B6: Inheritance, Variation and Evolution

AQA · GCSE Biology · Revision Notes

Specification reference: 4.6

Note: Sections marked ★ HIGHER TIER ONLY are for Higher tier students only. Foundation tier students should focus on the unmarked sections.

4.6.1 Reproduction

4.6.1.1–3 Sexual and Asexual Reproduction

Sexual reproduction involves two parents, fusion of gametes (sex cells), and produces genetically different offspring. Asexual reproduction involves one parent and produces genetically identical offspring (clones).

- Advantages of sexual reproduction: genetic variation helps species survive environmental change.
- Advantages of asexual reproduction: fast, energy-efficient, all offspring can reproduce.
- Many organisms can do BOTH (e.g. strawberry plants reproduce asexually by runners AND sexually by seeds).

4.6.1.2 Meiosis

Meiosis is the type of cell division used to produce gametes (sex cells: sperm, eggs, pollen). It produces 4 genetically **different** (non-identical) haploid cells.

- Chromosomes are copied, then the cell divides TWICE.
- Each daughter cell contains half the number of chromosomes (23 in humans — haploid).
- Genetic variation occurs because chromosomes shuffle before separating.

Exam Tip: Meiosis = sex cells (gametes). Mitosis = body cells (growth/repair). Remember: MEiosis MEans sEx cells.

4.6.2–3 Genetics

4.6.2–3 DNA, Genes and Inheritance

DNA is a double helix made of two strands. Each strand has bases: A, T, C, G. A pairs with T; C pairs with G. A gene is a section of DNA coding for a protein (sequence of amino acids).

- **Alleles** — different versions of the same gene (e.g. the eye colour gene has alleles for brown or blue).
- **Dominant allele** — always expressed, even with one copy (usually written as capital letter, e.g. B).
- **Recessive allele** — only expressed when two copies are present (written as lowercase, e.g. b).
- **Homozygous** — two identical alleles (BB or bb).
- **Heterozygous** — two different alleles (Bb).
- **Genotype** — the alleles an organism carries (e.g. Bb).
- **Phenotype** — the physical characteristic shown (e.g. brown eyes).

Punnett squares are used to predict the probability of offspring genotypes and phenotypes in genetic crosses.

Exam Tip: In a monohybrid cross between two heterozygous parents (Bb x Bb), the ratio is 3 dominant : 1 recessive.

4.6.3.3 Inherited Disorders

- **Polydactyly** — extra fingers/toes; caused by a **dominant** allele. Only one copy needed to show the condition.
- **Cystic fibrosis** — thick mucus in lungs and gut; caused by a **recessive** allele. Both parents can be carriers (Ff) without showing symptoms.

Key Terms

Carrier: A person who has one recessive allele for a disorder but does not show symptoms (Ff)

Embryo screening: Testing embryos for genetic disorders before implantation (used in IVF)

4.6.3 Sex Determination

Sex is determined by sex chromosomes: females are **XX**, males are **XY**. Each parent passes on one sex chromosome to the child. There is a 50% chance of having a boy or girl.

★ HIGHER TIER ONLY — DNA and Protein Synthesis

- DNA is made of nucleotides, each with a sugar, phosphate, and base (A, T, C, G).
- Each gene codes for a protein by determining the order of amino acids.
- Transcription: DNA is copied into mRNA (messenger RNA) in the nucleus.
- Translation: mRNA leaves the nucleus; ribosomes read the codons (3-base sequences) and assemble amino acids into a protein.
- Mutation: a change in the sequence of DNA bases. Can alter the protein produced.

4.6.4 Classification

Living organisms are classified into groups based on their similarities and differences. The classification system: **Kingdom** → **Phylum** → **Class** → **Order** → **Family** → **Genus** → **Species**.

Carl Woese introduced a three-domain system: Archaea, Bacteria, Eukarya. Evolutionary trees show how species are related based on shared characteristics and DNA evidence.

4.6.5 Evolution

4.6.5.1 Evidence for Evolution

- **Fossil record** — fossils show how species have changed over millions of years.
- **Antibiotic resistance** — bacteria evolving resistance is evolution by natural selection happening now.
- **DNA evidence** — species with similar DNA are more closely related.

4.6.5.2 Natural Selection

Charles Darwin's theory of natural selection explains how species change over time.

- 1. Individuals in a population show **variation** (due to mutation and genetic differences).
- 2. There is **competition** for limited resources (food, mates, space).
- 3. Individuals best adapted to the environment are more likely to **survive and reproduce**.
- 4. They pass on their **advantageous alleles** to offspring.
- 5. Over many generations, the frequency of beneficial alleles increases in the population.

Exam Tip: Key phrase: "Survival of the fittest" — but "fittest" means BEST ADAPTED to the environment, not strongest.

4.6.5.2 Selective Breeding

Selective breeding (artificial selection) is when humans choose individuals with desired characteristics to breed. Examples: high-yield crops, disease-resistant plants, docile farm animals, fast racehorses.

★ HIGHER TIER ONLY — Genetic Engineering

- Genetic engineering involves inserting a gene from one organism into another.
- Stages: the desired gene is cut out using restriction enzymes. It is inserted into a vector (usually a plasmid). The plasmid is put into the host organism's cells.
- Examples: bacteria engineered to produce human insulin; GM crops resistant to herbicides or producing higher yields.
- Issues: concerns about allergies, ethics, unknown ecological effects of GM organisms.

★ HIGHER TIER ONLY — Cloning

- Tissue culture: plant cells from a shoot tip are grown in sterile conditions to produce many identical plants.
- Embryo transplanting: an embryo is split early on; identical copies are placed in surrogate mothers.
- Adult cell cloning (e.g. Dolly the sheep): nucleus from an adult cell is placed in an enucleated egg cell. Embryo implanted in surrogate mother. Clone has identical DNA to the adult cell donor.

4.6.6 Darwin and Wallace / Speciation

Darwin and Alfred Russel Wallace independently developed the theory of evolution by natural selection. Initially resisted because: it challenged religious views, insufficient evidence at the time, no known mechanism for inheritance.

Speciation: when two populations of a species become isolated (e.g. by a geographical barrier), they evolve separately through natural selection. Eventually they become so different they can no longer interbreed — a new species has formed.