

Chapter 4: Principles of Inheritance and Variation

NCERT · Class 12 · Biology

Textbook exercises

Question 1

Mention the advantages of selecting pea plants for experiments by Mendel.

Solution

Ans: The pea plant (*Pisum sativum*) was chosen by Mendel for the following reasons:

1. The pea is an annual plant with a brief growing season. As a result, the findings can be achieved in a short amount of time.
 2. Pea has seven distinct features with easily distinguishable traits such as tall and short stature, round and yellow seeds, and so on.
 3. Self-pollination and cross-pollination are both viable options for pea propagation. Mendel was able to create pure lines as well as carry out various crosses between plants with contrasting features as a result of this.
 4. Each generation of the pea plant produces a great number of seeds. As a result, it can provide a vast volume of data that can be statistically more reliably analyzed, for example.
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Question 2

Differentiate between the following:

- (a) Dominance and Recessive
- (b) Homozygous and Heterozygous
- (c) Monohybrid and Dihybrid

Solution

Ans:

Dominance	Recessive
1. A trait that counteracts the effects of another trait, such as tallness suppressing dwarfism.	1. A trait that is suppressed as a result of the effect of another attribute. Dwarfness, for example, is suppressed by height.
2. A trait that will manifest itself even if the recessive trait is present.	2. A trait that only manifests when the dominant trait is absent.
3. A trait that manifests in both homozygous and heterozygous individuals.	3. A trait that can only be expressed in homozygous individuals.

Ans:

Homozygous	Heterozygous
1. For a trait, a genotype is made up of alleles that are similar. TT (for tall) or tt are examples of abbreviations (for short).	1. For a trait, a genotype with different alleles. e.g. Tt.
2. The person could be dominant or recessive. Individuals with the TT genotype, for example, will be tall plants, but those with the tt genotypes will all be short plants.	2. The person is usually dominant or partially dominant, but never recessive.
3. Individuals will only create one type of gamete. T or t for example	3. The person will create two different types of gametes. Both T and t gametes, for example.

Ans:

Monohybrid	Dihybrid
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1. A monohybrid is a person created by crossing parents that have different features for only one character, such as height. Tt (monohybrid for plant height) is an example.	1. A dihybrid is a person created by crossing parents who have different features for two characters, such as seed color and seed shape. RrYy (dihybrid for seed color and shape), for example.
2. A monohybrid cross is a cross between two parents that are homozygous for opposing character characteristics. For example, a cross between tall TT and short (S) tt.	2. A dihybrid cross occurs when two parents are homozygous for opposing features in two different characters, such as seed shape and seed color. A cross between RRYy (round and yellow seeds) and rryy, for example (wrinkled and green seeds).
3. Monohybrid cross is used to investigate the inheritance of a single character.	3. Dihybrid cross is used to investigate the inheritance of two characters.

Question 3

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

Solution

Ans: Gene loci are locations on the chromosome where genes are found. As a result, loci and genes might be considered interchangeable. If a diploid organism is heterozygous for four loci, it will have four distinct traits: Aa , Bb , Cc and Dd , and two gametes will be produced during meiosis, where n is the number of loci. As a result, 16 different types of gametes will emerge.

Question 4

Explain the Law of Dominance using a monohybrid cross.

Solution

Ans: Characters are governed by discrete units that appear in pairs, known as factors, according to Mendel's Law of Dominance. One component dominates over the other in a pair of distinct factors. As a

result, when two parents (P) with opposing qualities are crossed, the progeny (F_1) will only express one of the features. The dominant trait is the one that is expressed in the progeny and is known as the dominant trait, whereas the recessive trait is the one that is known as the recessive trait. When the (F_1) generation is selfed, the recessive characteristic emerges in the next generation (F_2). This suggests that the recessive feature did not vanish, but that the dominant allele reduced its expression. Using a monohybrid cross, it can be stated as follows. A monohybrid cross is a cross between two parents who are homozygous for opposing character characteristics.

For example, a cross between tall TT and short(s) tt .

Question 5

Define and design a test – cross?

Solution

Ans: A test cross is a cross between a plant with an unknown genotype and the recessive parent. To determine the genotype of an unknown plant, a test cross is utilized (i.e whether the plant is homozygous or heterozygous). If the test cross's progeny has a 1:1 Dominant: Recessive ratio, the unknown plant is heterozygous. If the progeny are all dominant, however, then the unknown plant is homozygous.

Question 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

Ans: When heterozygous male guinea pigs (Ww) with black coats are crossed with homozygous female guinea pigs (ww) with white coats, we can see that the male generates two types of gametes W and w , while the female produces only one form of gamete w .

We can see that the genotypic and phenotypic ratios in the (F_1) generations are the same, i.e., 1 : 1, using the Punnett square.

Question 7

When a cross is made between tall plants 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

Ans: When tall plants with yellow seeds (TtYy) are crossed with tall plants with green seeds (TtYy), The phenotypic proportion in the progeny should be three tall and green, one dwarf and green.

	TY	Ty	tY	ty
TY	TTYy	TTYy	TtYY	TtYy
Ty	TTYy	TTyy	TtYy	Ttyy
tY	TtYY	TtYy	ttyy	ttYy
ty	TtYy	Ttyy	ttYy	ttyy

Tall and green ratio is: $\frac{3}{8}$

Dwarf and green ratio is: $\frac{1}{8}$

Question 8

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?

