AP BIOLOGY · UNIT 7 · TOPIC 7.2

Natural Selection

Learning objective 7.2.A Describe the importance of phenotypic variation in a population, and 7.2.B explain how variation in molecules within cells connects to fitness.

Name: Date: Period:

Use the tool **Selection Cannot See a Genotype**. Parts 1 and 2 use **Hidden in plain sight**, Part 3 uses **When the middle one wins**, and Parts 4 and 5 use **Harmful where?** Topic 7.1 ran selection on a population where every individual wore its allele on the outside. Everything in this worksheet follows from removing that convenience: selection acts on the **phenotype**, and in a diploid organism an allele can be present without appearing.

Part 1 · The same allele in two kinds of population

A harmful allele starts at **0.50** and faces selection that removes **50%** of the fitness of the affected individuals. The selection is identical in both populations; the only difference is whether the allele can hide. Click Both together. The graph runs from generation 0 to generation 100, so generation 50 is its midpoint; read both frequencies there from the graph (the axis is in percent, so 4% is 0.04). Read the frequencies at generation 100 from the Haploid, after 100 generations and Diploid, after 100 generations readouts.

Population	Frequency at generation 0	At generation 50 (from the graph)	At generation 100	Cleared?
Haploid				
Diploid				

1. Explain what it means to say that natural selection acts on phenotypes rather than on genotypes.

2. Selection removes 50% of the fitness of affected individuals in both the haploid and the diploid population. Explain why the harmful allele is cleared from the haploid population but not from the diploid population.

Part 2 · Where the copies actually are

Fill in this table from the table Where the copies actually are, in the second panel. The last column is the share of all copies of the allele that are sitting in carriers, where they do not show.

Allele frequency	Copies in affected homozygotes	Copies hidden in carriers	Share hidden
0.500			
0.200			
0.100			
0.050			
0.010			
0.001			

3. Using the Part 2 table, describe the relationship between the frequency of the allele and the share of its copies hidden in carriers.

4. A severe recessive genetic condition has been selected against for thousands of generations, and the allele that causes it is still present. Using a value from the Part 2 table, explain why selection has not removed the allele.

5. Using the halving table in the section Why selection slows down exactly as it succeeds, explain why selection against a recessive allele becomes slower as the allele becomes rarer.

Part 3 · An allele selection refuses to remove

Switch to **When the middle one wins**. Here the heterozygote AS is the fittest of the three genotypes AA, AS and SS. Click Start at 0.01 and then Start at 0.90, and record each run.

Starting frequency	Direction it moves	Where it settles	Fitness of AA / AS / SS
0.01			
0.90			

6. In this model, SS homozygotes have a fitness of only 0.2. Explain how selection maintains the S allele in the population.

7. Using both rows of the Part 3 table, explain why the frequency at which the S allele settles is a stable equilibrium rather than a result of the starting frequency.

Part 4 · Harmful where?

Go to **Harmful where?** The same allele starts at the same frequency, 0.05, in two environments. Click Malaria absent and then Malaria present, and record each run.

Environment	Fittest genotype	After 120 generations	Rises or falls?
Malaria absent			
Malaria present			

8. A student claims that the sickle cell allele is a harmful mutation. Using both rows of the Part 4 table, evaluate the student's claim.

9. Using the Part 4 table, explain why describing an allele as harmful is incomplete unless the environment is also identified.

Part 5 · Variation you have before you need it

Use the second panel, Variation you have before you need it. A population holds some number of enzyme variants. A new challenge arrives, and each variant independently has a 15% chance of coping with it. The population survives if at least one variant copes. Click each number of variants in turn and record the chance that the population survives. Calculate each gain by subtracting the chance in the row above.

Variants held	Chance the population survives	Gain over the previous row
1		
2		
3		
5		
8		
12		

10. Using the Part 5 table, explain how variation in the number and types of molecules within cells affects the ability of a population to survive a change in its environment.

11. A student claims that the population developed its enzyme variants because it needed them. Using the 15% chance that each variant copes with the challenge, explain why the student's claim is incorrect.

What the model simplifies

Mating is random and the population is infinitely large, so genotype frequencies follow Hardy–Weinberg proportions exactly each generation before selection acts. Real populations are finite and mate non-randomly; Topic 7.4 takes up what that changes.

Fitness is assigned to a genotype as a single number that does not change over time or with the frequency of the allele. Real fitnesses vary between individuals of the same genotype and often depend on how common that genotype already is.

The sickle cell fitness values are of the right shape and roughly the right size but are illustrative rather than measurements from a particular population. Real values differ between regions with different malaria intensity, which is why the allele's frequency differs between them.

The enzyme-repertoire model treats each variant as independently having the same chance of coping with a new challenge. Real variants are related to one another and their chances differ, so the true benefit of a wide repertoire is less regular than this curve.

Only one gene is under selection at a time. Real genomes are under selection at many loci simultaneously, and alleles at nearby loci are dragged along with whatever is being selected beside them.