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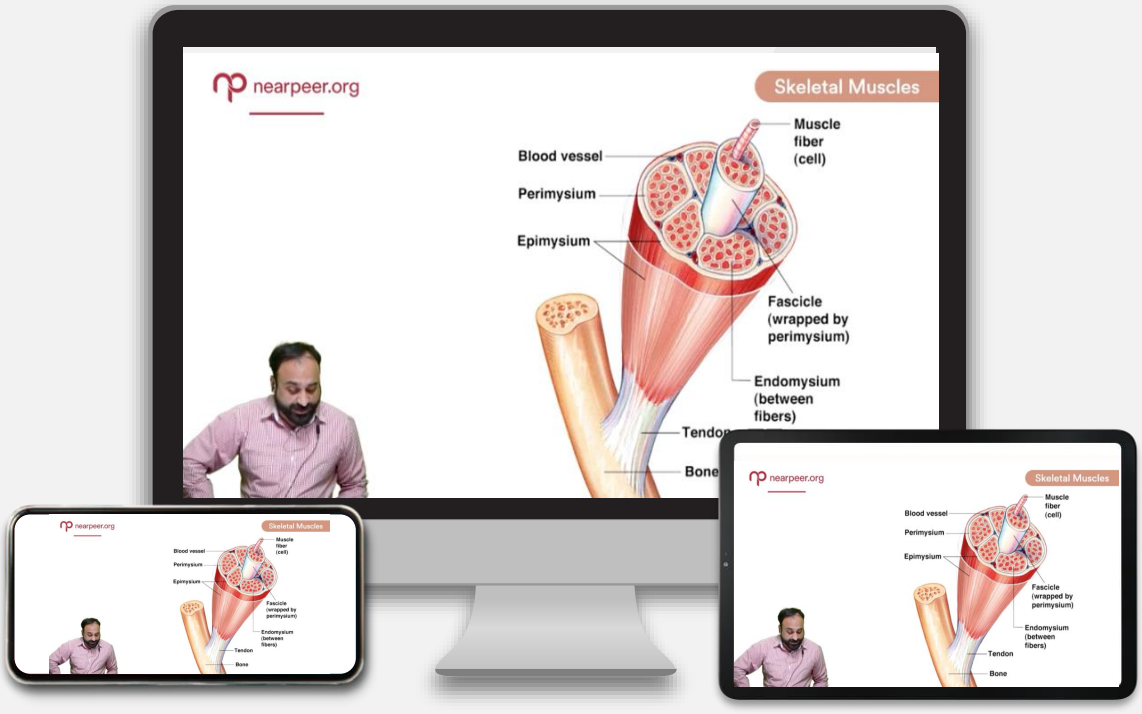


Variation and Genetics

Mendel's law of inheritance

Gregor John Mendel and his work

Mendel's experiment

Inheritance of single trait

Mendel's principles of inheritance

Inheritance of two traits

Law of independent assortment

Scope of independent assortment in variation

Statistics and probability relevant to genetics

Multiple alleles

Gene linkages and crossing over

Sex linkages in drosophila

Sex linkage in human o Genetics of hemophilia

Variation and Genetics

Important Definitions

Term	Definition
Gene	A portion of a DNA molecule that serves as the basic unit of heredity is called gene.
Allele	Partner of a gene pair occupying the same gene locus is called allele.
Locus	The position of a gene on the chromosome is called its locus.
Homozygous	Condition in which the alleles of a gene pair in an organism are identical is called homozygous.
Heterozygous	Condition in which the alleles of a gene pair in an organism are not identical is called heterozygous.
Dominant	A trait which expresses itself in F_1 generation is called dominant trait.
Recessive	A trait which hides over itself in F_1 generation is called recessive trait.
Phenotype	The form of appearance of a trait is called phenotype.
Genotype	The genetic constitution underlaying a single trait or set of traits is called genotype.
F_1 generation	The offspring resulting from a parental cross are referred to as the first filial generation (or F_1 generation).
F_2 generation	The offspring resulting from the cross between two F_1 individuals (from F_1 generation) are referred to as the second filial generation (or F_2 generation)
Epistasis	When a gene or gene pair at one locus interferes with or hides the effect caused by another gene or gene pair at another locus, such a phenomenon of gene interaction is called epistasis. E.g. Bombay phenotype.

