Chapter-9 Principles of Inheritance and Variation

1. What is the cross between the F_1 progeny and the homozygous recessive parent called? How is it useful?

A: Test cross.

Test cross is useful in determining the genotype of the plant in question.

2. Do you think Mendel's laws of inheritance would have been different if the characters that he chose were located on the same chromosome?

A: If the characters are present on the same chromosome they would not segregate independently as they are linked on the same chromosome. This depends on the distance between the genes. If the distance is very wide the percentage of segregating independently is very high.

3. Who proposed the Chromosome Theory of Inheritance?

A: Sutton and Boveri

4. Define true breeding. Mention its significance?

A: True breeding is stable trait inheritance and expression for several generations as a result of continuous self pollination. These are homozygous plants.

Significance:

1. They are used as parents in artificial hybridization as they provide gametes with all similar traits.
2. Homozygous recessive plants are used in Test cross to determine the genotype.

5. Explain the terms phenotype and genotype?

A: Phenotype is the external appearance of characters.

Genotype is the genetic makeup of an individual.

6. What is point mutation? Give an example?

A: Mutations involving a single base pair of DNA are called as point mutations.

E.g. Sickle cell anemia in Humans.

7. What is the genotype of wrinkled phenotype of pea seeds?

A: Wrinkle nature is recessive to round. Genotype of wrinkled phenotype is rr if R represents round.

8. What will be the phenotypic ratio in the offsprings obtained from the following crosses?

a) Aa x aa **b) AA x aa**

c) Aa x Aa **d) Aa x AA**

Note: Gene 'A' is dominant over gene 'a'

A: a) Aa:aa = 1: 1

b) Aa = 100%

c) (AA,Aa,aA) : aa = 3:1 d) AA : Aa = 1: 1

9. In garden pea, the gene T for tall is dominant over its allele for dwarf. Give the genotypes of the parents in the following crosses.

a) Tall x dwarf producing all tall plants

b) Tall x tall producing 3 tall and1 dwarf plants.

A: a) TT and tt

b) Tt and Tt

Short Answer Questions:

1. Mention the advantages of selecting pea plant for experiment by Mendel?

Ans: Advantages of selecting pea plant for experiment by Mendel are:

1. It is an annual plant that has well defined contrasting characters.
2. It can be grown and crossed easily.
3. It has bisexual flowers containing both female and male organs.
4. It can be self fertilized conveniently.
5. It has a short life cycle and produces large number of off springs.

2. Differentiate between the following.

a) Dominant and Recessive

b) Homozygous and Heterozygous

Ans: Characters are controlled by discrete units called factors which occur in pairs.

a) **Dominant**: In a dissimilar pair of factors pertaining to a character it is the factor that is **expressed phenotypically in both homozygous and heterozygous** condition.

Recessive: It is the character which is not expressed phenotypically in heterozygous condition. It is expressed only in homozygous condition.

b) **Homozygous**: In a diploid state the condition where an individual is having **two similar or identical alleles** for a single character is called homozygous. Only one kind of gametes are possible with reference to a gene.

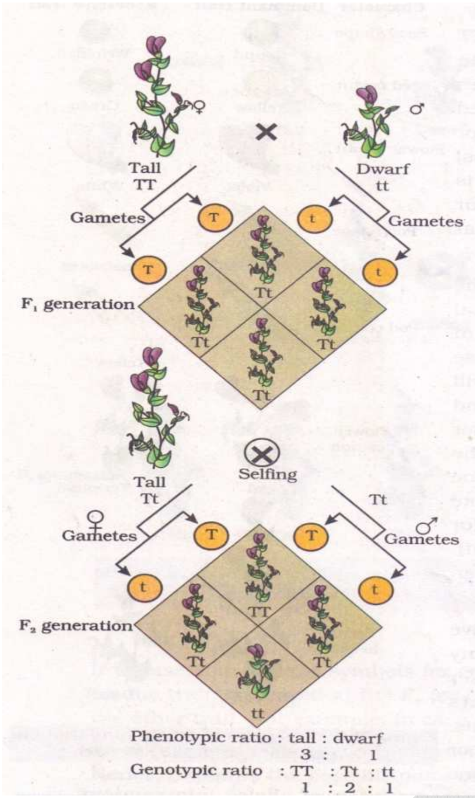
Heterozygous: In a diploid state an individual having **two different alleles** for a single character is called heterozygous condition. Two different types of gametes are possible with reference to a gene.

