Spoons, Forks, Chopsticks, Straws: Simulating Natural Selection

Kathryn M. Flinn

kathryn.flinn@gmail.com

Abstract

In this classroom activity, students participate in demonstrating how natural selection works. They play the roles of predators with different feeding appendages—spoons, forks, chopsticks, or straws—and compete to gather beans as prey. Only the most successful foragers survive and produce offspring with similar appendages. Over several generations, students can see changes in the frequencies of these heritable traits—that is, they experience the process of evolution by natural selection. This simulation provides a concrete basis for fruitful discussions of the conditions necessary for evolution by natural selection to occur, the possible long-term outcomes of selective pressures, the interplay between selection and drift, and the complications of additional biological realities.

Key Words: Evolution; natural selection; Darwin; variation; heritability; differential reproduction; survival of the fittest; struggle for existence

In *The Origin of Species*, Darwin elegantly expressed his theory of evolution by natural selection: “If variations useful to any organic being ever do occur, assuredly individuals thus characterised will have the best chance of being preserved in the struggle for life; and from the strong principle of inheritance, these will tend to produce offspring similarly characterised. This principle of preservation, or the survival of the fittest, I have called natural selection” (Darwin

1859, ch. 4 Summary). Despite the clarity and simplicity of this idea, many students have difficulty understanding the process of natural selection when they first encounter it. This simulation provides students with direct experience of the essential features of evolution by natural selection. It can follow some exposure to *The Origin of Species* or a brief introduction to the conditions necessary for evolution by natural selection to occur (e.g. Freeman et al., 2014, p. 454), and it nicely complements readings about empirical examples of evolution by natural selection (e.g. Boag and Grant, 1981; Weiner, 1994). The post-activity discussion could be adapted for any level from high school to advanced undergraduate. My colleagues and I have found this simple, playful activity an effective introduction to natural selection for introductory college biology courses and a useful icebreaker and review for the first days of an advanced course in evolutionary biology.

Materials

Utensils (enough of each for each student):

- Plastic spoons
- Plastic forks
- Pairs of chopsticks
- Drinking straws

Half a pound of small white beans

Simulation

1. Explain that students will play the roles of predators with different feeding appendages—spoons, forks, chopsticks, or straws—and compete to gather beans as prey. Individuals who

catch more than the median number of prey will survive and produce two offspring with the same appendage, then immediately die. Individuals who catch fewer than the median number of prey will die without reproducing.

2. Distribute the utensils to create a population with approximately 25% of the class having each type of feeding appendage. In a table on the chalkboard, record the frequencies of each appendage type for generation zero.

3. Spread the beans in the center of the (preferably carpeted) floor. Give the predators about one minute to forage with their feeding appendages. Students should use only the hand with the appendage to capture beans, and the other hand to store them. Encourage friendly competition.

4. Determine the median number of prey caught by having students call out their totals, writing them in order on the chalkboard, and drawing a line at the median. Individuals who fall below the median turn in their utensils to the boxes in the front of the room. Individuals who fall above the median keep their utensils, becoming their own offspring #1, and obtain another of the same utensil to give to an empty-handed classmate, who becomes their offspring #2.

5. Census the population and record the frequencies of each appendage type for generation one. Repeat steps 2-4 for 2-4 more generations.

6. Have students use the data on the chalkboard to generate a graph of the frequencies of each appendage type (on the y axis) over the generations (x axis; Figure 1).

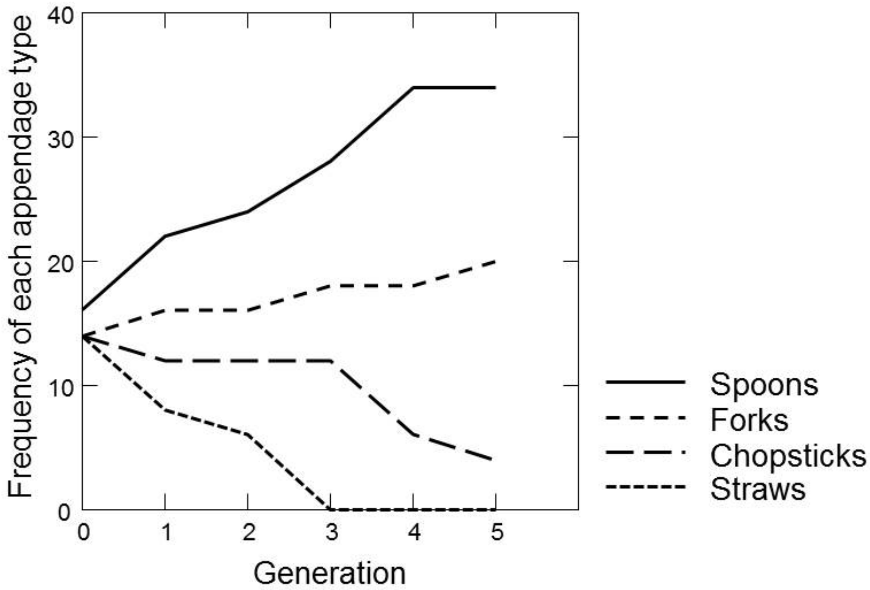

Figure 1. Example results of a simulation of evolution by natural selection, showing changes in the frequencies of feeding appendage types over five generations. These data were combined across several classes with a total of 58 students.

Discussion

The post-activity discussion might start with the question of whether the simulation included all of the conditions for evolution by natural selection to occur. Students can identify the features of the simulation that correspond to phenotypic variation (different appendages), heritability (offspring had the same appendage as their parent), differential reproduction (some individuals reproduced, some did not) and differential reproduction based on heritable phenotypic variation (individuals with certain appendages reproduced more than others). You could then ask students to identify the evidence that evolution has indeed occurred—this can reinforce the definition of evolution as the change in the genetic composition of a population over time. This could lead to a discussion of how the frequencies of each appendage type changed over time, and how they might continue to change if you continued the simulation for many more generations. You might ask whether the frequencies would continue unchanged, whether extinct appendages (often the chopsticks or straws) could reappear, or whether the most successful appendage (often the spoons) would eventually become fixed. Depending on the preparation of the students and the goals of the discussion, this could lead to a productive conversation about genetic drift, the loss of genetic variation in small populations, and the strength of selection relative to drift. Finally, some of the most interesting discussion results from asking students to think about ways the simulation differs from biological reality. Often students can explain how many real features of reproduction and inheritance and how other evolutionary forces might affect the outcome of the simulation. For example, what if reproduction required two parents? What if the appendage traits could be recessive? What if mutation or migration were incorporated? What if the environment changed? What if a predator were introduced, and chopsticks were the best defense? If this activity occurs near the beginning of a course that will go on to address many of these topics in detail, it can serve as a useful reference point throughout the course.

References

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