Bird Beak Buffet

Lesson Plan*

Teacher: Annie Martin
Subject: Science: Genetics and Evolution
Grade Levels: Middle School and High School

Summary
Inspired by observations of finches on the Galapagos Islands, Charles Darwin came up with an idea that is perhaps the most influential idea in all of science - natural selection. In this classic activity, students learn about natural selection by becoming birds foraging for food on an island (a large area of the schoolyard or classroom). The prey (beans) vary in their coloration such that some blend into the environment better than others. The birds vary in the type of beak they have (plastic forks, spoons and knives). Each season, any prey that survives has a baby bean the same color as the parent. In addition, the most successful birds has a baby with the same beak trait while the least successful birds die (and are reincarnated as the babies of the successful birds). Over several generations, the bird and bean populations shift depending on the environment. Well-

camouflaged beans survive and reproduce. Birds with beaks that can easily capture beans survive and reproduce. In this way, students model natural selection in 2 species and get a very good idea of how natural selection works.

Objectives

- Can explain what natural selection is and the conditions necessary for it to occur.
- Can discuss changes in a population in the context of natural selection.
- Can use terms such as natural selection, evolution, and adaptation scientifically.
- Can organize data in a table and graph.
- Can graph changes in a population over time.

Vocabulary

Trait
Population
Natural selection
Adaptation
Fitness
Evolution
Charles Darwin

Time

10 minutes Engagement
30 minutes Exploration and Explanation
10 minutes Elaboration
10 minutes Evaluation

Grouping (Please **click here** to see a video of the lesson.)

Each student is a bird foraging in the same feeding ground. At the end of each year, students gather in a group of similar-beaked birds to enter their foraging results on a clipboard. The introduction and final discussion occurs as a whole class in a classroom.

Note to Teacher: *If working as a whole class in a single feeding ground is too chaotic for your students, then this activity may be done in smaller groups of 3 or 6. Each group will get their own 1-meter square plot of ground or even a cafeteria tray on a table in the classroom to forage in. Each group starts with 1 or 2 representatives of each of the 3 beak types in the group and 100 beans of each color in the feeding*

ground. After each season, they should summarize their data and add new beans to their feeding ground. The bird that eats the most will reproduce and the bird that eats the least will die and get reincarnated.

Materials

- 1 pound of red beans
- 1 pound of black beans (of a similar size and shape as the other beans)
- 1 pound of white beans (of a similar size and shape as the other beans)
- 1 pound of pinto beans (of a similar size and shape as the other beans)
- 25 plastic forks
- 25 plastic sporks
- 25 plastic spoons
- 25 plastic knives
- 30 paper/plastic cups
- 1 stopwatch
- 1 whistle
- broom and dustpan for cleanup
- 1 copy of the Bird Beak student handout for each student (see below)
- 4 copies of the Bird Beak data tables (see below)
- 5 clipboards with a pencil/pen tied to each
- 30 small plastic cups
- 6 cafeteria trays
- 6 gallon size Ziploc bags
- 10lbs rice
- Large bag of each (you want candies of different sizes, shapes, textures, and densities)
- Gummy worms
- Gummy bears
- Skittles
- M&Ms
- Other oddly shaped candy
- Optional: masking tape or string to designate the borders of the feeding ground

Setting

The exploration takes place in an 80 square foot (9x9 foot square) feeding ground located in the classroom, on a concrete schoolyard or in a grassy field.

The engagement, explanation, elaboration, and evaluation takes place in the classroom.

Background Information

Perhaps the most important idea in all of biology, or perhaps all of science, is the idea of evolution through natural selection. This idea by Charles Darwin provides the foundation of all of current scientific thinking in life science.

What is evolution? Quite simply, evolution is descent with modification. This includes both the idea that the frequency of a gene will change in a population over time as environmental conditions change and also the idea that new species descend from common ancestors over many generations. Ultimately, evolution can explain the vast diversity of life on this planet and the idea that all life on Earth shares a common ancestor.

Although there are many mechanisms for organisms to change over time, the most important of these is natural selection. It works in this way:

- There is variation in a population. Different individuals have different traits.
- There is heredity. Traits can be passed on from parent to offspring through our genes.
- There is competition (sometime referred to as differential survival and reproduction) so that some individuals survive and reproduce more than others.

