Lesson - 2. Classical Genetics

1. Extra nuclear inheritance is a consequence of presence of genes in
   a) Mitrochondria and chloroplasts
   b) Endoplasmic reticulum and mitrochondria
   c) Ribosomes and chloroplast
   d) Lysososmes and ribosomes
2. In order to find out the different types of gametes produced by a pea plant having the genotype AaBb, it should be crossed to a plant with the genotype
   a) aaBB b) AaBB c) AABB d) aabb
3. How many different kinds of gametes will be produced by a plant having the genotype AABbCC?
   a) Three b) Four c) Nine d) Two
4. Which one of the following is an example of polygenic inheritance?
   a) Flower colour in Mirabilis Jalapa
   b) Production of male honey bee
   c) Pod shape in garden pea
   d) Skin Colour in humans
5. In Mendel's experiments with garden pea, round seed shape (RR) was dominant over wrinkled seeds (rr), yellow cotyledon (YY) was dominant over green cotyledon (yy). What are the expected phenotypes in the F_2 generation of the cross RRYY x rryy?
   a) Only round seeds with green cotyledons
   b) Only wrinkled seeds with yellow cotyledons
   c) Only wrinkled seeds with green cotyledons
   d) Round seeds with yellow cotyledons an wrinkled seeds with yellow cotyledons
6. Test cross involves
   a) Crossing between two genotypes with recessive trait
   b) Crossing between two F_1 hybrids
   c) Crossing the F_1 hybrid with a double recessive genotype
   d) Crossing between two genotypes with dominant trait
7. In pea plants, yellow seeds are dominant to green. If a heterozygous yellow seed pant is crossed with a green seeded plant, what ratio of yellow and green seeded plants would you expect in F_1 generation?
   a) 9:1 b) 1:3 b) 3:1 d) 50:50
8. Select the correct statement from the ones given below with respect to dihydrid cross
   a) Tightly linked genes on the same chromosomes show very few combinations
   b) Tightly linked genes on the same chromosomes show higher combinations
   c) Genes far apart on the same chromosomes show very few recombinations
   d) Genes loosely linked on the same chromosomes show similar recombinations as the tightly linked ones
9. Which Mendelian idea is depicted by a cross in which the F_1 generation resembles both the parents
   a) Incomplete dominance
   b) Law of dominance
   c) Inheritance of one gene
   d) Co-dominance
10. Fruit colour in squash is an example of
    a) Recessive epistatsis
    b) Dominant epistasis
    c) Complementary genes
    d) Inhibitory genes
11. In his classic experiments on Pea plants, Mendel did not use
    a) Flowering position
    b) Seed colour
    c) Pod length
    d) Seed shape

12. The epistatic effect, in which the dihybrid cross 9:3:3:1 between AaBb X AaBb is modified as
    a) Dominance of one allele on another allele of both loci
    b) Interaction between two alleles of different loci
    c) Dominance of one allele to another alleles of same loci
    d) Interaction between two alleles of some loci
13. In a test cross involving F_1 dihybrid flies, more parental type offspring were produced than the recombination type offspring. This indicates
    a) The two genes are located on two different chromosomes
    b) Chromosomes failed to separate during meiosis
    c) The two genes are linked and present on the some chromosome
    d) Both of the characters are controlled by more than one gene
14. The genes controlling the seven pea characters studied by Mendel are known to be located on how many different chromosomes?
    a) Seven b) Six c) Five d) Four
15. Which of the following explains how progeny can posses the combinations of traits that none of the parent possessed?
    a) Law of segregation b) Chromosome theory
    c) Law of independent assortment d) Polygenic inheritance
16. "Gametes are never hybrid". This is a statement of
    a) Law of dominance b) Law of independent assortment
    c) Law of segregation d) Law of random fertilization
17. Gene which suppresses other genes activity but does not lie on the same locus is called as
    a) Epistatic b) Supplement only c) Hypostatic d) Codominant
18. Pure tall plants are crossed with pure dwarf plants. In the F_1 generation, all plants were tall. These tall plants of F_1 generation were selfed and the ratio of tall to dwarf plants obtained was 3:1. This is called
    a) Dominance b) Inheritance
    c) Codominance d) Heredity
19. The dominant epistatis ratio is
    a) 9:3:3:1 b) 12:3:1 c) 9:3:4 d) 9:6:1
20. Select the period for Mendel's hybridization experiments
    a) 1856 - 1863 b) 1850 - 1870
    c) 1857 - 1869 d) 1870 - 1877
21. Among the following characters which one was not considered by Mendel in his experimentation pea?
    a) Stem – Tall or dwarf b) Trichomal glandular or non-glandular
    c) Seed – Green or yellow d) Pod – Inflated or constricted

