CBSE NCERT Solutions for Class 12 Science Chapter 5

Back of Chapter Questions

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

Solution:

Gregor Mendel chose pea plants for his experiments as it had multiple features to investigate regarding inheritance. Some of the advantages include:

The pea plant had various contrasting characteristics such as seed coat (round or wrinkled), seed colour (green or yellow), flower colour (violet or white) and plant height (tall or dwarf).

Pea plants have a shorter life span.

The flowers are bisexual and can exhibit both self and cross-pollination using which pure lines or contrasting characteristics can be obtained, respectively.

They can produce a large number of seeds in a single generation.

In pea plants, cross-pollination can be achieved easily by emasculation in which the stamen of the flower is removed without affecting the pistil.

It is easy to cultivate.

2. Differentiate between the following

(A) Dominance and Recessive

(B) Homozygous and Heterozygous

(C) Monohybrid and Dihybrid.

Solution:

(A) Dominance and Recessive

Dominance	Recessive
Dominance is the trait of a gene which is always expressed.	Recessive is a trait of a gene which is not always expressed.
A dominant allele can express itself even if a similar allele is not paired to express a phenotype, For example, the height of a plant. If T is tall, t is short; Tt will result in Tall plant.	A recessive allele can only express itself in the presence of another recessive allele for a phenotype — for example, the height of a plant. Two alleles with a recessive trait, t for dwarfness, will result in a dwarf plant.

(B) Homozygous and Heterozygous

Homozygous	Heterozygous
Homozygous refers to the identical pair of alleles for a specific trait.	Heterozygous refers to the non-identical pair of alleles for a specific trait.
Homozygous has either recessive or dominant alleles.	Heterozygous has both dominant and recessive alleles.
It produces one type of gametes.	It produces two types of gametes.
A homozygous allele is represented for a trait such as height by homozygous dominant (TT) which is tall or homozygous recessive (tt) which is dwarf.	A heterozygous allele is represented for a trait such as height by heterozygous pair of alleles represented by Tt, which expresses for Tall.
By crossing over such plants, pure breeds can be obtained.	By crossing over such plants, variations are obtained.
It does not show extra vigour.	The individuals can show extra vigour called hybrid vigour or heterosis.

(C) Monohybrid and Dihybrid.

Monohybrid cross	Dihybrid cross
Monohybrid cross is a cross between two pure plants to obtain progenies with a single contrasting character.	Dihybrid cross is a cross between two pure plants to obtain progenies with two contrasting characters.
The phenotypic ratio is 3:1 in the F_2 generation.	The phenotypic ratio is 9:3:3:1 in the F_2 generation.
It produces a genotypic ratio of 1 : 2 : 1 in F_2.	It produces a genotypic ratio of 1 : 2 : 1 : 2 : 4 : 2 : 1 : 2 : 1 in F_2.
Example: The cross of pea plants having tall and short traits.	Example: The cross of pea plants having round green seeds and wrinkled yellow seeds.

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

Solution:

Locus is a fixed position on a chromosome that is occupied by a single or more genes.

Heterozygous organisms will have different alleles for an allelic pair. Therefore, a diploid heterozygous organism will have four different loci for four different contrasting characters.

For example, if an organism is heterozygous at four different loci with four different characters, say Pp, Qq, Rr, Ss, then during meiosis, it will segregate to form 8 separate gametes.

If the genes are not linked, then the diploid organism will produce 16 different gametes.

However, if the genes are linked, the gametes will reduce their number and the linked genes will be inherited together during the process of meiosis.

4. Explain the Law of Dominance using a monohybrid cross.

Solution:

Mendel's law of dominance states that a dominant allele expresses itself in a monohybrid cross and suppresses the expression of the recessive allele.

However, this recessive allele for a character is not lost and remains hidden or masked in the progenies of F_1 generation and reappears in the next generation.

Example 1: A cross between a Tall and Dwarf plant, with Tall being dominant allele.

The crossing of Tall plant (TT) and Dwarf plant (tt) → TT X tt

Gametes are: T and t → T X t → Tt

The F_1 generation has all tall plants.

Upon self crossing the F_1 generation plants, the F_2 generation is represented by punnet square as :

F_2 generation: Tt X Tt

Tall /Dwarf	T	t
T	TT	Tt
t	Tt	tt

The phenotypic ratio is 3: 1, i.e., there are three tall plants and one dwarf plant obtained at the end of F_2 generation and the genotypic ratio is 1:2:1, which means that 1 homozygous tall plant, 2 heterozygous tall plants, and 1 homozygous dwarf plant were obtained from the F_2 generation.

We can observe that in the F_2 generation, both the alleles, tall and dwarf are expressed whereas, in the F_1 generation, only dominant allele, tall was expressed.

