

These notes explain the **why** behind every concept, not just the what. They include **analogies**, **real-life examples**, and explanations of **common mistakes**. Use these alongside your revision notes for full understanding.

4.6.1 Reproduction — Passing on Genetic Information

Reproduction is how species continue to exist. There are two fundamentally different ways to reproduce, and each has different consequences for the genetic diversity of the offspring.

- **Asexual reproduction** requires only one parent and produces genetically identical offspring (clones). Examples: bacteria dividing, strawberry plants producing runners, aphids reproducing in summer.
- **Sexual reproduction** requires two parents and combines their genetic material. This produces offspring that are genetically unique — not identical to either parent.

■ **Why does this happen?** Why has sexual reproduction evolved if asexual reproduction is faster and more efficient? Sexual reproduction creates genetic variation, which is essential for species to adapt to changing environments. A genetically diverse population is more likely to contain some individuals who can survive a new disease or environmental change. Asexual populations are vulnerable — if one individual is susceptible to a new pathogen, they all are.

Meiosis — The Division That Creates Gametes

Gametes (sex cells: sperm and eggs in animals; pollen and ovules in plants) are produced by meiosis. Unlike mitosis (which produces identical diploid cells), meiosis produces four genetically different haploid cells — each containing only 23 chromosomes (in humans), not the usual 46.

■ **Think of it like this:** Imagine shuffling a deck of cards (your 46 chromosomes), then randomly dealing them into four hands of 23. Each hand (gamete) is unique. When two hands are combined (fertilisation), you get a complete set of 46 again — but a unique combination never seen before.

"Meiosis is just mitosis but makes four cells."

✓ **Actually:**
chromosomes
diversity in

4.6.2–3 Genetics — The Language of Inheritance

Gregor Mendel, a 19th-century monk, discovered the rules of inheritance by breeding thousands of pea plants. His work was ignored for decades but we now understand why his results made sense — each characteristic is controlled by genes, and each gene can come in different versions called alleles.

Key Genetic Vocabulary

- **Gene:** A section of DNA that codes for a specific protein (and therefore a characteristic).
- **Allele:** A version of a gene. The gene for eye colour has many alleles — brown, blue, green, etc.
- **Dominant allele:** An allele that is expressed whenever it is present — even if only one copy exists (written as a capital letter, e.g. B).

- **Recessive allele:** An allele that is only expressed when two copies are present — masked when a dominant allele is also present (written as lowercase, e.g. b).
- **Homozygous:** Both alleles are the same — either BB or bb.
- **Heterozygous:** The two alleles are different — Bb. This is also called a carrier when one allele causes a recessive disorder.
- **Genotype:** The alleles an organism has (e.g. Bb).
- **Phenotype:** The observable characteristic (e.g. brown eyes).

■ **Think of it like this:** Think of alleles like two dice. A dominant allele is a loaded die — whenever it appears, it "wins" and determines the phenotype. A recessive allele only determines the phenotype when BOTH dice show it.

Using Punnett Squares

A Punnett square is a grid used to predict the possible genotypes and phenotypes of offspring from a genetic cross. The parents' alleles are written along the top and side, and every possible combination is shown in the grid.

Example: Cross Bb × Bb (two heterozygous parents). Results: BB (25%), Bb (50%), bb (25%). Phenotype ratio: 3 brown (dominant) : 1 blue (recessive).

Inherited Disorders — When Alleles Cause Disease

Cystic fibrosis is caused by a faulty recessive allele (f). Individuals must have two copies (ff) to be affected. Carriers (Ff) appear unaffected but can pass the allele to their children. Two carrier parents have a 1 in 4 (25%) chance of having an affected child with each pregnancy.

Polydactyly is caused by a dominant allele (D). Only one copy is needed to have the condition. If one parent is affected (Dd), each child has a 50% chance of inheriting the condition.

■ **Why does this happen?** Why are recessive disorders more common in populations that are isolated or where close relatives marry? Because related individuals are more likely to carry the same recessive alleles. If both parents carry the same recessive allele, the risk of an affected child is much higher.

4.6.5 Evolution — How Species Change Over Time

Evolution is the change in the inherited characteristics of a population over successive generations. Darwin's theory of natural selection explains the mechanism by which this happens.

Step 1	Variation exists	Within any population, individuals show variation in their characteristics — caused by mutations and genetic mixing during sexual reproduction.
Step 2	Resources are limited	All populations produce more offspring than the environment can support. There is competition for food, water, mates and space.
Step 3	Differential survival	Individuals with characteristics that make them better adapted to their environment are more likely to survive long enough to reproduce.
Step 4	Inheritance of advantageous alleles	Survivors pass on the alleles responsible for their advantageous characteristics to their offspring.

Step 5**Population changes over time**

Over many generations, the frequency of advantageous alleles increases in the population. Given enough time and reproductive isolation, a new species may form (speciation).

■ **Real-life example:** Peppered moths in industrial Britain: before industrial pollution, pale moths blended into lichen-covered trees and dark moths were easily spotted by birds. After pollution darkened tree bark with soot, dark moths had the survival advantage. In just a few decades, dark moths went from rare to dominant — observable evolution in real time.

Allele	A version of a gene
Dominant	Allele expressed with just one copy — masks recessive alleles
Recessive	Allele only expressed when two copies present
Genotype	The alleles an individual carries (e.g. Bb)
Phenotype	The observable characteristics resulting from the genotype
Carrier	A heterozygous individual who carries a recessive allele but does not show the condition
Natural selection	The process by which better-adapted individuals survive and pass on their genes
Speciation	Formation of a new species when populations become reproductively isolated and diverge genetically