Extensions to Mendelian analysis :

Extensions to Mendelian analysis divided into two broad categories

1-single gene inherence

a-in which pair of allels show deviation from complete dominance and recessiveness,

b-in which different forms of the gene are not limited to two alleles,

c:where one may determine more than one trait .

2-multifactorial inheritance in which phenotype arise from the interaction of one or more genes with environments, chance or with each other.

Variation in Dominance Relation

Mendel described and relied incomplete dominance in sorting out his ratios and law, but it is not only kind of dominance he observed

Dominance variations

- Dominance is interaction of alleles for the same gene (at the same locus)
- Complete dominance
- One allele completely masks the expression of the other.
- *AA* and *Aa* produce the same phenotype.
- So there are three genotypes, but only two phenotypes.

P AA X aa

G A a

F1 Aa x Aa

G A a A a

F2 AA, Aa , Aa, aa

Genotype ratio: 1: 2: 1

Phenotype ratio: 3: 1

- Incomplete dominance

Sometimes in a heterozygote dominant allele does not completely mask the phenotypic expression of the recessive allele and there occurs an intermediate phenotype in the heterozygote. This is called incomplete dominance.

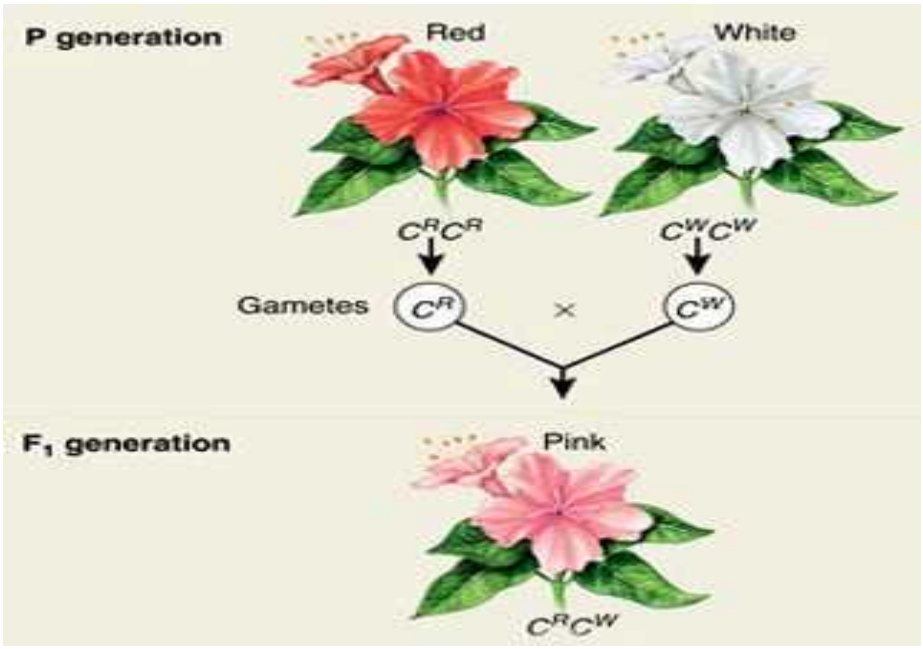
- AA and Aa produce different phenotypes. Hybrid (heterozygouse) does not resemble either pure- breeing (homozygouse)parents. thus incomplete dominance neither parental allele is dominant or recessive to the other.

- It is actually better here not to use the usual A and a as alleles codes. Using something like A^1 and A^2 is more logical because neither allele dominates over the other.

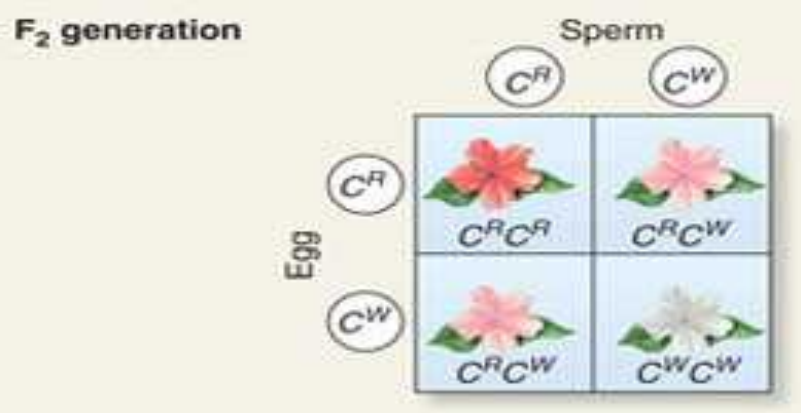
- So each genotype has a unique phenotype

