A-LEVEL BIOLOGY • EXERCISE SHEET

17.1 Variation

Name: _____ Class: _____ Date: _____ **Total: 22 marks**

KEY WORDS variation 变异 • genetic 遗传 • continuous 连续 • discontinuous 不连续 • continuous variation 连续变异

Objective

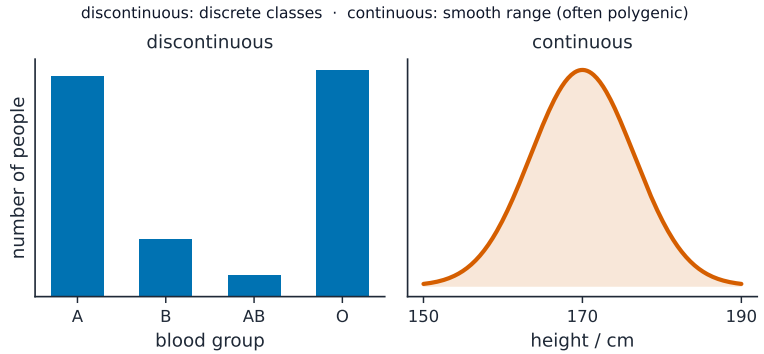
Build the skills to answer exam questions on **variation** — **genetic** 遗传 and **environmental** 环境 causes, **continuous** 连续 and **discontinuous** 不连续 variation, and comparing samples with the **t-test**.

You must be able to:

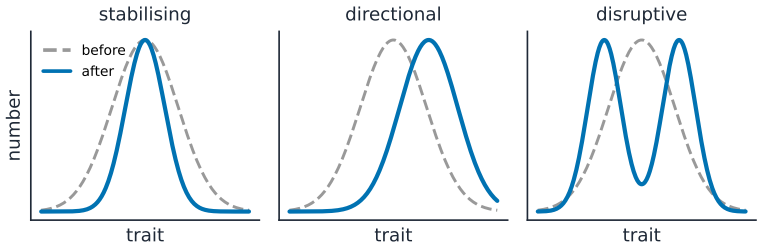
- explain genetic, environmental and combined causes of phenotypic variation
- explain continuous and discontinuous variation and their genetic basis
- use a t-test to compare the means of two samples

1 Worked examples

Causes and patterns of variation



Discontinuous variation falls into separate groups; continuous variation is a smooth range



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

Variation is acted on by the types of selection

- **genetic only** — set by alleles (e.g. blood group); **environmental only** — set by surroundings (e.g. a scar); most features are a **combination** (e.g. height).
- **discontinuous**: separate categories, controlled by one or a few **genes** 基因, little environmental effect.
- **continuous**: a smooth range, controlled by **many genes** plus the environment.

The t-test

The **t-test** compares the **means** of two samples to see whether their difference is real or just chance. A large t (beyond the critical value) means the difference is significant; a small t means it could be due to chance.

2 Practice

2.1 State whether each is continuous or discontinuous variation: human height; ABO blood group. [2]

2.2 Give **one** example of a feature caused by both genes and the environment. [1]

3 Exam-style questions

3.1 Which feature shows discontinuous variation? [1]

- **A** body mass
- **B** ABO blood group
- **C** height
- **D** skin colour

3.2 Continuous variation is usually caused by: [1]

- **A** a single gene only
- **B** many genes together, plus the environment
- **C** the environment only
- **D** a chromosome mutation

3.3 A student measures the heights of plants grown in sun and in shade and wants to know if the difference in mean height is significant.

(a) Name a statistical test the student should use. [1]

(b) The calculated t value is greater than the critical value at $p = 0.05$. State what this tells the student. [2]

3.4 Explain why two genetically identical plants can still differ in height. [2]

3.5 A student measured the height of 100 plants of one species growing in a field, and the number of plants of each of four flower colours.

(a) State, with a reason, whether height and flower colour show continuous or discontinuous variation. [4]

(b) Describe the causes of the variation in each characteristic. [3]

(c) The heights gave a mean of 42.0 cm and a standard deviation of 6.0 cm. Explain what the standard deviation tells you, and state approximately what percentage of the plants lie between 36.0 cm and 48.0 cm. [3]

(d) Explain why a t-test, rather than a comparison of means alone, would be used to compare this field with a second one. [2]

Solutions

2.1 height — continuous; ABO blood group — discontinuous.

2.2 e.g. height / body mass / skin colour.

3.1 B. ABO blood group falls into separate categories.

3.2 B. Continuous variation is polygenic and affected by the environment.

3.3 (a) the t-test.
(b) the difference between the means is significant; it is unlikely (less than 5% probability) to be due to chance.

3.4 the environment differs (e.g. light, water, minerals); environmental factors affect the phenotype as well as the genes.

3.5 (a) Height is **continuous** — any value within a range is possible, and the data form a smooth distribution with no distinct categories. Flower colour is **discontinuous** — each plant falls into one of a few distinct categories with nothing in between.
(b) Height is **polygenic**, controlled by many genes each of small effect, and it is strongly affected by the environment — light, water and minerals. Flower colour is controlled by one gene, or very few, with little or no environmental influence.
(c) The standard deviation measures the **spread** of the values about the mean — a small value means the plants are closely grouped. 36.0 to 48.0 cm is one standard deviation either side of the mean; for a normal distribution that contains about **68%** of the plants.
(d) The two samples will almost always have slightly different means by chance alone; the *t*-test uses the spread and the sample size to say whether the difference is larger than chance would explain, i.e. whether it is statistically significant.