NCERT Solutions for Class 12 Biology Chapter 5

Principles of Inheritance and Variation Class 12

Chapter 5 Principles of Inheritance and Variation Exercise Solutions

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Q1 :

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

Answer :

Mendel selected pea plants to carry out his study on the inheritance of characters from parents to offspring.

He selected a pea plant because of the following features.

(a) Peas have many visible contrasting characters such as tall/dwarf plants, round/wrinkled seeds, green/yellow pod, purple/white flowers, etc.

(b) Peas have bisexual flowers and therefore undergo self pollination easily. Thus, pea plants produce offsprings with same traits generation after generation.

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

(d) Pea plants have a short life span and produce many seeds in one generation.

Q2 :

Differentiate between the following -

(a) Dominance and Recessive

(b) Homozygous and Heterozygous

(c) Monohybrid and Dihybrid.

Answer :

(a) Dominance and Recessive

	Dominance	Recessive
1.	A dominant factor or allele expresses itself in the presence or absence of a recessive trait.	A recessive trait is able to express itself only in the absence of a dominant trait.
2.	For example, tall plant, round seed, violet flower, etc. are dominant characters 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
1.	It contains two similar alleles for a particular trait.	It contains two different alleles for a particular trait.
2.	Genotype for homozygous possess either dominant or recessive, but never both the alleles. For example, RR or rr	Genotype for heterozygous possess both dominant and recessive alleles. For example, Rr
3.	It produces only one type of gamete.	It produces two different kinds of gametes.

(c) Monohybrid and Dihybrid

	Monohybrid	Dihybrid
1.	Monohybrid involves cross between parents, which differs in only one pair of contrasting characters.	Dihybrid involves cross between parents, which differs in two pairs of contrasting characters.
2.	For example, the cross between 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.

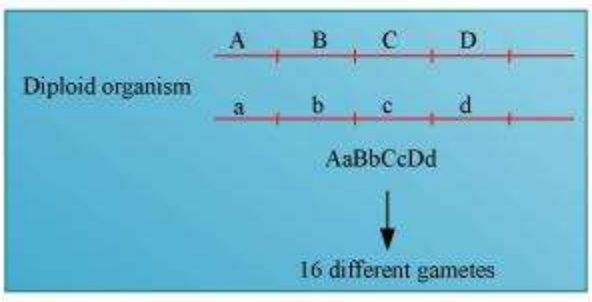
Q3 :

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

Answer :

Locus is a fixed position on a chromosome, which is occupied by a single or more genes. Heterozygous organisms contain different alleles for an allelic pair. Hence, a diploid organism, which is heterozygous at four loci, will have four different contrasting characters at four different loci.

For example, if an organism is heterozygous at four loci with four characters, say Aa, Bb, Cc, Dd, 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 as the genes might be linked and the linked genes will be inherited together during the process of meiosis.

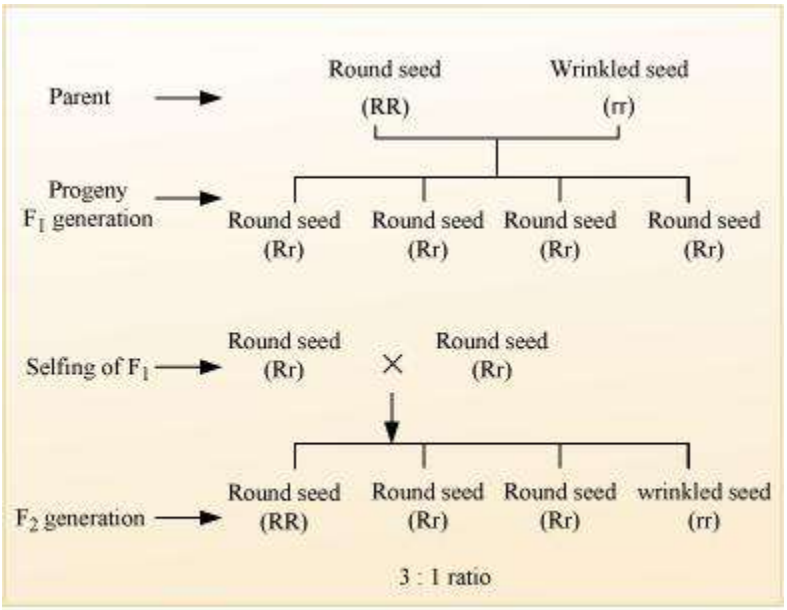
Q4 :

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 F_1 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 F_1generation 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 F_1 generation, the dominant character (round seeds) appeared and the recessive character (wrinkled seeds) got suppressed, which reappeared in F_2 generation.