Dominance

The physiological effect of an allele over its partner allele on the same gene locus is called dominance.
Following are the types of dominance:

i. Complete Dominance
ii. Incomplete Dominance
iii. Co-dominance
iv. Over Dominance

Complete Dominance

The type of inheritance in which both heterozygotes and dominant homozygotes have the same phenotype is called complete dominance. E.g. both '*RR*' and '*Rr*' produce round pea seeds.

Incomplete Dominance

The dominance in which the phenotype of the heterozygote is intermediate between phenotypes of the two homozygotes is called incomplete dominance.

Co-Dominance

The type of inheritance in which heterozygotes fully express both alleles is called co-dominance. E.g. MN blood group system.

Over Dominance

The type of inheritance in which the phenotypic expression of the heterozygote is greater than that of either homozygote is called over dominance.

E.g. in *Drosophila*, the heterozygote (w^+/w) has more quantity of fluorescent pigments in eyes than wild (w^+/w^+) or white eye (w/w) homozygotes.

Law of Segregation

The two coexisting alleles for each trait in an individual segregate (separate) from each other at meiosis, so that each gamete receives only one of the two alleles. Alleles unite again at random fertilization of gametes when zygote is formed.

Test Cross

The cross which is used to determine the genotype of an individual showing dominant phenotype is called test cross.

Mendel devised test cross to test the genotype of an individual showing a dominant phenotype.

Law of Independent Assortment

When two contrasting pairs of traits are followed in the same cross, their alleles assort independently into gametes.

- Dihybrid cross
- Always start with true breeding
- Once F1 is obtained, cross F1 generation with F1 (F1 x F1)

Polygenic Inheritance

The traits that are controlled or influenced by the alleles of two or more different gene pairs found at different gene loci in an additive way are called polygenic traits.

E.g. three different gene pairs, i.e. *Aa*, *Bb* and *Cc* at three different loci contribute to the wheat grain colour.

Linkage (Genes)

The phenomenon of staying together of all the genes located on the same chromosome that are linked to each other is called gene linkage. E.g. genes for colour blindness, haemophilia, gout etc form one linkage group on human X - chromosome.

- There are 23 linkage groups in humans.
- Genes for colour blindness, haemophilia, gout etc form linkage group on human **X-chromosome**.

- Genes for sickle cell anaemia, leukemia and albinism make linkage group on human **chromosome 11**.

Multiple Alleles

More than two alternate forms of a gene which arise by gene mutation are called multiple alleles.

- E.g. I^A, I^B and *i* are the three multiple alleles for ABO blood group system.
- Some genes may have as many as **300** alleles.
- Any two of the multiple alleles can be present in the genome of a diploid organism, but a haploid organism can have just one of them in its genome.

ABO Blood Group System

Phenotype	Genotype	Antigen on RBC Surface	Antibodies in Blood Plasma	Can Donate Blood to	Can Receive Blood From
A	I^AI^A, I^Ai	A	Anti-B antibodies	A, AB	A, O
B	I^BI^B, I^Bi	B	Anti-A antibodies	B, AB	B, O
AB	I^AI^B	Both A & B	None	AB	A, B, AB, O
O	Ii	None	Both Anti-A & anti-B antibodies	A, B, AB, O	O

RH Factor

Rhesus (Rh) factor is an inherited protein found on the surface of red blood cells.

- If a person has this blood protein, his is Rh positive.
- If a person lacks this blood protein, he is Rh negative.

Rh Blood Group System

Phenotype	Genotype	Antigen on RBC Surface	Anti-Rh Antibodies	Can Donate Blood to	Can Receive Blood From
Rh^+	DD or Dd	Present	Absent	Rh^+	Rh+, Rh-
Rh^-	dd	Absent	Present	Rh^-, Rh^+	Rh^-

Sex Determination

Sex Determination System	Example
XY-XX Sex determination System	Humans, Drosophila
XO-XX Sex determination System	Grasshopper, Protenor bug
XX-XY/ZZ-ZW Sex Determination System	Birds, Butterfly, Moth

Haemeophilia

Color Blindness

Cone Cells in Eyes

Normal trichromatic colour vision is based on three different kinds of cone cells in the retina, each sensitive to only one of the three primary colours, red, green or blue. Each type of cone cell has specific light absorbing proteins called opsins.

