Variation

4.6.2.1 · Biology · revision notes

Variation is the differences in characteristics between individuals, caused by genes, the environment or both. You need to know that all genetic variants arise from mutations and how the genome and the environment together shape the phenotype. It is often tested with data on twins or plants grown in different conditions.

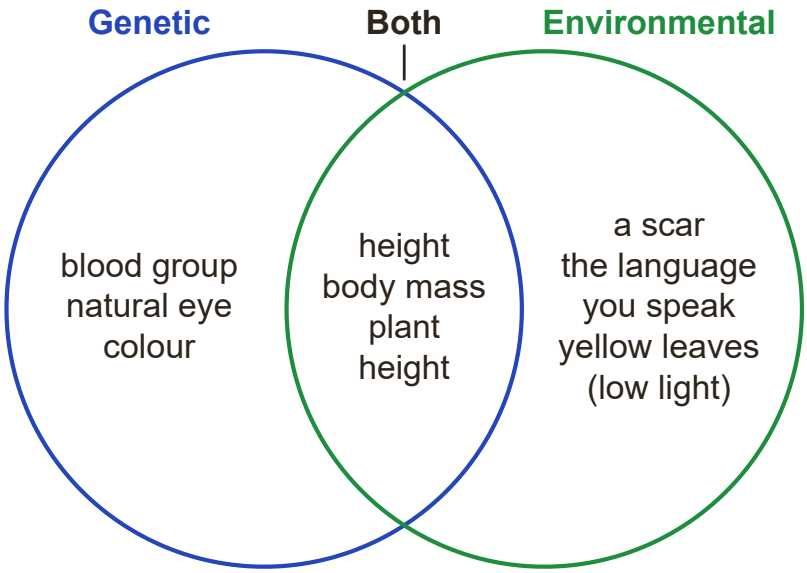
Key facts

- Variation = differences in the characteristics of individuals in a population
- Genome + environment → phenotype
- Mutation = a change in the DNA. All variants arise from mutations, which occur continuously
- A rare new phenotype suited to an environmental change → relatively rapid change in the species
- Causes: genetic, environmental, or a combination
- There is usually extensive genetic variation within a population
- Most mutations have no effect on the phenotype; some influence it; very few determine it
- Identical twins have the same genes, so their differences are environmental

Notes

Causes of variation

- **Variation** is the differences in the characteristics of individuals in a population.
- It may be due to differences in the **genes** they have inherited (genetic causes), the **conditions** in which they have developed (environmental causes), or a **combination** of genes and the environment.
- Genetic examples: blood group, natural eye colour.
- Environmental examples: a scar, the language you speak, a plant's leaves turning yellow because of a lack of light.
- Both: human height and body mass; the height of a plant, which depends on its genes and on light, water and mineral ions.



Causes of variation: genes, environment, or both.

- Your **genome** sets what is possible; your **environment** affects how those genes develop into your **phenotype**.

Mutations and variants

- There is usually **extensive genetic variation** within a population of a species.
- All genetic variants arise from **mutations** (changes in the DNA base sequence), which occur continuously.
- **Most** variants have **no effect** on the phenotype; **some influence** the phenotype; **very few determine** the phenotype.
- Very rarely a mutation leads to a **new phenotype**. If the new phenotype suits a change in the environment, it can lead to a **relatively rapid change** in the species.

Separating genes from environment

- Identical twins have the same genes, so any differences between them are caused by the environment.
- Non-identical twins have different genes, so they usually differ more.
- In plants, grow genetically identical plants (clones) in different conditions: any differences must be caused by the environment.

How to answer each type of question

Classify variation as genetic, environmental or both

1 to 3 marks | **Grade 4**

1. Ask: can this change during life because of conditions? If yes, the environment plays a part.
2. Ask: is it inherited? If yes, genes play a part.
3. Most measurable features, such as height and mass, are caused by both.

Example. Give the cause of each of these types of variation: genetic, environmental or both.
(a) A person's blood group
(b) A scar on a person's arm
(c) A person's body mass [3 marks]

Model answer.

(a) Genetic (1)
(b) Environmental (1)
(c) Both (1)

Explain the role of mutations

2 to 3 marks | **Grade 5**

1. All variants arise from mutations.
2. Most have no effect, some influence and very few determine the phenotype.
3. A rare new phenotype can spread quickly if it suits a change in the environment.

Example. Mutations happen all the time, but most mutations do not change an organism's phenotype. Explain how a mutation can occasionally lead to a rapid change in a species. [3 marks]

Model answer. Very rarely a mutation produces a new phenotype (1). If the environment changes and the new phenotype is suited to the new conditions, those individuals are more likely to survive and reproduce (1). So the allele is passed on and becomes common in the population relatively quickly (1).

Use twin or clone data

2 to 4 marks | **Grade 5**

1. State that identical twins (or clones) have identical genes.
2. So any differences between them must be caused by the environment.
3. Compare with non-identical twins: bigger differences show that genes also play a part.
4. Quote numbers from the data.

Example. Scientists measured the difference in body mass between the two people in pairs of adult twins. The table shows the results.

Type of twins	Mean difference in body mass in kg
Identical	4.1
Non-identical	9.6

What do these results suggest about the causes of variation in body mass? Explain your answer. [3 marks]

Model answer. Identical twins have the same genes, so their 4.1 kg difference must be caused by the environment, e.g. diet or exercise (1). Non-identical twins differ more (9.6 kg) because they also have different genes (1). So body mass is affected by both genes and the environment (1).

Don't lose marks

- ✕ Saying variation is only caused by genes. Many characteristics depend on both genes and the environment.
- ✕ Saying mutations are always harmful. Most have no effect on the phenotype.
- ✕ Saying identical twins have no variation. They can differ because of their environment.
- ✕ Classifying height or body mass as purely genetic.

More tips

Memory tricks

- Mutation effects from most to fewest: no effect → influence → determine (most, some, very few).
- Could it change during your life? Then the environment plays a part.
- Twins test: identical twins have the same genes, so any difference is environmental.

Exam technique

- In data questions, quote numbers and say what they show about genes compared with the environment.
- Use the words genotype, phenotype and environment accurately.
- When explaining a rapid change in a species, link mutation → new phenotype → suits a changed environment → natural selection.

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 3

Define variation

Differences in the characteristics of individuals in a population.

Grade 4

Classify causes of variation

Genetic (genes inherited), environmental (conditions of development) or a combination of both.

Grade 5

Give examples of each cause

Blood group is genetic, a scar is environmental, and body mass depends on both.

Grade 5

State that populations show genetic variation

There is usually extensive genetic variation within a population of a species.

Grade 5

Describe how mutations affect phenotype

All variants arise from mutations: most have no effect on the phenotype, some influence it and very few determine it.

Grade 5

Use twin or clone data

Identical twins and clones have the same genes, so differences between them are caused by the environment.

Grade 5

Explain how a mutation can change a species

A rare new phenotype that suits an environmental change can spread relatively quickly by natural selection.

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