A monohybrid cross between round and wrinkled pea seeds

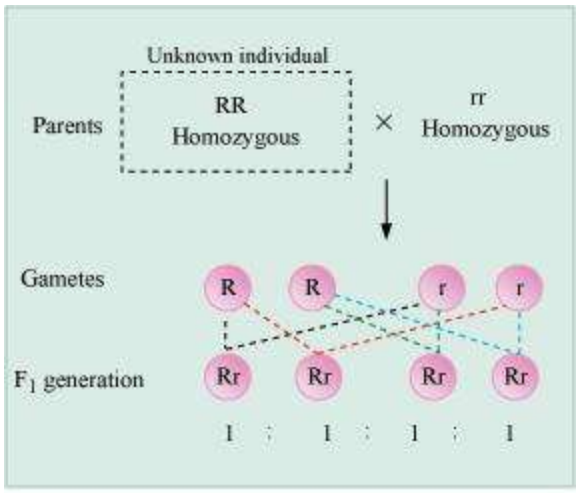
Q5 :

Define and design a test - cross?

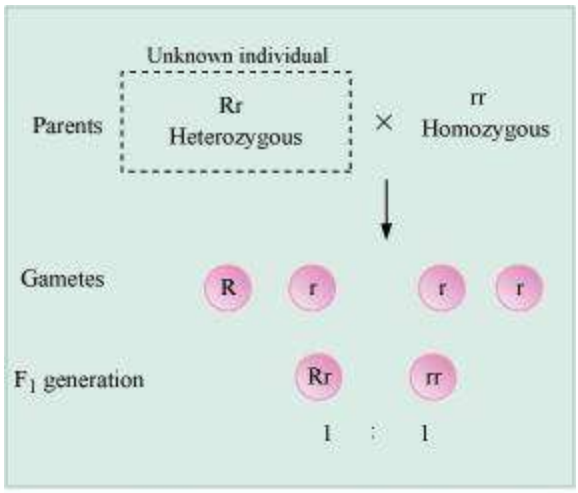
Answer :

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.



Cross between homozygous (unknown) individual and homozygous recessive individual



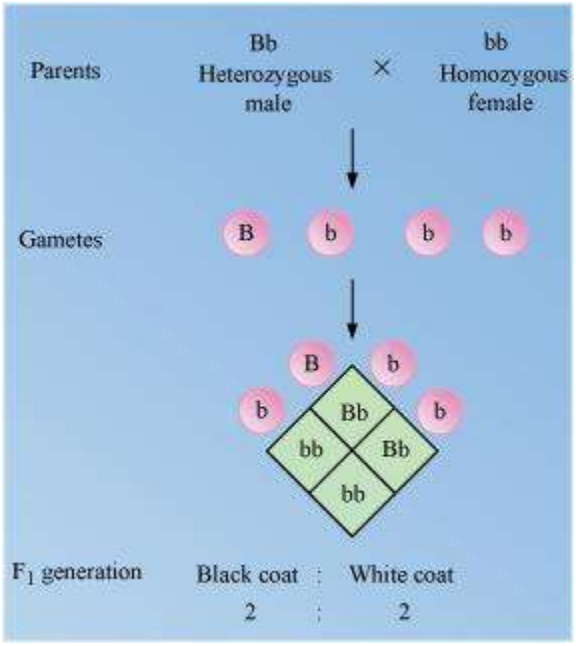
Cross between homozygous (unknown) individual and homozygous recessive individual

Q6 :

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.

Answer :

In guinea pigs, heterozygous male with black coat colour (Bb) is crossed with the female having white coat colour (bb). The male will produce two types of gametes, B and b, while the female will produce only one kind of gamete, r. The genotypic and phenotypic ratio in the progenies of F_1 generation will be same i.e., 1:1.



Q7 :

When a cross in 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.

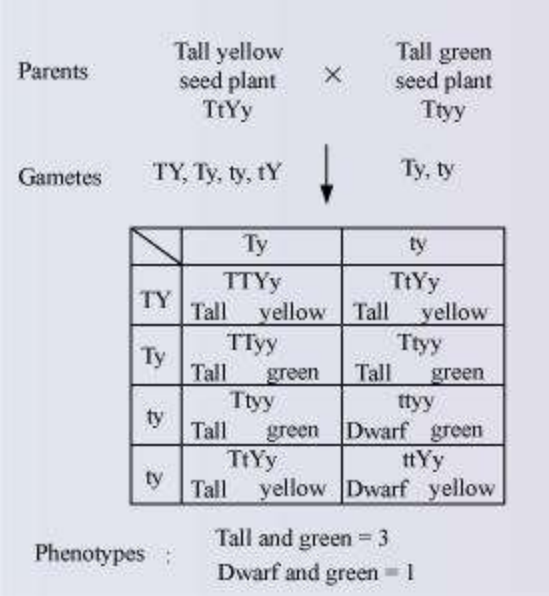
(b) Dwarf and green.