Example: flower color in 4 o'clocks

- **F1 generation**



incomplete dominance in 4-o'clock plants, F-1 generatio



Incomplete dominance in 4-o'clock plants, F-2 generation

- In such a case, F2 phenotypic ratio and genotypic ratio are the same, as follows:

F2 phenotypic ratio = 1 Red : 2 Pink : 1 White

F2 genotypic ratio = 1 RR : 2 Rr : 1 rr

The biochemical explanation of this type of incomplete dominance is that each allele of the gene under analysis of specific an alternative form of a protein molecules with enzyme role in pigment production. if the white allele does not give rise to a functional enzyme, no pigment appears. thus in four oclocks ,two red alleles per cell produce double dose of red-producing enzyme, which generates enough pigment to make the flowers look fully red .In heterozygote, one copy of the red allele per cell results in only enough pigment to make the flowers look pink. In the homozygote for the white allele ,where there is no functional enzyme and thus no red pigment, the flower appear white .

Another example of an intermediate expression may be the pitch of human male voices. The lowest and highest pitches apparently are found in men who are homozygous for this trait (AA and aa), while the intermediate range baritones are heterozygous (Aa). The child-killer disease known as Tay-Sachs* is also characterized by incomplete dominance. *Heterozygous individuals are genetically programmed to produce only 40-60% of the normal amount of an enzyme that prevents the disease. Tay–Sachs disease (also known as GM2 gangliosidosis or hexosaminidase A deficiency) is a rare autosomal recessive genetic disorder. In its most common variant (known as infantile Tay–Sachs disease), it causes a progressive deterioration of nerve cells and of mental and physical abilities that begins around six months of age and usually results in death by the age of four. The disease occurs

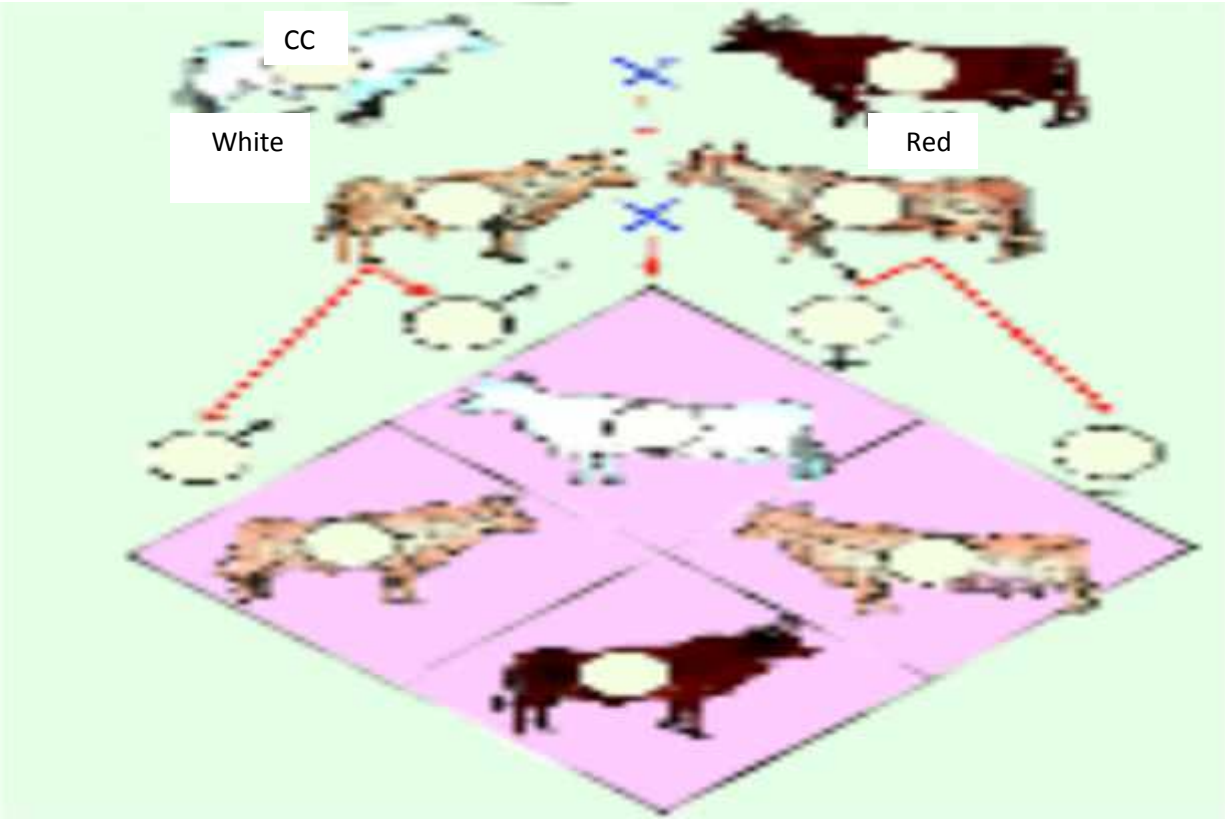
when harmful quantities of cell membrane components known as gangliosides accumulate in the brain's nerve cells, eventually leading to the premature death of the cells. A ganglioside is a form of sphingolipid, which makes Tay–Sachs disease a member of the sphingolipidoses. There is no known cure or treatment

