DP Biology – D4.1 (HL extension)

Selection and gene pools

- What can change allele frequencies in a population?
- What part does reproduction play in natural selection?

HL statements D4.1.9–15. Textbook pp. 790–797.
Image: a male guppy. 5snake5, CC0.



Objectives for each class

Class	Statements	By the end of the class, you can...
1	D4.1.9–10	Describe gene pools, and compare allele frequencies in separated populations
2	D4.1.11–12	Explain how selection changes allele frequencies, and compare three patterns of selection
3	D4.1.13–14	Use the Hardy-Weinberg equation and explain its conditions
4	D4.1.15	Explain artificial selection and how it differs from natural selection

The gene pool

- A **gene pool** is all the genes and all their alleles in an interbreeding population
- **Allele frequency** is the proportion of all copies of a gene that are one allele
- It is written as a decimal between 0 and 1
- Evolution is a change in allele frequencies over generations

Worked example

100 flowers: 49 RR, 42 Rr, 9 rr.
Copies of the gene: 200.
Copies of R: 98 + 42 = 140.
Frequency of R = 140 / 200 = 0.7.
Frequency of r = 0.3.

Key idea

Each population has its own gene pool, because mating happens mainly within it.

Allele frequencies differ between populations

D4.1.10

Allele (approximate frequency)	Northern Europe	East Asia	West Africa
Lactase persistence, -13910T	0.75	Close to 0	Close to 0
ALDH2 variant rs671 (alcohol flush)	Close to 0	0.25	Close to 0
Sickle cell, HbS	Close to 0	Close to 0	Up to 0.15

Rounded values from published population surveys. Frequencies vary within each region.

- Separated populations have different mutations, selection pressures and chance events
- Example: malaria selects for HbS carriers where the disease is common

Research it

Look up one allele in a public database such as dbSNP or Ensembl, and compare its frequency in two populations.

Selection changes allele frequencies

D4.1.11



Peppered moth, pale form. Chiswick Chap, CC BY-SA 3.0.

- Individuals vary in heritable traits
- Some survive and reproduce more than others
- They pass on more copies of their alleles, so those alleles rise in frequency
- Combining Darwin with genetics is called **neo-Darwinism**

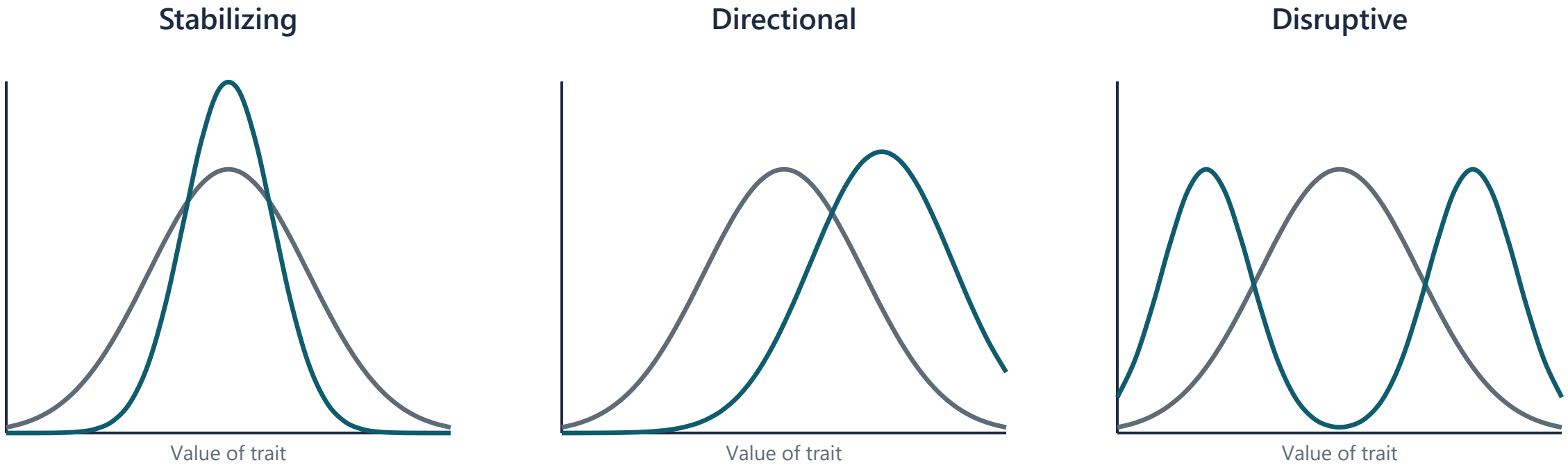
Soot darkens tree trunks → Dark moths are better hidden from birds → More dark moths survive to breed → The dark allele rises in frequency