Answer :

A cross between tall plant with yellow seeds and tall plant with green seeds will produce

(a) three tall and green plants

(b) one dwarf and green plant



Parents: Tall yellow seed plant TtYy × Tall green seed plant 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 green	ttyy Dwarf green
ty	TtYy Tall yellow	ttYy Dwarf yellow

Phenotypes : Tall and green = 3
Dwarf and green = 1

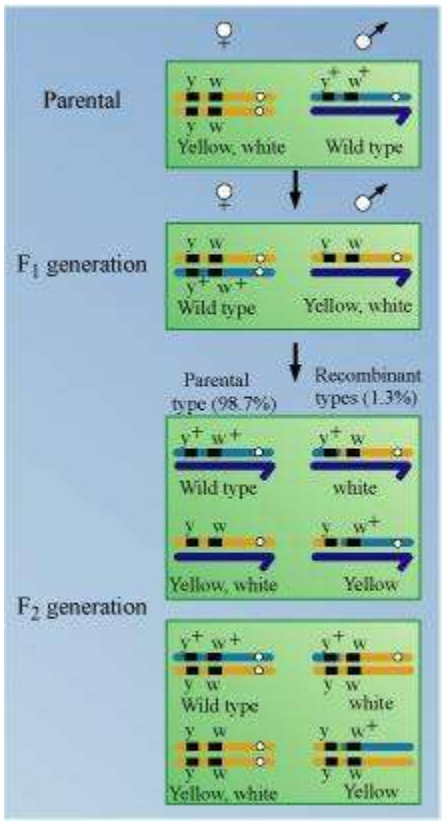
Q8 :

Two heterozygous parents are crossed. If the two loci are linked what would be the distribution of phenotypic features in F_1 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 progenies.



Q9 :

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

Answer :

Morgan's work is based on fruit flies (*Drosophila melanogaster*). He formulated the chromosomal theory of linkage. He defined linkage as the co-existence of two or more genes in the same chromosome and performed dihybrid crosses in*Drosophila* to show that linked genes are inherited together and are located on X-chromosome. His experiments have also proved that tightly linked genes show very low recombination while loosely linked genes show higher recombination.

Q10 :

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

Answer :

Pedigree analysis is a record of occurrence of a trait in several generations of a family. It is based on the fact that certain characteristic features are heritable in a family, for example, eye colour, skin colour, hair form and colour, and other facial characteristics. Along with these features, there are other genetic disorders such as Mendelian disorders that are inherited in a family, generation after generation. Hence, by using pedigree analysis for the study of specific

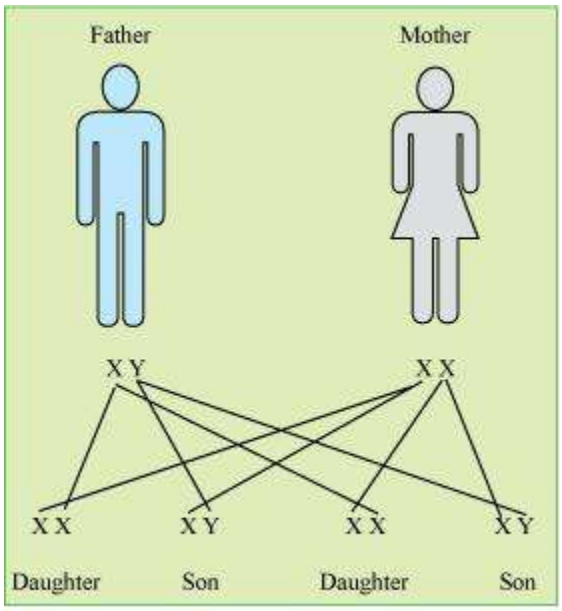
traits or disorders, generation after generation, it is possible to trace the pattern of inheritance. In this analysis, the inheritance of a trait is represented as a tree, called family tree. Genetic counselors use pedigree chart for analysis of various traits and diseases in a family and predict their inheritance patterns. It is useful in preventing hemophilia, sickle cell anemia, and other genetic disorders in the future generations.

Q11 :

How is sex determined in human beings?

Answer :

Human beings exhibit male heterogamy. In humans, males (XY) produce two different types of gametes, X and Y. The human female (XX) produces only one type of gametes containing X chromosomes. The sex of the baby is determined by the type of male gamete that fuses with the female gamete. If the fertilizing sperm contains X chromosome, then the baby produced will be a girl and if the fertilizing sperm contains Y chromosome, then the baby produced will be a boy. Hence, it is a matter of chance that determines the sex of a baby. There is an equal probability of the fertilizing sperm being an X or Y chromosome. Thus, it is the genetic make up of the sperm that determines the sex of the baby.



