

WJEC (Wales) Biology GCSE

Topic 2.4: Variation and Evolution

Notes

(‘Higher Tier only’ in **bold**)



Variation

Types of variation

Variation can be due to **genetics** or the **environment**.

Variation	Description
Genetic	Differences in the genotypes of organisms of the same species due to the presence of different alleles . It creates differences in phenotypes .
Environmental	Differences in phenotype that are acquired during the lifespan of an organism due to environmental factors e.g. diet, lifestyle, climate, exposure to light etc.

Some variation may be due to a **combination** of both genetics and the environment e.g. an individual's genes may make them predisposed to being tall, however, lack of nourishment during childhood may stunt growth.

There are two types of variation: **continuous** and **discontinuous**.

Variation	Description
Continuous	Produces characteristics which do not fall into distinct categories, instead showing a continuous range e.g. height, weight.
Discontinuous	Produces characteristics that fall into distinct categories e.g. gender, eye colour, blood group.

Genetic variation

Genetic variation can be due to **sexual reproduction** or **spontaneous mutations**.

Sexual reproduction

Sexual reproduction creates **genetic variation** in organisms.

Meiosis produces genetically different **gametes** (half the number of chromosomes). During fertilisation, one gamete from each parent fuses to form a **zygote** (full set of chromosomes). Genetic information from both parents is **mixed** to form a **unique** individual.

Asexual reproduction does **not** create genetic variation as it involves **mitosis** which produces genetically identical daughter cells known as **clones**.



Spontaneous mutations

A **mutation** is a random change to the base sequence in DNA which results in genetic variants. These changes can occur due to a variety of factors, including exposure to some **chemicals** and **ionising radiation**.

A gene mutation may affect an organism's phenotype:

- **Neutral mutation** does not change the sequence of amino acids. Protein structure and function remain the same. No effect on phenotype.
- Mutation may cause a **minor change** in an organism's phenotype e.g. change in eye colour.
- Mutation may **completely change** the sequence of amino acids. This could result in a **non-functional protein** and severe changes to phenotype.

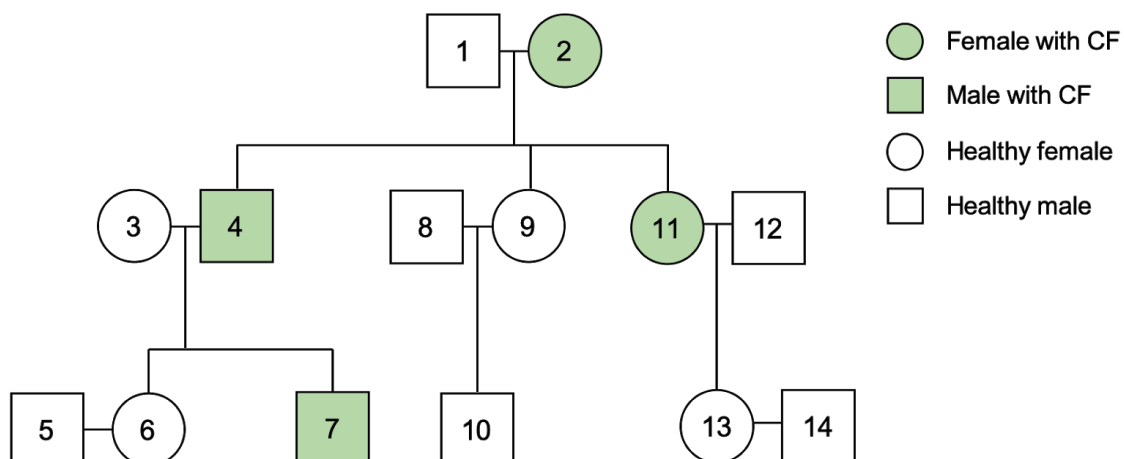
Inherited disease

Mutations may result in the formation of **harmful alleles**. If these alleles are present in an organism's sex cells (gametes) they may be **inherited** by offspring.

Cystic fibrosis is a **recessive** condition resulting in the production of sticky mucus that affects the lungs and digestive system.

Genotype	Description
FF	Healthy phenotype
Ff	Healthy phenotype. Carrier , can pass on the harmful allele to offspring.
ff	Cystic fibrosis phenotype

The inheritance of heritable diseases such as cystic fibrosis can be investigated using **family trees**.



