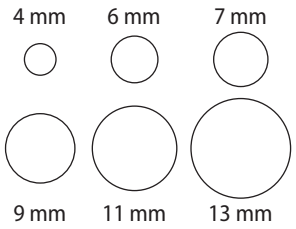
How to Create Drug-Resistant Bacteria: *A Lesson in Evolution*

▶ Materials

- sharp pencil
- scissors
- large Styrofoam™ bowl or meat tray
- dried beans of the types listed below*
  - 1 cup kidney beans
  - 1 cup lentils
  - 1 cup split green peas
  - 1 cup pinto beans
  - 1 cup black beans
- graph paper
- 4 differently-colored pencils or pens

**Don't use lima or garbanzo beans. They clog the holes in the bowl.*

▶ Procedure



1. Use your pencil to punch 6 holes of the sizes shown below in the bottom of a Styrofoam bowl. Trim the flaps from the edges to make the holes as "clean" as possible. The largest hole cannot be any bigger than the largest hole shown to the right (13 mm).

Think of the holes in the bowl as the action of the antibiotic. Beans are going to represent a population of bacteria…let's say Staphylococcus aureus (staph). The different types of beans represent differences in genetic makeup among the individuals in this staph population. A living population of bacteria would include millions, billions, or even more individuals, but you will work with much smaller numbers. To create the initial population of bacteria, select 5 beans of each type and place them in the bowl. This population of 25 beans/bacteria is Generation 1.

2. Shake the bowl 5 times. You will probably get the best results if you shake or tip the bowl from side to side. The beans/bacteria that fall through the holes are considered dead. Did all types fall out in the same numbers? The Generation 1 beans/bacteria remaining in the bowl are better adapted to their environment (which includes the presence of an antibiotic) and have survived. On the data table (next page), record the numbers of each type of bean at the "end" of Generation 1.

3. Only bacteria that survive can reproduce. So, for each of the Generation 1 beans/bacteria remaining in the bowl, add another one of the same type to indicate that these bacteria reproduced and passed similar traits on to the next generation. The beans in the bowl are now Generation 2. Record the numbers of each type of bean on the data table. What happened to the proportions of different types of beans in Generation 2?

4. Shake the bowl 15 times. Again, the beans/bacteria that fall through the holes are considered dead. The beans in the bowl are what's left of Generation 2. Record the numbers for the "end" of Generation 2.

5. Generation 2 needs to reproduce, so, once again duplicate the beans remaining in the bowl. These beans are now Generation 3. Record the numbers on the data table.

6. Shake the bowl 15 times. The beans in the bowl are what's left of Generation 3. Record the numbers for the "end" of Generation 3. Duplicate the beans remaining in the bowl. These beans are now Generation 4. Record the numbers on the data table. Repeat to create Generation 5.

7. Compare the numbers of each type of bean in each generation to see if there are changes in the proportions. Create a graph to show your results. Using your graph, predict the numbers in Generations 6 and 7 if the same trends occur.

▶ Data Table

Generation		kidney beans	lentils	peas	red beans	black beans
1	start					
	end					
2	start					
	end					
3	start					
	end					
4	start					
	end					
5	start					
	end					

▶ Questions

1. Use your results to decide which bean/bacteria types are
   - VERY susceptible to the antibiotic
   - moderately susceptible to the antibiotic
   - fairly resistant to the antibiotic
   - almost completely antibiotic resistant
2. What would happen if the holes were larger than every bean/bacteria ? What would this say about the antibiotic?
3. What would happen if the holes were smaller than every bean/bacteria ? What would this say about the antibiotic?

▶ What Happens

The beans that have the smallest diameter are most affected by the antibiotic because they can fall through all holes—small, medium, and large. The medium diameter beans can only fall through the medium and larger holes, meaning they are a somewhat resistant to the antibiotic. The largest beans can only fall through the largest hole. They are most resistant to the bacteria. In each generation, the proportion of the population made up of each type of bean/bacteria changes. The more resistant bacteria increase and the less resistant ones decrease. (Sample data is available in a separate document.)

The background reading "Don't Mess with MRSA" describes a patient who was prescribed a course of antibiotic treatment that she didn't finish. If she had completed her antibiotic treatment, more of the resistant bacteria would have eventually died, and her immune system would have been able to take care of the remaining infection. Because she ended her treatment too early, plenty of resistant bacteria were left to reproduce and make her sick again. The same antibiotic did not help against this resistant population.

This publication was made possible by a Science Education Partnership Award (SEPA) American Recovery and Reinvestment Act (ARRA) Administrative Supplement from the National Center for Research Resources (NCRR), a component of the National Institutes of Health (NIH). Developed by the Center for Chemistry Education at Miami University, Ohio, www.ccemu.org.