

Selection and evolution

A-Level Biology

Variation

Variation 变异 means the differences between individuals. It has three possible causes:

- **genetic** factors only —set by the **alleles** 等位基因 you inherit (for example human blood group).
- **environmental factors** 环境因素 only —set by your surroundings (for example a scar, or the language you speak).
- a **combination** of both —most features, such as height and body mass, depend on genes **and** on diet and lifestyle.

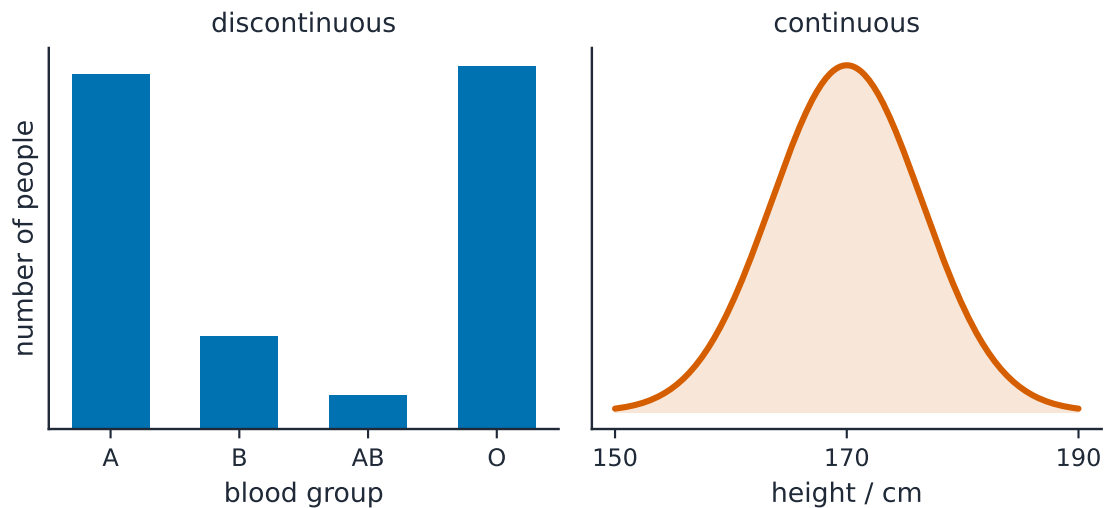


Banded snails (Cepaea nemoralis) show striking variation in shell colour and banding

Image: CC BY-SA 2.0 (commons.wikimedia.org)

There are two patterns of variation:

- **discontinuous variation** 不连续变异—clear, separate groups with nothing in between (for example blood group A, B, AB or O). It is usually controlled by one or a few **genes** 基因, with little effect from the environment.
- **continuous variation** 连续变异—a smooth range from one extreme to the other (for example height). It is controlled by many genes together, plus the environment.



Discontinuous variation 不连续变异 *falls into separate groups*; *continuous variation* 连续变异 *is a smooth range*

To compare the means of two samples (for example the heights of plants in sun and in shade), you use the **t-test**, which tells you whether the difference is large enough to be real, or just due to chance.

Natural selection

A **population** 种群 produces far more **offspring** 后代 than can survive, so the offspring must **compete** 竞争 for resources such as food and space. This is the "struggle for existence". The individuals that are best **adapted** 适应 are most likely to survive, **reproduce** 繁殖, and pass on their alleles to the next generation. Over many generations, the helpful alleles become more common in the population. This is **natural selection** 自然选择.



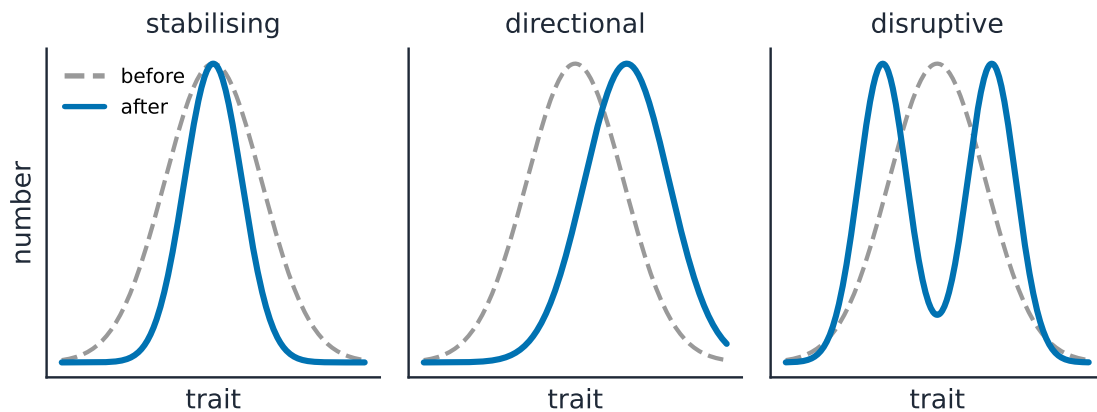
The **peppered moth** 桦尺蛾 shows natural selection: the dark form hides on dark, sooty bark, while the pale speckled form hides on pale **lichen** 地衣—birds eat whichever stands out