Genes for Opsin

The genes for red and green opsins are on **X chromosome**, while the gene for blue opsin is present on **autosome 7**. Mutations in opsin genes cause three types of colour-blindness.

Dichromacy

A dichromat can perceive two primary colours but is unable to perceive the one whose opsins are missing due to mutation.

1. Protanopia is red blindness.
2. Deuteranopia is green blindness
3. Tritanopia is blue blindness

Protanomalous and Deuteranomalous

Some people can detect red and green but with altered perception of the relative shades of these colours. They have abnormal but still partially functional opsins. They are protanomalous and deuteranomalous for red and green weakness respectively.

Monochromacy

A monochromat can perceive one colour. Monochromacy is true colour-blindness. Blue cone monochromacy is an X-linked recessive trait in which both red and green cone cells are absent. That is why it is also called red-green colour-blindness.

Assessment 1

1. The basic unit of biological information is:

(a) Gene (b) Locus
(c) Chromosome (d) Allele

2. Locus is a:

(a) Part of DNA (b) Position of a gene
(c) Partner of a gene (d) Complement of a gene

3. The _____ are like beans in a beanbag:

(a) Allele (b) Genes
(c) Traits (d) Characters

4. Phenotype is the form of appearance of:

(a) A gene (b) A character
(c) A trait (d) All the above

5. When two contrasting pairs of _____ are followed in the same cross, their alleles assort independently into gametes:

(a) Traits (b) Allele
(c) Genes (d) Characters

6. Which of the following best expresses the concept of the word "allele"?

(a) Genes for wrinkled & yellow (b) Genes for wrinkled & round
(c) Phenotypes (d) Mutations

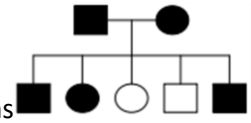
7. All of the following statements are correct regarding alleles except:

(a) A gene can have more than one allele
(b) Two identical alleles are said to be heterozygous with respect to that gene
(c) Alleles are found on corresponding loci of homologous chromosomes
(d) Alleles are alternative forms of the same gene

8. Based on the pedigree shown below, the characteristic indicated by the blackened figures is probably:

(a) Dominant
(b) Recessive
(c) Non-dominant
(d) Sex-linked recessive

9. Phenotype of an organism is the result of



(a) Genotype and environment interactions
(b) Mutations and linkages
(c) Cytoplasmic effects and nutrition
(d) Environmental changes and sexual dimorphism

10. The allele which is unable to express its effect in the presence of another is called:

(a) Codominant (b) Dominant
(c) Complementary (d) Recessive

Assessment 2

1. Based on the pedigree shown below, what are the genotypes of the parents?

(a) Both are homozygous dominant
(b) Both are heterozygous dominant
(c) Both are homozygous recessive
(d) The male is homozygous dominant; the female is homozygous recessive

2. An organism with two identical alleles is

(a) Dominant (b) Hybrid
(c) Heterozygous (d) Homozygous

3. An allele is dominant if it is expressed in:

(a) Both homozygous and heterozygous states
(b) Second generation
(c) Heterozygous combination
(d) Homozygous combination

4. Lack of independent assortment of two genes A and B in fruit fly Drosophila is due to

(a) Repulsion (b) Recombination
(c) Linkage (d) Crossing over

5. A and B genes are linked. What shall be genotype of progeny in a cross between AB/ab and ab/ab:

(a) AAbb and aabb (b) AaBb and aabb
(c) AABB and aabb (d) none of the above

6. Which of the following is suitable for experiment on linkage?

(a) aaBB x aaBB (b) AABB x aabb
(c) AaBb x AaBb (d) AAbb x AaBB

7. A gene pair hides the effect of another. The phenomenon is

(a) Epistasis (b) Dominance
(c) Mutation (d) Pleiotropy

8. A man of A-blood group marries women of AB blood group. Which type of progeny would indicate that man is heterozygous A?

