

Exercise walk-through

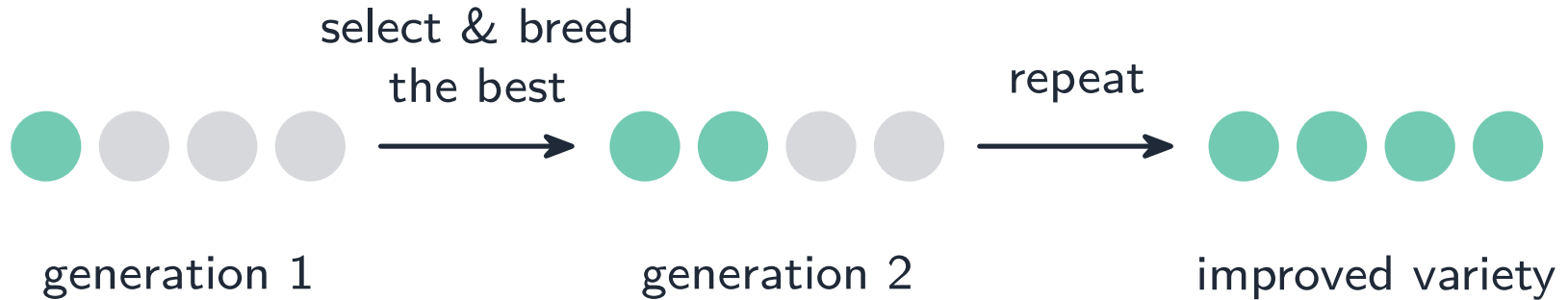
17.3

Evolution

A-Level Biology

Selective breeding

In **selective breeding** (artificial selection), humans choose which organisms breed. Used to breed **disease resistance** into crops and raise milk **yield** in cattle.



Two tools of the plant and animal breeder

Inbreeding

Inbreeding crosses close relatives to fix a desired trait – at the cost of losing variety and exposing harmful recessives.

Hybridisation

Hybridisation crosses two different inbred lines; the offspring are vigorous and uniform. This is how commercial maize is made.

The trade-off

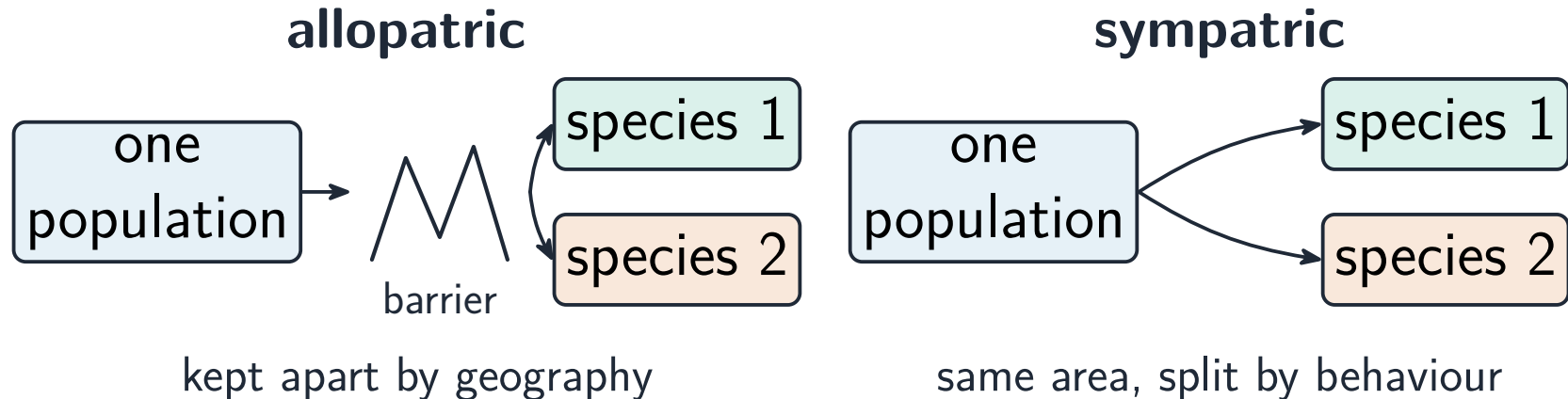
Uniformity is what a farmer wants and what a population's future does not: an identical crop meets an identical disease.

Selective breeding is directional selection with a human doing the selecting – the mechanism is unchanged.

Speciation

Evolution changes a population's **gene pool** over time; DNA shows how closely species are related.

