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**.

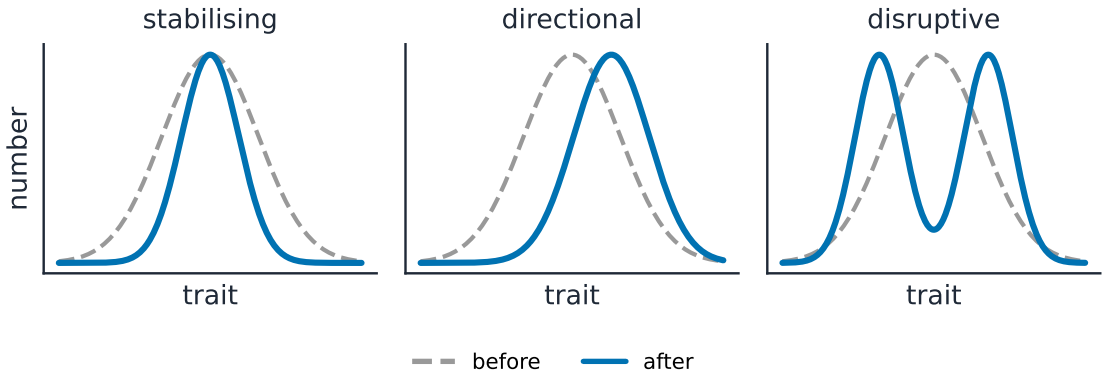
You must be able to:

- 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

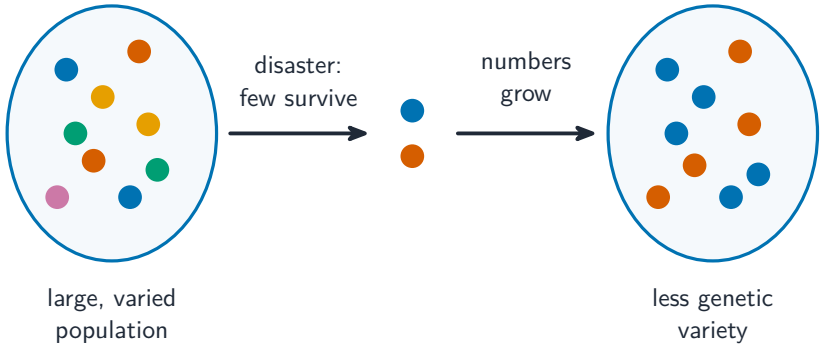
Populations make more offspring than can survive, so they **compete**; the best **adapted** survive, reproduce and pass on their alleles, so helpful alleles become more common.



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



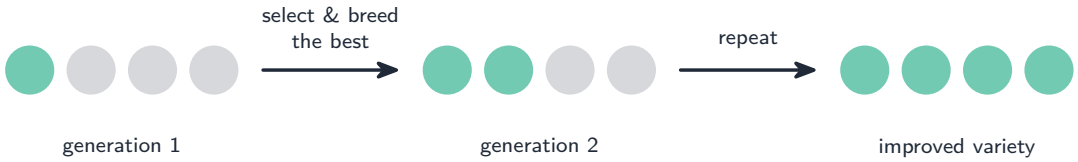
A bottleneck (or founder effect) leaves few alleles; genetic drift changes frequencies by chance

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