3. Explain the law of dominance using a monohybrid cross?

Ans: Characters are controlled by discrete units called **factors**.

Factors occur in **pair**.

In a pair of dissimilar contrasting characters, if one shields the effect of the other character it is called dominant character. The other contrasting character being shielded by the dominant character is called recessive character.



In the experiments of monohybrid cross, breeding of pure lines showing contrasting characters, for example, like **tall** and **dwarf** characters all the First generation plants will be of **Tall**. This is due to tall is **dominant over dwarf**.

After self-crossing, in the second or F_2 generation characters are segregated and Tall and dwarf characters reappear in **3:1** ratio respectively. Genotypic of Tall and dwarf will be 1:2:1. This can be explained using conventional representation of characters with letters 'T' for dominant and't' for recessive character. **TT** or **Tt** are tall **tt** is dwarf.

4. Define and design a test cross?

Ans: Crossing a plant with a homozygous recessive plant to know the genotype of the plant in question is called a test cross.

	C	c
c	Cc	cc

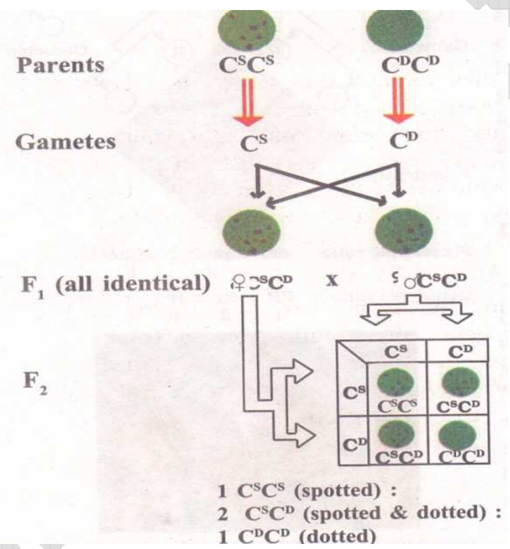
	AB	ab	Ab	aB
ab	AaBb	aabb	Aabb	aaBb

In a typical test cross, an organism like pea plant showing a dominant phenotype whose genotype has to be determined is crossed with a recessive parent instead of self fertilization. As recessive characters will not express in the F_1 generation, a homozygous recessive plant will be selected as parent. The progenies of such a cross can easily be analyzed to determine the genotype of the test organism.

For a monohybrid or single character if the test plant is heterozygous the ratio of dominant and recessive will be **1:1**. For two characters or dihybrid cross test cross the ratio will be **1:1:1:1**

5. Explain the Co-dominance with an example?

Ans: When F_1 hybrids in a cross resembles both the parents without showing any dominance it is called **Co-dominance**. Examples are ABO blood grouping in human beings and **seed coat pattern** in **lentle** plants.



Lentle (***Lens culinaris***) is a legume crop. A cross between pure-breeding **spotted** seeds with few big irregular patches and pure breeding **dotted** seeds with several circular dots produce heterozygotes that are both spotted and dotted.

The F_1 hybrids show a significant departure from complete dominance. They show the phenotypic features of **both the parents** which means that neither the 'spotted' nor the 'dotted' allele is dominant or or recessive to the other. As both the traits show up equally in the heterozygote's phenotype, the alleles are termed as **co-dominant**.