Sex determination in humans

Q12 :

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.

Answer :

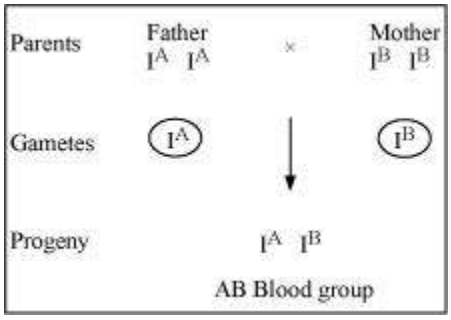
The blood group characteristic in humans is controlled by three set of alleles, namely, I^A, I^B, and i. The alleles, I^A and I^B, are equally dominant whereas allele, i, is recessive to the other alleles. The individuals with genotype, I^A I^A and I^A i, have blood group A whereas the individuals with genotype, I^B I^B and I^B i, have blood group B. The persons with genotype I^A I^Bhave 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

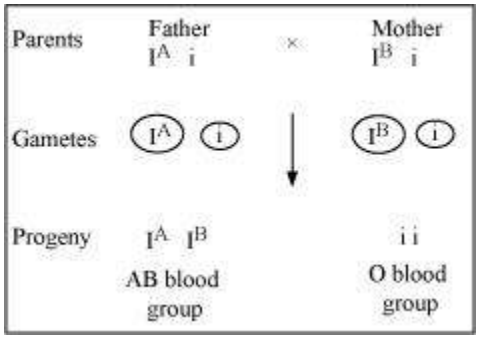
Father Mother

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.



A cross between heterozygous parents will produce progenies with AB blood group (I^AI^B) and O blood group (ii).



Q13 :

Explain the following terms with example

(a) Co-dominance

(b) Incomplete dominance

Answer :

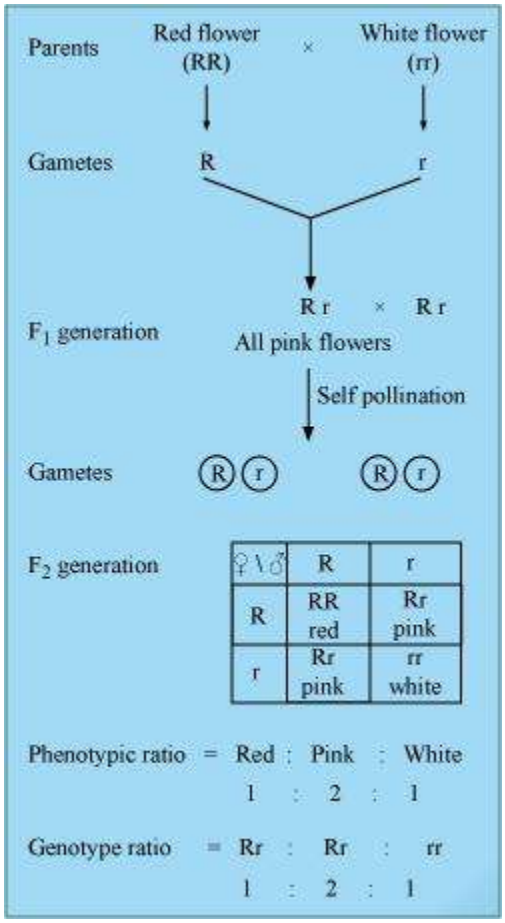
(a) Co-dominance

Co-dominance is the phenomenon in which both the alleles of a contrasting character are expressed in heterozygous condition. Both the alleles of a gene are equally dominant. ABO blood group in human beings is an example of co-dominance. The blood group character is controlled by three sets of alleles, namely, I^A, I^B, and i. The alleles, I^A and I^B, are equally dominant and are said to be co-dominant as they are expressed in AB blood group. Both these alleles do

not interfere with the expression of each other and produce their respective antigens. Hence, AB blood group is an example of co-dominance.

2. 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.



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 short arm of chromosome II gets replaced with valine at the sixth position.

Q15 :

Who had proposed the chromosomal theory of inheritance?

Answer :

Sutton and Boveri proposed the chromosomal theory of inheritance in 1902. They linked the inheritance of traits to the chromosomes.

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 Hb^A and Hb^S allele. The homozygous individuals with genotype, Hb^SHb^S, show the symptoms of this disease while the heterozygous individuals with genotype, Hb^A Hb^S, are not affected. However, they act as carriers of the disease.

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.

(b) Down's syndrome

It is an autosomal disorder that is caused by the trisomy of chromosome 21.

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.