Principles of Inheritance and Variation

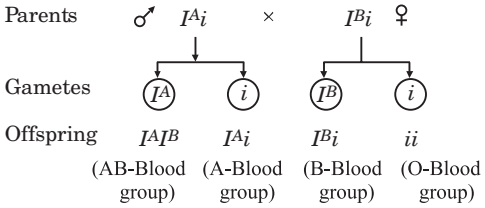
CHAPTER 5

NCERT FOCUS

ANSWERS

Topic 1

1. Child would have blood group O only when both the parents are heterozygous, *i.e.*, father I^Ai and mother I^Bi.



Thus, the genotypes of the parents of child with blood group O will be I^Ai and I^Bi. There is possibility of 3 other types of blood group of offsprings besides O, These are I^Ai (blood group A), I^Bi (blood group B) and I^AI^B (blood group AB).

2. Parent – (Tall Yellow) TtYy × (Tall Green) Ttyy

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

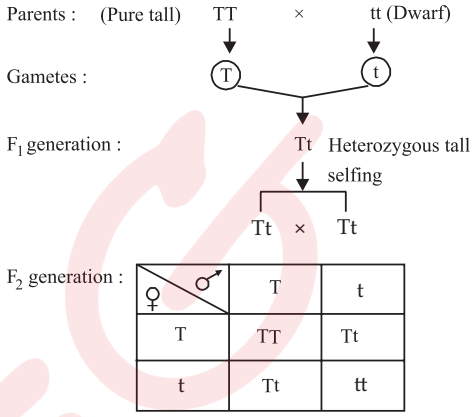
Phenotypes of the offsprings : 3 Tall Yellow
3 Tall Green
1 Dwarf Green
1 Dwarf Yellow

(a) Proportion of tall and green is 3/8.

(b) Proportion of dwarf and green is 1/8.

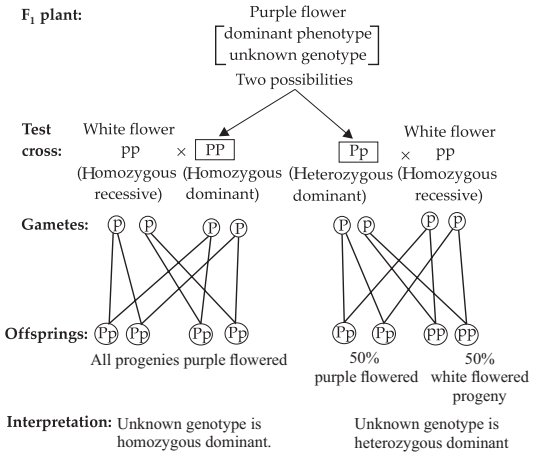
3. For a diploid organism, which is heterozygous for 4 loci, 2^4, *i.e.*, $2 \times 2 \times 2 \times 2 = 16$ types of gametes can be produced if the genes are not linked because for each heterozygous pair of genes there are two possibilities. So, for 4 pairs, the number of gametes will be 16.

4. Law of dominance states that when a pair of alleles or allelomorphs are brought together in F_1 hybrid, then only one of them expresses itself, masking the expression of other completely. Monohybrid cross was made to study simultaneous inheritance of a single pair of Mendelian factors. The cross in which only alternate forms of a single character are taken into consideration is called monohybrid cross. The trait which appeared in the F_1 generation was called dominant and the other which did not appear in the F_1 population was called recessive.



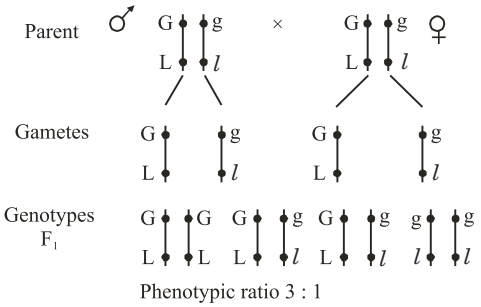
Thus, when a pair of alleles are brought together in F_1 hybrid, then only one of them expresses itself masking the expression of other completely. In the above example, in Tt – F_1 hybrid (tall) only 'T' expresses itself, so it is dominant and 't' is masked, thus recessive. This proves and explains the law of dominance.

