A-LEVEL BIOLOGY • EXERCISE SHEET

17.3 Evolution

Name: _____ Class: _____ Date: _____ **Total: 24 marks**

KEY WORDS species 物种 • evolution 进化 • sequence 序列 • speciation 物种形成 • allopatric 异域

Objective

Build the skills to answer exam questions on **evolution** — the theory of evolution, **DNA sequence** 序列 evidence, and **speciation** 物种形成 by genetic isolation.

You must be able to:

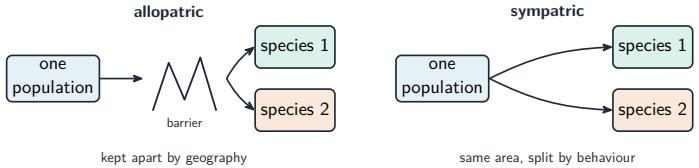
- outline evolution as the change in gene pools producing new species over time
- discuss how DNA sequence data shows evolutionary relationships
- explain allopatric and sympatric speciation

1 Worked examples

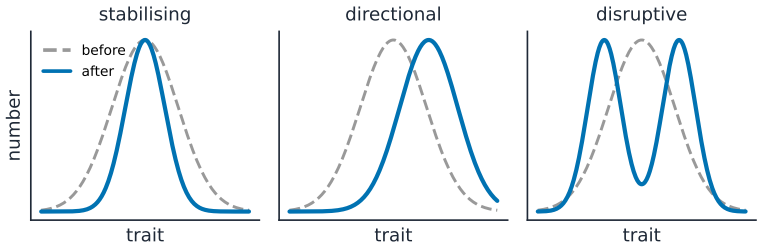
Evolution and DNA evidence

Evolution 进化 is the formation of new **species** 物种 from earlier ones as the **gene pool** 基因库 (all the alleles in a population) changes over generations. **DNA sequence data** shows relationships: the more similar two species' DNA, the more recently they shared a common ancestor.

Speciation



Allopatric speciation needs a physical barrier; sympatric speciation happens in the same area



directional: favors one extreme · stabilising: favors mean · disruptive: favors both extremes

Selection drives evolution and speciation

Speciation happens when two populations become genetically **isolated** 隔离 so they can no longer interbreed:

- **allopatric** 异域 — separated by a **geographical** barrier (sea, mountain).
- **sympatric** 同域 — in the same area, separated by behaviour or way of life.

2 Practice

2.1 Define **evolution** in terms of the gene pool. [2]

2.2 State the difference between allopatric and sympatric speciation. [2]

3 Exam-style questions

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]

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

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]

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]

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

(c) Describe how DNA sequence data could be used to estimate how long ago the two populations began to diverge. [3]

(d) Explain why comparing DNA sequences is better evidence of relatedness than comparing external appearance. [3]

Solutions

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

2.2 allopatric — populations separated by a geographical barrier; sympatric — populations in the same area separated by behaviour/ecology.

3.1 B. Very similar DNA suggests a recent common ancestor.

3.2 A. A geographical barrier causing speciation is allopatric.

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

3.5 (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.
(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.
(c) 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.
(d) 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.