Natural selection

D4.1 · SL

An environment can favour an existing inherited difference

Connect variation, differential reproduction and transmission

Shared D4.1: selection, mutation and sexual variation, competition, abiotic pressures, fitness, heritability, sexual selection and guppy evidence.

Numerical plant models are invented. Endler's published guppy means are real source data, not examination questions.

Explain change without giving plants an intention

1. **Inherited variation.** Plants differ in root depth; some of the difference is inherited.
2. **Pressure and contribution.** During a drought, some obtain more water and leave more viable, fertile offspring.
3. **Transmission.** Contributing alleles can become more frequent. The drought need not instruct an individual to produce a useful allele.

A theory supplies a tested explanatory framework

Selection is a mechanism rather than a promise of perfection

Darwin explained how differential survival and reproduction can produce evolutionary change. Selection contributed to biodiversity over immense timescales.

The selection framework differed from simply inheriting acquired improvements through use and disuse. A paradigm shift replaces an influential explanatory framework.

A scientific theory does not graduate into a law. Modern evolution includes mechanisms besides selection; a changed average alone does not identify the cause.

Separate the origin of alleles from new combinations

Process	Contribution and limit
Mutation	Can create new alleles; useful changes are not induced by need
Crossing over	Recombines alleles between homologous chromosomes
Assortment	Produces different combinations at suitably unlinked loci
Fertilization	Combines gametes; does not explain every new allele

Visible differences are not automatically inherited DNA differences

Ask what was inherited and what environment contributed

Deep roots may reflect genotype, soil conditions or an interaction. Selection acts on phenotypes; evolutionary response requires a heritable contribution.

Mutation can occur before or during pressure. Random with respect to need does not mean equal mutation probability at every site.

Sexual reproduction reshuffles existing variation; a useful phenotype is not evidence that an organism chose a mutation.

Resource competition can occur without fighting

1. **Potential increase.** Many more seeds can be produced than establish and reproduce.
2. **Shared requirements.** Same-species plants compete for water, light, minerals and space; reproductive adults may compete for mates.
3. **Selective condition.** Mortality alone is insufficient. A heritable difference must affect contribution to later generations for that feature to respond evolutionarily.

A density-independent event can still discriminate among genotypes

State a pressure, a feature and the reproductive consequence

Frost or drought can affect a population without depending on crowding. Genotypes can still differ in their physiological response.

Predators, pathogens and competitors also affect success. A trait's advantage depends on the particular environment.

Reduced stomatal opening conserves water but restricts carbon dioxide entry. Deep roots consume resources that could support other growth or reproduction.

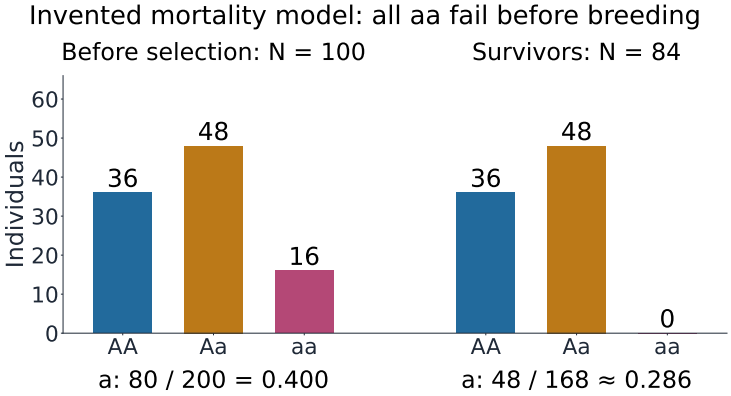
Compare offspring contribution per equivalent starting parent

1. **Invented comparison.** Twenty parents of each genotype: 60 versus 40 offspring reach the defined reproductive stage.
2. **Calculation.** Mean contributions 3 versus 2 per parent. Relative fitness, with first set to one: 1 versus $2/3 \approx 0.667$.
3. **Evaluation.** Raw totals mislead when starting numbers differ. Survival, lifespan or strength alone do not measure reproductive contribution.

