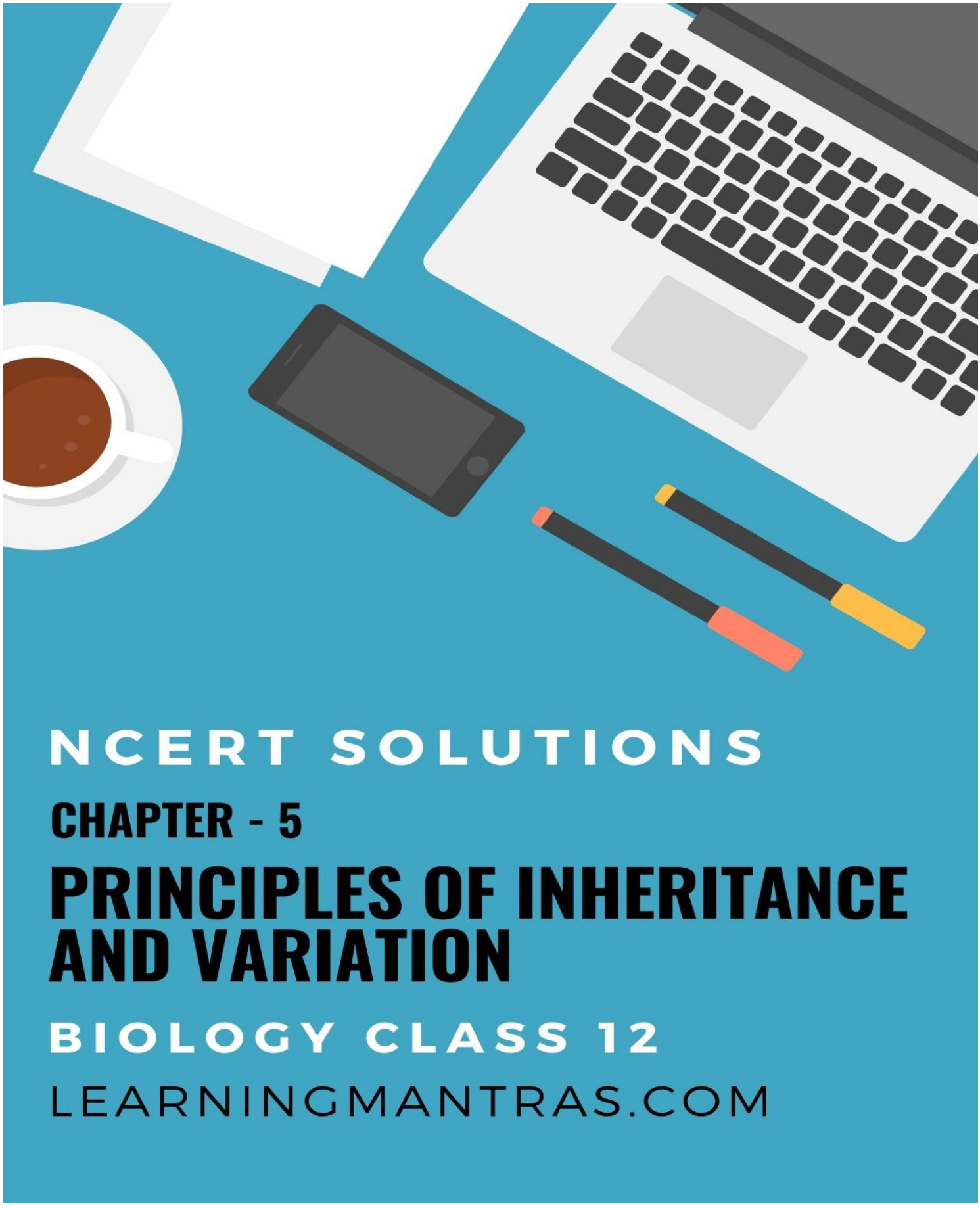

# NCERT SOLUTIONS

## CHAPTER - 5

# PRINCIPLES OF INHERITANCE AND VARIATION

## BIOLOGY CLASS 12

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**Q1.Mention the advantages of selecting pea plant for experiment by Mendel**

**Answer:** Mendel selected garden pea (Pisum Sativum) for the following reasons:

- It is an annual plant with a short life span and gives results within 3 months.
- The plant is grown easily and does not require after care except at the time of pollination.
- F1 hybrids are fertile.
- Seven pairs of contrasting characters are easily detectable.
- True breeding self pollination.