→ The end result is natural selection – the individuals with the traits that best fit the environment are most likely to survive, reproduce, and pass on their traits to the next generation. In this way, future generations, when viewed at the level of an entire population, will have more advantageous traits and fewer disadvantageous traits compared to their parents.

There are many other mechanisms for evolutionary change besides natural selection:

- Artificial selection is a common practice for humans to breed together plants or animals with the most advantageous traits (the sweetest tomato, the most loyal dog, the fastest horse, etc.). Thus, future generations will have more of these traits.
- Mutation can affect the distribution of traits by introducing a new trait to a population. This is the ONLY way for NEW genetic material to enter the gene pool.

- Sexual selection can favor certain traits for mating and thus increase those traits in future generations.
- Migration can rapidly change the overall distribution of traits in a population when a group of organisms with different traits enters a new area. For example, a group of small beaked finches is blown over to an island with primarily large beaked finches by a hurricane.
- Genetic drift can affect a population through a random chance event – like a hurricane or human activity – randomly destroying organisms with one trait but not another. For instance, when a new house is constructed in a neighborhood with both red and brown ground squirrels, it accidentally bulldozes the nest of the largest red ground squirrel family. Suddenly, brown ground squirrels predominate.

A final important term that is often misused by students is *adaptation*. An adaptation is a trait that is very well suited to a given environment that has, through natural selection, increased in the population over many generations. Students often talk and think about adaptation as if an organism can try to adapt or is able to get what it needs. In neither case are they correct. An organism can't get the genes it needs to survive by "trying"; it either has the genes or not. Similarly, natural selection doesn't have a goal in mind and cannot give a creature what it "needs"; either the genes are there in the population or not.

In this activity, students come to understand natural selection, evolution and adaptation through modeling changes in 2 populations – a population of birds with different beak traits and a population of beans with different color traits.

Student Prerequisites

None required although an understanding of variation in traits is helpful.

Getting Ready

- ☐ Purchase beans, candy, rice, Ziploc bags, cups and plastic utensils.
- ☐ Make copies of the Bird Beak student handout for each student.
- ☐ Make copies of the Bird Beak data tables. For each class that will do the activity you should have 4 copies of "Billed Bird Population Data" and 1 copy of "Bean Population Data" (see data sheets below). Attach these data tables to the 5 clipboards.
- ☐ On the 4 "Billed Bird Population Data" clipboards, fill in the blanks with "Fork", "Spoon", "Spork" and "Blade".
- ☐ For each class of students, count out 150 red, 150 black, 150 pinto and 150 white beans and mix them together in a Ziploc bag or cup.

☐ Optional: mark the feeding ground boundaries with tape or string.

ACTIVITY

Engagement

1. Open class with a discussion of human traits. What is a trait? Do we all have the same traits? Look at eye color, hair color, height, hitch hiker's thumb, tongue curl. What traits might help a person be more successful (Is it an advantage to be tall? Is it an advantage to have a specific hair or eye color? How about hair and eye color in another country like Africa or Sweden?) Leave the interpretation of "more successful" open and somewhat vague. If this seems to controversial for your group of students, then discuss variation in cat or dog traits and what might help a pet survive better (Is it an advantage for a cat to be shy? Is it an advantage for a dog to be friendly?).
2. Lead the discussion towards thinking about what "more successful" really means. Does that mean being more popular or making more money or more likely to live happily ever after? In scientific terms, what matters in the long run is whether you survive, find a mate, and reproduce, passing on your genes to the next generation.
3. Introduce the activity. Pass out the handout and describe the rules. Explain that all the birds are of the same species but have different beak traits. Similarly, all the beans are of the same species but have different color traits. Make sure students understand species (we are all human, a Labrador retriever and a husky are both dogs, a Persian and a Siamese are both cats, they can reproduce and their offspring can reproduce).
4. Explain that the birds that eat the most food will have a baby with a similar beak and that the birds that eat the least will die. Similarly, surviving beans (those not eaten) will have one baby with the same color trait.
5. Finally discuss the data collection that occurs after each round. Each student is responsible for counting the number of each type of bean they eat and entering their data on the bird population data clipboards. Once all the bird population data has been gathered, then a volunteer from each group will report their data on the bean population data clipboard. If data will also be collected in lab notebooks, have students copy or paste the data tables and graphs into their notebooks.

