CBSE Class 12 Biology
NCERT Exemplar Solutions
CHAPTER 5
PRINCIPLE OF INHERITANCE AND VARIATION

Multiple Choice Questions (MCQs)

1. All genes located on the same chromosome:

(a) Form different groups depending upon their relative distance

(b) Form one linkage group

(c) Will not from any linkage groups

(d) Form interactive groups that affect the phenotype

Ans. (b) Form one linkage group

Explanation: Morgan showed that genes located on the same chromosome formed one linkage group. But linkage or no linkage depends on proximity of two genes. Genes which are closer show more likelihood of linkage. Hence, option 'b' is correct.

2. Conditions of a karyotype 2n ± 1 and 2n ± 2 are called:

(a) Aneuploidy

(b) Polyploidy

(c) Allopolyploidy

(d) Monosomy

Ans. (a) Aneuploidy

Explanation: Failure of segregation of chromatids during cell division cycle results in gain or loss of chromosome. This condition is called aneuploidy

3. Distance between the genes and percentage of recombination shows:

(a) a direct relationship

(b) an inverse relationship

(c) a parallel relationship

(d) no relationship

Ans. (b) an inverse relationship

Explanation: Chances of recombination decreases with increased distance between genes. Hence there is an inverse relationship between the two.

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4. If a genetic disease is transferred from a phenotypically normal but carrier female to only some of the male progeny, the disease is:

(a) Autosomal dominant

(b) Autosomal recessive

(c) Sex-linked dominant

(d) Sex-linked recessive

Ans. (d) Sex-linked recessive

Explanation: In this case, the defective gene is present on the X-chromosome but the disease is manifested in men and women are carriers. So, it is a sex-linked recessive disease. Haemophilia is one example and is also referred to as X-linked recessive disease.

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5. In sickle cell anaemia glutamic acid is replaced by valine. Which one of the following triplets codes for valine?

(a) G G G

(b) A A G

(c) G A A

(d) G U G

Ans. (d) G U G

Explanation: The substitution of amino acid in the globin protein results due to the single base substitution at the sixth codon of the beta globin gene from GAG to GUG. Condon GUG codes for valine which results in sickle cell anaemia.

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6. Person having genotype $I^A I^B$ would show the blood group as AB. This is because of:

(a) Pleiotropy

(b) Co-dominance

(c) Segregation

(d) Incomplete dominance

Ans. (b) Co-dominance

Explanation: When F_1 generation resembles both parents, this is called co-dominance. This is often seen in ABO blood grouping. Since both A and B sugars are dominant, hence it results in AB blood group.

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7. ZZ / ZW type of sex determination is seen in:

(a) Platypus

(b) Snails

(c) Cockroach

(d) Peacock

Ans. (d) Peacock

Explanation: This type of sex determination is seen in birds. The female has a ZW

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combination while the male has ZZ combination.

8. A cross between two tall plants resulted in offspring having few dwarf plants. What would be the genotypes of both the parents?

(a) TT and Tt

(b) Tt and Tt

(c) TT and TT

(d) Tt and tt

Ans. (b) Tt and Tt

Explanation: In case of TT and Tt; all offspring would be tall (TT, Tt). In case of option 'c' no gene for dwarf is present, so all offspring will be tall. In case of option 'd' one of the parent plant is dwarf, so it is incorrect. In case of option 'b' most of the offspring will be tall and a few will be dwarf (TT, Tt, tt). Option 'b' is the correct answer.

9. In a dihybrid cross, if you get 9:3:3:1 ratio it denotes that:

(a) The alleles of two genes are interacting with each other

(b) It is a multigenic inheritance

(c) It is a case of multiple allelism

(d) The alleles of two genes are segregating independently.

Ans. (d) The alleles of two genes are segregating independently.

Explanation: This shows the perfect dihybrid ratio according to Mendel. Hence, the alleles of two genes are segregating independently.

10. Which of the following will not result in variations among siblings?

(a) Independent assortment of genes

(b) Crossing over

(c) Linkage

(d) Mutation

Ans. (c) Linkage

Explanation: Linkage happens in all cases whenever two genes are located on the same chromosome and are close to each other. Thus, linkage has nothing to do with variation.

