Teacher Preparation Notes for Evolution by Natural Selection

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This hands-on activity is intended for students who have a basic understanding of genetics. A useful introduction to genetics is provided by our "Genetics" hands-on activity, which is intended to be preceded by our "Mitosis, Meiosis and Fertilization" hands-on activity. In our experience, this natural selection activity, including introductory materials, performing the simulation, graphing the data, and analyzing the results, takes approximately 90-100 minutes with an average class of high school students. (For students with poor graphing skills, you may need more time.)

Equipment and Supplies:
- 2-3 yards of black cloth for habitat (should be faux bear fur or some other rough cloth) (1 per class)
- 2-3 yards of red cloth for habitat (should be furry fleece with a different texture than the black habitat) (1 per class). The size of the habitat should accommodate foraging by half the students in your class.
- 7 or 10 mm black, red and white pom poms (200 of each color per class) Pom poms can be purchased at your local craft store (for example: Michael's, JOANN's, or Wal-Mart) or on the internet.

The specific colors of the pom poms and habitats need not be black, red and white, so long as there is a very good color match between each habitat and one color of the pom poms. Both color cloths should be textured, since even pom-poms of a matching color tend to be readily visible on plain flat cloth. If possible, the textures should be as deep or deeper than the diameter of the pom poms. The textures should be different to demonstrate that different hunter adaptations may be more successful in different habitats. (This lab can also be done with different color beans or with paper circles made by using a hole punch, but we have found that it is easier to get a good match between the colors of the pom poms and the habitats, resulting in better camouflage and more interesting results from the simulation. Pom poms of different colors also have the same size and weight, whereas different color beans often differ in size and weight.)

- Plastic forks, knives, and spoons for hunter implements (1 of each for each student)
- Cups for hunter stomachs (1 per student) (To make the hunting task a little more challenging, you can use small plastic test tubes or the small plastic tubes that florists put on the ends of cut roses. Alternatively, plastic bottles with narrow necks can be used for hunter stomachs if you have trouble preventing your students from cheating, i.e. laying their cups on the habitat and shoveling multiple pom poms in with their implement.)
- calculator for calculating percents (page 4 of protocol) and watch or timer for timing 30 second feeding times

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[1] These teacher preparation notes and the related student handout are available at http://serendip.brynmawr.edu/sci_edu/waldron.

Teacher Preparations:

1. Before class, count out 2 batches of pom poms with 30 pom poms of each color in each batch. (If you have a particularly large class, you may want to have 40 pom poms of each color in each batch.) Prepare two charts on the board for recording the numbers of each type of pompom and hunter in both of the habitats for all three generations (see page 5 in the student protocol). For each class you teach, you will need two copies of the data sheet in 10 on the next page. In addition, you may want to prepare by posting larger versions of the charts on page 4 and the graphs on page 5 of the student handout on the board before class.

2. During class, disperse 1 batch of 90 pom poms in each habitat.

3. You may want to choose one or two students to be your helpers during the simulation.

4. When you are ready to begin the simulation, split the class in half (with each half of students becoming the hunters on one habitat type) and give each student a fork, spoon or knife (one third each). Explain the rules of the game to the students again.

5. They will have 15-30 seconds in which to feed. (You should adjust the number of seconds, depending on the number of students you have, cloth size, etc.)
   a. During this time they must try and pick up as many pom poms as possible and transfer them to their cups. They must pick up the pompom with their implement and put it in the cup.
   b. They must keep their cups upright at all times and are not permitted to tilt the cups and shovel pom poms into them.
   c. Competition for resources is fair (and acceptable) but once a pompom is on a feeding implement, it is off limits.

6. Start the students feeding and call stop after 15-30 seconds.

7. After feeding the students will count how many pom poms they have in their cups. Students from each habitat type will then line up separately in order of how many pom poms they have in their stomachs (least to greatest).

8. Once they are in line, you or your helpers should go down the line of students and record how many pom poms of each color were eaten. You may need to remind students **not** to put the pom poms they have "eaten" back onto the habitats since those pom poms are dead.

