ANSWER KEY.

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The Sieve Predator: A Natural Selection Lab

Biology | ANSWER KEY

Sample answers and data. Accept answers that match the group's own data and reasoning.

Draft lab. This lab has not been tested in a classroom yet. Your teacher may change some steps, times or amounts.

The Model

Your population is 30 dried beans of five sizes. Size is a **heritable trait**: offspring are the same size class as their parent, unless a **mutation** changes them. The **predator** is a colander. It can only catch prey small enough to slip through its holes. No one in your group chooses which beans live. The rules decide.

Size class	1	2	3	4	5
Bean	lentil	split pea	black bean	pinto bean	lima bean

Question

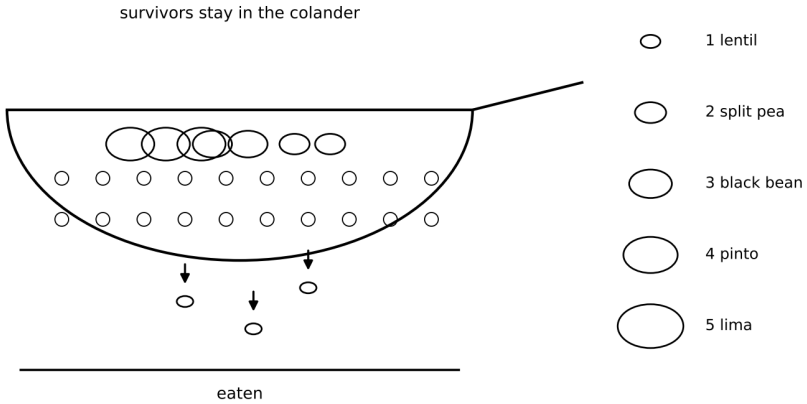
How does a population change over generations when a predator removes small individuals, and what happens when the environment changes?

Safety

- Do not eat the beans. Tell your teacher if you have a legume or bean allergy.
- Sweep up dropped beans right away. They are a slip hazard.

Materials (per group)

- Supply bins of each bean type (about 60 of each)
- Colander, a tray or bin to catch beans, 2 cups, 1 die
- Timer, calculator



Beans that fall through the holes are eaten. Beans left in the colander survive (Generations 1 to 6).

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Before the Lab

1. Predict how the mean size class will change over 6 generations. Explain.

   Answers vary. Expected: the mean size goes up, because small beans are eaten more often and leave fewer offspring.

Procedure

Generations 1 to 6

1. Start: put 6 beans of each size class (30 total) in a cup. This is Generation 0.
2. **Predator:** pour the population into the colander held over the tray. Shake it side to side for **3 seconds**. Beans that fall through are eaten. Return them to the supply bins.
3. **Reproduce:** each survivor has 2 offspring and then dies. To do this, keep each survivor and add one matching bean from the supply.
4. **Mutate:** roll the die once for each size class that has beans. On a 1, swap one bean of that class for one bean of the next smaller class. On a 6, swap one for the next larger class. On 2 to 5, nothing changes.
5. **Limited resources:** if there are more than 30 beans, mix them in the cup and, without looking, remove beans until 30 remain.
6. Count each size class and record it as the next generation. Repeat steps 2 to 6 until you finish Generation 6.

Generations 7 to 10: the environment changes

1. A new predator moves in. It catches big prey and cannot catch prey that slips through the holes.
2. Shake for 3 seconds. Beans that fall through **survive**. Count the beans left in the colander and remove every second one (keep, remove, keep, remove).
3. Reproduce, mutate, and limit to 30 as before. Record Generations 7 to 10.

Data

Mean size = (1 × class 1 count + 2 × class 2 count + ... + 5 × class 5 count) ÷ total. The new predator starts at the row marked *.

Table 1. Size classes by generation

Gen	Class 1 lentil	Class 2 split pea	Class 3 black bean	Class 4 pinto	Class 5 lima	Total	Mean size
0 (start)	6	6	6	6	6	30	3.00
1	**1**	**2**	**10**	**8**	**9**	**30**	**3.73**
2	**0**	**1**	**11**	**8**	**10**	**30**	**3.90**
3	**0**	**0**	**8**	**9**	**13**	**30**	**4.17**
4	**0**	**0**	**9**	**9**	**12**	**30**	**4.10**
5	**0**	**0**	**9**	**8**	**13**	**30**	**4.13**
6	**0**	**1**	**10**	**9**	**10**	**30**	**3.93**
7 *	**0**	**2**	**12**	**8**	**8**	**30**	**3.73**
8	**0**	**1**	**13**	**8**	**8**	**30**	**3.77**
9	**0**	**2**	**13**	**9**	**6**	**30**	**3.63**
10	**0**	**3**	**12**	**10**	**5**	**30**	**3.57**

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2. Make two bar graphs (histograms): size class counts at Generation 0 and at Generation 6. Draw them side by side.

Gen 0: five equal bars of 6. Gen 6 (sample): 0, 1, 10, 9, 10. The distribution shifts toward larger classes and the small classes nearly disappear.

Analysis

3. How did the mean size change from Generation 0 to Generation 6? Use numbers.

It rose from 3.00 to about 3.9 to 4.2 (sample: 3.93 at Gen 6, with a high of 4.17 at Gen 3).

4. Did any individual bean grow larger during the lab? What changed instead?

No. Each bean stayed the same size. The proportions of size classes in the population changed across generations.

5. Match each model rule to one of the four factors of evolution by natural selection: (a) potential to increase in number, (b) heritable variation, (c) competition for limited resources, (d) proliferation of those better able to survive.

(a) Each survivor makes 2 offspring. (b) Offspring keep the parent's size class, and the mutation die adds new variation. (c) The limit of 30 beans. (d) The colander predator: larger beans survive more often, so they leave more offspring.

6. Did the die roll more mutations toward larger sizes because large beans were better? Explain why this matters.

No. The die gave a 1 and a 6 equally often, no matter what the predator was doing. Mutations are random; selection is what favors some of them.

7. After the environment changed, did the population shift back toward small beans quickly or slowly? Explain using variation.

Slowly (sample mean fell only from 3.93 to 3.57 in 4 generations). Classes 1 and 2 were almost gone, so there was little small-bean variation for selection to favor. New small beans came mostly from rare mutations.

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8. Claim, evidence, reasoning: Explain why the population's mean size changed in Generations 1 to 6.

Claim

The population evolved toward larger size because the predator removed small beans, so larger beans left more offspring.

Evidence

The mean size rose from 3.00 to about 4 and classes 1 and 2 almost disappeared by Generation 6 (sample data).

Reasoning

Size was heritable and varied. More offspring were made than resources allowed (limit of 30), and larger beans survived the predator more often, so their size classes increased in proportion each generation.

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