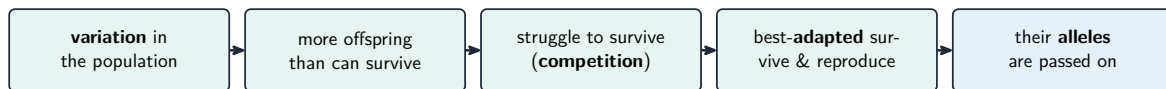


# Natural Selection

## AP Biology

### Introduction to Natural Selection

**Evolution** 进化 is a change in the heritable traits of a population over generations. **Natural selection** 自然选择 is its main driver: individuals vary, some variations are heritable, more offspring are produced than survive, and those with traits better suited to the environment survive and reproduce more. Over time, helpful traits become more common.

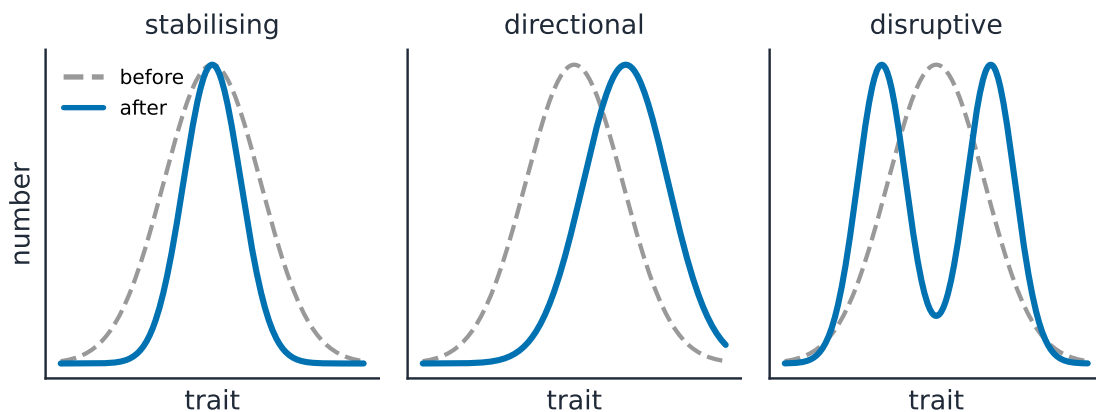


over many generations the population becomes better adapted

*Natural selection: the best-adapted survive, reproduce, and pass on their alleles*

### Natural Selection

Selection acts on **variation** 变异. **Fitness** 适合度 means reproductive success, not strength. Selection comes in modes: **directional** (favors one extreme), **stabilizing** (favors the average), and **disruptive** (favors both extremes). The environment does the "selecting," so a trait that helps in one setting may not in another. Well-suited traits are **adaptations** 适应.

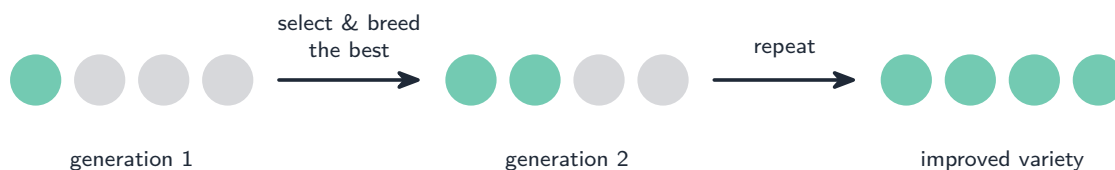


*Stabilising, directional, and disruptive selection*

### Artificial Selection

In **artificial selection** 人工选择, humans –not nature –choose which individuals breed, selecting for desired traits (crops, livestock, dogs). It works the same way as natural

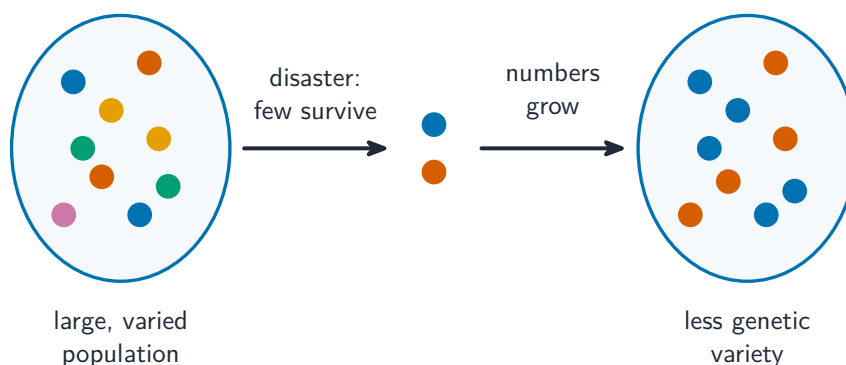
selection and, being fast and visible, is strong evidence that selection can reshape populations.



