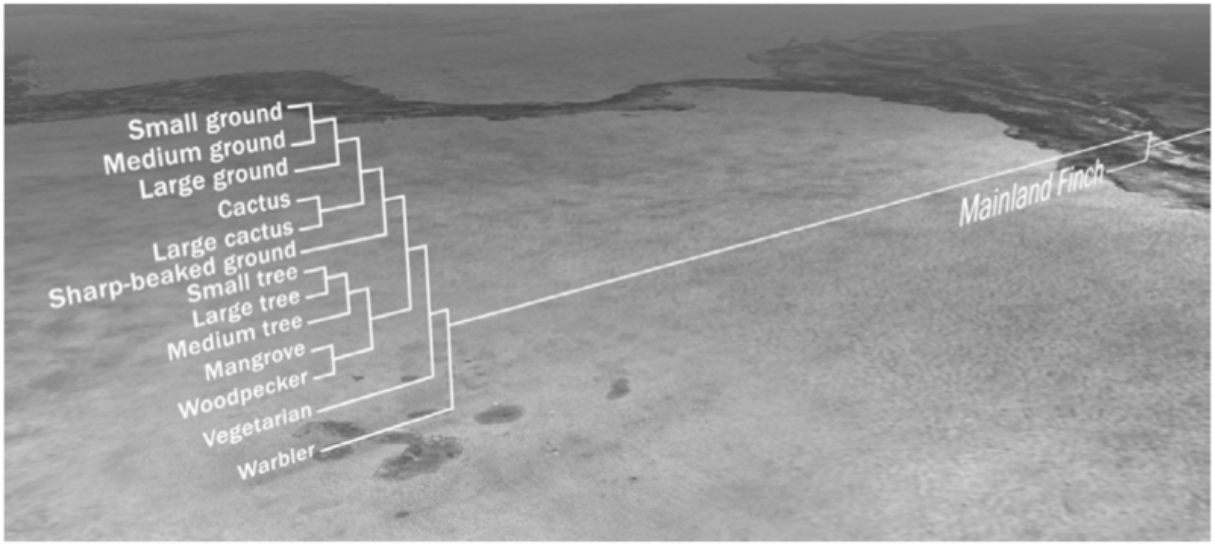

Figure 3. Phylogentic Tree Showing Evolutionary Relationships among Galápagos Finches.

7. After the class discussion, allow 10 minutes for students to revise their finch groups from Part 1 of the lesson. Do not allow more than 10 minutes, or students will be tempted to shift their entire grouping around. Teams that did not arrange their birds by beak shape or size might go back and regroup based on these characteristics. Emphasize that they do not necessarily have to group their cards according to beak shapes and sizes. If they think their groups are accurate, then they should keep them. If they decide to change their groups, they need to provide sufficient evidence for their thinking.

PART 3: Examining Finch Beaks

8. Show students the second segment of *The Beak of the Finch* from time stamp 5:36 minutes to 9:00 minutes. Discuss the answers to the two questions.

a. Describe the beak sizes of the medium ground finch population (species #12 in the finch cards).

b. How did the population of medium ground finches on the island of Daphne Major change as a result of environmental changes?

Students should understand that there is variation among individuals within one species—some medium ground finches have smaller beaks than others—but as a whole, the population has different-shaped beaks from other finch species. As a result of the drought, the average beak size in the population changed as more individuals with smaller beaks died.

9. Allow 8–10 minutes for the prediction (including sharing). Students prepare their graphs individually and then share them with other members of their team. Note that student graphs will not look like the one in the film; students will be making predictions about something they don't have a much experience with.