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11. Mendel's Law of independent assortment holds good for genes situated on the:

(a) non-homologous chromosomes

(b) homologous chromosomes

(c) extra nuclear genetic element

(d) same chromosome

Ans. (a) non-homologous chromosomes

Explanation: Independent assortment cannot take place in case of options (b), (c) and (d).

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12. Occasionally, a single gene may express more than one effect. The phenomenon is called:

(a) multiple allelism

(b) mosaicism

(c) pleiotropy

(d) polygeny

Ans. (c) pleiotropy

Explanation: (c) pleiotropy

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13. In a certain taxon of insects some have 17 chromosomes and the others have 18 chromosomes. The 17 and 18 chromosome-bearing organisms are:

(a) males and females, respectively

(b) females and males, respectively

(c) all males

(d) all females

Ans. (a) males and females, respectively

Explanation: XO type of sex determination is seen in these insects. In such cases, the males have only one X-chromosome and the females have a pair of X-chromosome.

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14. The inheritance pattern of a gene over generations among humans is studied by the pedigree analysis. Character studied in the pedigree analysis is equivalent to:

(a) quantitative trait

(b) Mendelian trait

(c) polygenic trait

(d) maternal trait

Ans. (b) Mendelian trait

Explanation: The pattern of inheritance of Mendelian disorders can be traced through pedigree analysis.

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15. It is said that Mendel proposed that the factor controlling any character is discrete and independent. His proposition was based on the:

(a) results of F_3 generation of a cross.

(b) observations that the offspring of a cross made between the plants having two contrasting characters shows only one character without any blending.

(c) self-pollination of F_1 offsprings

(d) cross pollination of F_1 generation with recessive parent.

Ans. (b) observations that the offspring of a cross, made between the plants having two contrasting characters shows only one character without any blending.

Explanation: During dihybrid cross, Mendel observed that when two pairs of contrasting characters were selected for analysis; it was found that a particular character behaved independently from another character. Hence, option 'b' is correct.

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16. Two genes 'A' and 'B' are linked. In a dihybrid cross involving these two genes, the F_1 heterozygote is crossed with homozygous recessive parental type (aa bb). What would be the ratio of offspring in the next generation?

(a) 1: 1: 1: 1

(b) 9: 3: 3: 1

(c) 3: 1

(d) 1: 1

Ans. (a) 1: 1: 1:1

Explanation: (d) 1: 1: 1: 1

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17. In the F_2 generation of a Mendelian dihybrid cross the number of phenotypes and genotypes are:

(a) phenotypes - 4; genotypes - 16

(b) phenotypes - 9; genotypes - 4

(c) phenotypes - 4; genotypes - 8

(d) phenotypes - 4; genotypes – 9

Ans. (d) phenotypes - 4; genotypes – 9

Explanation: Let us take example of dihybrid cross between round yellow (RRYY) and wrinkled green (rryy). In F_2 generation there were four Phenotypes: round yellow, round green, wrinkled yellow and wrinkled green. The genotypes were; RRYY, RRYy, RRyy, RrYY, RrYy, Rryy, rrYY, rrYy and rryy. Option 'd' is correct.

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18. Mother and father of a person with 'O' blood group have 'A' and 'B' blood group respectively. What would be the genotype of both mother and father?

(a) Mother is homozygous for 'A' blood group and father is heterozygous for 'B'

(b) Mother is heterozygous for 'A' blood group and father is homozygous for 'B'

(c) Both mother and father are heterozygous for 'A' and 'B' blood group, respectively

(d) Both mother and father are homozygous for 'A' and 'B' blood group, respectively

Ans. (c) Both mother and father are heterozygous for 'A' and 'B' blood group, respectively

Explanation: Possible genotype of parents are; I^Ai (A blood group) and I^Bi (B blood group) and phenotype of offspring is ii (O blood group).