Example 2: when pea plants with round seeds (RR) are crossed with plants with wrinkled seeds (rr), all seeds in the F_1 generation were found to be round (Rr). When these round seeds were self-fertilized, both the round and wrinkled seeds appeared in F_2 generation in 3: 1 ratio. Hence, in the F_1 generation, the dominant character (round seeds) appeared and the recessive character (wrinkled seeds) got suppressed, which reappeared in the F_2 generation.

5. Define and design a test-cross.

Solution:

A test cross is a cross between F_1 progeny having dominant genotype with a homozygous recessive parent in order to determine if the F_1 generation is homozygous or heterozygous dominant. Hence the crossover between the two can be represented as

Tall (Tt or TT) X dwarf. (tt)

There are two possibilities.

(A) If the F_1 generation is homozygous tall, then the cross with a homozygous recessive parent is represented in Punnett square for F_1 generation as

F_1/ recessive parent	**t**	**t**
T	Tt	Tt
T	Tt	Tt

This interprets that the F_1 generation was homozygous tall.

(B) If the F_1 generation is heterozygous tall then the cross with a homozygous recessive parent is represented in Punnett square for F_1 generation as

F_1 /Dwarf	**t**	**t**
T	Tt	Tt
t	tt	tt

This interprets that the F_1 generation was heterozygous tall.

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

Solution:

Let us consider the height as a trait for our analysis and if T represents tall and t represents dwarf, then when the male is heterozygous, the alleles are represented by Tt, and when the female is homozygous, the alleles are represented by tt.

Hence, a cross between a heterozygous male and homozygous female for a single locus is represented by

Tt X tt

The Punnett square is written for the first generation as

Heterozygous male \Homozygous female	t	t
T	Tt	Tt
t	tt	tt

The resulting phenotype ratio is 2 (tall): 2 (dwarf).

7. 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) tall and green.

(B) dwarf and green.

Solution:

A cross between a tall plant with yellow seeds (TtYy) which is heterozygous tall and has heterozygous yellow seed colour and tall plant with a green seed (Ttyy) which is heterozygous tall and has homozygous green seed colour is performed.

The crossing between the two plants can be represented as

TtYy X Ttyy

The gametes for a tall plant with yellow seeds (TtYy) are TY, Ty, tY, ty.

The gametes for a tall plant with the green seed (Ttyy) are Ty, ty

The Punnett square can be represented by

Crossover	Ty	ty
TY	TTYy (Tall and yellow)	TtYy (Tall and yellow)
Ty	TTyy (Tall and green)	Ttyy (Tall and green)
tY	TtYy (Tall and yellow)	ttYy (dwarf and yellow)
ty	Ttyy (Tall and green)	ttyy (dwarf and green)

There are eight progenies obtained from the crossover between these two plants and

Total number of tall and green plants are 3

Total number of dwarf and green plant is 1

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

Solution:

Heterozygous condition refers to having a contrasting pair of alleles such as T and t in which T is tall, and t is dwarf. Locus is a point on a chromosome where one or more genes can be present. If the loci are linked, it means that the genes in the loci are linked and are inherited together.

Let us consider the linked genes of *Drosophila melanogaster*, a fruit fly. The linked genes are of the colour of body and eye, hence upon crossing over the yellow-bodied, white-eyed fly with brown-bodied, red-eyed flies produced both yellow-bodied, white-eyed and brown-bodied, red-eyed varieties, hence in the dihybrid cross, the linked genes were expressed together and not independently in the next generation.

9. Briefly mention the contribution of T.H. Morgan in genetics.

Solution:

Thomas Hunt Morgan studied the *Drosophila melanogaster*, fruit fly, formulated a chromosomal theory of linkage and derived the following conclusions.

Genes that are linked co-exist on the same chromosomes.

The genes are linearly aligned on a chromosome.

A dihybrid cross in drosophila fly led to the conclusion that the linked genes existed on X-chromosomes.

The linked genes are not affected during inheritance.

The closer the linked genes are positioned, the stronger they are, and the strength decreases as the linked genes are positioned away from one another.

The chances of recombination are less if the linked genes are closely positioned, and the chance of recombination is high if the linked genes are positioned away from one another.

10. What is a pedigree analysis? Suggest how such an analysis can be useful.

Solution:

Pedigree analysis is the study of the inheritance of certain traits that are being transmitted over generations and the possibility of their occurrence in the future generations and is represented in a family tree.

Importance of pedigree analysis:

The pedigree analysis helps us know the genetic counsellors to advice intending couples about the possibility of having children with genetic defects like

Haemophilia, colour blindness, alkaptonuria, Phenylketonuria, Thalassemia, sickle cell anaemia (recessive traits), Brachydactyly and Syndactyly (dominant traits). The symbolic representation in the pedigree analysis helps us know the relationships of the families and the interlinks between them.

