AP BIOLOGY · UNIT 7 · TOPIC 7.3

Artificial Selection

Learning objective 7.3.A Explain how humans can affect diversity within a population.

Name: Date: Period:

Use the tool **Choosing the Parents**. Parts 1 and 2 use **One round**, Part 3 uses **Twelve generations**, and Part 4 uses **Back in the wild**. Topics 7.1 and 7.2 let the environment do the choosing. Here a human does it, on purpose, and the point of the topic is how little else changes: the same requirement for heritable variation, the same differential reproduction, the same cost paid in diversity. The population is **4,000** individuals, each with a heritable component and an environmental component to its trait value.

Part 1 · One round of selection

The breeder keeps the top **20%** of the population as parents and breeds only from them. Press Heritable trait and record the first row, then press No heritable component and record the second row. S is the selection differential and R is the response. The means of the offspring are in the table Two ways to get the same number, in the second panel.

Trait	Mean of population	Mean of chosen parents	S	Mean of offspring	Response R
Heritable					
No heritable component					

1. Describe the process of artificial selection.

2. (a) Describe what the selection differential, S, measures.

(b) Describe what the response, R, measures.

(c) Identify which of S and R is under the breeder's control. Using the two rows of the Part 1 table, provide reasoning to justify your identification.

Part 2 · Why the offspring fall short

Stay on the heritable trait. The chosen parents averaged **52.02** and their offspring averaged **50.99**, which is better than the population and worse than the parents. Complete the table before you answer questions 3 to 5.

Quantity	Value	How you got it
Response R, observed		
Heritability h^2		
Predicted response $h^2 \times S$		
$R \div S$		

3. Explain why the offspring of the selected parents fall back toward the population mean.

4. In the second row of the Part 1 table, the breeder achieved a selection differential of about 2.0 but a response of only about 0.03. Explain what this result indicates about the requirements for any kind of selection to change a population.

5. The simulation bred 4,000 individuals one at a time and never used the equation $R = h^2S$, and the equation's prediction was calculated without the simulation's result. Explain why the close agreement between the observed response and the predicted response is stronger evidence than either value alone.

Part 3 · Twelve generations, and what it costs

Go to **Twelve generations**. Click each Keep the top button in turn and record the Heritability now readout. Then record the gain in the mean and the heritable variance remaining for each intensity from the table How hard you select, and what it costs, in the second panel.

Top fraction kept	Gain in the mean	Heritable variance left	h^2 at generation 12
50%			
20%			
5%			

6. (a) Describe how the gain per generation changes as the breeding program continues.

(b) Explain why the gain per generation changes in this way.

7. Using the Part 3 table, explain how artificial selection affects genetic diversity within a population.

8. Using the Part 3 table, explain why a breeder cannot achieve a faster gain without a greater loss of genetic diversity.

Part 4 · Back in the wild

Go to **Back in the wild**. The same population is now scored on how well it would survive and reproduce in the environment its ancestors came from. Nothing about the breeding program changes; only the question being asked of the population changes. Click each Generation button in turn and record the readouts.

Generation	Trait mean	Value to the breeder	Fitness in the wild
0			
2			
4			
8			
12			

9. Using the Part 4 table, explain why a population improved by artificial selection becomes less fit in its natural environment, even though the breeding program worked as intended.

10. (a) Explain why reduced genetic diversity is a problem for a breeding population.

(b) Describe one way that breeders respond to this problem.

11. (a) Describe one way in which artificial selection differs from natural selection.

(b) Describe one way in which artificial selection and natural selection are the same.

What the model simplifies

The trait is controlled by many loci of small effect and its heritable component is treated as a single number that halves and recombines cleanly between parent and offspring. Real traits have loci of unequal effect, and alleles at linked loci are inherited together rather than independently.

Heritability is set at 0.50 and the environmental variance is held constant throughout. Real heritabilities differ between traits, between populations and between environments, and a change in husbandry changes the heritability of the same trait in the same animals.

Every selected individual contributes equally and mating among the selected parents is random. Real programs use a few outstanding sires far more than the rest, which reduces the effective population size and removes diversity faster than these figures show.

The population is 4,000 individuals with no mutation and no immigration, so heritable variance can only fall. Real populations gain a small amount of new variation by mutation each generation, which is why long-running programs do not stall completely.

Natural fitness is modeled as a single peak at the population's original mean. Real environments impose many demands at once and the peak itself moves, so a domesticated organism's problem in the wild is rarely as simple as one trait sitting in the wrong place.