**Q2. Differentiate between the following –**

**(a) Dominance and Recessive**

**(b) Homozygous and Heterozygous**

**(c) Monohybrid and Dihybrid.**

**Answer:**

**(a) Dominance and Recessive**

| Dominance | Recessive |
|---|---|
| A dominant factor or allele expresses itself in the presence or absence of a recessive factor. | A recessive trait is able to express itself only in the absence of a dominant factor. |
| For example, tall plants, round seeds, violet flowers, etc. are dominant traits in a pea plant. | For example, dwarf plant, wrinkled seed, white flower, etc. are recessive traits in a pea plant. |

**(b) Homozygous and Heterozygous**

| Homozygous | Heterozygous |
|---|---|
| It contains two similar alleles for a particular trait. | It contains two different alleles for a particular trait. |
| Genotypes for homozygous possess either dominant or recessive, but never both the alleles. For example, RR or rr | Genotypes for heterozygous possess both dominant and recessive alleles. For example, Rr |
| It produces only one type of gamete. | It produces two different kinds of gametes. |

**(c) Monohybrid and Dihybrid**

| Monohybrid Cross | Dihybrid Cross |
|---|---|
| Monohybrid Cross involves cross between parents, which differs in only one pair of contrasting characters. | Dihybrid Cross involves cross between parents, which differs in two pairs of contrasting characters. |
| For example, the cross between a tall and dwarf pea plant is a monohybrid cross. | For example, the cross between pea plants having yellow wrinkled seed with those having green round seeds is a dihybrid cross. |

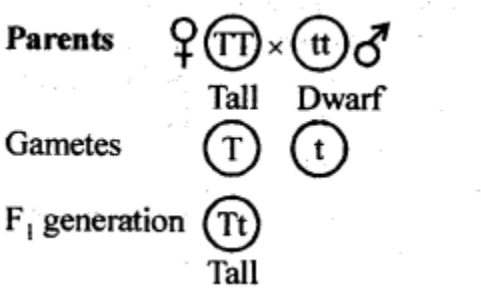
**Q3. A diploid organism is heterozygous for 4 loci, how many types of gametes can be produced?**

**Answer:** For a diploid organism, which is heterozygous for 4 loci, then 24 i.e. 2 x 2 x 2 x 2 = 16 types of gametes can be produced if the genes are not linked because for each heterozygous pair of genes there are two possibilities. So, for 4 pairs the number of combinations will be 16 gametes.

**Q4. Explain the Law of Dominance using a monohybrid cross.**

**Answer:** Mendel's law of dominance states that a dominant allele expresses itself in a monohybrid cross and suppresses the expression of recessive allele. However, this recessive allele for a character is not lost and remains hidden or masked in the progenies of F1 generation and reappears in the next generation.