9. Determine which hunters will get to survive and reproduce, i.e., which ones caught enough pom poms. For each habitat, have the students stay in line. The half of the students in each habitat who "ate" the most pom poms will survive and reproduce. The half of the students who "ate" the fewest pom poms will die and be "reborn" as the children of the half of the students who survived. Start with the person with the lowest number of pompoms, apologize that they did not eat enough to survive, and tell them that they are now the offspring of a hunter that survived. Give the student the same implement as the person with the highest number of pompoms. Work your way up the line of students, matching each low person with the next person from the high end of the line. If you have an odd number of students, the student in the middle survives but does not get to reproduce. In the chart on the next page, record how many hunters of each type there are in the next generation **after** all the implements have been changed.

10. Calculate how many pom poms of each color survived, using the chart below. Since each surviving pompom is joined by two offspring, the number of pom poms to add to each cloth/habitat type will be twice the number of surviving pom poms for each color. Scatter the appropriate number of offspring pom poms of each color on the habitat. Depending on your students, you may be able to speed the process by having student helpers carry out the calculations and post information for the charts (from page... of the student handout) on the board and having other student helpers collect and sort the pom poms that were eaten into groups of 10 of the same color, ready to count out and then scatter the appropriate number of offspring pom poms on the habitat.

Habitat Type:			
Pom pom Color	Black	Red	White
# in generation 1			
# eaten			
# remaining *(# generation 1 - # eaten)*			
# new *(2 X # remaining)*			
# in generation 2 *(# remaining + # new)*			
# eaten			
# remaining *(# generation 2 - # eaten)*			
# new *(2 X # remaining)*			
# in generation 3 *(# remaining + # new)*			
Hunter Type	Spoon	Fork	Knife
# in generation 1			
# in generation 2			
# in generation 3			

11. Once the new pom poms have been scattered on the habitats and everyone has their implements for the second generation, start the second round.
12. After the second round is finished and all the counting and recording is done (make sure not to forget to get hunter numbers for generation 3) the students sit down. Finish putting the data in the charts on the board and have the students record the data in their worksheet.

Teaching Points:

- Different individuals in a population have different characteristics; this is <u>variation</u>.
- Some of this variation in characteristics can be inherited by a parent's offspring; these are <u>heritable characteristics</u>.
- Some characteristics make some individuals better at surviving and reproducing than others. <u>Fitness</u> refers to the ability to survive and produce offspring which are capable of reproducing. The specific characteristics which contribute to fitness will differ in different environments.
- A characteristic that increases an individual's fitness is an <u>adaptation</u>. Notice that biologists use the terms adaptation and fitness to have different meanings than the common meanings of these words in every day language.
- Heritable adaptive characteristics become more common in a population over many generations. This process is called <u>evolution by natural selection</u>.
- Evolution by natural selection is a gradual process that takes place over many, many generations. (Remind them that the simulation is a simplified version of reality.)
- Evolution by natural selection results in changes in the frequency of characteristics and alleles or genes in a population, not changes in an individual.
- Which characteristics are adaptive and how a population evolves depends on what kind of environment the population is in. The same population will evolve differently if placed in a different environment. Organisms are not evolving to some pre-ordained "perfection" but are evolving to maximum fitness in a given environment.

Depending on your students, it may be useful to discuss the original sources of variation in heritable characteristics, including random mutation and, in sexually reproducing organisms, recombination and independent assortment.

Possible Simplification

This activity can be simplified by removing variation from the hunter population and focusing solely on the evolution in the pom pom population. This simplification will speed up the simulation, data analysis and discussion. For example, you do not have to have the students line up after each round, and you can omit the data charts for the hunters on page 5, the graphs for the hunters on page 6, and discussion question 2 on page 7.

Additional Resources:
Two good web sites with information and activities for teaching evolution:
> http://evolution.berkeley.edu/ and http://www.pbs.org/wgbh/evolution

For example, the "All in the Family" activity at http://www.pbs.org/wgbh/evolution/change/family/ is a very useful activity to help students understand the importance of homology and similarities in development for establishing phylogenetic relationships.