2, 3, 5 Marks Questions

1. Name the seven contrasting traits of Mendel.

S.NO	Character	Dominant	Recessive
1.	Plant height	Tall	Dwarf
2.	Flower position	Axial	Terminal
3.	Flower colour	Purple	White
4.	Pod form	Inflated	Constricted
5.	Pod colour	Green	Yellow
6.	Seed shape	Round	Wrinkled
7.	Cotyledon colour	Yellow	Green

2. What is meant by true breeding or pure breeding lines / strain?

- Plant has undergone continuous self- pollination having stable trait inheritance from parent to offspring is called true breeding lines.

3. Give the names of the scientists who rediscovered Mendelism.

- Hugo de Vries - Holland
- Carl Correns - Germany
- Erich von Tschermak - Austria.

4. What is back cross?

- It is a cross of F_1 hybrid with any one of the parental genotype is called back cross.
- The back cross is of two types.

Dominent back cross

- When the F_1 offsprings are crossed with the dominant parents.

Recessive back cross

- When the F_1 offsprings are crossed with the recessive parents.

5. Define : Genetics.

- Genetics is the branch of biological science which deals with the mechanism of transmission of characters from parents to off springs.

6. What are multiple alleles ?

- Three or more allelic forms of a gene occupy the same locus in a given pair of homologous chromosomes; these are known as multiple alleles..

7. What are the reasons for Mendel's successes in his breeding experiment?

- He applied mathematics and statistical methods to biology.
- He followed scientific methods and kept accurate and detailed data records of the outcome of his crosses.
- His experiments were carefully planned and he used large samples.
- The parents selected by Mendel were pure breed lines.
- The purity was tested by self crossing the progeny for many generations.

8. Explain the law of dominance in monohybrid cross.

- The characters are controlled by discrete units called factors which occur in pairs.
- In a dissimilar pair of factors one member of the pair is dominant and the other is recessive.
- This law gives an explanation to the monohybrid cross.
- The expression of only one of the parental characters in F_1 generation.
- The expression of both in the F_2 generation.
- It also explains the proportion of 3:1 obtained at the F_2.

Parent **Tall** **Dwarf**
TT **tt**

Gametes **T** **t**

F1 = **Tt (Tall)**

F_1 (Selfed) **Tt** x **Tt**

F2 =

Gametes	T	t
T	**TT** Tall	**Tt** Tall
t	**Tt** Tall	**tt** Dwarf

Genotypes : **TT** **Tt** **tt**
Genotypic Ratio : **1** : **2** : **1**

Phenotypes : **Tall** **Dwarf**
Phenotypic Ratio : **3** : **1**

9. Differentiate incomplete dominance and co dominance.

S.NO	Incomplete dominance	Co dominance
1.	Effect of one of the two alleles is more conspicuous.	Effects of both the alleles are equally conspicuous.
2.	The effect in hybrid is intermediate expression of the two alleles.	Both the alleles are produces their effect independently
3.	It produces new phenotype.	Does not produce new phenotype.
4.	Qualitative approach of the gene expression.	Quantitative approach of the gene expression.
5.	Ex. Mirabilis jalapa.	Ex : Red and white flowers of Camellia.

10. What is meant by cytoplasmic inheritance?

- DNA is the universal genetic material. Certain traits are governed either by the chloroplast or mitochondrial genes.
- Cytoplasmic organelles such as chloroplast and mitochondrion that act as inheritance vectors, it is also called Cytoplasmic inheritance.