Exploration

- Distribute a cup to each student. Next, give each student a plastic utensil. *Make sure you bring clipboards, beans, a stopwatch, and a whistle.*
- Place the 5 data clipboards in different locations near the feeding ground.
- Have students stand on the edge of the feeding ground. Sprinkle the mixed beans (150 of each type) into the feeding ground.
- Blow the whistle and give students 20 seconds to "eat" as many beans as possible. Look out for students that cheat (have cups touching the ground, interfere with other students, etc.) and dump out the contents of their cups or eliminate them from the game. Blow the whistle again to signal the end of the year.
- Each student should go to the clipboard for their beak type, count the number of beans of each type they ate, and enter that information in the data table.
- Each group should calculate the grand total number of beans of each type that were eaten by their group (the bottom row of the table).
- One volunteer from that group can bring that information to the bean population data clipboard and enter their groups' information. The volunteers can then help to complete the bean data table and count out the proper number of beans to add to the feeding ground. Make sure the students understand they are adding a bean for each bean that DID NOT get eaten. They will need to calculate what this amount is for each bean type.
- While the volunteers are entering bean population data, the rest of the students should help to sort their beans by color and return them to the stockpiles.
- Finally, have students line up by the total number of beans they ate. Have the 5 students that ate the fewest beans act out a grisly death. (Acting out the deaths helps students realize that they are actually dying and entering the game as a new bird with new traits, not just trading in one tool for another.) Confiscate their utensils. Give them new beaks that match the beaks of the 5 students that ate the most beans.
- Have a student enter this information (the number of birds that died and number of babies born) on the bird population data clipboards. Repeat steps 5-11 for each of the next 3 years of the game for a total of 4 rounds.
- Collect the clipboards, cups and utensils. Sweep up any remaining beans.

Explanation: Organize, Graph and Discuss Data

1. Create data tables on the board (or make and overhead copy) similar to the ones on the second page of the Bird Beak Student handouts.
2. Use the information from the clipboards to fill in the summary table. Divide the students into 5 groups and have each group be responsible for reading off the numbers while you fill in the graph on the board. Have students fill in their tables as well.
3. Have students graph the data for each population (red beans, white beans, black beans, fork-bills, spoon-bills, blade-bills) with years 1-5 on the x-axis and the number of organisms at the start of a year on the y-axis. The graphing may be done:
    - individually in their lab notebooks
    - groups of 4 can each graph one bird and one bean and compare graphs as a group
    - a group of students can create large poster sized graph for one of the populations to display around the room.
4. Discuss the graphs. Notice patterns such as one population going up while another goes down. See if the population is growing steadily or exponentially.
5. Discuss the reasons why one population did well while another did poorly. Is there a different scenario in which a different bird or bean would do best?
6. At this point it is possible to formally address some of the vocabulary.
7. Discuss natural selection – the process by which organisms with traits that best suit the environment are most likely to survive, reproduce, and pass on their genes to the next generation. In this activity, the bean that had the best camouflage and that was the hardest to catch survived, reproduced, and passed on their genes.
8. Discuss evolution – descent with modification, most often as the result of natural selection. In this activity, we started with the same number of beans of each type but ended up with the population skewed towards the beans with the best-suited traits.
9. Discuss adaptation – a trait that is very well suited to a given environment that has, through natural selection, increased in the population over many generations. In this case, a particular color of bean could be considered an adaptation since it increased in the population through natural selection.

10. Describe Charles Darwin's adventures on the Beagle and how his observations (particularly of the finches on the Galapagos Islands) led him to propose the idea of natural selection.
    Begin the process of busting the misconceptions that students have about evolution. See the Understanding Evolution website:
    http://evolution.berkeley.edu/evosite/misconceps/index.shtml
    It has a fabulous overview of the common misconceptions students have and responses to those misconceptions.
11. Finally, return to the discussion you used to open this activity – what human traits might help someone be more successful – and revisit those issues in the light of what your students now know about natural selection and evolution. In particular, you can discuss whether and how natural selection has worked and is still working on the human species.

Elaboration

Explain that we will now repeat the activity we did outside only this time we will be doing it in our table groups. Our environment will change and so will our available food source.