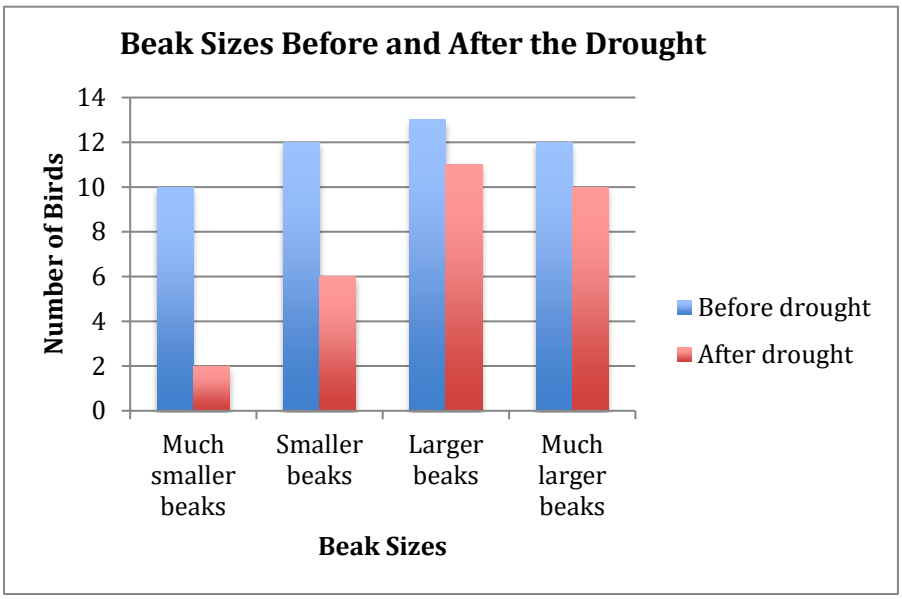

Figure 4. Example of a Student's Graph. The *y*-axis shows the numbers of finches (notice the student used very small numbers for the prediction), and the *x*-axis shows four different categories of beak sizes.

10. Allow students to share and discuss their graphs.

11. Show the third segment of *The Beak of the Finch* from time stamp 9:00 minutes to 11:12 minutes. When students look at graphs in their teams, each team should have at least one graph that resembles that in the film. You may want to pause the film on the graph so students can compare their graphs.

    Possible evidence they could have pulled from the segment follows.

    - **The drought eliminates small seeds, causing a greater number of the small-beaked finches to die.**
    - **While some large-beaked finches also died, more of them survived and reproduced, causing the population to change.**

12. Ask students, the following:

    - What was the response of Peter and Rosemary Grant to the dramatic change in the distribution of beak sizes in just one generation of birds? If the drought had continued longer, what would you expect your beak graph to look like?

    You may decide to have students participate as a class or prepare their predictions individually and then share them in either small teams or with the class. Regardless, students will have to extrapolate this information from the film, so you may need to guide them. Possible discussion points include these:

    - The Grants were not expecting to see such dramatic results in such a short period of time. The film does not explain why this change would have occurred so quickly. The short answer is that because the

drought reduced the amount of food available, the only finches that survived were the ones that could eat. Therefore, they are the ones that reproduced.

- If the drought were to continue, the average beak size of the population might continue to change. Students may also predict that, if the drought continued too long, all the medium ground finches would die.

PART 4: Understanding Speciation

13. Show the final segment of *The Beak of the Finch* from time stamp 11:12 minutes to 15:45 minutes.
14. Working in their teams, students create graphic representations of the process leading to 13 different finch species. Students do not have to graphically represent all 13 speciation events but rather should represent one speciation event that can then be extrapolated to the rest. In other words, how does one species of finch give rise to two distinct species? Students should prepare their museum exhibit representations graphically rather than verbally, which allows students a different way to demonstrate their understanding. Allow 10–15 minutes for preparing the representation, including writing the captions. Depending on your class, students may need more time.
15. Students should then visit other presentations. During this gallery walk, students are not allowed to explain their team's representation verbally, but they should offer constructive feedback in writing. The feedback needs to be in the form of questions that move the conversation forward. Consider offering your own feedback during this process so that students can integrate that feedback into their revisions. Allow 15 minutes for the gallery walk (about five minutes per model for each student).
16. After receiving written feedback, allow students to revise their graphic representations. Allow five to eight minutes for revision.

PART 5: Summary Activities

Part 5 of the lesson can be assigned as homework or completed in class on the third day. Student responses will depend on their familiarity with the evolution unit in their biology class:

- If this lesson is done early in the unit, students may have misconceptions (even after viewing the film) that will need to be addressed through further instruction.
- If the lesson is done later in the evolution unit, students should be able to discuss natural selection and adaptation more coherently and use evidence from the film.

AUTHORS

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