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Curriculum topics:

- Adaptation
- Evolution
- Fitness
- Natural Selection
- Predator-Prey Interactions
- Variation

Subject:
Life Science

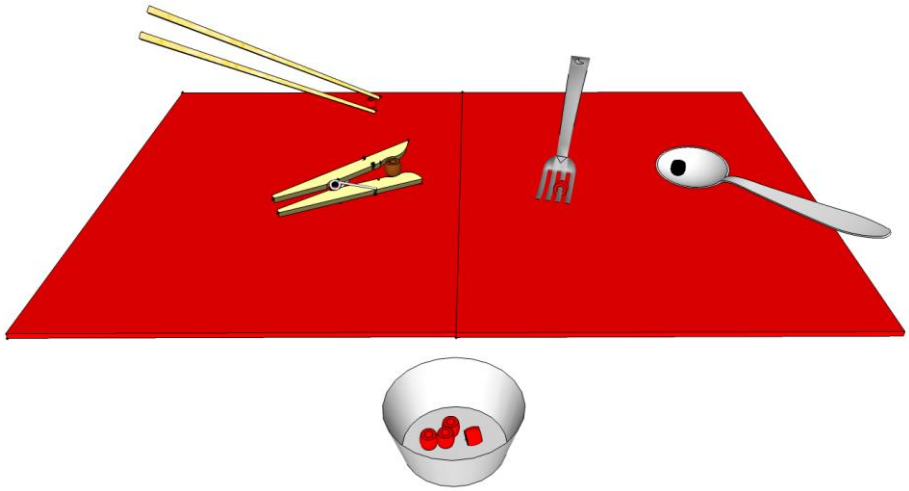
Grade range: 3 – 12

EVOLUTION BY NATURAL SELECTION

Simulate evolution with critters and beaky birds



Simulate evolution with some colorful “critters” and carnivorous “beaky birds”. Simulations are helpful to demonstrate processes like evolution that take place over many years. Observe how adaptations such as camouflage help organisms survive and pass on traits to offspring. Recognize evolution happening simultaneously in both the predator and prey (bird and critter) populations.



Who we are:

Resource Area for Teaching (RAFT) helps educators transform the learning experience through affordable “hands-on” activities that engage students and inspire the joy and discovery of learning.

For more ideas and to see RAFT Locations

www.raft.net/visit-raft-locations

http://www.raft.net/raft-idea?isid=648

Materials required

For each activity station of 3 to 6 students:

- 210 regular pony beads, 70 each of red, brown, black
- 2 felt sheets or similar fabric, 1 black and 1 red, 30 x 46 cm (12” x 18”)
- 6 portion cups, 2 oz.
- 4 plastic forks
- 4 plastic spoons
- 3 clothespins
- 3 sets of chop sticks
- 1 container
- Tape, clear
- 1 watch or timer
- Bird Evolution Table, page 6, 2 copies (a table for 4 players is available at www.raft.net/raft-idea?isid=648)
- Critter Evolution Table, page 7, 2 copies

> *Tip: To keep beads from rolling away, play on a carpeted floor or place a large cloth under the habitat*

How to build it

1 Count out and put 30 red, 30 brown, and 30 black beads into a container, mix, and set aside.

Running the simulation (for 3 to 6 players)

Players/Items	Role
Students	Hunters (Beaky Birds)
Felt Sheets	Habitat
Beads	Prey (critters)
Forks, spoons, clothespins, chop sticks	Beaks
Portion cups	Bird stomachs

1 Lay habitat red on floor or table. Tape corners to floor or table to prevent movement during use (see Figure 2).

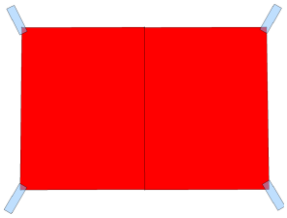


Figure 1

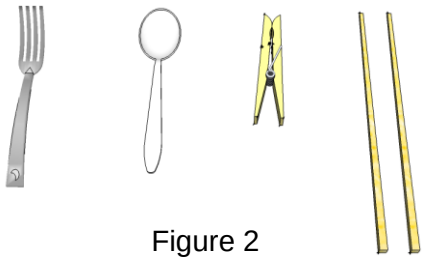


Figure 2

2 Beak Assignments: Each player (beaky bird) uses one of the four beak types (see Figure 2). If there are more than four birds, use a beak type more than once. Record the starting beak assignments in the Bird Evolution Table (page 6). Assign a timekeeper (part of the group or independent). Each player gets a portion cup for a stomach.