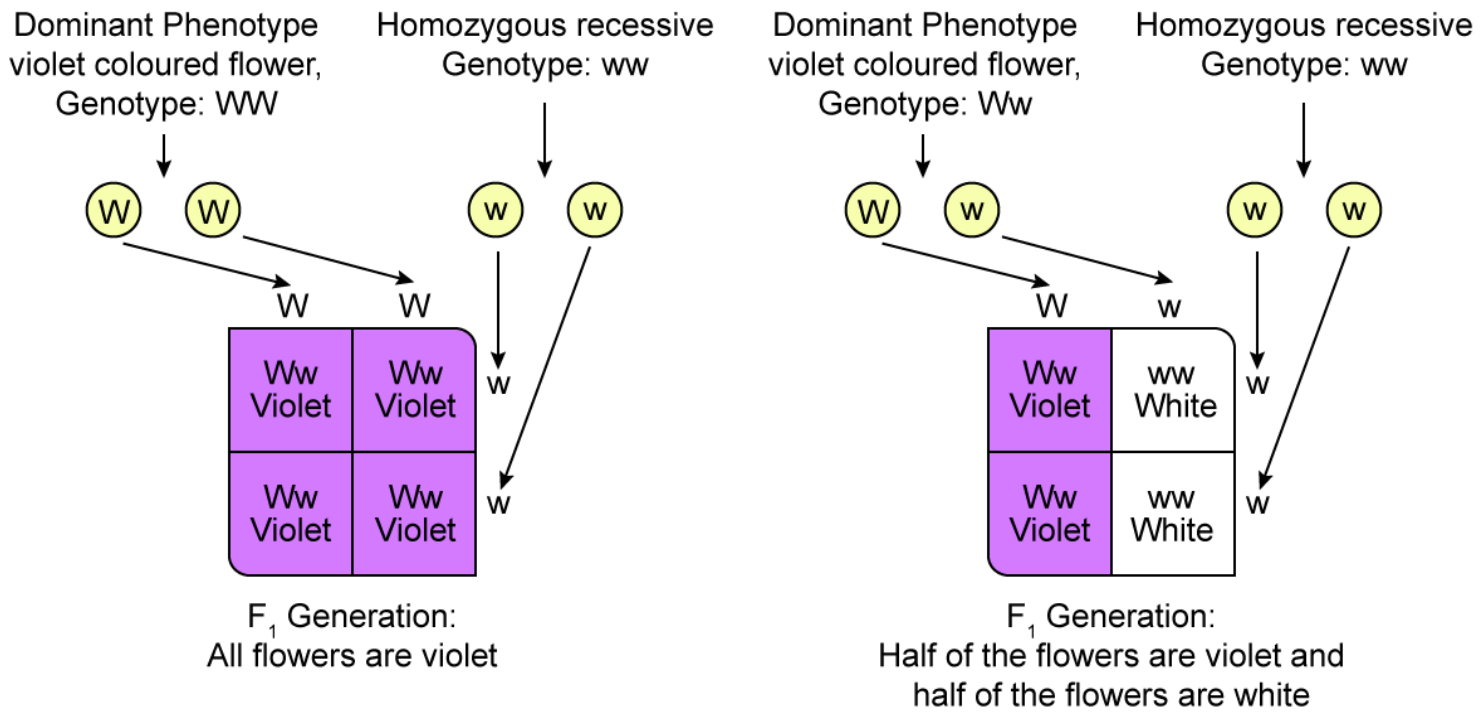
For example, when pea plants with round seeds (RR) are crossed with plants with wrinkled seeds (rr), all seeds in F1 generation were found to be round (Rr). When these round seeds were self fertilized, both the round and wrinkled seeds appeared in F2 generation in 3: 1 ratio. Hence, in F1 generation, the dominant character (round seeds) appeared and the recessive character (wrinkled seeds) got suppressed, which reappeared in F2 generation.




**Q5. Define and design a test-cross.**

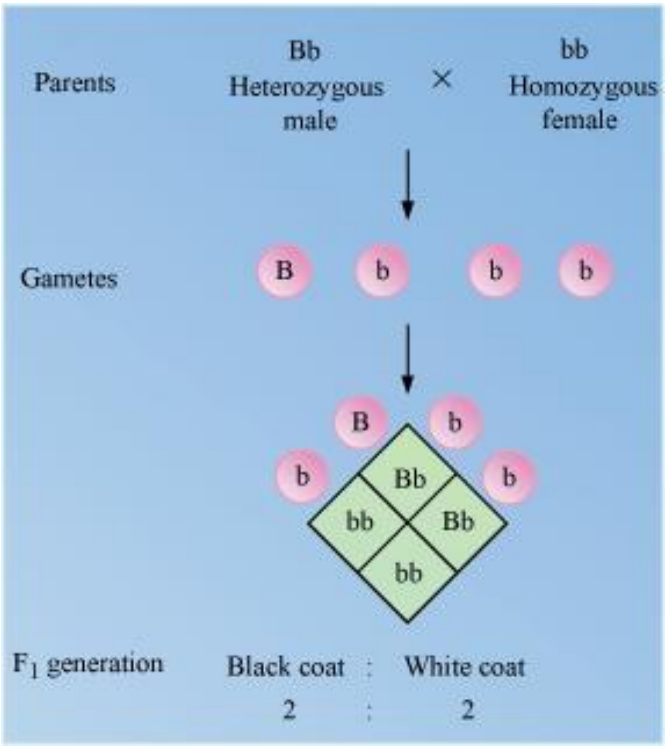
**Answer:** Test cross is a cross between an organism with unknown genotype and a recessive parent. It is used to determine whether the individual is homozygous or heterozygous for a trait.

If the progenies produced by a test cross show 50% dominant trait and 50% recessive trait, then the unknown individual is heterozygous for a trait. On the other hand, if the progeny produced shows dominant trait, then the unknown individual is homozygous for a trait.




**Q6. Using a Punnett Square, workout the distribution of phenotypic features in the first filial generation after a cross between a homozygous female and a heterozygous male for single locus.**

**Answer:** In guinea pigs, a heterozygous male with black coat colour (Tt) is crossed with the female having white coat colour (tt). The male will produce two types of gametes, T and t, while the female will produce only one kind of gamete, r. The genotypic and phenotypic ratio in the progenies of F1 generation will be same i.e., 1:1.