*Selective breeding makes a wanted feature more common over generations*

## Population Genetics

**Population genetics** 群体遗传学 studies the pool of alleles in a population. Evolution is a change in **allele frequencies** 等位基因频率 over time. Besides natural selection, allele frequencies change through **mutation** (new alleles), **gene flow** 基因流 (migration), and **genetic drift** 遗传漂变 (random change, strongest in small populations –the bottleneck and founder effects).



*A population bottleneck reduces genetic variety*

## Hardy-Weinberg Equilibrium

The **Hardy-Weinberg** 哈迪-温伯格 model gives the allele and genotype frequencies expected when a population is **not** evolving. With allele frequencies  $p$  and  $q$  ( $p + q = 1$ ):

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

where  $p^2$  and  $q^2$  are the homozygotes and  $2pq$  the heterozygotes. It holds only under five conditions (no selection, no mutation, no migration, random mating, large population); when real data differ from the prediction, the population **is** evolving.

**Worked example.** In a population, 16% of individuals show the recessive phenotype, so  $q^2 = 0.16$  and  $q = \sqrt{0.16} = 0.4$ . Then  $p = 1 - q = 0.6$ . The predicted **carrier** frequency

(heterozygotes) is  $2pq = 2(0.6)(0.4) = 0.48$ , i.e. 48%, and the homozygous dominants are  $p^2 = 0.6^2 = 0.36$ , i.e. 36%. As a check,  $0.36 + 0.48 + 0.16 = 1$ . This is the standard route: recessive phenotype  $\rightarrow q^2 \rightarrow q \rightarrow p \rightarrow$  everything else.

## Evidence of Evolution

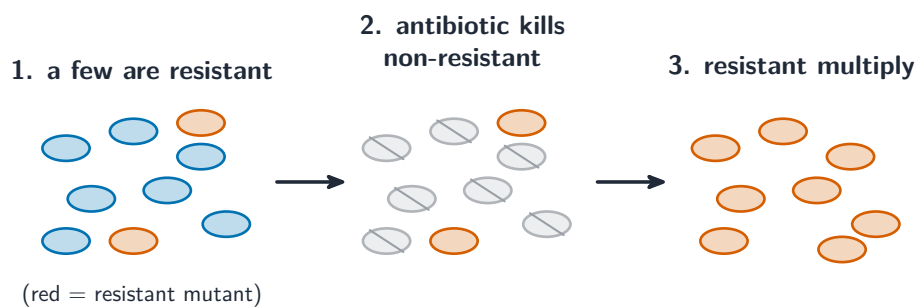
Multiple independent lines support evolution: the **fossil record** 化石记录, **homologous structures** 同源结构 (shared anatomy from common ancestry), **vestigial structures** 痕迹器官, shared **embryology**, and molecular evidence –the near-universal genetic code and matching DNA/protein sequences.

## Common Ancestry

All life shares a **common ancestor** 共同祖先, shown by universal features: the same DNA/RNA machinery, the same genetic code, ribosomes, and core metabolic pathways in all organisms. The more features and sequences two species share, the more recently they diverged.

## Continuing Evolution

Evolution is ongoing and observable: antibiotic-resistant bacteria, pesticide-resistant insects, and rapid changes in fast-breeding species. Because environments keep changing, selection keeps acting –evolution has no endpoint.