3 Carefully spread critters (the 30 red, 30 brown, and 30 black beads) evenly over habitat.

4 Timekeeper begins Round 1 with a signal and the beaky birds quickly catch the critters and put them in their stomachs one at a time for **15** seconds using assigned beaks. Stomachs must be held in one hand and be off the habitat. Competition during simulation is acceptable and encouraged, but critters caught in beaks become off limits to others. Critters "eaten" or off the habitat are considered dead and cannot be put back into the habitat.

5 When time expires, each bird counts his or her total number of critters eaten. Record the totals eaten per beak type in the Bird Evolution Table in the row "Total critters eaten" for Round 1 (page 6). Which bird ate the most and which ate the least? Which birds ate the second-most and second-least?

6 The bird that ate the lowest number of critters has died. He or she is "reborn" with the beak of the bird with the highest count and will use that beak type in Round 2. For example, if the fork had the highest count at 27 critters while the spoon had the lowest count at only 15 critters, the spoon will be replaced by a fork in Round 2. The bird with the second lowest count acquires the beak type of the bird with the second highest count. The bird with a middle count, if any, does not change beak types. Record new beak assignments for Round 2 in the Bird Evolution Table.

7 Separate and count critters eaten by color for the whole group of birds. How many critters of each color are left after Round 1? Record the group total eaten per color in the Critter Evolution Table in the "Number eaten" row.

8 Calculate and record the remaining number of left over critters for each color by subtracting the number eaten from the initial count (see example in the Critter Evolution Table).

9 Determine the offspring for each group: Each leftover critter has one offspring. Record the number of offspring for Round 1 (see example in the Critter Evolution Table). Notice that the number of offspring equals the number of leftover critters.

10 Calculate the new critter counts for each color by adding the remaining number of critters to the number of offspring calculated in step 9 and record the sum under New Total for Round 2.

11 Add enough critters of each color to the habitat, bringing the totals to those calculated in step 10. Begin Round 2 of the simulation according to steps 4-10 with the red habitat, recording the sum of left over plus offspring under Final on the Critter Evolution Table. How many critters of each color are left?

12 Repeat the simulation using the black habitat and new copies of the Bird and Critter Evolution Tables. Start the simulation with an initial count of 30 for each bead color as in step 1 of **How to build it**.

13 Compare the data obtained from the red and black habitats. Discuss the results with the group and draw conclusions in terms of adaptation, inherited traits, fitness, and natural selection in both the beaky bird and critter populations.

Note: Remind students that natural selection is a mechanism of evolution that best explains change over time in organism populations. Natural selection is not synonymous with evolution, however, because there are several mechanisms at work that allow selection to take place.

Curriculum Standards:

Life cycles
(Next Generation Science Standards: Grade 3, Life Science 1-1)

Traits of organisms
(Next Generation Science Standards: Grade 3, Life Science 3-1 & 3-2; Middle School, Life Science 4-4 & 4-6)

Characteristics & survival
(Next Generation Science Standards: Grade 3, Life Science 4-2 & 4-3)

Body structures
(Next Generation Science Standards: Grade 4, Life Science 1-1)

Ecosystems and populations
(Next Generation Science Standards: Middle School, Life Science 2-1 & 2-4; High School, Life Science 4-5)

National Selection
(Next Generation Science Standards: High School, Life Science 4-4)

Additional standards at: http://www.raft.net/raft-idea?isid=648

Learn more

- Continue simulation for additional generations.
- Add more variation in beak type and/or bead color.
- Use heavily-textured or patterned fabric in place of felt.
- Use another type of object to represent the critters such as beans or buttons.

Extend this activity with the following suggestions:

- Design a predator best suited to a specific environment based on concepts learned from the simulation.
- Use data and knowledge about natural selection to infer about a common ancestor for the beaky birds in terms of ancestral vs. derived traits.
- Graph number of critters eaten vs. beak type for each habitat color.
- Make a bar chart showing mean number of critters eaten for each color critter for each habitat.

