Incomplete dominance and co-dominance

The secret of inheritance mechanism of all the traits or characters in an organism, from parents to off-springs, lies in the genes. It is now an established fact that the segments of DNA express in a very well defined manner to produce a trait or character. Each gene has two alternative forms called alleles, each of which occurs at the same locus in each homologous chromosome. As you all know, the term 'allele' comes from 'allelomorph' and refers to the different forms of a gene which affect a phenotype in an organism. Thus number of allelic forms of a gene may be many in a population, but since each organism has only one pair of homologous chromosome of a kind, only two of its variants are present in an organism.

Various interactions may occur between alleles of same genes or alleles of different genes, which give rise to different phenotypes, making the inheritance patterns complex. The phenotypic expression of these characters could not be explained by Mendel's laws alone and thus this has opened a whole new myriad of allelic and non-allelic interactions. Broadly categorizing, such interactions can be classified as-

1. **Intragenic interactions:** When the two alleles of same gene interact with each other and affect a phenotype, it is known as inter-allelic, allelic gene or intragenic interactions, for examples- incomplete dominance, codominance and multiple alleles.
2. **Intergenic interactions:** If the alleles of different genes, located on separate loci, interact with each other and influence a phenotype, it is known as non-allelic or intergenic interactions. For example-complementary gene interaction, epistasis, supplementary gene interaction and duplicate genes.

DOMINANCE AND COMPLETE DOMINANCE:

Gregor Mendel's experiments laid the very basis of the concepts of heredity, however, these studies were confined to the seven traits of pea plant, the conclusions were also restricted to the observations obtained thereof. The only relationship established by Mendel between the factors or alleles of a trait was dominance and recessiveness. This simplicity of the Mendel's principles also come from the fact that the inheritance patterns of the seven traits selected by Mendel were fortunately all straight forward and showed no complexities. Later when the study was extended to other traits or organisms, it became evident that the inheritance patterns are far more complex than the simple genetic pattern described by Mendel. A variety of new traits and characters were investigated which were the result of some undefined genic/allelic interactions.

Complete dominance, as inferred by Mendel, refers to the type of dominance in which one allele completely masks the expression of other allele and is therefore said to be completely dominant. The allele which is masked or remains unexpressed is called recessive. The genotype of organism exhibiting complete dominance is heterozygous. A dominant feature of a trait is represented by allele 'A' and its recessive feature by allele 'a'. The homozygous condition 'AA' is responsible for its prominent phenotype while 'aa' gives its contrasting phenotype. When both the alleles appear together in heterozygous condition (Aa), the expression of 'a' is completely masked and only the phenotype of 'A' is visible. In such a case the allele 'A' is said to be completely dominant over allele 'a', and thus 'a' is said to be recessive.

Incomplete Dominance (Blending Inheritance or Semi/Intermediate Dominance):

Another type of interaction between two alleles was discovered by Karl Correns in 1900, while experimenting with Four O' Clock plant (*Mirabilis jalapa* belonging to family Nyctaginaceae). When he crossed the homozygous plant with **red flowers** (RR) with homozygous recessive plant with **white flowers** (rr), he noticed a strange phenotype in F_1 hybrids. The flowers of heterozygous (Rr) plants were **pink**, instead of being red by virtue of dominance. He concluded that this was due to an intra-allelic interaction in which the dominant allele could express itself partially in heterozygous condition. Since the character appeared to be intermediate between the dominant and recessive phenotypes, the phenomenon was called '**incomplete dominance**'.

Further, if selfing is done among F_1 hybrids, the phenomenon of incomplete dominance persists and phenotypic and genotypic ratios obtained in F_2 generation are Red1: Pink2: White1 (Fig. 2.2).