Self-pollination of the spotted/dotted F_1 generation produces F_2 progeny in the ratio of

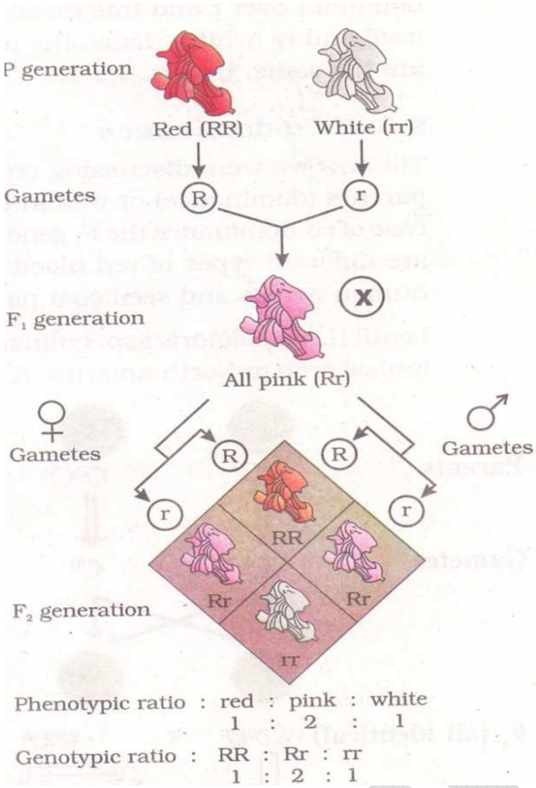
1 spotted: 2 spotted & dotted: 1 dotted.

The Menedelian **1:2:1** ratio among these F_2 progeny establishes that the spotted and dotted traits are determined by **alternative alleles of a single gene**. Once again, because the heterozygotes can be distinguished from both homozygotes , the **phenotypic and genotypic ratios coincide**.

6. Explain the Incomplete dominance with an example?

Ans: When experiments on peas were repeated using other traits in other plants, it was found that sometimes the F_1 had a phenotype that **did not resemble either of the two parents** and was in between the two.

The inheritance of flower colour in the dog flower (snapdragon or ***Antirrhinum sp.***) is a good example to understand incomplete dominance. In a cross between true-breeding **red-flowered (RR)** and true breeding **white-flowered** plants **(rr)**, the F_1 **(Rr)** was **pink**.



When the F_1 was self-pollinated the F_2 resulted in the following ratio **1** (RR) **Red**: **2** (Rr) **Pink**: **1** (rr) **White**. Here the genotype ratios were exactly as we would expect in any Mendelian monohybrid cross, but the phenotype ratios had changed from the 3:1 dominant: recessive ratio. What happened was that **R** was not completely dominant over **r** and this made it possible to distinguish Rr as pink from RR (red) and rr (white) .Thus the phenotypic and genotypic ratios in F_2 progeny are the same, that is, 1:2:1.

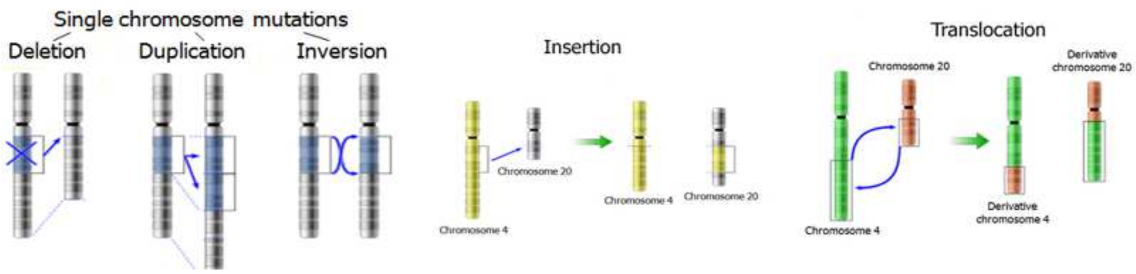
7. Write a brief note on chromosomal mutations and gene mutations?