Reversal

After clean air laws, pale moths were better hidden again and the dark allele fell in frequency.

Three patterns of selection

D4.1.12



Grey: population before selection. Teal: population after selection.

Favours the mean	Favours one extreme	Favours both extremes
Human birth weight	Dark moths; larger turkeys	Finches with very large or small beaks

All three can change allele frequencies; stabilizing selection removes alleles that give extreme phenotypes.

The Hardy-Weinberg equation

D4.1.13

$$p + q = 1$$

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

Symbol	Meaning	Who has it
p, q	Frequencies of two alleles	p dominant, q recessive
p^2	Genotype frequency	Homozygous dominant
2pq	Genotype frequency	Heterozygous
q^2	Genotype frequency	Homozygous recessive

Tip

Start with the homozygous recessive group, as it is the only genotype you can see directly from the phenotype.

Worked example: albinism

1. About 1 person in 20 000 has albinism (aa)
2. $q^2 = 1 / 20\,000 = 0.00005$
3. q = square root of 0.00005 = 0.007
4. p = 1 − q = 0.993
5. Carriers: $2pq = 2 \times 0.993 \times 0.007 = 0.014$

Meaning

About 1 person in 70 is a carrier, even though only 1 in 20 000 has the condition. Most copies of a rare recessive allele are hidden in carriers.

Try it

Tay-Sachs disease (tt) has a frequency of 0.0003 in one population. Calculate q and the frequency of carriers.

Conditions for Hardy-Weinberg equilibrium

D4.1.14

Condition	What breaks it
Random mating	Choosing mates by phenotype
No selection	Some genotypes survive or reproduce better
No mutation	New alleles arise
No migration	Individuals move in or out with different alleles
Very large population	Chance changes in small populations (genetic drift)

Using it

If observed genotype frequencies do not fit the equation, at least one condition is not being met, so something is changing the population.

Artificial selection

D4.1.15



Two dogs, one species: selective breeding. Elf, CC BY-SA 3.0.



Bread wheat. Bluemoose, CC BY-SA 3.0.

- Dogs from wolves
- Wheat with larger grains

	Natural selection	Artificial selection
What selects	The environment	People, deliberately
Favours	Traits that aid survival and reproduction	Traits people want, even if harmful to the organism

Careful

Antibiotic resistance is natural selection: nobody chose it.

Check that you can explain

1. What a gene pool and an allele frequency are
2. Why allele frequencies differ between separated populations
3. How natural selection changes allele frequencies
4. Stabilizing, directional and disruptive selection
5. How to use $p + q = 1$ and $p^2 + 2pq + q^2 = 1$
6. The conditions for Hardy-Weinberg equilibrium, and what a poor fit means
7. How artificial selection differs from natural selection

Exit activity: 5 minutes

On your own and without notes. Hand this in as you leave.

1. Define gene pool.

2. In a population, 4% are homozygous recessive. Calculate the frequency of the dominant allele.

3. State why antibiotic resistance is not an example of artificial selection.

Image credits

Poecilia reticulata – Guppy, male, cobra-green morph (cropped).jpg – 5snake5 – CC0

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