Mendelian Inheritance

Big Picture

Using Mendel's theories, we can predict the characteristics of an offspring given the physical characteristics of the parents. A Punnett square uses probability to help us determine an offspring's genetic makeup and physical appearance. These methods of prediction were found through Gregor Mendel's discoveries. Codominance and incomplete dominance, however, are considered to be under a non-Mendelian influence.

Key Terms

Gene: Segment of DNA that codes for a single protein or RNA. Controls what characteristics are expressed.

Alleles: Variants of a specific gene.

Dominant Allele: The allele that is expressed as long as a dominant allele is present.

Recessive Allele: The allele that is expressed as long as no dominant alleles are present.

Genotype: The genetic makeup of an organism. An individual's inherited alleles make up its genotype.

Phenotype: The physical appearance or expression of an inherited genotype.

Probability: The chance or likelihood that an event will occur.

Punnett Square: A chart used to determine the probability of different genotypes in the offspring of two parents.

Mendelian Influence

Homozygote: An organism that inherits two alleles of the same type (*BB* or *bb*).

Heterozygote: An organism that inherits two alleles of differing types (*Bb*).

Monohybrid Cross: A cross dealing with only one characteristic.

Dihybrid Cross: A cross in which two independent traits are being determined by crossing parents that differ in genotype.

Non-Mendelian Influence

Codominance: A phenotype in which both alleles are expressed equally.

Incomplete Dominance: Occurs when the dominant allele is not completely dominant, resulting in an intermediate phenotype.

Polygenic Characteristics: A characteristic (a phenotype or genotype) that is controlled by more than one gene, with the possibility that each gene has two or more alleles. These genes may be located on the same or different chromosome.

Genotype and Phenotype

From his experiments, Mendel concluded that an offspring inherits two **alleles** for each **gene**.

- Each parent contributes one allele, and the inherited alleles may be the same or different.
- The two alleles that an offspring inherits make up the **genotype**.
- The way an organism expresses the genotype is called the **phenotype**.

In writing genotypes,

- the **dominant allele** is represented with a capital letter (example: *B*)
- the **recessive allele** is represented with the same letter as the dominant allele but in lower case (example: *b*)

The three possible genotypes are *BB*, *bb*, *Bb* (the order that the alleles are listed does not matter, so *bB* is the same as *Bb*)

- A **homozygote** has two alleles of the same type: *BB* or *bb*
- A **heterozygote** has two different alleles: *Bb*

There are only two phenotypes:

- homozygous dominant traits (*BB*) and heterozygous traits (*Bb*) will express the phenotype in one way
- homozygous recessive traits (*bb*) will express the phenotype in another way

A genotype containing at least one dominant allele will express the dominant allele.

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Mendelian Inheritance cont.

Using a Punnett Square

Based off of the parents' genotypes, we can determine the **probability** that their offspring has a given genotype and phenotype by using a **Punnett square**. Use the image here as a visual guide for using Punnett squares in a **monohybrid cross**.

- A Punnett square is divided into four smaller squares.
- One parent's genotype is placed on top of a square, and the second parent's genotype is placed on the left. The two alleles in the genotype are in different columns or rows.
- Similar to a multiplication table, fill in the squares with each parent's allele from the same column and row.
- The four squares are the four possible genotypes and give the probability of inheriting a specific genotype.

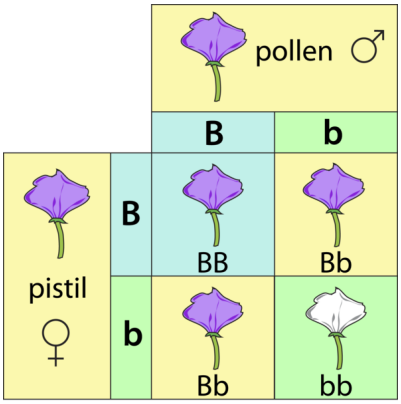

Image Credit: CK-12 Foundation, CC-BY-NC-SA 3.0

Predicting the Genotype

Both of the parents above were heterozygous. Their offspring, according to the Punnett square, has a 25% chance of having the genotype *BB*, a 25% chance of having the genotype *bb*, and a 50% chance of having the genotype *Bb*.

Predicting the Phenotype

The dominant allele *B* dominates over the recessive allele *b*. In this case, the coloring of the petals is purple whenever *B* is expressed. The offspring has a 75% chance of receiving the genotype of *BB* or *Bb*, or of having the phenotype of purple petals. It has a 25% chance of receiving the genotype of *bb*, or of having the phenotype of white petals.

The ratio 3:1 is typical for a monohybrid cross where both parents are heterozygous.

Predicting Multiple Traits

Punnett squares do not have to only consider one characteristic at a time. A Punnett square can also be used for a **dihybrid cross**.

The ratio 9:3:3:1 is typical for a dihybrid cross between two heterozygous parents.

Non-Mendelian Inheritance

Inheritance does not always behave like Mendel's pea plants. **Codominance**, **incomplete dominance**, and **polygenic characteristics** complicate inheritance.

- For example, the flower on left has red and white petals because of codominance. Red-petal and white-petal alleles are contributing to the phenotype of this flower.
- The flower on right has pink petals because of incomplete dominance with a red-petal allele and a recessive white-petal allele.
- Skin color and height are examples of polygenic characteristics.

Image Credit: Darwin Cruz, CC-BY 2.0

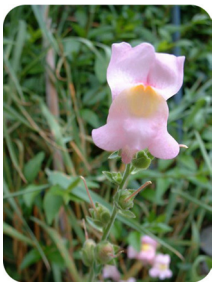

Image Credit: Magnus Forrester-Barker, CC-BY-NC-SA 2.0

New Traits

Although genes are inherited, their expression can be modified by interaction with the environment. New inheritable characteristics come from new combinations of genes or from gene mutations in reproductive cells, which will change the genetic makeup of the offspring. (See the *Mutation* biology study guide for more details.)

Notes