

Variation and evolution

Revision notes • Causes of variation, evolution by natural selection, selective breeding, genetic engineering and cloning.

For AQA GCSE Biology 8461 and Combined Science: Trilogy 8464. **Triple only** is not in Combined Science. **Higher tier** is only on the Higher paper.

Variation and evolution Spec 4.6.2

Variation Spec 4.6.2.1

Differences in the characteristics of individuals in a population are called **variation**. Variation may be due to differences in:

- the genes they have inherited (genetic causes)
- the conditions in which they have developed (environmental causes)
- a combination of genes and the environment.

The phenotype of an organism develops from its genome and the way the genome **interacts with the environment**.

Causes of variation	
Cause	Examples
Genetic	Eye colour, blood group
Environmental	A scar from an injury; a plant that grows poorly in poor soil
Both	Body mass or height: genes set a potential, but diet and lifestyle affect what is reached

Mutations

There is usually extensive genetic variation within a population of a species. All variants arise from **mutations**. Of these:

- most have **no effect** on the phenotype
- some **influence** the phenotype
- very few **determine** the phenotype.

Mutations occur continuously. Very rarely a mutation leads to a new phenotype. If the new phenotype is suited to an environmental change, it can lead to a relatively rapid change in the species.

Exam tip: 'Mutation' is the only source of new variants. Sexual reproduction shuffles existing alleles into new combinations, but mutations are where new alleles come from.

Evolution Spec 4.6.2.2

Evolution	A change in the inherited characteristics of a population over time through a process of natural selection, which may result in the formation of a new species.
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The theory of evolution by natural selection states that all species of living things have evolved from simple life forms that first developed more than **three billion years ago**.

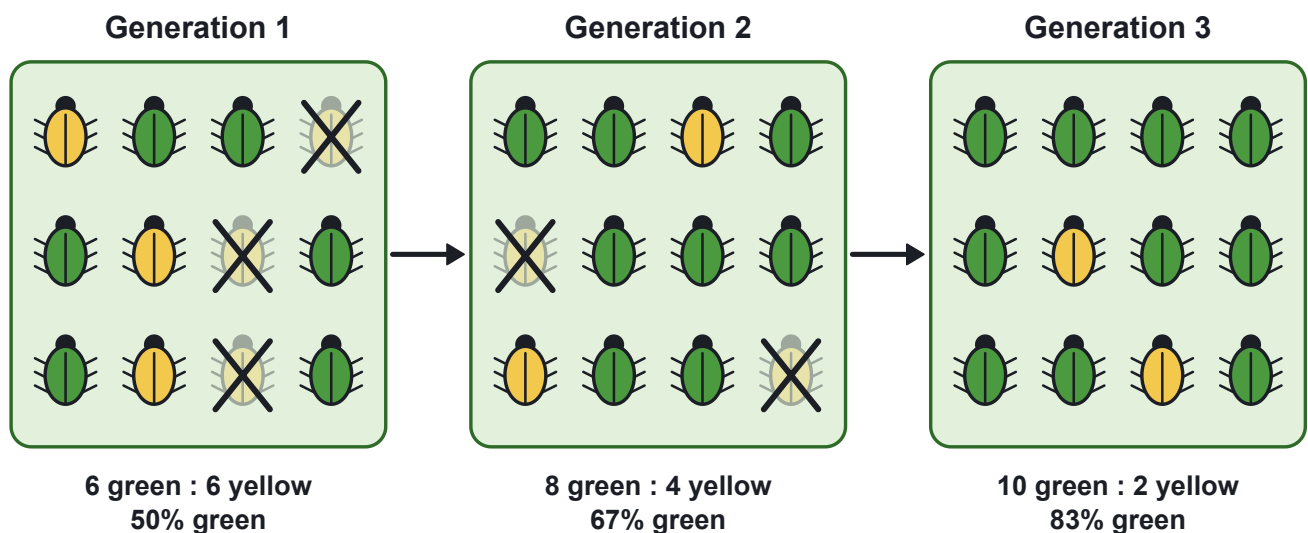
How natural selection works

1. Individuals in a population show variation in their phenotypes, caused by differences in their genes.
2. The environment puts pressure on the population. For example, there may be predators, disease or competition for food.
3. Individuals with phenotypes **best suited** to their environment are more likely to **survive and breed**.
4. They pass on the alleles for the useful characteristic to their offspring.
5. Over many generations, a greater proportion of the population has the characteristic.

New species

If two populations of one species become so different in phenotype that they can no longer **interbreed to produce fertile offspring**, they have formed two new species.

Common mistake: Individuals do not 'adapt' or 'evolve' during their lives. Populations evolve, because the better-suited variants survive and reproduce. Do not write that organisms 'need' a characteristic so they develop it.