Codominance: Sometimes both alleles of a gene in a heterozygote lack the dominant and recessive relationship, i.e., each allele is capable of some degree of phenotypic expression. In a sense, codominance is no dominance at all, the heterozygote showing the phenotypes of both homozygotes. Hence, heterozygote genotype gives rise to a phenotype distinctly different from either of the homozygous genotypes.

As for incomplete dominance, each of the three genotypes produces its own unique phenotype the phenotypic and genotypic ratios coincide.

Symbolism for codominant alleles For codominant alleles, all upper case base symbols with different superscripts are used letters indicate that each allele can express itself to some degree even when in the presence of its alternative allele (heterozygous).

Examples. 1. The coat color of the Shorthorn breed of cattle represent a classical example of codominance. when a cattle of red coat (CRCR) is crossed with the cattle of white coat (CwCw), the F1 heterozygote or hybrid is found to possess roan coat(CRCW) (Fig.). In roan coat the red and white hairs occur in definite patches but no hair has intermediate color of red and white.



2- The alleles governing the M-N blood group system in humans are codominants and may be represented by the symbols LM and LN, base letter L being assigned in honor of its discoverers Landsteiner and Levine). Here, three blood groups are possible–M, N and MN–and these are determined by the genotypes LMLM, LNLN, and LM LN, respectively. Blood groups actually represent the presence of an immunological antigen on the surface of red blood cells. People of LMLN genotype have both antigens. In the following summary chart, agglutination is represented by + and nonagglutination by – sign

Genotype	Reaction with antisera Anti–M Anti–N	Blood group
$L^M L^M$	+ -	M
$L^M L^N$	+ +	MN
$L^N L^N$	_ +	NN

3- The inheritance pattern of human disease sickle-cell anemia shows,

besides many other genetic phenomena, the incomplete dominance (at cellular or cell shape level) and codominance (at molecular, i.e., haemoglobin level). The gene pair concerned Hb^A (for haemoglobin A) and Hb^S (for haemoglobin S) affects the oxygen transport molecule haemoglobin the major constituent of red blood cells (erythrocytes). The three genotypes have different phenotypes, as follows

Hb^A Hb^A : Normal. Red blood cells never sickled; they contain one type

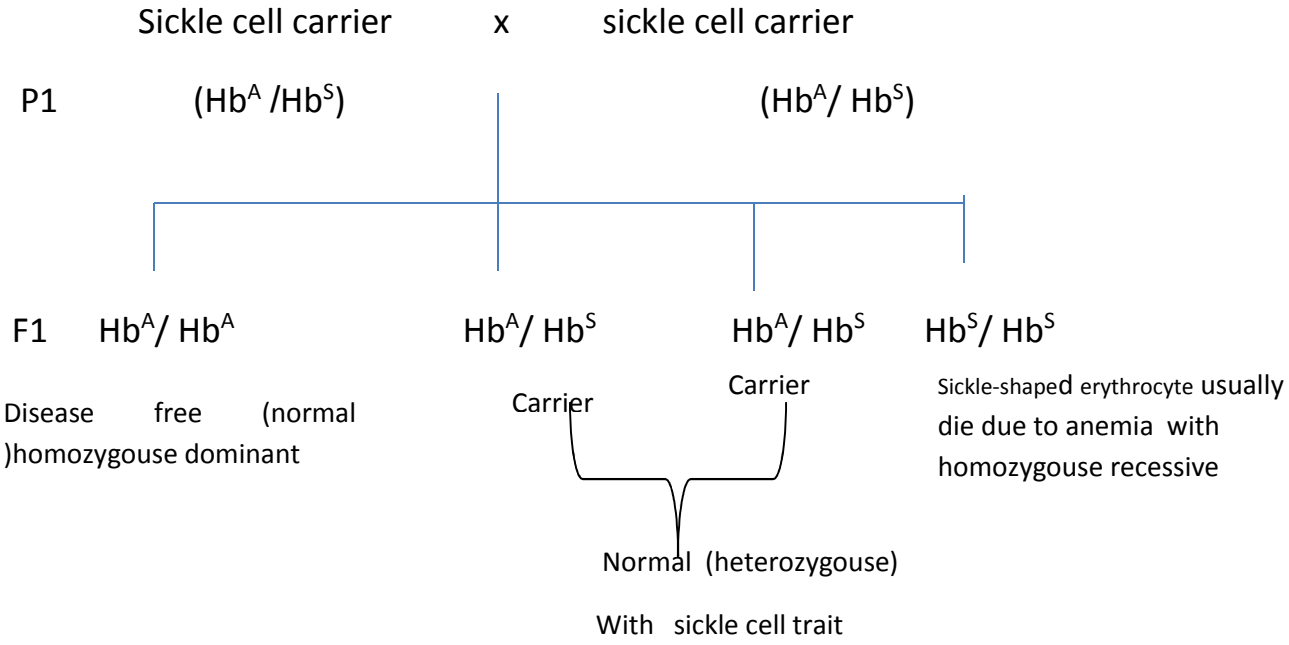
of haemoglobin, i.e haemoglobin A.,.