Ans: Mutation is a phenomenon which results in alteration of DNA sequences and consequently results in changes in the genotype and the phenotype of an organism that are **carried to the next generations.**

Mutations can be **spontaneous** or **induced**. Mutations can be induced by mutagens.

Mutations may result from changes in **chromosomes** or **genes**.

Chromosomal mutations: Changes in number and structure of chromosomes is called chromosomal mutations. In addition to recombination, mutation is another phenomenon that leads to variation in DNA.



Loss (**deletions**) or gain (**insertion/duplication**) of a segment of DNA, result in alteration in chromosomes. Since genes are known to be located on chromosomes, alteration in chromosomes results in abnormalities or aberrations.

Chromosomal aberrations are commonly observed in cancer cells. Chromosomal aberrations result in **polyploids , monosomy, trisomy etc.**

Gene mutations or point mutations: Mutations also arise due to change in a single base pair of DNA. This is known as **point mutation**. A classical example of such a mutation is sickle cell anemia. Deletions and insertions of base pairs of DNA, causes **frame-shift mutations**.

Many chemical and physical factors induce mutations. These are referred to as **mutagens**. UV radiations can cause mutations in organisms – it is a mutagen.

8. Define law of segregation and Law of Independent Assortment.

Ans: **Law of Segregation**: "When the two alleles of a gene present together in a heterozygous state, they **do not fuse or blend** in any way, but **remain distinct** and segregate during meiosis or in the **formation of gametes** so that each meiotic product or gamete will carry only one of them".

Law of Independent assortment: "When two pairs of traits are combined in a hybrid, segregation of **one pair** of characters **is independent** of the **other pair** of characters".

Long Answer Questions

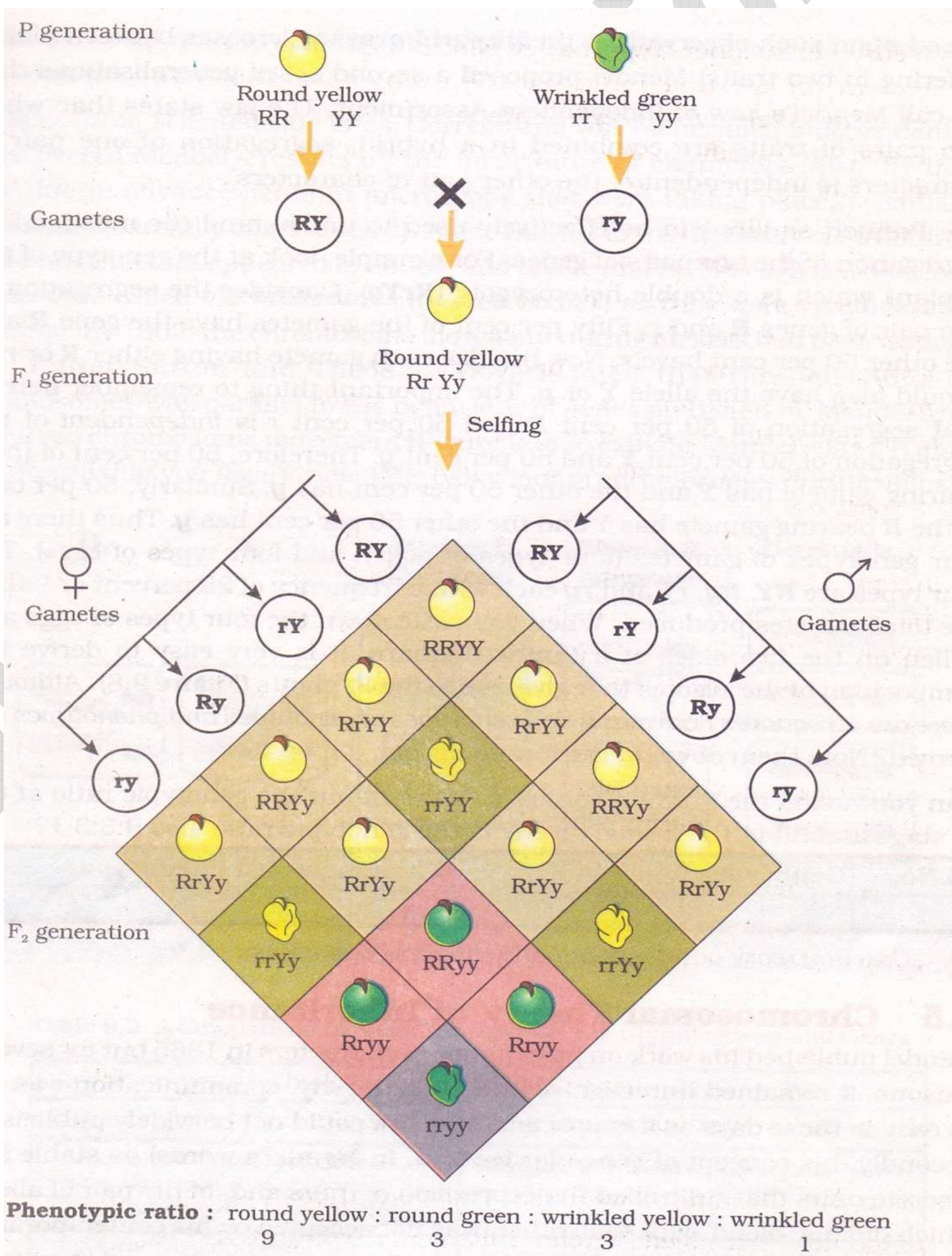
1. Explain the dihybrid cross with the help of Punnet square board by taking contrasting traits, seed colour and seed shape?