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Very Short Answer Type Questions

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

Ans. The cross between the progeny of F_1 and the homozygous recessive parent is called test cross. The progenies of a test cross are studied to determine the phenotype in F_1 generation.

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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.

Ans. If the characters were located on some chromosome, then results could have been entirely different. This was seen by Morgan's experiments on Drosophilla. He observed that the phenotype in the F_1 generation was in a different ratio than what was observed by Mendel. This happened because the characters were located on the same chromosome.

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3. Enlist the steps of controlled cross pollination. Would emasculation be needed in a cucurbit plant? Give reasons for your answer.

Ans. Following are the steps of controlled cross pollination:

Emasculation → Transfer of pollen from a different flower → Pollination → Fertilisation

Plants of cucurbitaceae have unisexual flowers, so cross pollination is the norm and emasculation is not needed. But in case of a monoecious plant, emasculation would be necessary.

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4. A person has to perform crosses for the purpose of studying inheritance of a few traits / characters. What should be the criteria for selecting the organisms?

Ans. For this type to study, the organism should meet following criteria:

- There must be easily identifiable sets of contrasting characters.
- Life cycle of the organism should be short enough so that study can be conveniently completed within a couple of years.
- Hybridization should be easy to induce in the organism.

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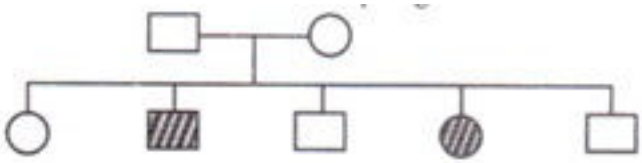
5. The pedigree chart given below shows a particular trait which is absent in parents but present in the next generation irrespective of sexes. Draw your conclusion on the basis of the pedigree.



Ans. The first row shows mating between parents. The next row shows the number of progenies. There are three male and 2 female children. One boy and one girl are affected with some genetic disorder. Thus, the trait is autosome linked and recessive in nature.

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6. In order to obtain the F_1 generation Mendel pollinated a pure-breeding tall plant with a pure breeding dwarf plant. But for getting the F_2 generation, he simply self-pollinated the tall F_1 plants. Why?

Ans. When plants of F_1 generation were produced, all of them were tall plants. After that, Mendel wanted to understand the fate of recessive character. He did not want any other character set to mask the effect of inheritance to F_2 generation. Hence, he simply self-pollinated the tall F_1 plants

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7. "Genes contain the information that is required to express a particular trait." Explain.

Ans. During Mendel's period, genes were not known to the scientists. But after the discovery of chromosomes, scientists could discover that genes are present on chromosomes and they were responsible for inheritance of characters. Hence, it is said that genes contain the

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information that is required to express a particular trait.

8. How are alleles of particular gene differ from each other? Explain its significance.

Ans. Genes which code for a pair of contrasting characters are called alleles. Alleles of a pair are slightly different from each other. This difference may or may not be manifested as observable characters or phenotype. But the difference can be in the form of absence or presence of an extra molecule of a particular substance; such as sugar polymers present on the gene I which controls the ABO blood grouping. Alleles are significant in the sense that a particular trait can be dominant or recessive. In some instances, co-dominance can also be seen.

9. In a monohybrid cross of plants with red and white flowered plants, Mendel got only red flowered plants. On self-pollinating these F_1 plants got both red and white flowered plants in 3:1 ratio. Explain the basis of using RR and rr symbols to represent the genotype of plants of parental generation.

Ans. Symbols RR and rr are used for the sake of convenience and using a particular alphabet has no scientific basis. Usually, the first letter of a particular trait is used to describe that character and the contrasting character is shown by the same letter but in a different case. As per convention, dominant trait is shown by capital letter and recessive trait is shown by lower case letter.

10. For the expression of traits genes provide only the potentiality and the environment provides the opportunity. Comment on the veracity of the statement.

Ans. Genes are the carriers of inheritable traits and hence it can be said that the genes provide the potentiality for the expression of a particular trait. Expression of a particular trait is termed as phenotype and it is dependent on many factors. A particular trait may become recessive if it gets combined with a dominant trait. Moreover, survival of a particular trait also depends on the fact whether the trait passes the natural selection. Hence, it can be said that the environment provides the opportunity for expression of a particular trait.