5. Crossing of F_1 individual having dominant phenotype with its homozygous recessive parent is called test cross. Test cross is performed to determine the genotype of F_2 plant. In a typical test cross, an organism showing dominant phenotype and whose genotype is to be determined is crossed with one that is homozygous recessive for the allele being investigated, instead of self-crossing. The progenies of such a cross can easily be analysed to predict the genotype of the test organism. Following is an illustration of test cross.



Topic 2

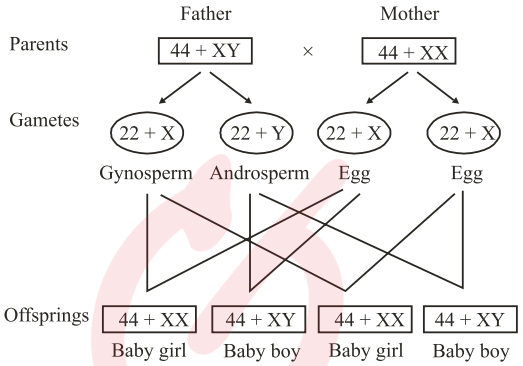
1. Two heterozygous parents (*i.e.*, GgL*l* and GgL*l*) are crossed and if the two loci are linked then the cross will be



This means, if 'G' represent grey body (dominant), 'g' black body (recessive), '*l*'-long (dominant) and '*l*'-short (recessive) then the distribution of phenotypic features in F_1 generation will be 3 : 1 *i.e.* 3/4 will show the dominant feature, grey and long, either in homozygous (GGLL) or in heterozygous (GgL*l*) condition and 1/4 will show the recessive feature, black and short (gg*ll*).

2. 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. In 1910, he discovered linkage and distinguished linked and unlinked genes. Morgan and Castle (1911) proposed "Chromosomal 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 centi Morgan (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 passed 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.

3. Chromosomal determination of sex in human beings is of XX-XY type. Human beings have 22 pairs of autosomes and one pair of sex chromosomes. The female possess two homomorphic (= isomorphic) sex chromosomes, named XX. The males contain two heteromorphic sex chromosomes, *i.e.*, XY. All the ova formed by female are similar in their chromosome type (22 + X). Therefore, females are homogametic. The male gametes or sperms produced by human males are of two types, gymnosperms (22 + X) and androsperms (22 + Y). Human males are therefore, heterogametic. Sex of the offspring is determined at the time of fertilisation. Fertilisation of the egg (22 + X) with a gymnosperm (22 + X) will produce a female child (44 + XX) while fertilisation with an androsperm (22 + Y) gives rise to male child (44 + XY). As the two types of sperms are produced in equal proportions, there are equal chances of getting a male or female child in a particular mating. As Y-chromosomes determines the male sex of the individual, it is also called androsome.



4. 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.

Topic 3

1. A record of inheritance of certain genetic traits for two or more generations presented in the form of a diagram of family tree is called pedigree. Pedigree analysis is study of pedigree for the transmission of particular trait and finding the possibility of absence or presence of that trait in homozygous or heterozygous state in a particular individual.

Pedigree analysis is useful for the following :

(i) It is useful for the genetic counsellors to advice intending couples about the possibility of having children with genetic defects like haemophilia, colourblindness, alkaptonuria, phenylketonuria, thalassemia, sickle cell anaemia (recessive traits), brachydactyly and syndactyly (dominant traits).

(ii) It can indicate the origin of a trait in the ancestors, *e.g.*, haemophilia appeared in Queen Victoria and spread in royal families of Europe through marriages.

(iii) It helps to know the possibility of a recessive allele to create a disorder in the progeny like thalassemia, muscular dystrophy, haemophilia.

(iv) It can indicate about the harm that a marriage between close relatives, may cause.

2 When heritable alterations occur in a very small segment of DNA molecule, *i.e.*, a single nucleotide or nucleotide pair, then mutations are called point mutations (gene mutations). Example, phenylketonuria is an inborn, autosomal, recessive metabolic disorder in which the homozygous recessive individual lacks the enzyme phenylalanine hydroxylase needed to change phenylalanine (amino acid) to tyrosine (amino acid) in liver.

