

17.2 Natural and artificial selection

Name: _____ Class: _____ Date: _____

Total: 25 marks

KEY WORDS natural selection • selective breeding
 • hardy–weinberg principle • founder effect • genetic drift

Objective

Build the skills to answer exam questions on **natural and artificial selection** – **natural selection**, types of selection, the **founder effect** and **genetic drift**, the **Hardy–Weinberg principle** – , and **selective breeding**.

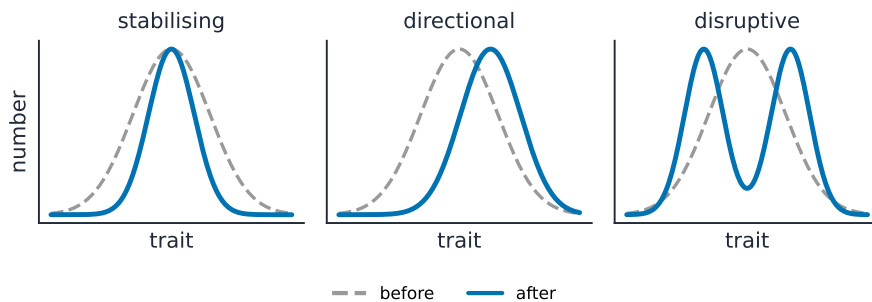
You must be able to:

- explain natural selection and how it acts as a stabilising, directional or disruptive force
- explain the founder effect, genetic drift and the bottleneck effect
- use the Hardy–Weinberg principle and describe selective breeding

1 Key knowledge and worked examples

■ Natural selection and its forces

Populations make more offspring than can survive, so they **compete**; the best **adapted** survive, reproduce and pass on their alleles, so helpful alleles become more common.



stabilising: favours the mean • directional: one extreme • disruptive: both extremes

Stabilising favours the average; directional favours one extreme; disruptive favours both extremes

■ Changing allele frequencies



A bottleneck (or founder effect) leaves few alleles; genetic drift changes frequencies by chance

Antibiotic resistance is natural selection: a chance mutation makes some bacteria resistant; the antibiotic kills the rest; the resistant survivors reproduce.

■ Hardy–Weinberg

With $p + q = 1$ and $p^2 + 2pq + q^2 = 1$, you can find allele and genotype frequencies (when the population is large, mating random, and there is no mutation, migration or selection).

■ Selective breeding



Humans choose which organisms breed, so useful features (e.g. disease resistance, milk yield) increase

2 Practice

2.1 Name the type of selection that favours the average and removes the extremes. [1]

2.2 State **two** conditions under which the Hardy–Weinberg principle holds. [2]

3 Exam-style questions

3.1 A change that favours one extreme of a range, shifting the mean, is: [1]

- ☐ **A** stabilising selection
B directional selection
C disruptive selection
D genetic drift

3.2 The bottleneck effect reduces a population's: [1]

- ☐ **A** mutation rate
B genetic variety (allele variety)
C birth rate
D number of chromosomes

3.3 In a population, the recessive phenotype (genotype q^2) occurs in 16% of individuals.

(a) Calculate the frequency of the recessive allele, q . [2]

(b) Calculate the frequency of heterozygotes ($2pq$). [2]

3.4 Explain how the overuse of antibiotics leads to a resistant bacterial population, using the idea of natural selection. [3]

3.5 A population of moths on an island is normally pale. After a volcanic eruption darkened the tree bark, the proportion of dark moths rose from 3% to 78% in twelve generations.

(a) Explain this change in terms of natural selection, in the correct order. [5]

(b) Name the type of selection shown, and describe how it differs from stabilising selection. [3]

(c) A small group of these moths is blown to a second, unaffected island and founds a new population there. Name and explain the effect this is likely to have on that population's allele frequencies. [3]

(d) Explain **one** way in which artificial selection differs from natural selection. [2]

Solutions

Each answer shows the steps, then the **result**.

2.1

- stabilising selection

2.2

- any two: large population; random mating; no mutation; no migration; no natural selection

3.1 B

- Directional selection shifts the mean towards one extreme

3.2 B

- A bottleneck leaves few survivors, reducing allele variety

3.3

(a)

- $q^2 = 0.16$, so $q = \sqrt{0.16} = 0.4$

(b)

- $p = 1 - q = 0.6$; $2pq = 2(0.6)(0.4) = 0.48$

3.4

- a chance mutation makes some bacteria resistant; using the antibiotic kills the non-resistant bacteria; the resistant ones survive and reproduce, so the resistant allele becomes more common

3.5

(a)

- The dark form already existed in the population, produced originally by **mutation**, so there was pre-existing variation; after the eruption the pale moths were conspicuous on dark bark and the dark moths were camouflaged; birds ate proportionally more pale moths – this is the **selection pressure**; the surviving dark moths were more likely to reach reproductive age and pass on the allele for dark colour; so the frequency of that allele rose generation by generation

(b)

- **Directional** selection. It favours one extreme of the range, so the mean shifts; stabilising selection favours the intermediate and acts against both extremes, so the mean stays put and the variation narrows

(c)

- The **founder effect**. The few individuals that arrive carry only a small, unrepresentative sample of the original population's alleles; so allele frequencies in the new population differ from the old one, some alleles are missing altogether, and genetic diversity is low

(d)

- In artificial selection a **human** chooses which individuals breed, according to a trait people want; in natural selection the environment does the selecting, and the trait that spreads is whichever improves survival and reproduction