Geno type	Frequency	Phenotype	Frequency
YYRR	 1	Yellow Round	9
YYRr	 2		
YyRR	 2		
YyRr	 4		
YYrr	 1	Yellow Wrinkled	3
Yyrr	 2		
yyRR	 1	Green Round	3
yyRr	 2		
yyrr	1	Green wrinkled	1

The nine different types of genotypes expected in F_2 generation occur in the ratio of 1 : 2 : 2 : 4 : 1 : 2 : 1 : 2 : 1. This is known as **Dihybrid genotypic ratio.**

2-7 MENDEL'S LAW OF INHERITANCE

On the basis of the results of his experiments Mendel recognized the **phenomenon of dominance** and formulated the following two laws :

1. Law of segregation ;
2. Law of Independent Assortment.

I The phenomenon of dominance :

Definition : When two homozygous individuals with one or more sets of contrasting characters are crossed, the characters that appear in the F_1 hybrids are called **dominant characters** and those do not appear in F_1 are **recessive characters.**

In other words, a trait or character which appears only in homozygous individual is called a **recessive** character (e.g. dwarfness). A character which can phenotypically expresses itself in the homozygous as well as heterozygous individual is called **dominant** character (e.g. tallness).

Explanation : In all his hybridization experiments, Mendel observed that when two alternative forms of a character are crossed and brought together, only one form is able to express itself in F_1

hybrids i.e., the trait of only one parent was observed. He called the one which appeared in F_1 as the **dominant** character. The other form, which remains masked or unexpressed in the hybrid is called **recessive character.**

After Mendel, several workers tested the validity of the phenomenon of dominance by performing cross-breeding experiments. They found its wide application in various plants and animals.

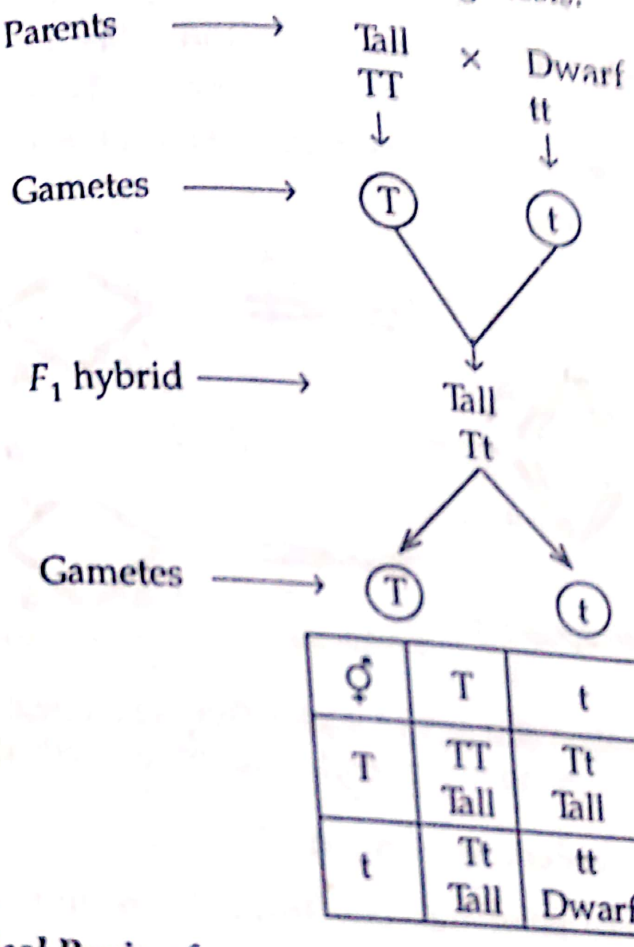
II Law of Segregation :

Definition : Mendel's first law of inheritance is called the **law of segregation.** This law states that in a heterozygote a dominant and a recessive allele remain together throughout the life (from zygote to the gametogenesis stage). Without contaminating or mixing with each other they finally separate or segregate from each other during gametogenesis. So that each gamete receives only one allele either dominant or recessive. As the gametes are pure for a given character (e.g. Tallness or Dwarfness), this law is also known as **Law of purity of gametes.**

Explanation : The homozygous tall plants possess two genes (factors) TT for tallness and dwarf plants possess, two genes tt for smallness. The gametes formed by tall plant will have a gene 'T' and the gametes coming from dwarf plant will carry gene 't'. Their union form F_1 hybrid which will have the genetic constitution as Tt. This hybrid is apparently tall as T is dominant over t. When this F_1 hybrid form gametes, the two genes T and t separate from each other and pass on to separate gemetes. As a result, two types of gametes are produced from the heterozygote in equal numbers. 50% of the gametes carry gene 'T' and the other 50% of the gametes carry gene 't'. The genes (allels of a gene) thus segregate and the gamete can carry only one of the two alternative genes. Therefore, these gametes are pure either for tallness or dwarfness. Hence, the law of segregation is also called as **law of purity of gametes.**

These gametes during the process of fertilization can unite in three possible combinations, Viz. TT, Tt and tt to produce two types

of individuals in F_2 generations. Thus, in F_2 generation 75% individuals have long stems and 25% short stems (Dwarf). The appearance of Dwarf plants in F_2 generation indicate that in the F_1 hybrid, the allele (t) for dwarfness remains along with allele (T) for Tallness, but does not mix with it or get contaminated by it. These alleles separate or segregate during gametogenesis.



