

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. Identical selection in both populations — the only difference is whether the allele can hide.

Population	Frequency at generation 0	At generation 50	At generation 100	Cleared?
Haploid				
Diploid				

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

2. The selection pressure is identical in both populations. Explain why the outcome is not.

Part 2 · Where the copies actually are

Fill this in from the table on 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. Describe what happens to the share hidden in carriers as the allele becomes rarer.

4. A severe recessive genetic condition has been selected against for thousands of generations and the allele is still present. Explain why, using a figure from your table.

5. Explain why selection against a recessive allele gets slower the more successful it has been.

Part 3 · An allele selection refuses to remove

Switch to **When the middle one wins**. Here the heterozygote is the fittest of the three genotypes. Run it from a low start and from a high start.

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

6. Explain how selection can maintain an allele that reduces fitness to 0.2 in homozygotes.

7. Explain why this counts as a stable equilibrium rather than as a consequence of where the run happened to start.

Part 4 · Harmful where?

Go to **Harmful where?** The same allele, the same starting frequency of **0.05**, two environments.

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

8. “The sickle cell allele is a harmful mutation.” Evaluate that statement using both rows of your table.

9. Explain why the phrase “a harmful allele” is incomplete without naming something else.

Part 5 · Variation you have before you need it

Use the second panel. 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 does.

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

10. Explain how variation in the number and types of molecules within cells affects a population's ability to survive a change in its environment.

11. A student says the population “developed” these enzyme variants because it needed them. Explain what is wrong with that, referring to the probability each variant has of being useful.

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.