

Genetics (Quickstudy: Academic)

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GENETICS

Basic Concepts

A. Organizational Reproduction

1. One of the most important requisites of all life, from the earliest life forms to present-day organisms, is reproduction.
2. Characteristics or traits of organisms must be passed on during reproduction.

B. Cellular Reproduction

1. Life as we know it is based on the cell, the basic unit of life.
2. Cell theory states all organisms are made up of cells and arise from cells.

C. DNA

1. DNA (deoxyribonucleic acid) is the molecule of inheritance in ALL cellular forms of life.

D. Chromosomes

1. Eukaryotic cells possess nuclear DNA with structural and enzymatic proteins, forming chromosomes, which is visible as chromosomes during parts of the cell cycle.
2. Prokaryotic cells possess simpler DNA.
3. Sexually reproducing organisms typically have pairs of homologous chromosomes (homologous chromosomes).

E. RNA

1. RNA (ribonucleic acid) is found in several forms, most of which are used in protein synthesis.
2. RNA is the molecule of inheritance in some viruses, which are not cell-based life forms.

F. Genes

1. Functional units of inheritance and basis for most traits.
2. Located at loci, or specific positions, on DNA, to be preserved and transmitted.
3. Control biological processes through production of proteins and RNA.

Genes Form Basis of Inheritance

G. Ploidy

1. Homologous chromosome pairs have the same loci, then genes.
2. When both chromosomes are present, for each gene there are two representations; this is represented by the symbol $2n$ or diploid condition.
3. When only half of each homologous chromosome pair is present, such as in gametes, this is represented by the symbol n or haploid.

H. Alleles

1. Alternate forms of the same gene that could occupy the same locus (e.g., brown versus blue eye color).

I. Homologous chromosomes possess two representatives of each gene (i.e., $2n$).

J. Homozygous refers to the diploid condition where both alleles of the genotype are identical (e.g., AA, aa).

K. Heterozygous refers to the diploid condition where both alleles of the genotype are different (i.e., Aa). **Dominant alleles** form a phenotype regardless of the other allele on the matched chromosome (is also recessive (e.g., "aa" genotype is the only way for the phenotype designated by the "a" allele to be expressed, assuming no other gene pairs influence inheritance (see epistasis discussion in Gene Action Categories, page 22)).

L. Recessive alleles fail to form a phenotype expression unless the other allele on the matched chromosome is also recessive (e.g., "aa" genotype is the only way for the phenotype designated by the "a" allele to be expressed, assuming no other gene pairs influence inheritance (see epistasis discussion in Gene Action Categories, page 22)).

M. Additional types of allele interactions will be discussed in subsequent sections.

N. Determining genotype: Assuming there are no mutations, alleles present in gametes are determined by the distinct genotypes of parents.

- a. For **homozygous** genotypes, haploid gametes will be identical for the given trait (i.e., AA individual would produce "A" gametes only, AaAa individual would produce "a" gametes only).
- b. For **heterozygous** genotypes, haploid gametes will be different for the given trait (i.e., Aa individual would produce "A" or "a" gametes; AaAa individual would produce "A" and "a" gametes—assuming two traits are analyzed (see Independent Assortment & Dihybrid Crosses, page 22)).

Mendelian Genetics

A. Gregor Mendel (1822-1884)

1. An Austrian monk who, through his love and interest in nature, developed the basic ideas of genetics long before chromosomes and genes (i.e., molecular biology) were discovered.
2. His results and interpretations contrasted with a prevailing (at that time) theory of inheritance called "blending"—the concept that inherited traits mixed to create a composite, characteristic, or offspring.

B. Mendel's Genetics Laws

1. Segregation of Alternate Factors & Monohybrid Crosses

- a. Specifically, Mendel discovered that with certain traits, there were individual plants which, if only crossed with other plants just like them, would always always produce the exact same phenotype.
1. These individuals were called **true-breeders**.
2. We now call this condition **homozygous**.
3. The other breed that some individuals with similar appearance, when crossed, would not have all offspring of the same kind.
4. We now call this condition **heterozygous**.
5. Mendel decided to systematically do **single-trait crosses** to determine the causes for the previously noted observations.
6. Specifically, a **parental generation (P)** isolated these experimental crosses by using true-breeding pea plants for opposite phenotypes (e.g., purple versus white flowers).
7. **Offspring** from this cross (**F₁**) all showed only one of the traits (e.g., purple flowers), and this trait was called the **dominant trait**.
8. Traits from the P generation "did not blend" in these F₁ individuals.
9. F₁ individuals, the **hybrids**, were **cross-pollinated**—the **monohybrid cross**—to produce F₂ individuals.
10. 1/2 of the F₂ individuals expressed the dominant trait, while 1/2 expressed the trait of the other P parent (e.g., white) that had not been expressed in the F₁ generation—this latter trait was the **recessive form**.
11. The expected **phenotypic ratio** of the F₂ individuals in **monohybrid crosses** would be 3:1.
12. The expected **genotypic ratio** of the F₂ individuals in **monohybrid crosses** would be 2:1:1.
13. The diagram at right, called a **Punnett square**, summarizes results of a dihybrid cross similar to those done by Mendel on pea plants and other organisms.

Mendel's 1st Law: Segregation of Alternate Factors

P generation	(true female) (GG)	(true male) (gg)
Gametes produced by P generation	G	g
F ₁ generation	Gg	Gg
Gametes produced by F ₁ generation	G, g	G, g
F ₂ generation	GG, Gg, Gg, gg	GG, Gg, Gg, gg

1. Mendel concluded there had to be some physical entities or "factors" passed on by each parent of a cross.
2. We now know these to be genes.
3. He also concluded that these factors came in pairs, which then became separated (in the production of gametes, which occurs during meiosis) and **recombined** during fertilization.
4. The two P generation individuals had the factors in alternate forms called **alleles** (e.g., purple versus white flowers).

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