38.1 Natural selection

Name: _____ Class: _____ Date: _____ **Total: 26 marks**

KEY WORDS natural selection • variation • selection pressure • sexual selection • artificial selection • allele frequency

Objective

Build the skills to answer exam questions on **natural selection** : variation, overproduction, competition, survival and inheritance, sexual selection, and how selection changes populations.

You must be able to:

- explain natural selection: variation, overproduction, competition, survival and reproduction, inheritance
- explain the sources of variation: mutation, meiosis and fertilization
- explain sexual selection and the guppy experiments of John Endler
- distinguish between natural and artificial selection
- use the Hardy–Weinberg equation, and compare directional, disruptive and stabilizing selection

1 Key knowledge and worked examples

■ Natural selection

The steps:

1. **Variation:** individuals in a population differ, because of **mutation**, **meiosis** (crossing over, independent assortment) and **random fertilization**.
2. **Overproduction:** more offspring are produced than the environment can support, so there is **competition** for resources.
3. **Selection:** individuals better adapted to the **selection pressures** (predators, disease, climate, food) are more likely to survive and reproduce.
4. **Inheritance:** they pass on their alleles, so over many generations the **frequency of favourable alleles rises**.

Only **heritable** characteristics are selected: changes acquired during life (such as larger muscles) are not passed on.

Sexual selection: traits that make an individual more attractive to mates (bright colours, displays) become more common even when they increase the risk from predators. **Endler's guppies:** in streams with many predators, males were dull; when moved to streams with few predators, males became brightly coloured within a few generations.

Artificial selection: humans choose which individuals breed, for traits useful to humans (crop yield, dog breeds).

HL: a **gene pool** is all the alleles in a population. **Hardy–Weinberg:** $p + q = 1$ and $p^2 + 2pq + q^2 = 1$, where p and q are the frequencies of two alleles. It applies when there is no selection, no mutation, no migration, random mating and a large population. **Directional** selection favours one extreme; **disruptive** selection favours both extremes; **stabilizing** selection favours the middle and removes the extremes.

Worked example. 16% of a population show a recessive trait: $q^2 = 0.16$, so $q = 0.4$, $p = 0.6$; carriers $2pq = 2 \times 0.6 \times 0.4 = \mathbf{0.48}$ (48%).

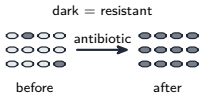
Answer shapes: variation → selection pressure → survive and reproduce → pass on alleles → allele frequency changes over generations.

2 Practice

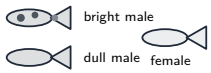
2.1 State two sources of genetic variation in a population. [2]



2.2 Bacteria in a hospital became resistant to an antibiotic. Explain this change using natural selection. [3]



2.3 Male guppies in streams with few predators are brightly coloured. Explain this observation. [3]



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2.4 In a population, 9% of individuals show a recessive phenotype. Use the Hardy–Weinberg equation to calculate the percentage of carriers. [3]

$$p + q = 1$$
$$p^2 + 2pq + q^2 = 1$$

2.5 Distinguish between directional and stabilizing selection. [3]

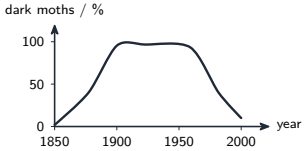


3 Exam-style questions

3.1 The peppered moth has a light form and a dark form. The graph shows the percentage of dark moths near an industrial city.

(a) State the percentage of dark moths in 1900. [1]

(b) Explain the change between 1850 and 1900. [3]

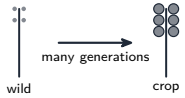


(c) Suggest a reason for the change after 1960. [2]

3.2 The diagram shows two stages in breeding a crop plant.

(a) Distinguish between natural selection and artificial selection. [2]

(b) Outline how a farmer could breed plants with larger seeds. [3]



(c) Suggest one disadvantage of artificial selection. [1]

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Solutions

Marking: **M1** a correct method, **A1** the correct answer, **B1** an independent mark.

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

2.1

any two: mutation; crossing over / independent assortment in meiosis; random fertilization

2.2

a mutation gave a few bacteria resistance (variation); the antibiotic killed non-resistant bacteria, so resistant ones survived and reproduced; they passed on the resistance allele, so its frequency rose

2.3

females prefer to mate with brightly coloured males: sexual selection; with few predators, bright males are not much more likely to be eaten; so bright males have more offspring and the alleles for bright colour become more common

2.4

$q^2 = 0.09$, so $q = 0.3$; $p = 1 - 0.3 = 0.7$; $2pq = 2 \times 0.7 \times 0.3 = 0.42$, so **42**%

2.5

directional selection favours one extreme of the range; so the mean shifts in that direction; stabilizing selection favours the middle and removes both extremes, so the mean stays the same and the range narrows

3.1

(a) 95% (accept 93–97%)

(b) soot darkened tree bark, so light moths were seen and eaten by birds more often; dark moths survived and reproduced more; the allele for dark colour was passed on and became more frequent

(c) clean-air laws reduced soot, so bark became lighter again; dark moths were now seen and eaten more, so the light form was selected

3.2

(a) in natural selection the environment decides which individuals survive and reproduce; in artificial selection humans choose which individuals breed, for traits useful to them

(b) choose the plants with the largest seeds; breed them together / collect and sow only their seeds; repeat over many generations

(c) e.g. less genetic variation, so the crop is more likely to be wiped out by a new disease

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