= eaten by birds. Yellow beetles are easier to see on green leaves, so they are more likely to be eaten. Green beetles are more likely to survive, breed and pass on their alleles, so the proportion of green beetles rises.

Better-suited individuals are more likely to **survive and breed**, so their alleles become more common in each generation.

Selective breeding Spec 4.6.2.3

Selective breeding (artificial selection) is the process by which humans breed plants and animals for particular genetic characteristics. Humans have been doing this for thousands of years, since they first bred food crops from wild plants and domesticated animals.

1. Choose parents with the **desired characteristic** from a mixed population.
2. Breed them together.
3. From the offspring, choose those with the desired characteristic and breed them together.
4. Continue over **many generations** until all the offspring show the desired characteristic.

The characteristic can be chosen for usefulness or appearance. Examples:

- disease resistance in food crops
- animals which produce more meat or milk
- domestic dogs with a gentle nature
- large or unusual flowers.

Impact of selective breeding

Benefits and risks	
Benefits	Risks
Crops and animals that give higher yields of food	Can lead to inbreeding , where some breeds are particularly prone to disease or inherited defects
Disease-resistant crops	Reduces the number of different alleles in the population, because only a few individuals are bred
Animals or plants with useful or attractive features	Some people have ethical objections to animals being bred for human use

Exam tip: Always say what is selected and what happens next: 'select the cows that give most milk, breed them, select the best of the offspring, repeat over many generations'.

Genetic engineering Spec 4.6.2.4

Genetic engineering	A process which involves modifying the genome of an organism by introducing a gene from another organism to give a desired characteristic.
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In genetic engineering, genes from the chromosomes of humans and other organisms can be 'cut out' and transferred to cells of other organisms.

- Plant crops have been genetically engineered to be resistant to diseases or to produce bigger, better fruits.
- Bacterial cells have been genetically engineered to produce useful substances such as **human insulin** to treat diabetes.

Crops that have had their genes modified in this way are called **genetically modified (GM) crops**. GM crops include ones that are resistant to insect attack or to herbicides. GM crops generally show increased yields.

Benefits, risks and objections

Genetic engineering in agriculture and medicine		
	Potential benefits	Potential risks and objections
Agriculture	Increased yields; resistance to insects, herbicides or disease; bigger, better fruits	Effects on populations of wild flowers and insects; some people feel the effects of eating GM crops on human health have not been fully explored
Medicine	Bacteria can make useful substances such as human insulin; research is exploring genetic modification to overcome some inherited disorders	Some people object to altering the genes of organisms, especially humans; long-term effects may not be known

Some people have objections to genetic engineering, even though it has huge potential benefits.

