Non-Mendelian Patterns of Inheritance

Incomplete Dominance

In incomplete dominance, a heterozygote shows a blended phenotype between the two homozygous phenotypes. This means that neither allele is dominant over the other.

An example of incomplete dominance is flower color in four o'clock plant. When a pure red-flowered four o'clock plant is crossed with a pure white-flowered four o'clock plant, the offspring will produce neither red nor white flowers. Instead, all flowers will be pink.

In incomplete dominance, it is only the phenotype that is a combination. The red and white alleles remain separate and distinct. Half the gametes of the pink four o'clock carry the allele for red and half carry the allele for white. Therefore, the genotypic ratio also becomes the phenotypic ratio.

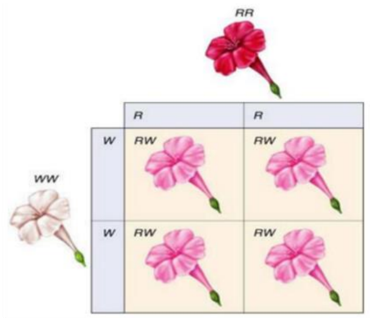

Figure 1. Punnett square showing a cross between red and white four o'clock flowers

Key concept: Incomplete dominance is a form of inheritance in which one allele for a specific trait is not completely dominant over the other allele. This results in a third phenotype in which the expressed physical trait is a combination of the dominant and recessive phenotype.

Codominance

Another pattern of inheritance is codominance. This results when one allele is not dominant over the other. The resulting heterozygotes exhibit the traits of both parents. One example of codominance is fur color in cattle. Cattle can be red (RR = all red hairs), white (WW = all white hairs), or roan (RW = red & white hairs together). Roan cattle have a unique speckled pattern, resulting from the expression of both red and white alleles in their fur. Just like in incomplete dominance, the genotypic ratio in codominance also becomes the phenotypic ratio.

Figure 2. Codominance in cattle

Key concept: In codominance, both alleles are expressed equally in the phenotype of the heterozygote.

Multiple Alleles

Sometimes, even if only two alleles control a trait, there may actually be more than two types of alleles available. This will also lead to more than two phenotypes expressed. Another blood group system in humans, the ABO system, is an example of a character governed by multiple alleles. Three alleles are responsible for this blood system: I^A, I^B, and i. There are four possible blood types.

Table 1. Human ABO blood types and their phenotypes

Blood Types	Genotypes
A	$I^A I^A$, $I^A i$
B	$I^B I^B$, $I^B i$
AB	$I^A I^B$
O	*ii*

The I^A and I^B alleles are dominant over the i allele, which is always recessive. However, when the I^A and I^B alleles are inherited together, both alleles are expressed equally. This also makes IA and IB codominants of each other.

Key Concepts:

- In humans, there are four blood types (phenotypes): A, B, AB, O.
- Blood type is controlled by three alleles: A, B, O.
- O is recessive, two O alleles must be present for a person to have type O blood.
- A and B are codominant. If a person receives an A allele and a B allele, their blood type is type AB.

The inheritance of some characters does not strictly follow Mendel's Law of Independent Assortment. There are many traits that are inherited together more frequently. For example, the expression of certain traits depends on whether one is male or female. Apparently, the expression of the traits is determined by or related to one's sex.

Sex Chromosomes and Sex Determination

Humans have 46 chromosomes in each cell. Observation of the human body cells shows 23 pairs of chromosomes for both males and females. Twenty- two pairs are somatic chromosomes. The 23rd pair consists of sex chromosomes. Human males and some other male organisms, such as other mammals and fruit flies, have non-identical sex chromosomes (XY). Females have identical (XX) sex chromosomes.

Let us study gamete formation based on the sex chromosomes. You will observe that all egg cells receive an X chromosome; while half of the sperm cells receive X chromosomes and the other half receive Y chromosomes.

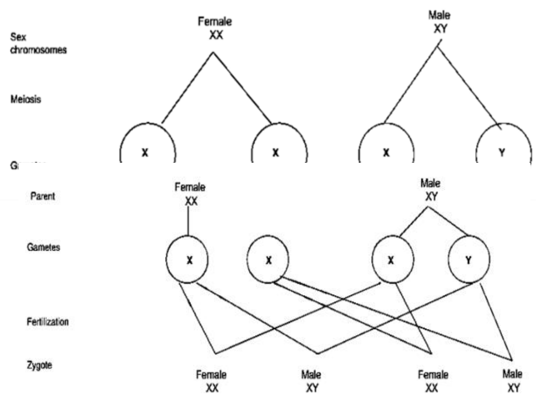

Figure 4. Sex determination

If an egg is fertilized by a sperm with a Y chromosome, the offspring is male. When an egg is fertilized by a sperm carrying an X chromosome, the offspring is female. Note that there is a 50 percent chance of having a male or female offspring. The greater the number of offspring, the greater is the chance of getting the expected 1:1 ratio of male and female.

Key Concepts

- Males have 44 body chromosomes and two sex chromosomes X and Y. The males determine the sex of their children.
- Females have 44 body chromosomes and two sex chromosomes, both X.
- The total number in each cell of an individual is 46. These chromosomes contain the genes, which are the factors of heredity