Design a test that separates family and growing conditions

1. **Common conditions.** Compare offspring from contrasting parents at comparable ages in controlled soil and water conditions.
2. **Independent replication.** Use independent families and replicate pots. One family in one pot confounds family with pot conditions.
3. **Stronger inference.** Reciprocal environments test interactions. Common conditions do not remove every parental effect; connect inheritance with function and reproductive success.

Count copies again after mortality changes the population



A changed denominator matters; survivors are not yet a new generation.

Track both copies in each ordinary diploid genotype

1. **Before.** AA 36, Aa 48, aa 16; $N = 100$. $A = 120/200 = 0.60$; $a = 80/200 = 0.40$.
2. **Survivors.** All aa fail: $N = 84$. $A = 120/168 = 5/7$; $a = 48/168 = 2/7 \approx 0.286$.
3. **Transmission.** No surviving genotype changed. Equal gamete contribution alone need not lower a again; continuing selection or another process is needed for systematic further change.

Keep percentage points separate from relative percentage change

1. **Invented records.** 90, then 120, then 140 of 200 copies: 45%, 60%, 70%.
2. **Different comparisons.** $45 \to 60$ is $+15$ percentage points; relative increase $= 15/45 \times 100 \approx 33.3\%$. The next rise is $+10$ percentage points.
3. **Causation.** Migration, drift, sampling and changed population boundaries can also alter records. Frequency change alone does not uniquely establish selection.

Mating advantage and survival cost can act in different directions

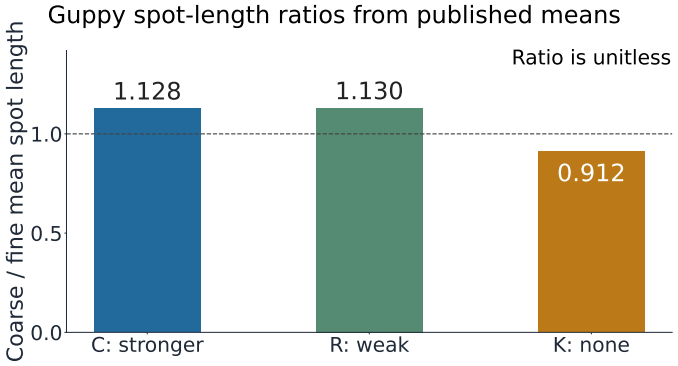
Bird-of-paradise plumage and courtship provide a context

Mate choice and competition can change mating or fertilization success. Inherited traits associated with greater contribution can spread.

Elaborate plumage and display consume resources and may increase predator exposure. The most conspicuous male need not always leave most offspring.

Preferences and environments vary. Control background, illumination and other cues when evaluating mate responses; do not infer an intentional inherited colour change.

Compare gravel effects within each predator regime



Coarse/fine ratios exceed one with predators and fall below one without.

Interpret a descriptive ratio before claiming a mechanism

1. **Published data.** Endler (1980), Table 3 all-spots means; stronger C, weaker R, no-predator K regimes.
2. **Pattern.** C 1.128; R 1.130; K 0.912. Mean spot length relates differently to gravel background without predators.
3. **Evaluation.** Pond, not each fish, is the independent treatment unit. Ratios alone give no significance test or unique causal explanation; control allocation and measurement matter.

Work through the complete handout questions

Build a chain, compute a comparison, evaluate the evidence

Shared questions connect mutation, competition, pressure, fitness, heritability, sexual selection and population copy counts.

Practice fitness: ten parents per group leave 50 versus 30 offspring at the defined stage. Compute contribution and relative fitness.

Check the shared numerical comparisons

1. **Fitness.** $50/10 = 5$; $30/10 = 3$. Relative fitness 1 and $3/5 = 0.60$.
2. **Frequency.** $90/200 = 45\%$; $120/200 = 60\%$; $140/200 = 70\%$. Changes $+15$ and $+10$ percentage points; first relative rise 33.3%.
3. **Survivors.** A $120/168 \approx 0.714$; a $48/168 \approx 0.286$. Individual genotypes remain unchanged.

Check yourself

Use the population, denominator and assumptions named by the question

Link heritable variation, pressure, reproductive contribution and transmission. Separate individual acclimatization from population evolution.

Distinguish percentage points from relative change, a survival benefit from total fitness, and a descriptive pattern from a unique causal demonstration.