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Class 12 – Biology

Chapter 4 – Principles of Inheritance and Variation

Short types question with answer

Q.1. How is it possible for a child to have a blood group O if the parents have blood groups A and B?

A.1. Case I- If the father is I^A and mother is I^B, the child will have blood groups AB, A, B, O. Case II- If a father is I^A and mother is I^B, the child will have the same blood groups as in the case I, i.e., AB, A, B, and O. Thus if the parents have heterozygous alleles, the child will have blood group O.

Q.2. Explain Down's syndrome.

A.2. Down's syndrome is an autosomal genetic disorder caused by trisomy at chromosome 21, i.e., there is an extra copy of chromosome 21. This condition affects an individual both physically and mentally. Children born with Down's syndrome have a flat nose and small ears. They face problem in thinking, understanding and reasoning throughout their lives. They might have trouble hearing and seeing. They are often dwarf.

Q.3. Why is it that women exceeding 40 years of age have more chances of having a child with Down's syndrome?

A.3. The women exceeding 40 years of age have more chances of having a child with Down's syndrome because increased age affects the meiosis of chromosomes adversely. The meiosis remains incomplete until fertilization. It remains arrested at prophase-I and the chromosome is unpaired. If the fertilization occurs after a very long gap, the chromosomes will have to remain unpaired for a longer time. The longer the time of unpairing, the greater are the chances of its non-disjunction, and hence conditions like trisomy arise.

Q.4. How was it known that the genes are located on chromosomes?

A.4. The chromosomal theory of inheritance proposed by Bovine and Sutton stated that the genes are present on specific locations on a chromosome. Later, Thomas Morgan observed mutation in the eye colour of the fruit flies and based on the inheritance patter concluded that the gene responsible for the eye colour is located on the X-chromosome.

Q.5. A plant with yellow flowers was crossed with a plant with red flowers. The F1 progeny obtained had orange flowers. What is the inheritance pattern?

A.5. The inheritance is incomplete dominance. In this, a new intermediate phenotype between the two original phenotypes is obtained. One allele for a specific trait is not completely expressed over the other allele for the same trait.

Q.6. Mention the characteristics of a true-breeding line.

A.6. Characteristics if true breeding is as follows:

- It undergoes self-pollination.
- It depicts stability in the inheritance for several generations.
- Provide gametes with similar traits, hence used as parents for artificial hybridization.
- Homozygous recessive plants are used to identify the genotype through a test cross.

Q.7. Who had proposed the chromosomal theory of inheritance?

A.7. Theodor Boveri and Walter Sutton are the two scientists who were credited with developing the Chromosomal Theory of Inheritance during the early 1900s.

Q.8. What is recombination? Mention its applications with reference to genetic engineering.

A.8. Recombination is the process of producing a new combination of genes by crossing over during meiosis.

Applications:

- It is a means of introducing new traits.
- Variability is increased, which is necessary for natural selection.

- It is used for preparing linkage chromosome maps.
- The desired recombinants produced as a result of crossing over are selected by the plant breeders to produce new crop varieties.

Q.9. Why does sickle-cell anaemia persist in the human population when it is believed that the harmful alleles get eliminated from the population after a certain time?

A.9. Sickle cell anaemia is an autosomal recessive disease in which the red blood cells become sickle-shaped, inhibiting the oxygen-carrying capacity of the blood. Despite this, it protects the carrier from malaria. Individuals with heterozygotes HbAS survive more than the homozygotes HbSS because they are not exposed to the same severity of risks.

Q.10. Define artificial selection. Has it affected the process of natural selection?

A.10. Artificial selection is the intentional breeding of plants and animals where the breeders select the desired traits and make them breed to produce offsprings with the required characteristics. It is an ancient method of genetic engineering. It surely affects the process of natural selection. The individuals cannot evolve on their own. The process is a threat to biodiversity. The traits are not selected considering the fitness of the organism.

Q11.What are Sex chromosomes?

A11. Sex chromosomes are defined as a pair of chromosomes, which determine whether an individual is male or female. In all mammals, including humans, have sex chromosomes X and Y in their cells. Females have two X chromosomes(XX), and males have an X and a Y chromosome (XY).

Q12.What are chromosomes and who discovered chromosomes?