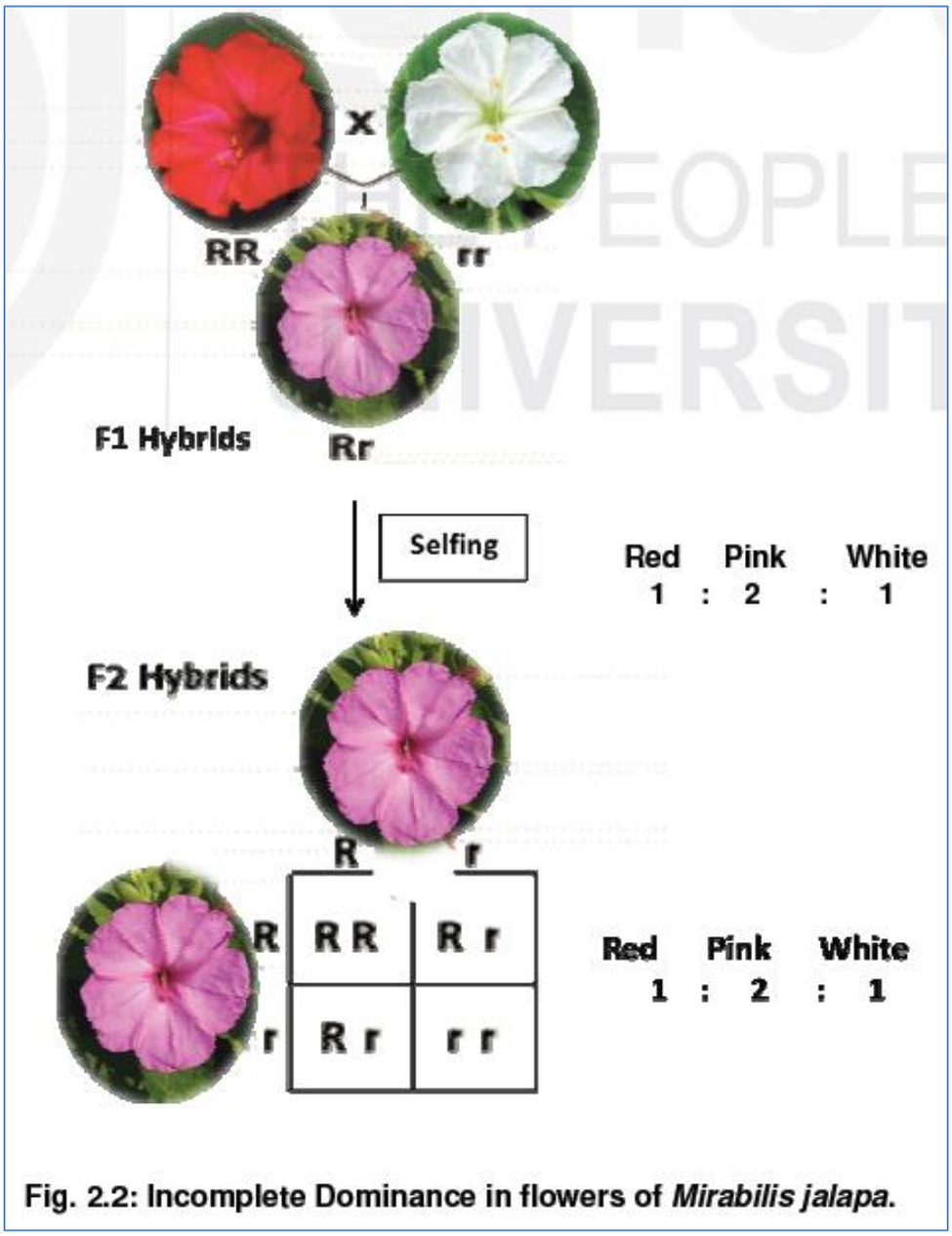

Fig. 2.2: Incomplete Dominance in flowers of *Mirabilis jalapa*.

Co-dominance:

Codominance is a phenomenon in which both the alleles are completely expressed in the heterozygous condition, the phenotype of the heterozygous individual is a mixture of both. Since the characters expressed by both the alleles exist simultaneously in equal amount, there is no appearance of intermediate phenotype in heterozygotes as is seen in incomplete dominance. Codominance is observed in the MN blood groups of humans. This classification of human blood is based on the presence of M and N antigens on the surfaces of red blood cells. The M and N antigens are produced by a pair of codominant alleles designated as L^M & L^N. The homozygous condition of allele L^M produces marker antigen M, while an L^N produces marker antigen N, on the surface of red blood cells. Homozygotes L^ML^M have only M while L^NL^N have only N markers, however, heterozygotes L^ML^N have both types of marker antigens in equal amounts on the cell surface. If a cross occurs between individuals with L^ML^N genotypes, the probablility of occurance of M, MN, and N blood types would be as given below:

Table2.1: Codominance in the MN blood groups in humans.

Genotype	Phenotype	Antigen present on RBCs
$L^M L^M$	M	M
$L^M L^n$	MN	M N
$L^M L^N$	N	N

Another classical example of codominance is inheritance of colour of flower in *Camellia* plants. If white *Camellia* are crossed with red *Camellia*, the flowers produced in F_1 generation produce flowers with mixed patches of red and white colour. The alleles for both red and white petal colour are codominant and both the colours are expressed simultaneously in equal amounts.

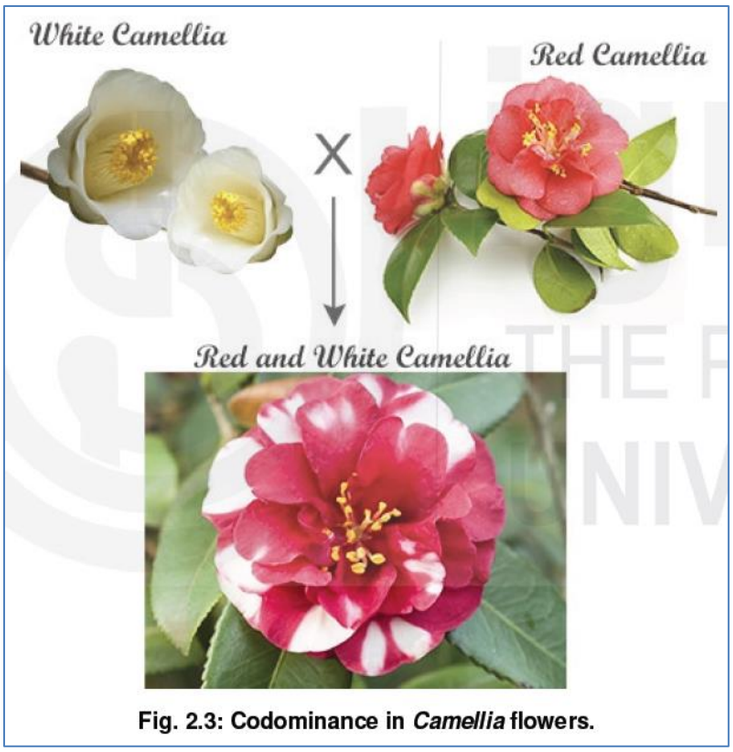

Fig. 2.3: Codominance in *Camellia* flowers.