Modelling the bottleneck effect

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In this short activity students model the bottleneck effect using plastic bottles and jelly beans of different colors. Originally, there is a diverse, colorful population of jelly beans “living” inside the bottle. However, only a small number of them manage to pass through the neck of the bottle, as the bottle is shaken and turned upside-down. The individuals that managed to leave the bottle are then simulated to reproduce. Several groups of students model the bottleneck with the same initial population and observe the results after the simulated reproduction of the surviving individuals took place.

8.1 Aims

- To introduce genetic drift as one of the mechanisms of evolution.
- To explore the effects of a bottleneck on a sample population.
- To explain how human activities may lead to a bottleneck in wildlife populations and thus affect the chances of survival of the affected population.
- To understand the impact of genetic bottlenecks in conservation biology.

8.2 Structure

- Students run the simulation in pairs or small groups of up to four students (15 min).
- Entire classroom discussion (15 min).

8.3 Materials

- Jelly beans of at least four different colors (50 for each pair or small group)
- Blank sheet of paper
- Bottle (0,5 liter, transparent, plastic mineral water bottle with a thin neck)
- Colored pencils or markers of the same colors as the jelly beans

The teacher should ensure that the jelly beans are large enough to get a bit stuck in the neck of the bottle, and that only a small number of them are able to fall out of the bottle when the bottle is turned upside-down.

8.4 Procedure

1. The teacher prepares the initial populations for each student group and distributes them in bottles to the student groups. The initial populations should be identical for all student groups: They should contain the same number of jelly beans of each color.
2. Students record the number of each color of jelly beans in their population.
3. The teacher tells the students a short story about their populations being hit suddenly by an environmental disaster or human activity (forest fire, flood, hurricane, humans building a highway etc.) which only a small number of individuals have survived. The students model this situation by shaking their bottles and turning them upside-down, allowing a small number of jelly beans pass through the thin neck of the bottle. The jelly beans that manage to leave the bottle represent those individuals that have survived the disaster.
4. Students record the number of surviving individuals and their colors in a data table.
5. Once the disaster is over, the surviving individuals can start to reproduce. The students model reproduction by drawing first the survivors (they should be careful to use the same number as the jelly beans), and then by drawing an exact copy of each of them to model the first generation of offspring.

6. In the same way, students model the reproduction of a few following generations, doubling the number of dots of each color for each generation, until they get approximately the same number of individuals as in the initial population. The students record the numbers of individuals in each generation.
7. The students compare the initial population (they return the surviving individuals to the jelly beans remaining in the bottle) with the resulting population after the bottleneck—at first just visually, by placing the bottle and the picture side by side, then by comparing the frequencies of individuals of each color in the initial and the resulting populations.
8. Students compare their surviving populations with one another. There should be differences between them.
9. The teacher summarizes the activity, explaining the significance of the bottleneck effect for evolution, as well as its implications for nature conservation.

Figure 1: The original population before the bottleneck.

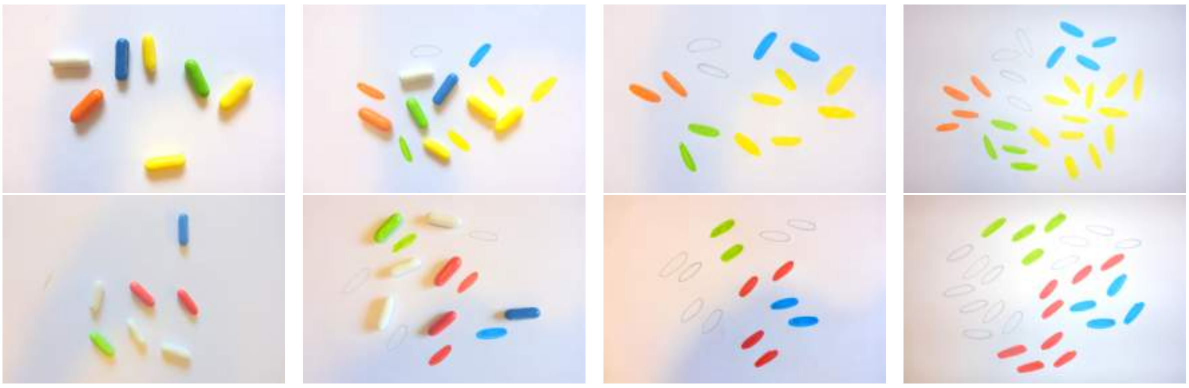

Figure 2: Simulation of two different populations after the bottleneck.