Related activities: See RAFT Idea Sheets:

Nesting Like a Birdbrain -
http://www.raft.net/ideas/Nesting Like a Birdbrain.pdf

Models and Theories as Scientific Representations:

A Model Apple -
http://www.raft.net/ideas/Model Apple.pdf

Aquatic Quadratics!-
http://www.raft.net/ideas/Aquatic Quadratics.pdf

Bloodless Hematocrit -
http://www.raft.net/ideas/Bloodless Hematocrit.pdf

Resources

Visit www.raft.net/raft-idea?isid=648 for “how-to” video demos & more ideas!

See these websites for more information on the following topics:

- **General information on evolution** – http://evolution.berkeley.edu
- **Evolution activities** – http://www.pbs.org/wgbh/evolution/change/family/

The science behind the activity

Evolution by natural selection is a slow, gradual process that depends on three main factors: variation in characteristics, heritability of characteristics, and differences in fitness. **Variation** refers to different individuals in a population having different characteristics. For example, zebras have stripes but all will vary in terms of the shape, location, and pattern of their stripes. Characteristics passed on from parent to offspring are **heritable characteristics,** some of which make particular individuals in a population more likely to survive and reproduce than others. **Fitness** refers to an individual's ability to survive and produce offspring that are capable of reproducing. The particular characteristics that increase fitness will vary between populations and environments. Characteristics that increase an organism's fitness are called **adaptations.** When individuals in a population are fit they are more able to pass on adaptations to offspring as heritable characteristics and thus these characteristics become more common in the population.

A common misconception about evolution by natural selection is that it happens to an individual. Evolution by natural selection occurs due to changes in genetic make-up (allele and gene frequencies) within a population's gene pool that code for adaptations best suited for the environment. As gene frequencies gradually change in favor of adaptations over several generations, the favorable genes for the adaptations become more common. One explanation for this favorable shift is that less-fit individuals produce fewer offspring and contribute fewer genes into the gene pool. A declining gene pool contribution, coupled with predation, competition, and other environmental factors, can cause individuals with favorable adaptations to become more predominant in the population. In other words, evolution by natural selection happens at the population level, not the individual level.

This simulation provides a meaningful and simplified way to observe how evolution by natural selection operates in the real world. The bead color and beak type provide sources of variation to simulate favorable adaptations. Beads that closely match the habitat color tend to be difficult to see, representing the adaptation of camouflage, which tends to increase fitness. As a result, more beads in the next generation match the habitat color (passing on the genes for the adaptation). One beak type is typically more adapted to picking up beads and hence influences the beak type passed on to future generations. The simulation explores two distinct but related lines of evolution by natural selection, survival in the critter population based on color and survival in the bird population due to beak type, which at first might seem unrelated. This activity illustrates some of the complex interactions between organism populations that biologists study and that also tend to perplex life science students.

Working with the students

It is important to talk about evolution as a theory and provide examples of the evidence supporting the theory in order to be sensitive to personal/family beliefs students may hold regarding the origins of organismal change over time. It may be beneficial to review the idea that science is a dynamic body of knowledge that is constantly refined as scientists learn more about the world. This helps to avoid uncomfortable situations where a student's personal beliefs regarding the origins of life and agents of change are challenged. Incorporating material on the history of scientific discovery might also be helpful.

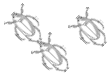
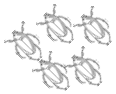
Evolution by Natural Selection ~ Bird Evolution Table

Habitat color: **Red** **Black** (circle one)

Players		Bird 1	Bird 2	Bird 3	Bird 4	Bird 5	Bird 6
Round 1	Starting beak types (circle one)						
	Total critters eaten						
Round 2	New beak types (circle one)						
	Total critters eaten						
Final	Ending beak types (circle one)						

Evolution by Natural Selection ~ Critter Evolution Table

Habitat color: **Red** **Black** (circle one)

	Bead Color	*Example*	Red	Brown	Black
Round 1	Start 	30	30	30	30
	Number Eaten 	22			
	Left Over  –  (Starting number – number eaten)	30 – 22 = 8			
	Offspring – 1 per left over critter 	8			
Round 2	New Total (Left Over + Offspring) 	8 +8 = 16			
	Number Eaten 	6			
	Left Over  –  (New total – number eaten)	16 - 6 = 10			
	Offspring – 1 per left over critter 	10			
Final	Ending critter count (Left Over + Offspring) 	10 + 10 = 20			