Higher tier

The main steps in genetic engineering

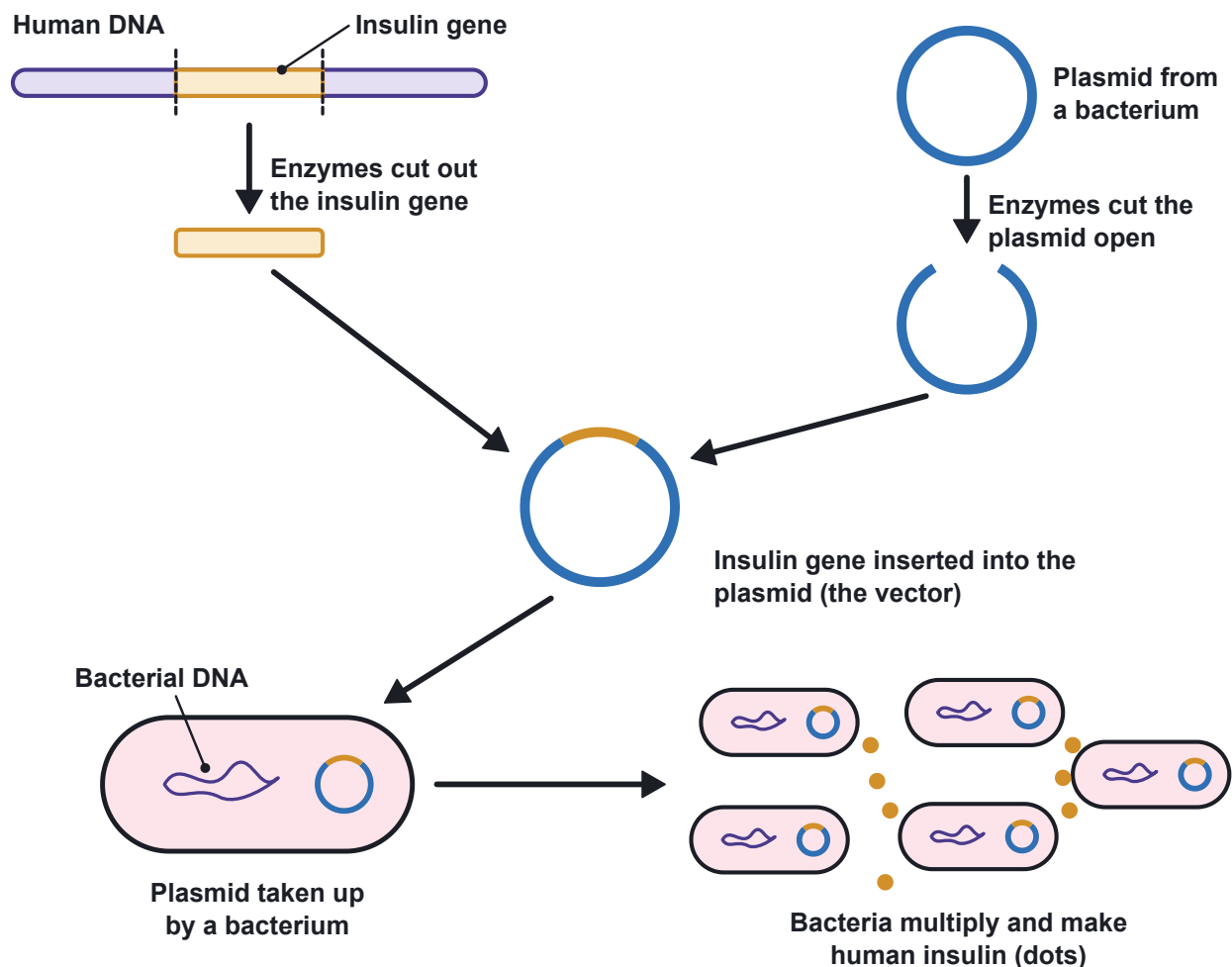
Higher tier

1. **Enzymes** are used to isolate the required gene.
2. The gene is inserted into a **vector**, usually a bacterial plasmid or a virus.
3. The vector is used to insert the gene into the required cells.
4. Genes are transferred to the cells of animals, plants or microorganisms at an **early stage in their development**, so that they develop with the desired characteristics.

Higher tier

Exam tip: Use the key words in order: enzymes isolate the gene, the gene goes into a vector (plasmid or virus), the vector puts it into the cells, at an early stage of development.

Higher tier



Enzymes isolate the gene, a **plasmid (vector)** carries it into a bacterium, and the bacteria multiply and make **human insulin**.

Cloning Spec 4.6.2.5 Triple only

Methods of cloning		
Method	What happens	Used for
Tissue culture	Small groups of cells from part of a plant are used to grow identical new plants	Preserving rare plant species; commercially in nurseries
Cuttings	An older, but simple, method: a piece of the parent plant is used to grow a new plant	Gardeners producing many identical new plants from a parent plant
Embryo transplants	Cells from a developing animal embryo are split apart before they become specialised, then the identical embryos are transplanted into host mothers	Producing several identical animals
Adult cell cloning	See the steps below	Producing an animal with the same genes as an adult

Adult cell cloning

1. The **nucleus is removed** from an unfertilised egg cell.
2. The nucleus from an **adult body cell**, such as a skin cell, is inserted into the egg cell.
3. An **electric shock** stimulates the egg cell to divide to form an embryo.
4. These embryo cells contain the same genetic information as the adult skin cell.
5. When the embryo has developed into a ball of cells, it is **inserted into the womb** of an adult female to continue its development.

Benefits, risks and objections

Cloning in agriculture and medicine	
Potential benefits	Potential risks and objections
Many identical copies of plants or animals with a useful characteristic can be produced	Clones have the same genes, so there is less genetic variation and a single disease could affect them all
Rare plant species can be preserved	Some people have ethical objections to cloning animals
Plants can be produced quickly and cheaply, all with the desired characteristic	Cloned animals may be less healthy than normally produced animals

Exam tip: Adult cell cloning: the nucleus comes from the adult body cell, and the egg cell has its own nucleus removed. If you mix these up you lose the marks.

Quick check

1. Give the three possible causes of variation.
2. What do all variants arise from?
3. When have two populations become two new species?
4. Name one problem caused by selective breeding.
5. What is a GM crop?

Quick check answers

Variation and evolution

1. Genetic causes, environmental causes, or a combination of genes and the environment.
2. Mutations.
3. When they are so different in phenotype that they can no longer interbreed to produce fertile offspring.
4. Inbreeding, where some breeds are prone to disease or inherited defects.
5. A crop that has had its genes modified by genetic engineering.