11. A, B, D are three independently assorting genes with their recessive alleles a, b, d, respectively. A cross was made between individuals of Aa bb DD genotype with aa bb dd. Find out the type of genotypes of the offspring produced.

Ans. The following Punnett Square shows the genotype of F_1 generation:

	abd
AbD	AabbDd
abD	aabbDd

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12. In our society, a woman is often blamed for not bearing male child. Do you think it is right? Justify.

Ans. From the concept of sex determination in humans, it is clear that Y chromosome which is present in males comes from the father and not from the mother. Hence, it is the man who should be blamed for not having a male child rather than the woman. But probability of an X or Y chromosome ending up in the zygote is equal, i.e. 50: 50. So, it is purely a chance that a girl or a boy is borne and no one should be blamed or rewarded for that. The society should learn to respect the girl child as well.

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13. Discuss the genetic basis of wrinkled phenotype of pea seed.

Ans. Seeds dry before they are ready for dispersal and subsequent germination. If there is enough amount of starch in the seed, then the seed is round otherwise wrinkled seeds are produced. Relative amount of starch in seed is controlled by a gene. A mutant gene in pea plants results in enzymes which lessen the amount of starch in seeds and thus seeds become wrinkled.

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14. Even if a character shows multiple allelism, an individual will only have two alleles for that character. Why?

Ans. Most of the organisms are diploid and thus alleles can only be present in pairs. Hence, in spite of multiple allelism; an individual will only have two alleles for that character. A good example of this can be shown by I^A, I^B and i alleles which govern the ABO blood grouping in humans.

15. How does a mutagen induce mutation? Explain with example.

Ans. Mutagens are chemical and physical factors which can induce mutation. They do so by altering the base pair sequence in the DNA during replication.

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Short Answer Type Questions

1. In a Mendelian monohybrid cross, the F_2 generation shows identical genotypic and phenotypic ratios. What does it tell us about the nature of alleles involved? Justify your answer.

Ans. When plants of F_1 generation are allowed to reproduce without cross, the alleles segregate and one allele goes to one parent while another allele goes to another parent. This is in accordance with transfer of halved number of chromosome during meiosis. This segregation is a random process and there is 50% chance of a particular allele going to either the male gamete or the female gamete. Due to this, the genotype produced in F_2 generation is same as the phenotype produce in that generation. So, percentage of plants with pure genotype and those with mixed genotype will be same, i.e. 50%

2. Can a child have blood group O if his parents have blood group 'A' and 'B'. Explain.

Ans. A child from parents with blood group 'A' and 'B' can have blood group O. If genotype of one parent is I^Ai and that of another parent is I^Bi; then gametes from the parents can have any one of the genotype, i.e. I^A or I^B or i. If fertilization happens between gametes with i only, then the child's genotype will be ii and hence the child can have blood group O.

3. What is Down's syndrome? Give its symptoms and cause. Why is it that the chances of having a child with Down's syndrome increases if the age of the mother exceeds forty years?

Ans. Down's syndrome is a chromosomal disorder. A person suffering from Down 's syndrome shows following symptoms:

- Short stature
- Small round head
- Furrowed tongue and partially open mouth
- Palm is broad with characteristic palm crease.
- Physical, psychomotor and mental development is retarded in the person.

This condition happens because of an extra copy of chromosome 21. As per various research reports, chances of having a child with Down's syndrome increases with advancing maternal age because ova are present in females right from their birth. More is the age of the mother, cells will be more older. Hence, chances of chromosomal non-disjunction will be more because of various physico-chemical exposures during the mother's life-time.

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4. How was it concluded that genes are located on chromosomes?

Ans. Walter Sutton and Theodor Boveri studied the behaviour of chromosome and genes during meiosis. They observed that the movement of chromosome and that of gene was similar. Based on this observation, thy proposed that genes are located on chromosomes.