Solution

Ans: When two genes are inherited together, they are referred to as linked genes, and linkage is the term used to describe this process. There will be no segregation of alleles if two genes are connected, and the alleles will be inherited together as a single gene. If two genes are connected, the phenotype of the F1 generation will solely contain parental features and no recombinants. There may be few

recombinants in the case of inadequate linkage, but the proportion of parental phenotypes will be higher.

Question 9

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

Solution

Ans: T.H. Morgan made significant contributions to genetics through his research on the fruit fly *Drosophila melanogaster*. The following are some of his key contributions to the science of genetics:

1. He confirmed the Chromosomal Theory of Inheritance empirically. According to this view, genes are located on chromosomes, which are inherited by daughter cells.
2. He established the presence of interconnected genes. Genes that are linked are those that are found on the same chromosome. According to the hypothesis of linkage, genes on the same chromosome are inherited together and are less likely to recombine.
3. He proved that the distance between genes on a chromosome influences the rate of recombination.

The closer two genes are connected, the more likely they will be passed down in the same family. The further apart two genes are on a chromosome, the more probable recombinants will develop.

1. During meiosis, he exhibited chromosomal crossing over.
2. In the fruit fly, he demonstrated X-linked inheritance. *Drosophila melanogaster* is a type of *Drosophila*.

Question 10

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

Solution

Ans: Pedigree Study is a type of genetic analysis in which the inheritance of a specific gene is traced through a person's lineage. It is accomplished by the use of a pedigree chart, which is a scientific chart

of ancestors produced using precise symbols to identify male, female, carrier, disease, and so on. The following are some of the benefits of pedigree analysis:

1. Determine whether the gene is homozygous or heterozygous or homozygous or heterozygous for heterozygous or homozygous or heterozygous or homozygous or heterozygous for homozy
2. Examination of the gene's inheritance over successive generations of the same family.
3. Determine whether a particular genetic condition is caused by a dominant or recessive gene.
4. To look into the origins of the sickness in the family and try to figure out what caused it.
5. To determine whether or not this gene will be passed down via future generations, as well as the likelihood of this happening.
6. To provide genetic counseling to families who are at high risk for various genetic disorders such as hemophilia, sickle cell anemia, and so on.

Question 11

How is sex determined in human beings?

Solution

Ans: Humans have an XY sex determination pattern. Female sex chromosomes are XX , while male sex chromosomes are XY . Females can only generate gametes with X chromosomes, but men can produce gametes with both X and Y chromosomes.

When a male Y chromosome-containing gamete fertilizes with a female X chromosome-containing gamete, the result is a male fetus. When a male X chromosome-containing gamete fertilizes with either a female or a male gamete, the fetus is a female.

Question 12

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

Solution

Ans: Human blood groups are determined by three types of alleles: I , I^B and i . While I^A , I^B are codominant, i is recessive. I^A stands for blood group A , and I^B stands for blood group B . The i allele codes for the O blood group.

There are two possible allele combinations for a person with blood group A . They are: $I^A I^A$ or $I^A i$. There are also two possible allele combinations for a person with blood group B . They are: $I^B I^B$ or $I^B i$. The blood group AB is formed when both I^A and I^B are present, while the blood type O is formed when both are absent. Because both the father and mother have dominant alleles but the child has a recessive phenotype, the parent's dominant A and B alleles must be present in the heterozygous situation. This is because if the alleles were homozygous in either parent, the child would have the dominant phenotype rather than the recessive phenotype. As a result, under the preceding scenario, the other offspring could have the A , B or AB blood group.

Question 13

Explain the following terms with examples:

1. Codominance

Solution

Ans: Codominance occurs when both opposing alleles of a gene pair are equally expressed. For example, in the human blood group, both A and B are equal prominent, and when both are present, the AB blood group appears instead of either A or B .

1. Incomplete dominance

Ans: Incomplete dominance occurs when a dominant allele does not entirely cover the effects of a recessive allele, resulting in a blending of both alleles in the organism's

physical appearance. It's also termed as half dominance or semi-dominance. Take, for example, the flower color of a snapdragon plant. The red flower color (R) has an imperfect dominance over the white flower color (r). When both alleles (R) are present in the same plant, (R) is unable to completely repress (r), resulting in a pink flower phenotype.

Question 14

What is point mutation? Give one example.

Solution

Ans: Point mutation happens when a mutation arises in a single base pair of DNA. For example, in sickle cell anemia, glutamic acid is replaced by valine in the sixth position of the beta globin chain of hemoglobin, resulting in sickle-shaped RBCs rather than biconcave RBCs.

Question 15

Who had proposed the chromosomal theory of inheritance?

Solution

Ans: The chromosomal hypothesis of inheritance was presented by Sutton and Boveri in 1902. This states that chromosomes serve as carriers for gene inheritance.

Question 16

Mention any two autosomal genetic disorders with their symptoms.

Solution

Ans:

1. Sickle Cell Anemia - When glutamic acid is replaced by valine in the sixth position of the beta globin chain of hemoglobin due to a point mutation, the biconcave shape of hemoglobin transforms into a sickle shape. This causes a reduction in blood oxygen delivery, as well as weakness and fatigue.
2. Phenylketonuria - Phenylketonuria is a condition in which a person lacks an enzyme that transforms amino acids and phenylalanine to tyrosine. The phenylalanine then builds up and is converted to phenyl pyruvic acid and other derivatives. Mental retardation is a symptom of this disease. They are eliminated in the urine due to inadequate renal absorption.