**Q7. When a cross is made between tall plant with yellow seeds (TtYy) and tall plant with green seed (Ttyy), what proportions of phenotype in the offspring could be expected to be**

**(a) tali and green.**

**(b) dwarf and green.**

A cross between tall plant with yellow seeds (TtYy) & tall plant with green seed (Ttyy) is given below.

**Parents** Tall yellow seeds Tt Yy × Tall green seeds Tt yy

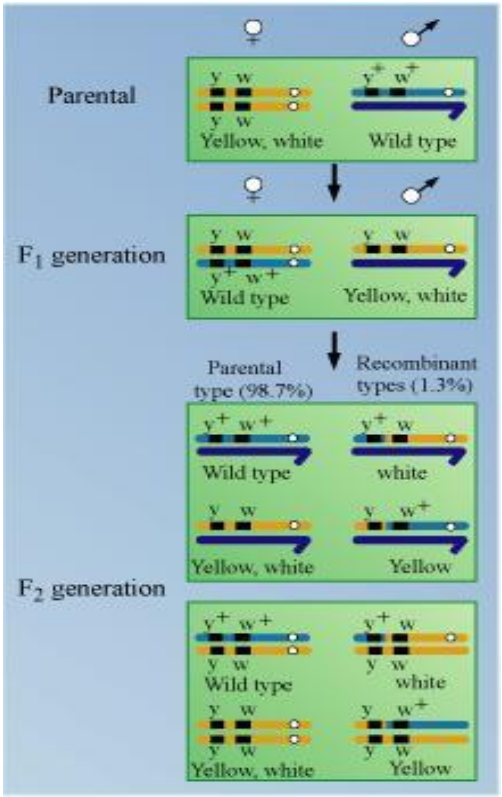
**Gametes** (TY) (Ty) (tY) (ty) × (Ty) (ty)

| | Ty | ty |
|---|---|---|
| TY | TTYy Tall yellow | TtYy Tall yellow |
| Ty | TTyy Tall green | Ttyy Tall green |
| tY | TtYy Tall yellow | ttYy Dwarf yellow |
| ty | Ttyy Tall green | ttyy Dwarf green |

Phenotypes Tall and green = 3
Dwarf and green = 1

**Q8. Two heterozygous parents are crossed. If the two loci are linked what would be the distribution of phenotypic features in F1 generation for a dihybrid cross?**

**Answer:** Linkage is defined as the coexistence of two or more genes in the same chromosome. If the genes are situated on the same chromosome and lie close to each other, then they are inherited together and are said to be linked genes.For example, a cross between yellow body and white eyes and wild type parent in a Drosophila will produce wild type and yellow white progenies. It is because yellow bodied and white eyed genes are linked. Therefore, they are inherited together in progeny.



**Q9. Briefly mention the contribution of T.H. Morgan in genetics.**

**Answer:** Thomas Hunt Morgan (1866-1945), an American geneticist and Nobel Prize winner of 1933, is considered as "Father of experimental genetics" for his work on and discovery of linkage, crossing over, sex linkage, criss cross inheritance, linkage maps, mutability of genes, etc. He is called fly man of genetics because of selecting fruit fly (Drosophila melanogaster) as research material in experimental genetics. It was largely due to his book, "The Theory of Gene", that genetics was accepted as a distinct branch of biology. In 1910, he discovered linkage and distinguished linked and unlinked genes. Morgan and Castle (1911) proposed "Chromosome Theory of Linkage" showing that genes are located on the chromosomes and arranged in linear order. Morgan and Sturtevant (1911) found that frequency of crossing over (recombination) between two linked genes is directly proportional to the distance between the two. 1% recombination is considered to be equal to 1 centiMorgan (cM) or 1 map unit. He worked on sex linked inheritance and reported a white eyed male Drosophila in a population of red eyed and proved that gene of eye colour is located on X-chromosome. The male passes its genes on X-chromosomes to the daughter while the son gets genes on X-chromosome from the female (mother): It is called criss-cross inheritance.

**Q10. What is pedigree analysis? Suggest how such an analysis can be useful.**

**Answer:** Pedigree analysis is the study of pedigree for the transmission of a particular trait and finding the possibility of absence or presence of that trait in a homozygous or heterozygous state in a particular individual. Pedigree analysis helps-

- In analysis of transmission of character in family over generation.
- In genetic counselling of diseases like haemophilia.
- To identify whether a particular genetic disease is due to a recessive gene or a dominant gene.
- To identify the possible origin of the defective gene in the family or in a population.