It is easier to trace a particular trait over generations.

It can also 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.

It helps to know the possibility of a recessive allele to create a disorder in the progeny like Thalassemia, Muscular dystrophy, Haemophilia.

It helps to identify whether a particular genetic disease is due to a recessive gene or a dominant gene.

The risk of inheriting a disease due to marriage in close relatives can be studied.

It can be of great help in the field of research.

Pedigree analysis indicates that Mendel's principles are also applicable to human genetics with some modifications which were found out later like quantitative inheritance, sex-linked characters, and other linkages.

In some cases, it may help to identify the genotypes of offspring yet to be born.

11. How is sex determined in human beings?

Solution:

There are two genders in human beings - female and male. The female chromosomes are XX (homozygous), and male chromosomes are XY(heterozygous). Hence the crossing over between the homozygous female and heterozygous male can result in two possible genders or sex -either a male or a female.

The cross between XY (male) and XX (female) results in

	X	Y
X	XX	XY
X	XX	XY

The sperm released from the male reproductive organ carries haploid chromosomes(n) and either carries an X or a Y chromosome along with 22 other chromosomes, i.e., (22+X) or (22+Y) number of chromosomes. Hence, depending on whether the chromosomes in the sperm is X or Y, the sex in human beings can be determined.

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

Solution:

The blood groups are A, B, and O. The homozygous allele for A group is IAIA , for B group is IBIB and for O group is ii, where " i" is a recessive allele.

If the crossover takes place between homozygous A father and homozygous B mother,

Father X mother

$$I^AI^A \text{ X } I^BI^B$$

$$\downarrow$$

$$I^AI^B \text{ (AB)}$$

The resulting child will have AB blood group.

If the crossover takes place between heterozygous A father and heterozygous B mother,

Father X mother

$$I^Ai \text{ X } I^Bi$$

$$\downarrow$$

$$I^AI^B \text{ (AB) } I^Ai \text{ (A) } I^Bi \text{ (B) ii (O)}$$

Then the resulting child will have either blood group or genotypes of AB, A, B or O.

A child has O blood group since the father has heterozygous A blood group and mother has heterozygous B blood group.

13. Explain the following terms with an example

(A) Co-dominance

(B) Incomplete dominance

Solution:

(A) Co-dominance

Co-dominance is a type of non-mendelian inheritance, in which both the alleles of a trait are expressed independently in a heterozygous condition and produce a progeny with phenotype which is neither dominant nor recessive. AB blood group is an example for co-dominance since the alleles for both blood groups A and B are expressed independently.

(B) Incomplete dominance

Incomplete dominance is a type of non-mendelian inheritance, in which neither of the alleles for a trait is completely expressed over the other allele and produce a progeny which is intermediate to both the alleles. In the

snapdragon flower, there are two pure-breeding varieties of flower, red and white. Upon crossing between these two flowers, the progeny produced pink colour flowers, which is an intermediate colour to red and white.

Cross between Red (RR) and white (rr) flower producing plants resulted in Pink flower producing plants (Rr).

14. What is point mutation? Give one example.

Solution:

The mutation is a change in the sequence of a gene or chromosomes in DNA, which can cause diseases such as cancer or improper expression of protein and so on.

Point mutation is a type of mutation in which there is a change in a single base pair in a sequence of DNA in a chromosome, which can result in the expression of a different gene or protein. One of the example for point mutation is Sickle cell anaemia, which refers to abnormal sickle-shaped red blood cells.

15. Who had proposed the chromosomal theory of the inheritance?

Solution:

Theodor Boveri and Walter Sutton proposed the chromosomal theory of inheritance.

16. Mention any two autosomal genetic disorders with their symptoms.

Solution:

The autosomal genetic disorders include

Sickle cell anaemia: It is an autosomal recessive disorder in which the point mutation takes place in the sequence for haemoglobin. If both the parents are heterozygous for this disorder, then the disease is inherited by the child. This disorder is characterized by the formation of sickle-shaped red blood cells which do not carry oxygen molecules like the normal red blood cells.

Symptoms: Rapid heartbeat, weakness, excessive thirst, chest pain, fever, and reduced fertility.

Polyketonuria: It is an autosomal recessive disorder which is also an inborn error in metabolism, where the enzyme required to convert phenylalanine to tyrosine is not produced and as a result, excessive accumulation of phenylalanine takes place and gets converted to phenyl-pyruvic acid and other metabolites, derivatives.

Symptoms: odor in the skin, breath, and urine, abnormal skin and hair tone, seizures, skin rashes.

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