

D.4.1 · Natural selection

International Baccalaureate · IB Diploma · Biology · HL

Scope and prerequisites

This handout covers selected HL/SL topics for the course first assessed in 2025; it is not the whole syllabus.

Prerequisites: variation and inheritance from D.1 and evolution evidence from A.4.1.

The examples are original and fictional: they are not real measurements or real student investigations.

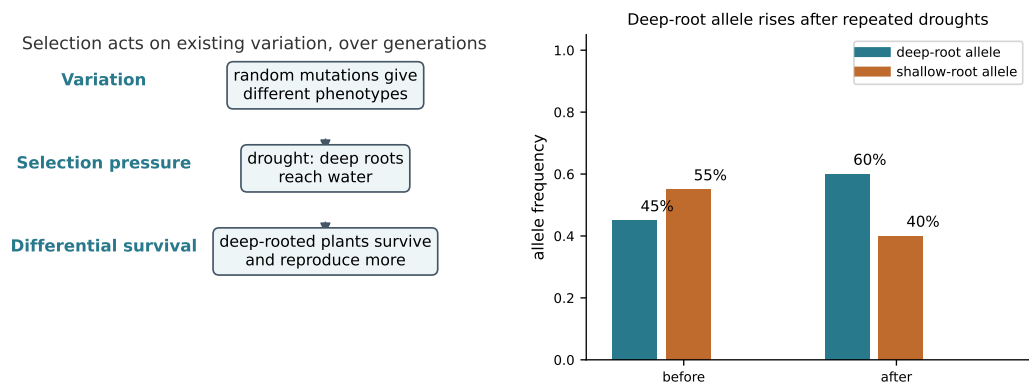
Natural selection

■ What would explain this observation?

- After several dry summers, most plants in a population have deeper roots than their grandparents' generation did. Nobody chose this – how did the population change?

■ Build the model

- Natural selection** needs three ingredients: inherited **variation** exists in the population; a **selection pressure** makes some variants survive and reproduce better than others; and the successful variants' alleles become commoner in the next generation. Over generations the population's traits shift.
- Mutation can occur before or during exposure to a selection pressure; it is not directed by an organism's needs. Selection acts on available heritable variation. Over generations, the population's **allele frequency** can change.
- natural selection: The process by which heritable variants that fit the environment leave more offspring, changing allele frequencies over generations; variation: Inherited differences among individuals of a population; selection pressure: An environmental factor that affects survival or reproduction; allele frequency: The proportion of one allele among all copies of that gene in a population.



Repeated droughts raise the deep-root allele from 45% to 60%

■ Choose evidence that can test it

- The model predicts the direction of change: after repeated droughts, measure the deep-root allele's frequency in stored seed collections or dated samples – it should rise. If it does not, the explanation fails.
- A fair test compares the SAME population across time or matched populations across a boundary, so that migration or sampling differences cannot fake the shift.

■ Work from known quantities

- Known: before the droughts, 200 gene copies include 90 copies of the deep-root allele; after several generations, 120 of 200. Allele frequency = copies of the allele / total copies. Before: $90/200 = 45\%$. After: $120/200 = 60\%$. The frequency rose by 15 percentage points – evidence of selection acting on the population.

Example:

In a new generation, 140 of 200 copies carry the deep-root allele. Find the frequency and the change from the previous generation using the same sequence: known quantities → model → relation → substitution → unit and interpretation. (Answer: $140/200 = 70\%$; change = $70\% - 60\% = +10$ percentage points. Frequencies of two alleles at one gene sum to 100%.)

■ Check the conclusion and its limits

- A frequency shift shows association between the trait and survival; proving the mechanism needs the variation to be heritable and the survival difference measured. Genetic drift in small populations can shift frequencies with no selection at all.

Warn:

An organism develops a useful adaptation during its lifetime because it needs one.

This claim is false: mutation is random with respect to need – the deep-root alleles existed before the drought. Selection only changes which variants leave more offspring; individuals do not evolve.

Key:

Natural selection: inherited variation + a selection pressure + differential reproduction shifts allele frequencies over generations. Track the shift with allele counts divided by total copies, and remember that the population evolves – never the individual.

■ **Write from an a frequency of 0.4**

- A population of 100 plants has genotypes AA 36, Aa 48, aa 16.
- Find the a frequency: $(48 + 32) \div 200 = 0.4$ – count alleles, not individuals.

■ **Write from a frequency of 0.29 after selection**

- A drought kills every shallow-rooted aa plant; the 84 survivors (AA 36 + Aa 48) breed equally.
- Find the new a frequency: $48 \div 168 \approx 0.29$ – selection changed the allele pool, not any single plant.

■ **Write from the direction of the shift**

- The next generation is grown from the survivors' seeds only.
- Say which alleles rise: a falls toward 0.29 and below; A rises – the population evolves, the individuals never did.