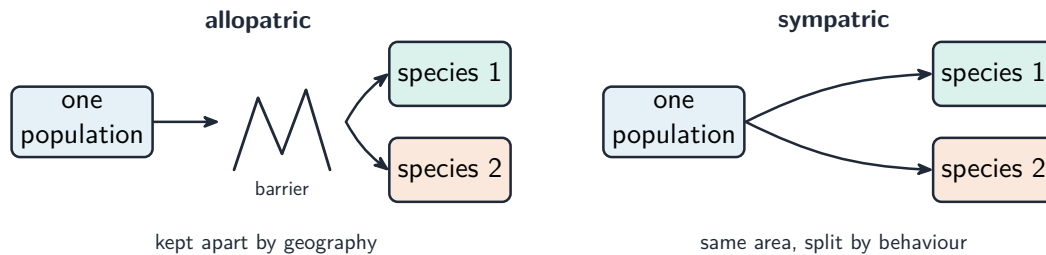
*How antibiotic resistance spreads through a population by natural selection*

## Phylogeny

A **phylogenetic tree** 系统发育树 (cladogram) diagrams evolutionary relationships, with branch points marking common ancestors and shared derived traits grouping related species. Trees are hypotheses, revised as new (especially molecular) data arrive.

# Speciation

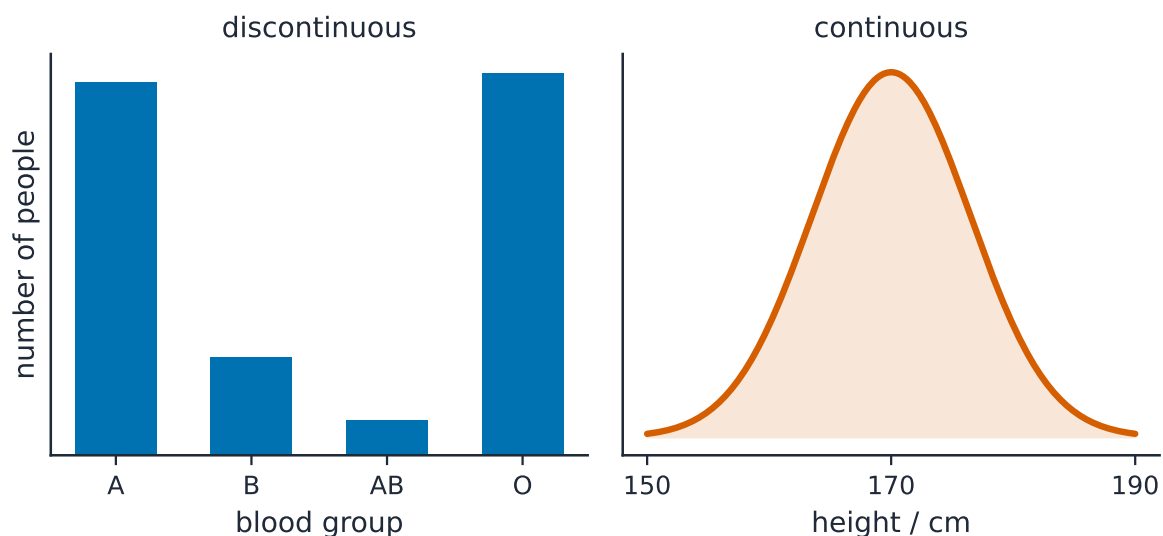
**Speciation** 物种形成 is the origin of new species, usually when populations become **reproductively isolated** 生殖隔离 and diverge. **Allopatric** speciation follows a geographic split; **sympatric** speciation happens without one. Once populations can no longer interbreed, they are separate species.



*Allopatric and sympatric speciation*

# Variations in Populations

Genetic **diversity** 多样性 helps a population survive change –if conditions shift, some variants may already be suited to them. Low diversity (as in an endangered species) leaves a population vulnerable. Variation arises from mutation and the reshuffling of meiosis and sexual reproduction.



*Discontinuous and continuous variation*

# Origins of Life on Earth

Evidence suggests early Earth's conditions could form simple organic molecules (the Miller–Urey type experiments), which assembled into polymers, then self-replicating

**RNA** (the "RNA world"), and eventually membrane-bound cells. The first cells were prokaryotes; eukaryotes arose later through **endosymbiosis** 内共生.

## Exam tips

- State natural selection cleanly: **variation** → **differential survival and reproduction** → **helpful traits become common**.
- **Fitness = reproductive success**, not strength or health.
- Evolution is a change in **allele frequencies** in a **population** —individuals do not evolve.
- Use **Hardy–Weinberg** ( $p^2 + 2pq + q^2 = 1$ ): start from the recessive phenotype  $q^2 \rightarrow q \rightarrow p$ .
- Cite independent **evidence** (fossils, homologous structures, DNA) and explain speciation via reproductive isolation.