♂ / ♀	T	t
T	TT Tall	Tt Tall
t	Tt Tall	tt Dwarf

Physical Basis of segregation : The phenomenon of segregation can be easily explained on the basis of behaviour of homologous chromosomes during meiosis. As a consequence of segregation, the two alleles of a gene separate and go into different gametes. In F_1 hybrid or heterozygote, one of the two alleles of a gene (T) is present in one chromosome, while the allele (t) is present in its homologue. The two homologous chromosomes pair during prophase I and orient at the metaphase plate during metaphase I. At anaphase I, one of the two homologous chromosomes move to one pole, while the other chromosome of this pair move to the opposite pole. Thus, each pole receives only one member of a homologous pair of chromosomes. As a

result, one of the two alleles (T) goes to one pole, while the other allele (t) goes to the opposite pole.

At anaphase II, the two sister chromatids of each chromosome separate and move to opposite poles producing four daughter cells each having a single chromatid from each homologous pair of chromosomes. Two of these four cells receive sister chromatids from one of the two homologues, while the other two receive sister chromatids from the other homologue. Thus, separation of homologous chromosomes during meiosis result in the segregation of two alleles of a gene.

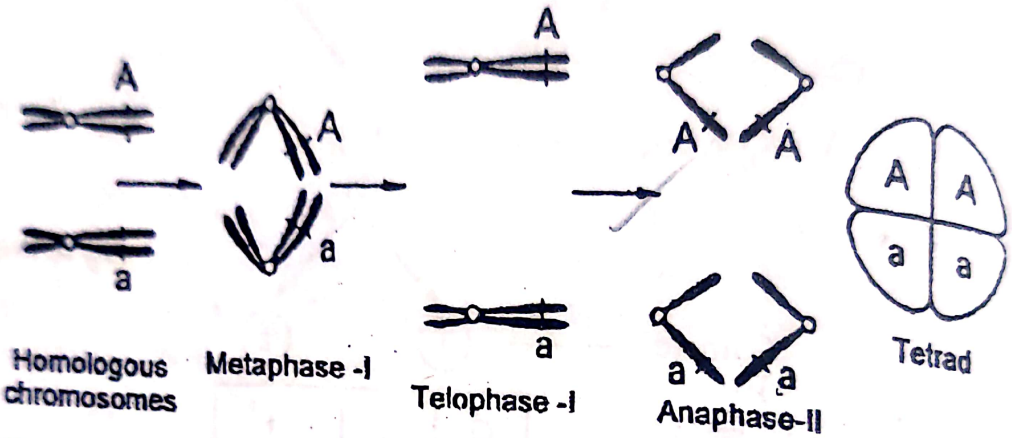


Fig. 2·3 : Segregation of a pair of alleles (Aa) as a result of movement of homologous chromosomes and of sister chromatids during meiosis

III Law of Independent Assortment :

Mendel formulated this law from the results of a dihybrid cross. According to this law :

"the factors or genes for different pairs of contrasting characters present in a parent assort (separate) independently from one another during gamete production". Thus, any allele of one gene is equally likely to combine with any allele of the other gene and pass into the same gamete. Independent assortment of two genes produces four different types of gametes in equal proportion. A random union among these gametes gives rise to 16 possible zygotes. These zygotes yield a 9 : 3 : 3 : 1 phenotypic ratio, which is known as the typical dihybrid ratio.

Explanation : The mechanism of independent assortment can be understood from a dihybrid cross. In one of his hybridization experiments, Mendel crossed a homozygous pea plant having yellow round seeds (YYRR) with the homozygous pea plant having green wrinkled seeds (yyrr). The F_1 hybrids were found to have yellow round seeds (YyRr). When these F_1 hybrids were allowed to cross among themselves, they produced four types of seeds in the ratio of 9 : 3 : 3 : 1 given as below.