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5. A plant with red flowers was crossed with another plant with yellow flowers. If F_1 showed all flowers orange in colour, explain the inheritance.

Ans. Sometime, dominance of a particular trait over another trait may not be complete. This results in a situation that both the characters manifest together in some progeny. This condition is called incomplete dominance. Let us assume that red flowers have genotype RR and yellow flowers have genotype rr. All progenies in the F_1 generation will have Rr genotype. Since red colour fails to completely dominate the yellow colour; all plants in F_1 generation produce orange flowers.

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6. What are the characteristic features of a true-breeding line?

Ans. Following are the characteristic features of a true-breeding line:

- Self-pollination through successive generation.
- Stable trait inheritance through several generations.

- Stable expression of characters through several generations.

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7. In peas, tallness is dominant over dwarfness, and red colour of flowers is dominant over the white colour. When a tall plant bearing red flowers was pollinated with a dwarf plant bearing white flowers, the different phenotypic groups were obtained in the progeny in numbers mentioned against them:

- **Tall, Red = 138**
- **Tall, White = 132**
- **Dwarf, Red = 136**
- **Dwarf, White = 128**

Mention the genotypes of the two parents and of the four offspring types.

Ans. Genotypes of parents: TtRr and ttrr

Offspring: Tall, Red: TtRr

Offspring: Tall, White: Ttrr

Offspring: Dwarf, Red: ttRr

Offspring: Dwarf, White: ttrr

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8. Why is the frequency of red-green colour blindness is many times higher in males than that in the females?

Ans. The genes that produce photopigments are present on X-chromosomes. If some of the gene is missing or damaged, it can result in colour blindness. Since males have only one X-chromosome, the chances of colour blindness is very high in males. In case of females, to be colourblind must have the allele for it in both her X-chromosomes. In case, if female possesses the allele for colourblind in only one X-chromosome, then she will act as a carrier and won't be affected by it.

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9. If a father and son are both defective in red-green colour vision, is it likely that the son inherited the trait from his father? Comment.

Ans. The genes for colour blindness are present on the X chromosome. But X chromosome in a son (male child) is not contributed by the father but comes from the mother. Hence, even if a father and his son both are suffering from colour blindness, the son has inherited this trait from his mother.

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10. Discuss why Drosophila has been used extensively for genetical studies.

Ans. Following features of Drosophila make it ideal for genetical studies:

- It can be grown on simple synthetic medium in laboratory.
- It completes its life cycle in two weeks.
- A single mating produces a large number of offsprings.
- There is clear cut sexual dimorphism in Drosophila.
- It has many hereditary variations which can be easily observed with a low power microscope.

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11. How do genes and chromosomes share similarity from the point of view of genetical studies?

Ans. Following are the similarities in genes and chromosomes from the point of view of genetical studies:

They are found in pairs.

They segregate at the time of gamete formation and only one of the pair is transmitted to a gamete.

Independent pairs segregate independently of each other.

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12. What is recombination? Discuss the applications of recombination from the point of view of genetic engineering.

Ans. The gene combination which is different from parental genes is called recombination. This can happen naturally during meiosis. This can also be artificially induced through genetic engineering. Genetic engineering has been applied in creating recombination for various species to produce useful products for humans. For example; Bt cotton and Bt brinjal

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have been produced through genetic engineering. Some vaccines are also being produced through this process, e.g. hepatitis B vaccine.

13. What is artificial selection? Do you think it affects the process of natural selection? How?

Ans. Artificial selection is the selective breeding of plants and animals to include beneficial traits in them. This is also called selective breeding. While some selective breeding can be purely artificial, many others are natural breeding done in a controlled environment. From the point of ethics, it may be wrong to go for artificial selection. But if we follow the law of natural selection and survival of the fittest, then it can be safely assumed the even in case of artificial selection only those varieties are going to survive which are fit to survive. Hence, it can be inferred that artificial selection is not going to affect the process of natural selection.

14. With the help of an example differentiate between incomplete dominance and co-dominance.

Ans.