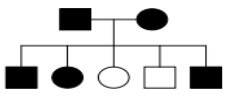
(a) AB (b) A
(c) O (d) B

9. A child of O-group has B-group father. The genotype of father will be

(a) $I^{\circ}I^{\circ}$ (b) $I^{B}I^{B}$
(c) $I^{A}I^{B}$ (d) $I^{B}I^{\circ}$

10. Which blood type can be transfused to an individual whose blood type is unknown?

(a) AB^{+} (b) AB^{-}
(c) O^{+} (d) O^{-}



Assessment 3

1. **A couple expecting their second child is worried about Rh incompatibility. Their first child was Rh^+. They have their blood typed. Which result would be cause for alarm?**
   (a) Both parents Rh^- (b) Both parents Rh^+
   (c) Man Rh - and woman Rh^+ (d) Man Rh+ and woman Rh^-
2. **Red Antirrhinum (RR) is crossed with white (WW) one. Offspring RW are pink. This is an example of:**
   (a) Complete dominance
   (b) Incomplete dominance
   (c) Codominance
   (d) Over dominance
3. **A polygenic inheritance in human beings is**
   (a) Skin colour (b) Phenylketonuria
   (c) Colour blindness (d) Sickle cell anaemia
4. **All such altered alternative forms of a gene, whose number is more than two, are called:**
   (a) Alleles (b) Genes
   (c) Multiple alleles (d) Genotype
5. **The type of inheritance in which the phenotype of the heterozygote is intermediate between phenotypes of the two homozygotes is called:**
   (a) Co-dominance (b) Complete dominance
   (c) Over dominance (d) Incomplete dominance
6. **When dominant and recessive alleles express themselves together it is called:**
   (a) Codominance (b) Complete dominance
   (c) Incomplete dominance (d) Over dominance
7. **Different alleles of a gene that are both expressed in a heterozygous condition are called:**
   (a) Codominance (b) Complete dominance
   (c) Over dominance (d) Dominance
8. **A man with blood group 'N' has a genotype:**
   (a) L^ML^M (b) L^NL^N
   (c) L^ML^N (d) Both L^NL^N and L^ML^N
9. **Based on the pedigree shown below, if one parent has type A blood and the other parent has type B blood, what blood type will the offspring denoted by the white square and circle have?**
   (a) Type A
   (b) Type B
   (c) Type AB
   (d) Type O
10. **Genotype I^oI^o is a homozygous:**
    (a) Dominant (b) Recessive
    (c) Co dominant (d) Over dominant

Assessment 4

1. **64 zygotes are produced by self crossing the wheat grain of genotype AaBbCc, how many red colour kernels will be produced?**

(a) 6 (b) 15

(c) 20 (d) 1

2. **When two independent events are occurring simultaneously like in dihybrid cross, the ratio of each joint phenotypic combination can be obtained by multiplying the probabilities of individual phenotypes. It is called:**

(a) Probability rule (b) Product rule

(c) Law of segregation (d) Law of independent assortment

3. **Monohybrid test cross ratio of F_2 is:**

(a) 3:1 (b) 2:1

(c) 1:1 (d) 9:3:3:1

4. **The cross in which parents differ in two pairs of contrasting characters is called:**

(a) Monohybrid cross (b) Dihybrid cross

(c) Test cross (d) Back cross

5. **In Mendel's dihybrid cross, the phenotypic ratio of F_2 for a single character is:**

(a) 1:2:1 (b) 9:3:2:2

(c) 3:1 (d) 9:3:3:1

6. **Which of the following statements is true regarding the law of independent assortment?**

(a) Factors assort independent of each other when more than one pair of characters are present together

(b) Independent assortment leads to variation

(c) Independent assortment leads to formation of new combinations of characters

(d) All of these

7. **Each gametes carry:**

(a) Only recessive allele (b) Only dominant allele

(c) Only one of the alleles (d) All of these

8. **All of this obeys Mendel's laws except:**

(a) Linkage (b) Independent assortment

(c) Dominance (d) Purity of gametes

9. **The geometrical device that helps to find out all the possible combinations of male and female gametes is called:**

(a) Punnett square (b) Bateson square

(c) Mendel square (d) Morgan square

140. **Which of the following genetic crosses would be predicted to give a phenotypic ratio of 9:3:3:1?**

(a) SSYY x ssyy (b) SsYY x SSYy

(c) SsYy x SsYy (d) SSyy x ssYY

31. When 64 zygotes are produced by self crossing the wheat grain of genotype AaBbCc, how