Hb^SHb^S : Severe, often fatal anemia. Red blood cells sickled-shaped; contain one type of haemoglobin, i.e., haemoglobin S

.

Hb^A Hb^S : No anemia. Red blood cells sickle-shaped only under abnormally low oxygen concentration contain both types of haemoglobins, i.e., haemoglobin A and haemoglobin S. Thus, in regard to anemia the Hb^A allele is dominant. In regard to blood cell shape there is incomplete dominance. And lastly, in regard to haemoglobin, there is codominance. The Hb^S allele in homozygous condition (Hb^SHb^S) acts as a lethal gene, i.e., it causes the death of its bearer; the homozygotes dies of fatal anemia before they attain sexual maturity.

A marriage between two carriers (i.e., heterozygotes possessing a deleterious recessive allele hidden from phenotypic expression by the dominant normal allele) results in carriers and disease free children in the ratio of 3 : 1, that changes, later on, into the ratio of 2 : 1 due to the death of homozygotes.



- **Variation on complete dominance do not negate Mendel's law of segregation**

Variation in dominance does not change Mendel's law of segregation. Alleles still come in pairs and segregate during gamete production. The difference is only in how the alleles are expressed when two different ones occur together. Incomplete dominance or codominance depend on the kind of proteins determine by the alleles and biochemical function of those proteins in the cell.

Multiple alleles

Menedle analyzed trait controlled by genes with two alternative alleles, but for many traits there are more than two alternative**s.** Human blood types provide an example. If person with blood group A mates with a person with blood type B,it is possible in some cases for the couple to have a child that is neither A nor B ,But a third blood type called O .

The reason? The gene for blood type has three alleles: **I^A,I^B** and **i as shown in table (1)**

Phenotype (blood type)	Genotype	Antigen type	Antibodies made by body	Blood-recipient reactions to donor blood: A (B anti-bodies)	B (A anti-bodies)	AB (no anti-bodies)	O (A and B antibodies)
A	I^AI^A or I^Ai	A	B				
B	I^BI^B or I^Bi	B	A				
AB	I^AI^B	A and B	None				
O	ii	None	A and B				

Table(1)ABO blood type are determine by three alleles of one gene.

Note in table (1) that the a phenotype can arise from two genotypes, I^AI^A or I^Ai. The same is true for the B blood type which can produced by I^BI^B or I^Bi . but combination of the two alleles I^AI^B generate blood type AB.

We can draw several conclusion from these observa potions :

1- A given gene may have more than two alleles or multiple alleles; in our example, the series of alleles is donated I^A , I^B,i.
2- Only each person carries no mor than two alleles for each gene,no matter how many alleles there are in series. Mendels law of segregation remain intact since in any sexually reproducing organism, the two alleles of a gen separate during game B te formation.
3- An alleles is not inherently dominance or recessiveness is always relative to a second allele. In other words,domance relations are unique to a paire of alleles.In our example,I^A is completely dominance to I,but it is codomanance with $I^{B.}$

Given these domanace relation ,the six genotype possible with I^B ,I^A and I generate foure different phenotype :blood group A,B,AB and O . With this background ,you can understand how type a A and a type parent could produce a type O child: the parent must be I^Ai and I^Bi heterozygotes ,and the child receives an I allele from each parent.