- Individuals 2, 4, 7 and 11 have cystic fibrosis so must have the genotype ff



- If an individual has cystic fibrosis their parents must each carry at least one recessive allele
∴ individuals 1 and 3 must be carriers and have the genotype Ff.
- If individual 3 is heterozygous and individual 4 is homozygous, individual 6 must be a carrier and have the genotype Ff.
- If individual 11 has cystic fibrosis, their offspring 13 must be a carrier of the recessive allele and have the genotype Ff.
- We do not know whether individuals 9, 12 and 10 have the genotypes FF or Ff.

Gene therapy

Gene therapy refers to a number of techniques used to counteract the effects of a defective allele within DNA.

There are two methods of gene therapy:

- Insertion of a functional allele into DNA which replaces the faulty allele. A healthy dominant allele can counteract the recessive faulty allele.
- 'Turning off' the faulty allele.

There are ethical issues surrounding the use of gene therapy:

- Expensive - money could be better invested elsewhere.
- Religious objections to genetic manipulation.
- Health implications - new gene may have unintended side effects, e.g: an immune response.

Evolution

Natural selection

Evolution is the gradual change in the inherited traits within a population over time. It occurs due to natural selection:

1. Genetic variation exists due to spontaneous mutations
2. Competition between organisms (as limited resources)
3. A mutation may give an organism a selective advantage
4. Organism is better adapted to the environment and survives
5. Organism reproduces, passing on its beneficial alleles
6. Frequency of advantageous alleles increase



The theory of natural selection was proposed by **Charles Darwin** and **Alfred Russel Wallace**.

Wallace proposed a theory of natural selection that was similar to Darwin's and gathered **greater evidence** to support the theory. **Darwin** and **Wallace** worked together and published their ideas in the scientific literature.

Darwin studied a variety of organisms whilst travelling on the **HMS Beagle**. He noted that traits could be passed from **parents to offspring** and proposed the idea of '**survival of the fittest**'. He established the theory of natural selection and published his ideas in '**On the Origin of Species**'.

Extinction

When a species becomes **extinct**, all members of the species have died. This can happen because:

- Organisms are **not adapted** to their environment.
- Organisms have not adapted **rapidly enough** to **changing environmental conditions**.
- **Outcompeted** by better adapted species.

Modelling natural selection

Artificial models can be used to represent **natural selection**. In this example different coloured squares of paper are used to illustrate the effect of **camouflage** on predation:

1. Take a large piece of blue paper (background).
2. Disperse an equal number of smaller squares of blue and white paper across the paper background
(**smaller squares represent prey populations**).
3. Set a stopwatch for 30s and instruct a volunteer to collect as many squares as possible
(**volunteer represents predator**).
4. Record the number of blue and white squares remaining.
5. Repeat three times.

The white squares will be easier to spot than the blue squares (which are camouflaged against the blue background). By the end of the experiment, it would be expected that only blue straws remain.



However, there are **limitations** of this method:

Model	Reality
Straws do not move	Prey move - speed affects likelihood of capture
Extreme difference in straw colours	Prey more similar in colour
Paper is one colour	Environment is not one colour
Potential bias by volunteer	No bias
Not affected by other factors	Other factors affect survival

Modern day evolution

Examples of modern day evolution include:

- **Antibiotic-resistant bacteria**
- **Pesticide resistance**
- **Warfarin-resistant rats**

Antibiotic resistance

The development of **antibiotic resistance** is a good study for evolution; bacteria reproduce very rapidly, allowing the first-hand observation of evolution.

1. **Genetic variation** exists due to **spontaneous mutations**.
2. A mutation may give a bacterium **antibiotic-resistance**.
3. If an antibiotic is administered, the bacterium is **better adapted** and **survives**.
4. Bacterium reproduces, **passing on its resistant variant**.
5. **Frequency** of antibiotic-resistant allele **increases**.

Bacterial resistance to antibiotics is increasing due to **overprescription** and **antibiotic misuse** (e.g. not completing the entire course).

The Human Genome Project

The **Human Genome Project** was a scientific research project involving thousands of scientists across the globe which successfully **mapped** the **entire human genome**. Its results are extremely important for future medicine:

- Enables scientists to understand how **lifestyle factors** **interact** with **genes**, allowing the identification of possible **predisposition** to disease and potential preventions.



- Disease-causing alleles identified more rapidly and the appropriate treatments prescribed earlier on.
- Scientists can predict an individual's response to certain drugs. New drugs can be developed which are tailored to a specific allele.

Scientists now aim to identify the function of every gene in the human genome.