- The students can choose any beak type they wish to use but they cannot trade it in once the activity begins. Try to have at least one of each beak type and remind the students that the same advantages might not apply in the new environment with the new food.
- The same rules apply as before.
- Once students have selected their beaks, pass out a cafeteria tray to each group and pour a baggy with rice and candies onto each tray.
- Students get to keep whatever is in their stomachs (cups) at the end of 2 rounds EXCEPT the rice is bad for this species of bird. It makes them sick. For every piece of rice in their stomach, they will have to put back a piece of candy at the end of each round.
- Time the students for 20 seconds.
- Discuss briefly what advantages they saw and how the population might change if the species stayed in this environment.
- Go for 1 more 20 second round.

Evaluation

1. Ask the students to answer any 2 questions from 1-6 on their conclusions sheets plus answer any 1 part of question 7.
2. Collect the students' graphs and responses to the conclusion questions. If these are in science notebooks, walk around while they are making the

graphs and answering the questions. Discuss their responses to the questions.

Going Further

i. Conduct a deeper investigation of the Galapagos finches. There are many resources that you can use to help you in this quest. First of all, read the Pulitzer Prize winning book *The Beak of the Finch*, by Jonathan Weiner http://www.amazon.com/gp/product/067973337X/104-8354728-3538318?v=glance&n=283155

The book flips back and forth between Darwin's original studies and the modern day work of Peter and Rosemary Grant. The Grants have spent over 20 consecutive years studying the Galapagos finches. They recognize each and every finch living on the island and know the family relationships between every individual bird. Several lesson plans for teachers have been developed from their work:

- The PBS evolution site provides a downloadable pdf file with several graphs showing changes in finch beaks over time
  http://www.pbs.org/wgbh/evolution/library/01/6/l_016_01.html
  One of PBS's online courses addresses some of the questions raised by the data and may be appropriate to use directly with high school students:
  http://www.pbs.org/wgbh/evolution/educators/course/session4/elaborate_b.html
- Teachers Domain has adapted the data from the PBS evolution site slightly to create a lesson plan for teachers with discussion questions about the data.
  http://www.teachersdomain.org/9-12/sci/life/evo/finchdata/index.html
- There is a good 1995 video of the Grants' work called "What Darwin Never Saw", produced by PBS for "The New Explorer" series with Bill Kurtis. Several teacher groups have created lesson plans that follow the video including one from ENSI web: http://www.indiana.edu/~ensiweb/lessons/vid.wdns.html and one from the Chicago Academy of Sciences:
  http://www.chias.org/www/edu/cse/wdnhome.html

Finally, for the most advanced students, go straight to some original data and look for patterns and correlations. Prentice Hall has created a lesson plan suitable for AP Biology and college level courses looking at the effect of drought on one species of finch.

http://cwx.prenhall.com/bookbind/pubbooks/stiling4/chapter1/essay13/deluxe-content.html

ii. Another hands-on approach to further investigations of bird beaks is provided in this lesson from TERC. Students use a spring scale to measure the force required to crack a nut with pliers that represent different types of bird beaks (http://www2.terc.edu/handsonIssues/f97/activity.html).

iii. Finally, there are several videos that provide excellent information on evolution and Charles Darwin.

-PBS produced a fabulous 7 episode series on evolution http://www.pbs.org/wgbh/evolution/

-There are excellent snippets on the evolution of drug resistance in HIV, summaries of Darwin's work, discussions of evolution and religion, and more. *Unfortunately, it is expensive, at $100 for the DVD set alone or $130 for the educators' set with curriculum.*

-As part of the PBS evolution series, there are several movie clips that can be viewed over the internet:
http://www.pbs.org/wgbh/evolution/educators/teachstuds/svideos.html
and an associated teacher's curriculum guide with activities and lesson ideas:
http://www.pbs.org/wgbh/evolution/educators/teachstuds/tguide.html

Sources

The Bird Beak Buffet activity is a classic in the teaching of natural selection and evolution. There are hundreds of write-ups out there with all sorts of different variations. I first learned about the activity from Kimberly Tanner, currently faculty at San Francisco State University. I found a box of materials to borrow from Chris Giorni of *Tree Frog Treks* (http://www.treefrogtreks.com/). Then I participated in a workshop with Karen Kalamuck of the Exploratorium Teachers' Institute.