Yellow Round — 315 (9)

Yellow Wrinkled — 101(3)

Green Round — 108(3)

Green Wrinkled — 32(1)

From this data, it becomes evident that yellow and green seeds appeared in the ratio of 416 : 140 *i.e.*, 3 : 1. Similarly round and wrinkled seeds appeared in the ratio of 423 : 133 *i.e.*, 3 : 1. Thus each of the two pairs of alternate characters viz. yellow-green pair and round-wrinkled pair, behave exactly as in a monohybrid cross. This indicates that at the time of gamete formation, the alleles for colour of seed do not interfere with alleles for shape of seed coat and the two pairs of alleles behave independent of each other. This principle is known as Mendel's *Law of Independent Assortment.*

This independent assortment holds good for two or more than two pairs of characters, which are located in different homologous pairs of chromosomes. On the other hand, if the alleles for different characters are present in the same homologous pair of chromosomes they enter into the same gamete. Thus, law of independent assortment is not applicable to such cases, where linkage between genes is in operation.

2-8 BACK CROSS AND TEST CROSS

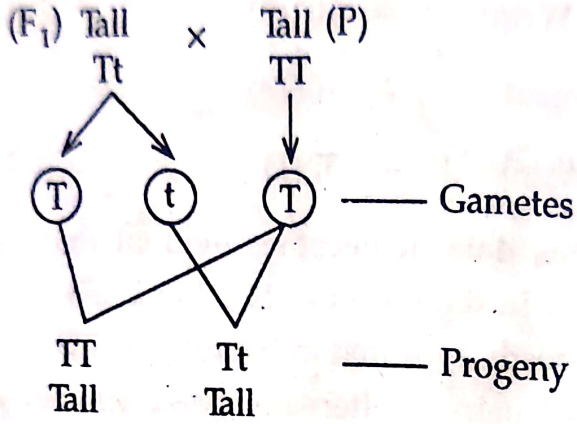
Mendel used two types of tests to distinguish homozygous or from heterozygotes having the same phenotype (e.g. TT and Tt for

tall phenotype). If a homozygous tall palnt (TT) is selfed, it will breed true, producing only tall plants. But when heterozygous tall plants (Tt) are selfed, tall and dwarf plants appear in 3 : 1 ratio.

Back cross :

When F_1 individuals are crossed with one of the two parents from which they were derived, then such a cross is called back cross. In such backcrosses, when F_1 is back crossed to the parent with dominant characters, no recessive individuals are obtained in the progeny.

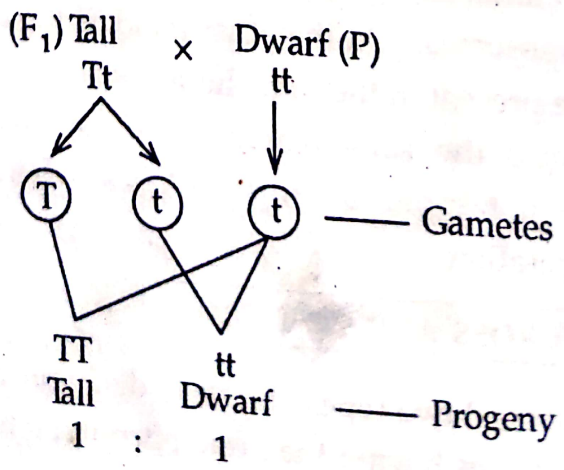
Example :



Test Cross :

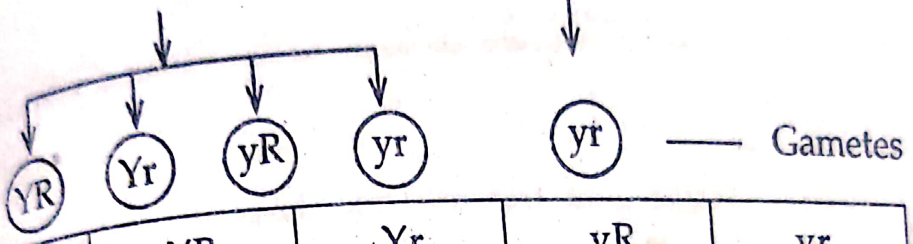
When F_1 individuals are crossed with recessive parent, both phenotypes appear in the progeny. This is known as *test cross*, because it is used to test whether an individual is homozygous (pure) or heterozygous (hybrid). For a monohybrid the test cross ratio is 1 : 1, but, for a dihybrid the test cross ratio becomes 1 : 1 : 1 :1.

Example (1) :



Example (2) :

YyRr
Yellow
Round
× yyrr
Green
Wrinkled



	YR	Yr	yR	yr
yr	YyRr Yellow Round	Yyrr Yellow Wrinkled	yyRr Green Round	yyrr Green wrinkled

Test cross ratio = 1 : 1 : 1 : 1

Questions

1. Discuss Mendel's Laws of inheritance.
2. Describe the monohybrid and dihybrid experiments that were conducted by Mendel on Pisum sativum.
3. *Write short notes on* :
   (a) Law of Dominance
   (b) Law of Segregation
   (c) Law of Independent Assortment
   (d) Back cross and Test Cross
4. What is law of Independent Assortment ? Explain it with dihybrid ratio.