**Q11. How is sex determined in human beings?**

**Answer:** Sex determination refers to the mechanisms employed by organisms to produce offsprings that are of two different sexes. The sex of an individual is determined by the genetic information present in the individual's sex chromosomes. Sex determination in human is done by XY type chromosome. In humans, females have two XX chromosomes and males have two different chromosomes (XY).

**Q12. A child has blood group O. If the father has blood group A and mother of blood group B, work out the genotypes of the parents and the possible genotypes of the other offspring.**

**Answer:** The blood group characteristic in humans is controlled by three set of alleles, namely, $I^A$, $I^B$, and i. The alleles, $I^A$ and $I^B$, are equally dominant whereas allele, i, is recessive to the other alleles. The individuals with genotype, $I^A$ $I^A$ and $I^A$ i, have blood group A whereas the individuals with genotype, $I^B$ $I^B$ and $I^B$ i, have blood group B. The persons with genotype $I^A$ $I^B$ have blood group AB while those with blood group O have genotype ii.

Hence, if the father has blood group A and mother has blood group B, then the possible genotype of the parents will be

Father Mother

$I^A$ $I^A$ or $I^A$ i $I^B$ $I^B$ or $I^B$ i

A cross between homozygous parents will produce progeny with AB blood group.

**Q13. Explain the following terms with example**
**(a) Co - dominance**
**(b) Incomplete dominance**
**Answer:**
**(a) Codominance:** Codominance is the phenomenon of two contrasting alleles of the same gene lacking dominant recessive ratio and expressing themselves simultaneously when present together. E.g. ABO blood group system – Human blood group AB is formed when alleles of blood groups A and B are present together (IAIB). Such RBCs carry both antigen A & B showing that both die alleles are expressing their effect phenotypically & codominant.
**(b) Incomplete dominance:** Incomplete dominance is a phenomenon in which one allele shows incomplete dominance over the other member of the allelic pair for a character. For example, a monohybrid cross between the plants having red flowers and white flowers in Antirrhinum species will result in all pink flower plants in $F_1$ generation. The progeny obtained in $F_1$ generation does not resemble either of the parents and exhibits intermediate characteristics. This is because the dominant allele, R, is partially dominant over the other allele, r. Therefore, the recessive allele, r, also gets expressed in the $F_1$ generation resulting in the production of intermediate pink flowering progenies with Rr genotype. Phenotypic and Genotypic ratio in $F_2$ generation is always the same in case of incomplete dominance.

**Q14. What is point mutation? Give one example.**
**Answer:** Point mutation is a change in a single base pair of DNA by substitution, deletion, or insertion of a single nitrogenous base. An example of point mutation is sickle cell anaemia. It involves mutation in a single base pair in the beta-globin chain of haemoglobin pigment of the blood. Glutamic acid in the short arm of chromosome II gets replaced with valine at the sixth position.

**Q15. Who had proposed the chromosomal theory of inheritance?**
**Answer:** Chromosomal theory of inheritance was proposed by Sutton and Boveri independently in 1902. The two workers found a close similarity between the transmission of Mendelian hereditary factors (genes) and behaviour of chromosomes during gamete formation and fertilisation. They proposed that chromosomes were the carriers of the Mendelian factors. It is the chromosome and not genes which segregate and assort independently during meiosis and recombine at the time of fertilisation in the zygote. Chromosomal theory of inheritance was expanded by Morgan, Sturtevant and Bridges.

**Q16. Mention any two autosomal genetic disorders with their symptoms.**
**Answer:** Two autosomal genetic disorders are as follows.
**1. Sickle cell Anaemia**
It is an autosomal linked recessive disorder, which is caused by point mutation in the beta-globin chain of haemoglobin pigment of the blood. The disease is characterized by sickle shaped red blood cells, which are formed due to the mutant haemoglobin molecule. The disease is controlled by the HbA and HbS allele.
**Symptoms:** Rapid heart rate, breathlessness, delayed growth and puberty, jaundice, weakness, fever, excessive thirst, chest pain, and decreased fertility are the major symptoms of sickle cell anaemia disease.
**2. Down syndrome**
It is an autosomal genetic disorder caused by trisomy of chromosome 21. Symptoms of Down syndrome include short stature with a round head, protruding tongue, slanting eyes, broad short hands etc.
**Symptoms:** The individual is short statured with round head, open mouth, protruding tongue, short neck, slanting eyes, and broad short hands. The individual also shows retarded mental and physical growth.

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