There are many variations of this activity on the web from many different organizations:

- USGS (http://pubs.usgs.gov/of/1998/of98-805/lessons/chpt2/act5.htm)
- The National Aviary (http://www.aviary.org/curric/beaks.htm)
- Understanding Evolution by the UC Museum of Paleontology has 2 versions of the lesson Clipbirds: (http://www.ucmp.berkeley.edu/education/lessons/clipbirds/) and Battle of the Beaks (http://www.ucmp.berkeley.edu/education/lessons/birdbeaks/birdbeaks.html).

For background resources on better understanding evolution, nothing beats the Understanding Evolution site from the UC Museum of Paleontology (http://evolution.berkeley.edu/evosite/evohome.html). There you can find everything from evolution 101 to scientific articles to student misconceptions to lesson plans. It's a one-stop resource for all a teachers' needs.

Finally, if your school district, administrators or parents opposes the teaching of evolution, see the National Center for Science Education (http://www.ncseweb.org) for articles and resources that can help you justify what you are doing in your classroom.

Standards

Grade 7

Evolution

3. Biological evolution accounts for the diversity of species developed through gradual processes over many generations. As a basis for understanding this concept:

- Students know both genetic variation and environmental factors are causes of evolution and diversity of organisms.
- Students know the reasoning used by Charles Darwin in reaching his conclusion that natural selection is the mechanism of evolution.
- Students know that extinction of a species occurs when the environment changes and the adaptive characteristics of a species are insufficient for its survival.

Grade 9-12

7. The frequency of an allele in a gene pool of a population depends on many factors and may be stable or unstable over time. As a basis for understanding this concept:

a. Students know why natural selection acts on the phenotype rather than the genotype of an organism.

d. Students know variation within a species increases the likelihood that at least some members of a species will survive under changed environmental conditions.

8. Evolution is the result of genetic changes that occur in constantly changing environments. As a basis for understanding this concept:

a. Students know how natural selection determines the differential survival of groups of organisms.

b. Students know a great diversity of species increases the chance that at least some organisms survive major changes in the environment.

_____-billed Bird Population Data

Year 1

Number of birds at the start of year 1 _____

Name	# red beans	# white beans	# black beans	# pinto beans	Total beans
Grand total					

Number of birds that died in year 1 _____

Number of new babies born in year 1 _____

Year 2

Number of birds at the start of year 2 _____

Name	# red beans	# white beans	# black beans	# pinto beans	Total beans
Grand total					

Number of birds that died in year 2 _____

Number of new babies born in year 2 _____

Year 3

Number of birds at the start of year 3 _____

Name	# red beans	# white beans	# black beans	# pinto beans	Total beans

Grand total					

Number of birds that died in year 3 _____
Number of new babies born in year 3 _____

Year 4

Number of birds at the start of year 4 _____

Name	# red beans	# white beans	# black beans	# pinto beans	Total beans
Grand total					

Number of birds that died in year 4 _____
Number of new babies born in year 4 _____

Year 5

Number of birds at the start of year 5 _____

Bean Population Data

Year 1

	Red beans	White beans	Black Beans	Pinto Beans
# at start of year 1				
# eaten by fork-bills				
# eaten by spoon-bills				
# eaten by spork-bills				
# eaten by blade-bills				
Total # eaten in year 1				
# that survived year 1 (# at start - # eaten)				
# bean babies born (= # that survived)				

Year 2

	Red beans	White beans	Black Beans	Pinto Beans
# at start of year 2				
# eaten by fork-bills				
# eaten by spoon-bills				
# eaten by spork-bills				
# eaten by blade-bills				
Total # eaten in year 2				
# that survived year 2 (# at start - # eaten)				
# bean babies born (= # that survived)				

Year 3

	Red beans	White beans	Black Beans	Pinto Beans
# at start of year 3				
# eaten by fork-bills				
# eaten by spoon-bills				
# eaten by blade-bills				
# eaten by spork-bills				
Total # eaten in year 3				
# that survived year 3 (# at start - # eaten)				
# bean babies born (= # that survived)				

Year 4

	Red beans	White beans	Black Beans	Pinto Beans
# at start of year 4				
# eaten by fork-bills				
# eaten by spoon-bills				
# eaten by spork-bills				
# eaten by blade-bills				
Total # eaten in year 4				
# that survived year 4 (# at start - # eaten)				
# bean babies born (= # that survived)				

Year 5

	Red beans	White beans	Black Beans	Pinto Beans
# at start of year 5				