- **allopatric** – a physical barrier
- **sympatric** – same area, different behaviour



Two routes to a new species

What speciation is

Speciation

happens when two populations become genetically separated, so they can no longer breed together.

Allopatric speciation

Allopatric speciation geographical separation

: the populations are kept apart by a
– a sea, a mountain range, a new river.

Sympatric speciation

Sympatric speciation

: they live in the **same** area but are separated by differences in behaviour, timing or way of life.

Then what

Once gene flow stops, mutation and selection act separately on each population until the differences are large enough to prevent interbreeding.

Say which *barrier* first – geographical or reproductive – and the rest of the answer follows from it.

Exam tips

- Explain **natural selection** as a sequence: variation → selection pressure → the better-adapted survive and reproduce → allele frequency changes.
- Use the **Hardy–Weinberg** equations ($p + q = 1$, $p^2 + 2pq + q^2 = 1$); q^2 is the recessive-phenotype frequency – a common calculation.
- Distinguish **stabilising, directional and disruptive** selection with an example of each.
- Distinguish **allopatric vs sympatric** speciation (geographic vs reproductive isolation).

Exercises 2.1·2.2

2.1 Define **evolution** in terms of the gene pool.

[2]

2.2 State the difference between allopatric and sympatric speciation.

[2]

Exercises 2.1·2.2

2.1 Define **evolution** in terms of the gene pool.

[2]

2.1

- evolution is the change in the gene pool / allele frequencies of a population over many generations, leading to new species

2.2 State the difference between allopatric and sympatric speciation.

[2]

2.2

- allopatric – populations separated by a geographical barrier; sympatric – populations in the same area separated by behaviour/ecology

Exercises 3.1-3.2

3.1 Two species share a very similar DNA base sequence. This suggests they: [1]

☐

- A** are not related
- B** shared a recent common ancestor
- C** live in the same habitat
- D** have the same number of chromosomes

3.2 A mountain range divides a population into two, which slowly become different species. This is: [1]

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- B** sympatric speciation
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3.1 B

- Very similar DNA suggests a recent common ancestor

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- ☐ **A** allopatric speciation
B sympatric speciation
C genetic drift
D artificial selection

3.2 A

- A geographical barrier causing speciation is allopatric

Exercises 3.3-3.4

3.3 Explain how allopatric speciation can lead to the formation of two new species. [4]

3.4 Explain how comparing DNA sequences can be used to show how closely related different species are. [2]

Exercises 3.3-3.4

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3.3

- a geographical barrier separates the population into two; each population faces different conditions and undergoes different selection / mutations / drift; their gene pools change in different ways; eventually they are so different they can no longer interbreed to produce fertile offspring – two species

3.4 Explain how comparing DNA sequences can be used to show how closely related different species are. [2]

3.4

- the more similar the DNA base sequences, the more recently the species shared a common ancestor; large differences indicate they diverged longer ago

Exercise 3.5 (a)

3.5 Two populations of a fish species live in one lake. One feeds at the surface, the other on the bottom. They breed at different depths and no longer interbreed, although in the laboratory they can produce fertile young.

(a) Explain, using the biological definition of a species, whether these are one species or two. [3]

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(a)

- A species is a group of organisms with similar features that can **interbreed to produce fertile offspring**. These populations can do so in the laboratory, so by that definition they remain one species; but they are reproductively isolated in the wild, so they are diverging and would be described as incipient species or subspecies

Exercise 3.5 (b)

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(b) Name the type of speciation occurring here, and explain how it differs from the other type. [3]

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(b)

- **Sympatric** speciation – the two populations occupy the same geographical area; they are separated by a behavioural or ecological barrier, here breeding depth. Allopatric speciation instead begins with a **physical** barrier such as a river or mountain that geographically separates the populations

Exercise 3.5 (c)

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- Sequence the same gene in both populations and count the number of base differences; mutations accumulate at a roughly constant rate over time – the molecular clock; so the number of differences, divided by that rate, estimates the time since the populations shared a common ancestor

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- Appearance can mislead in two opposite ways: unrelated species may evolve similar features because they face the same selection pressure – convergent evolution; and closely related species may look very different if their environments differ. DNA is the actual heritable material, so the number of sequence differences reflects ancestry directly, and it can compare organisms with no visible features in common at all

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Reduced gene flow across the barrier; different selection pressures and/or drift change allele frequencies; differences accumulate over generations; reproductive isolation develops so the groups no longer produce fertile offspring together.