A12. Chromosomes are thread-like structures present within the nucleus of a cell. Each species has a unique number of chromosomes and it varies from one organism to another. Humans have 23 pairs of chromosomes and Humans have 23 pairs of chromosomes.

Carl Wilhelm von Nageli, a Swiss botanist, discovered chromosomes. He was the first person to observe chromosomes in plant cells in the year 1842.

Long Answer Type Questions

Q.1. What is aneuploidy? Differentiate between aneuploidy and polyploidy.

A.1. Aneuploidy is the chromosomal abnormality in which one or more chromosomes are gained or lost during meiosis due to the non-disjunction of chromosomes.

Differences between aneuploidy and polyploidy:

Polyploidy is a type of chromosomal aberration containing an entire extra set of chromosomes. It may be triploid or tetraploid. This phenomenon is common in plants. It is, however, lethal in animals.

Q.2. Describe the individuals with the following chromosomal abnormalities:

1. **Trisomy at chromosome 21**
2. **XXY**
3. **XO**

A.2.

1) **Trisomy**– Trisomy results in an autosomal linked genetic disorder known as Down's syndrome. The individuals exhibit the following characteristics:

- Protruding tongue
- Roundhead
- Slanting eyes
- Short height
- Open mouth
- Short neck
- Mental retardation
- Under-developed genitals and gonads

2) **XXY**– The presence of an additional copy of an X-chromosome results in Kleinfelter's syndrome. The patient exhibits the following characteristics:

- The male individual possesses feminine characteristics.
- Development of breasts in males
- Male is sterile
- Poor beard growth

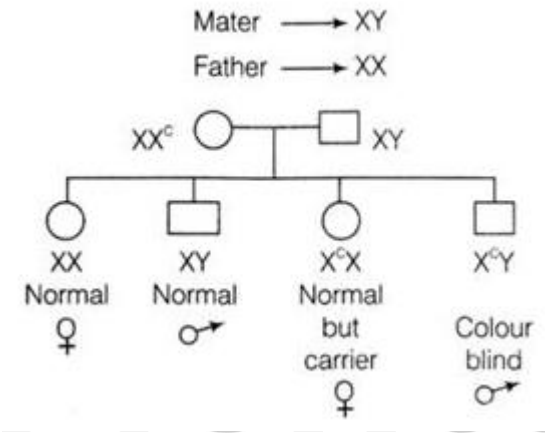
- Feminine voice

3) **XO**– Loss of X-chromosome results in Turner's syndrome. Characteristics:

- The female is sterile.
- The ovaries are immature.
- Webbed neck
- Thorax is shield-shaped
- Under-developed breasts.
- Puffy fingers
- Short height
- Uterus is small

Q.3. A colour-blind father has a daughter with normal vision. The daughter marries a man with a normal vision. What is the probability of her children to be colour blind? Explain with the help of a pedigree chart.

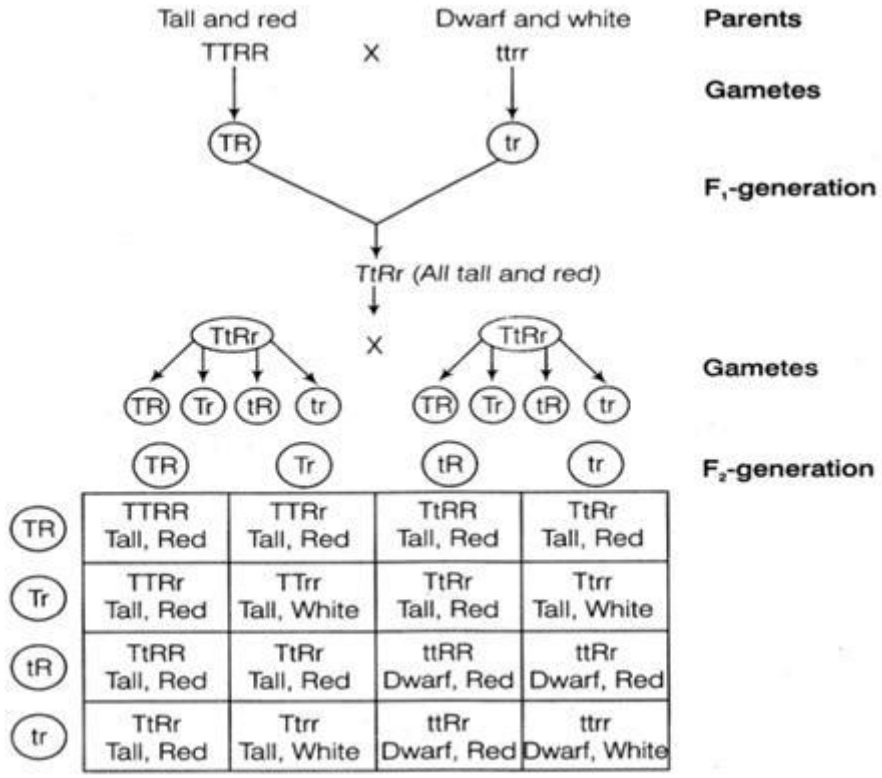
A.3.