3. (i) Cystic fibrosis is an autosomal recessive disorder of infants, children and young adults that is due to a recessive autosomal allele present on chromosome 7. The disease gets its name from the fibrous cysts that appear in the pancreas. In 70% of cases, it is due to deletion of three bases which produces a defective glycoprotein. The defective glycoprotein causes formation of thick mucus in skin, lungs, pancreas, liver and other secretory organs. Accumulation of thick mucus in lungs results in obstruction of airways. Mucus deposition in pancreas blocks secretion of pancreatic juice. There is maldigestion of food with high fat content in stool. Liver may undergo cirrhosis and there is impaired production of bile. Vasa deferentia of males undergo atrophy.

(ii) Huntington's disease or Huntington's chorea is a dominantly autosomal inherited disorder in which muscle and mental deterioration occurs. There is gradual loss of motor control resulting in uncontrollable shaking and dance like movements (chorea). The brain shrinks between 20–30% in size followed by slurring of speech, loss of memory and hallucinations.

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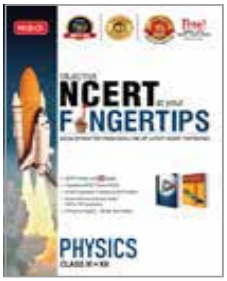

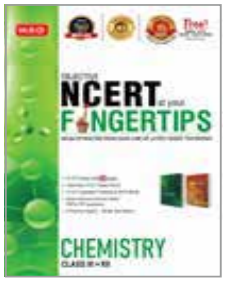

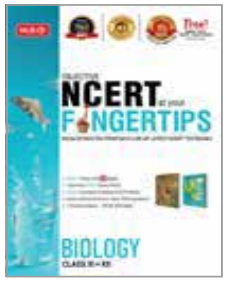

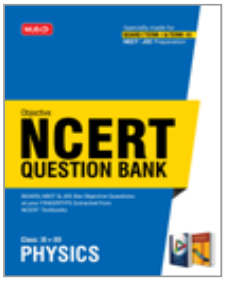

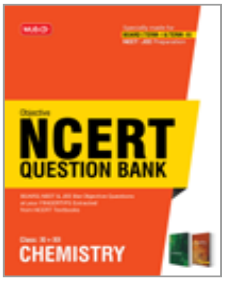

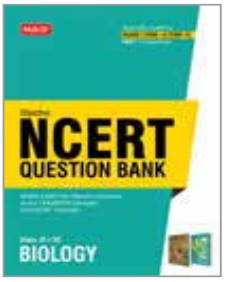

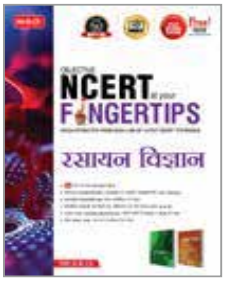

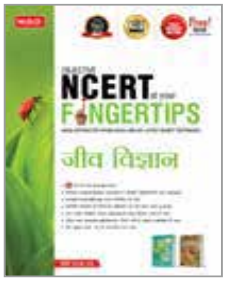

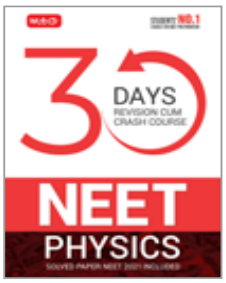

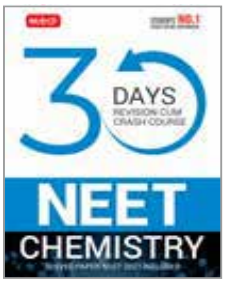

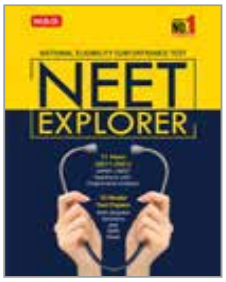

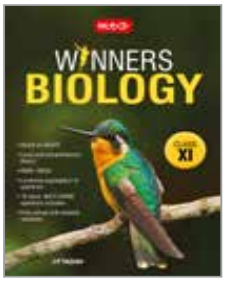

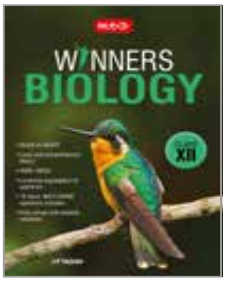

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