Ans: In the dihybrid cross, the phenotypes **round, yellow**; wrinkled**, yellow**; **round, green** and **wrinkled, green** appeared in the ratio **9:3:3:1**.

The ratio of **9:3:3:1** can be derived as a combination series of **3 yellow:1 green**, with **3 round : 1 wrinkled**. This derivation can be written as follows:

(3 Round: 1 Wrinkled) (3 Yellow: 1 Green) = 9 Round, Yellow: 3 Wrinkled, Yellow: 3 Round, Green: 1 Wrinkled, Green

In other words, the probability of round yellow is 3/4 x 3/4 =9/16, wrinkled yellow is 1/4 x 3/4 =3/16, round green is 3/4 x 1/4 = 3/16, green wrinkled is 1/4 x 1/4 =1/16.



Based upon such observations on dihybrid crosses i.e. crosses between plants differing in two traits Mendel proposed a second set of generalizations that we call Mendel's Law of Independent Assortment.

The law states that **'when two pairs of traits are combined in a hybrid, segregation of one pair of characters is independent of the other pair of characters'.**

The Punnett square can be effectively used to understand the independent segregation of the two pairs of genes during meiosis and the production of eggs and pollen in the F_1 RrYy plant. Consider the segregation of one pair of genes **R** and **r**. Fifty per cent of the gametes have the gene **R** and the other **50 per cent** have **r**. Now besides each gamete having either **R** or **r**, it should also have the allele **Y** or **y**.

The important thing to remember here is that segregation of 50 per cent **R** and 50 per cent ***r*** is **independent** from the segregation of 50 per cent **Y** and 50 per cent **y**. Therefore, 50 per cent of the **r** bearing gametes has **Y** and the other 50 per cent has **y**.

Similarly, 50 per cent of the R bearing gametes has Y and the other 50 per cent has y. Thus there are four genotypes of gametes (four types of pollen and four types of eggs). The four types are **RY, Ry, r*Y*** and **ry** each with a frequency of 25 per cent or 1/4th of the total gametes produced.

When we write down the four types of eggs and pollen on the two sides of a Punnett square it is very easy to derive the composition of the zygotes that give rise to the F_2 plants.

There are sixteen squares indicating 16 possible combinations. 9 different genotypes can form.