Incomplete dominance	Co-dominance
(i) Phenotypes from both the parents are partially manifested in F_1 generation.	(i) Phenotypes from both the parents are completely manifested in F_1 generation.
(ii) Example: When snapdragon plants with red flowers were crossed with flowers, the F_1 generation produced pink flowers.	(ii) Example: ABO blood grouping in humans shows co-dominance.

15. It is said, that the harmful alleles get eliminated from population over a period of time, yet sickle cell anaemia is persisting in human population. Why?

Ans. The sickle cell anemia is controlled by a single pair of allele; Hb^A and Hb^S. If both the parents are heterozygous (Hb^AHb^S) then the offspring can suffer from this disease. The offspring should be homozygous (Hb^SHb^S). Heterozygous individuals are carriers of this of this disease. Heterozygous individuals are advantageous in terms of adaptation. Due to this, sickle cell anemia is persisting in human population.

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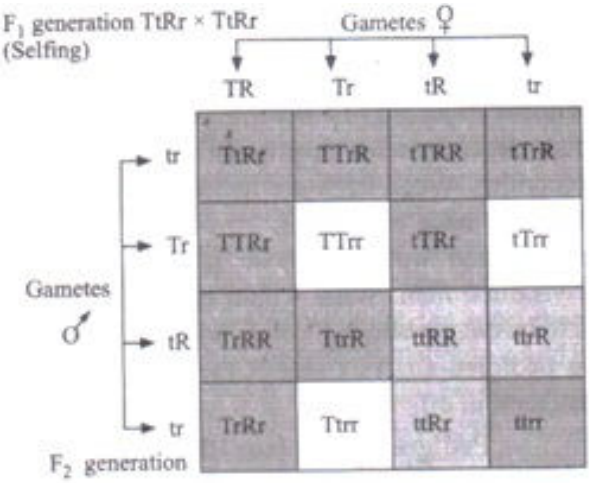
Long Answer Type Questions

1. In a plant tallness is dominant over dwarfness and red flower is dominant over white. Starting with the parents work out a dihybrid cross. What is standard dihybrid ratio? Do you think the values would deviate if the two genes in question are interacting with each other?

Ans. The following Punnett Square shows cross between tall plant with red flowers (TTRR) and dwarf plant with white flowers (ttrr). All the plants in F_1 generation will be tall and will produce red flowers.



When plants of F_1 generation are allowed to self-pollinated, phenotype of plants in F_2 generation can be shown by following Punnett Square.

In this case, the standard dihybrid ratio 9 : 3 : 3 : 1 which can be shown as follows:

- Tall plant red flower = 9
- Tall plant white flower = 3
- Dwarf plant red flower = 3
- Dwarf plant white flower = 1

The standard dihybrid ratio works only when the genes for contrasting characters are on different chromosomes. If characters are on the same chromosome, they may interact with each other. In that situation, the dihybrid ratio would show variation from the standard dihybrid ratio.

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2. (a) In humans, males are heterogametic and females are homogametic. Explain. Are there any examples where males are homogametic and females heterogametic?

(b) Also, describe as to, who determines the sex of an unborn child? Mention whether temperature has a role in sex determination.

Ans. (a) In humans, the 23^{rd} pair of chromosome contains and X chromosome and a Y chromosome. Hence, males are called heterogametic. Females, on the other hand, have XX chromosomes in the 23^{rd} pair. Hence, females are called homogametic. But in bird's females have ZW chromosome and male have ZZ Chromosome. So, in some cases, males can be homogametic and females can be heterogametic.

(b) In case of humans, sex is determined by X and Y-chromosomes. Out of the 23 pairs of chromosomes in human beings, the 23^{rd} pair is called sex chromosome while the remaining 22 pairs are called autosomes. All males have X and Y-chromosomes in the 23^{rd} pair while females have XX-chromosomes in the 23^{rd} pair. Thus, a sperm can have either X or Y-chromosome, while all the eggs will have X-chromosome. When a sperm with X chromosome fertilizes the ovum; the zygote will result in development of a girl child. If a sperm with Y-chromosome fertilizes the ovum; the zygote will result in development of a male child.