Image: Martinowksy at Dutch Wikipedia

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Environmental conditions can push selection in three ways:

- **stabilising selection** 稳定选择 favours the average and removes the extremes (the population stays the same).
- **directional selection** 定向选择 favours one extreme, so the mean shifts that way.
- **disruptive selection** 分裂选择 favours both extremes and removes the average.

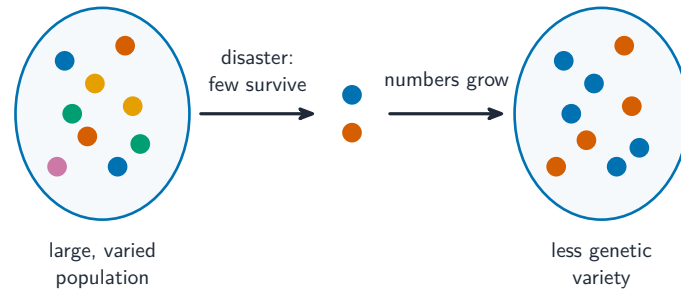


Stabilising 稳定选择 narrows the range, *directional* 定向选择 shifts the mean, *disruptive* 分裂选择 splits it in two

Allele frequencies can also change in other ways:

- the **founder effect** 奠基者效应—a few individuals start a new population, so they carry only some of the alleles of the original group.
- **genetic drift** 遗传漂变—in a small population, allele frequencies change by chance from generation to generation.

- the **bottleneck effect** 瓶颈效应—a sudden fall in population size leaves few survivors, reducing the variety of alleles.



A bottleneck 瓶颈效应: only a few survive a disaster, so the recovered population has less genetic variety

Antibiotic resistance as natural selection

A chance **mutation** 突变 makes a few bacteria **resistant** to an **antibiotic** 抗生素. When the antibiotic is used, the non-resistant bacteria die, but the resistant ones survive and reproduce. Over time the **resistance** 耐药性 spreads through the population. This is natural selection in action.

The Hardy–Weinberg principle

The **Hardy–Weinberg principle** 哈迪-温伯格原理 lets you calculate the **allele frequencies** 等位基因频率 and **genotype** 基因型 frequencies in a population. It only holds true when there is a large population, mating is random, and there is no mutation, no migration and no natural selection.

Selective breeding (artificial selection)

In **selective breeding** 选择育种, also called **artificial selection** 人工选择, humans (not nature) choose which organisms breed, so that useful features are passed on. Examples:

- breeding **disease resistance** 抗病性 into varieties of wheat and rice.
- using **inbreeding** 近交 and **hybridisation** 杂交 (crossing different lines) to make vigorous, uniform maize.
- breeding dairy cattle to improve their milk **yield** 产量.

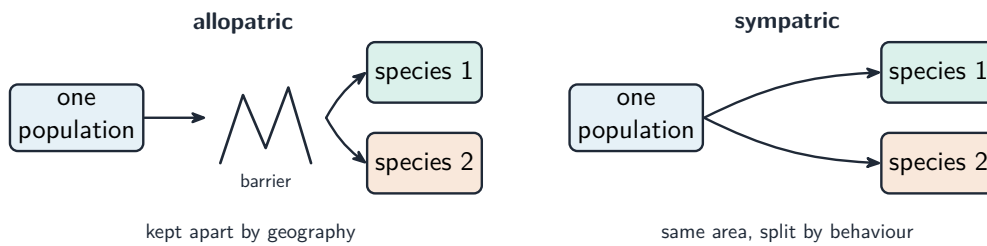
Evolution

Evolution 进化 is the slow formation of new **species** 物种 from earlier ones, as the **gene pool** 基因库 (all the alleles in a population) changes from generation to generation.

DNA **sequence** 序列 data can show how closely related two species are: the more similar their DNA sequences, the more recently they shared a common ancestor.

Speciation 物种形成 happens when two populations become genetically separated, so they can no longer breed together. This genetic **isolation** 隔离 can come about in two ways:

- **allopatric speciation** 异域物种形成—the populations are kept apart by a **geographical separation** 地理隔离, such as a sea or a mountain range.
- **sympatric speciation** 同域物种形成—the populations live in the same area but are separated by differences in behaviour or way of life.



Allopatric speciation 异域物种形成 *needs a physical barrier*; *sympatric speciation* 同域物种形成 *happens in the same area*