50% of daughters are carrier while 50% have a normal vision. 50% of sons are diseased while the other 50% will have normal vision.

Q.4. A tall plant with red flowers (dominant) is crossed with a dwarf plant with white flowers (recessive). Work out a dihybrid cross and state the dihybrid ratio. What will be the effect on the dihybrid ratio if the two genes are interacting with each other?

A.4.



The standard dihybrid ratio observed is 9:3:3:1. If the two genes interact with the values will deviate. This is because when the genes are linked they do not exhibit independent assortment and remain together in the gametes and the offsprings. The dihybrid ratio thus obtained is 3:1.

Q.5. Why is Drosophila used extensively for genetic studies?

A.5. Drosophila is extensively for genetic studies because it has the following characteristics:

- They have a life span of two weeks.
- They can be grown in the laboratory on simple synthetic medium.
- A large number of progenies are produced by a single mating.
- The male and the female Drosophila can be differentiated easily.
- It has many variations easily visible under a simple microscope.

Q6. List out the characteristics of the chromosome theory of Inheritance.

A6.

The important characteristics of the chromosome theory of Inheritance are:

1. Fertilization restores diploid condition.
2. Chromosomes segregate and assort independently.
3. Homologous chromosomes separate at the time of meiosis.
4. Both chromosomes, as well as genes, exist in pairs within the diploid cells.
5. Gamete contains only one chromosome of a particular type and only one of the two alleles of a character.

Q7. Define autosome, hemizygous, homozygous, and heterozygous?

A7. Autosome– All chromosomes apart from the sex chromosomes are called the Autosomes. The number of autosomes differs from one organism to another. Humans have 44 number or 22 pairs of autosomes.

Hemizygous– It is a condition in which an organism has only one copy of a gene or DNA sequence present in diploid cells.

Homozygous— It is a condition in which an organism has two similar alleles of a given gene (XX).

Heterozygous–It is a condition in which an organism has two different alleles of a given gene (XY).

Q8. What is Sex-linkage?

A8. Sex linkage can be defined as the phenotypic expression of an allele, which is dependent on the individual's gender. It describes the presentation of the chromosome and the sex-specific patterns of inheritance. Sex linkage is directly tied to the sex chromosomes – homogametic sex and heterogametic sex. In mammals, the homogametic sex (XX) is female and the heterogametic sex (XY) is male. Thus, the sex-linked genes are carried on the X chromosome.

Q9. Why is colour blindness more prominent in males than females?

A9. Colour blindness is a sex-linked disorder and the genes responsible are present on the X-chromosome. To become affected by the disease, the female should possess the alleles for colour blindness on both the X-chromosomes. If the allele is present on only one chromosome, the female becomes a carrier of

the disease. Since males have only one X-chromosome, it carrying the allele renders them affected. That is why males are more prone to colour blindness.

Q10.Why did scientists select fruit flies for his genetics experiments?

A10. Drosophila melanogaster is a small common fly species, which belongs to the family Drosophilidae. This species is generally known as the vinegar fly or a fruit fly.

In the year 1830, Drosophila melanogaster was established as a key model organism for biomedical science and it is due to the considerable biological similarity to mammals and an abundance of available genetic tools.

Like humans, these fruit flies species have a similar distribution of chromosomes. An individual with a pair of X chromosomes is female fruit fly and an individual with one X and one Y chromosome is male.