Temperature dependent sex determination is found in many animals, e.g. in crocodiles. When eggs are incubated at higher temperature, it results in birth of male crocodiles.

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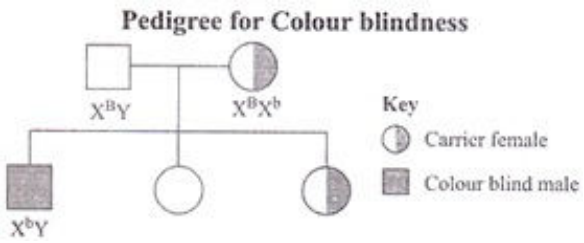
3. A normal visioned woman, whose father is colour blind, marries a normal visioned man. What would be probability of her sons and daughters to be colour blind? Explain with the help of a pedigree chart.

Ans. Following pedigree analysis shows the probability of prevalence of colour blindness in offspring:



- The P generation shows a normal husband and a carrier wife.
- The F_1 generation shows one male child and two female children.

The male child will suffer from colour blindness and one of the females may be a carrier.

The genes for colour blindness are mainly present on the X-chromosome. We know that only one X-chromosome is present in males. Hence, if a boy has defective X-chromosome (without some genes of photoreception) the boy would be colour blind. Females have another X-chromosome which compensates for the deficiency of its counterpart. Due to this, females, are usually carriers of this disease and seldom suffer from this disease. In terms of prevalence; about 8% of the male population suffers from colour blindness, while just 0.5% of the females suffer from this condition.

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4. Discuss in detail the contributions of Morgan and Sturtevant in the area of genetics.

Ans. Morgan and his group conducted various experiments in the field of genetics. Sturtevant was a student of Morgan. Some of the contributions by them are as follows:

Morgan carried out several dihybrid crosses of Drosophila. He observed that the phenotypic ratio was not similar to the standard phenotypic ratio as observed by Mendel. Morgan and his team were aware that the genes were located on X chromosome. Thy inferred that when the genes were situated on the same chromosome, they did not segregate independently of each other.

When the genes are situated on the same chromosome, the chances of parental combination are much higher than non-parental combination. The physical association of genes on the same chromosome was termed as linkage; by Morgan. Morgan also coined the term recombination to describe generation of non-parental combination.

Sturtevant came out with the finding that relative distance between two genes on the same chromosome was an important factor in recombination or lack of recombination. If the

genes were tightly linked, they did not show recombination. But if the genes were far apart then chances of recombination were higher. Today's genetic mapping could be developed because of contributions made by Morgan and his team.

5. Define aneuploidy. How is it different from polyploidy? Describe the individuals having following chromosomal abnormalities.

(a) Trisomy of 21st Chromosome

(b) XXY

(c) XO

Ans. Failure of chromatid segregation during cell division results in loss or gain of a chromosome. This is called aneuploidy. Failure of cytokinesis; after telophase; results in an increase in a whole set of chromosomes. This condition is called polyploidy. Polyploidy is often seen in plants but is rare in animals.

(a) **Trisomy or 21th Chromosome:** Presence of an additional copy of 21th chromosome is called trisomy of 21th chromosome. This was first described by Langdon Down (1866) and hence is called Down's Syndrome. The person suffering from Down's syndrome is short stature and has small round head. He has furrowed tongue and partially opened mouth. His palm is broad with characteristic palm crease. Physical, psychomotor and mental development is retarded in such person.

(b) **XXY:** This genetic disorder happens because of an additional copy of X chromosome resulting in a karyotype of 47. There are three chromosomes (XXY) in the 23rd set. This condition is knowns as Klinefelter's syndrome. Such a person shows overall masculine development but also show enlarged breasts (gynaecomastia). Such a person is sterile as well.

(c) **XO:** This genetic disorder happens because of lack of an X chromosome resulting in a ploidy of 45 (XO). This condition is called Turner's syndrome. Ovaries are rudimentary in such females and hence such females are sterile. Secondary sexual characters are also absent in such females.