11. Explain with an example how single gene affect multiple traits and alleles the phenotype of an organism.

- A single gene affects multiple traits and alter the phenotype of the organism is called Pleiotropy.
- The Pleiotropic gene influences a number of characters simultaneously. Such genes are called pleiotropic gene.
- Mendel noticed pleiotropy while performing breeding experiment with peas (Pisum sativum).
- purple flowers, brown seeds and dark spot on the axils of the leaves crossed with white flowers, light coloured seeds and no spot on the axils of the leaves,
- The three traits for flower colour, seed colour and a leaf axil spot all were inherited together as a single unit.
- This is due to the three traits were controlled by a single gene with dominant and recessive alleles.

12. Describe dominant epistasis with an example.

- The gene that suppresses or masks the phenotypic expression of a gene at another locus is known as epistatic.
- The inhibiting gene is called epistatic gene .The inhibited gene is called hypostatic gene.

Parent **White fruit** **Yellow fruit**
WWgg **wwGG**

Gametes **Wg** **wG**

F_1 (Selfed) **WwGg**

WwGg X wwGg

F_2 =

	WG	**Wg**	**wG**	**wg**
WG	**WWGG** White	**WWGg** White	**WwGG** White	**WwGg** White
Wg	**WWGg** White	**WWgg** White	**WwGg** White	**Wwgg** White
wG	**WwGG** White	**WwGg** White	**wwGG** Yellow	**wwGg** Yellow
Wg	**WwGg** White	**Wwgg** White	**wwGg** Yellow	**wwgg** Green

Phenotypes : White fruit Yellow fruit Green fruit
12 : 3 : 1

- Ratio : 12 : 3 : 1
- In the summer squash the fruit colour locus has a dominant allele 'W' for white colour and a recessive allele 'w' for coloured fruit.
- 'W' allele is dominant that masks the expression of any colour.
- The white fruit (WWgg) is crossed with yellow fruit (wwGG).
- The F_1 plants have white fruit and are heterozygous (WwGg).
- The F_1 heterozygous plants are crossed.
- They give rise to F_2 with the phenotypic ratio of 12 white : 3 yellow : 1 green.
- Dominent white (W) hides the effects of yellow or green.
- Homozygous recessive ww genotypes only give the coloured fruits (4/16).
- Double recessive 'wwgg' will give green fruit (1/16).
- The Plants having only 'G' in its genotype (wwGg or wwGG) will give the yellow fruit (3/16).

13. Differentiate continuous variation with discontinuous variation.

S.NO	Continuous Variation	Discontinuous Variation
1	This variation due to the combining effects of environmental and genetic factors	This variations are genetically determined by inheritance factors.
2	The phenotype is determined by many genes, and environmental factors.	The phenotypic expression is unaffected by environmental conditions.
3	Directions of continuous variations is predictable.	Directions of discontinuous variations is unpredictable.
4	This is also called as quantitative inheritance	This is also called as qualitative inheritance.
5	Ex : Human height and skin colour	Ex : Style length in primula plant height of garden pea.

14. Explain polygenic inheritance with an example.

- A group of genes that together determine a characteristic of an organism is called polygenic inheritance.
- It was first demonstrated by Swedish Geneticist H. Nilsson - Ehle in wheat kernels.
- Kernel colour is controlled by two genes each with two alleles, one with red kernel colour was dominant to white.
- He crossed the two pure breeding wheat varieties dark red and a white.
- Dark red genotypes $R_1R_1R_2R_2$ and white genotypes are $r_1r_1r_2r_2$.
- In the F_1 generation medium red were obtained with the genotype $R_1r_1R_2r_2$.
- F1 selfing produces four types of gametes R_1R_2, R_1r_2, r_1R_2, r_1r_2.
- The intensity of the red colour is determined by the number of R genes in the F2 generation.
- Four R genes - A dark red kernel colour.
- Three R genes - Medium dark red.
- Two R genes - Medium red.
- One R gene - Light red.
- Absence of R gene - White kernel colour.

Parent **Dark Red** **white**

$\mathbf{R_1R_1R_2R_2}$ $\mathbf{r_1r_1r_2r_2}$

Gametes $\mathbf{R_1R_2}$ ⇩ $\mathbf{r_1r_2}$

F_1 = $\mathbf{R_1r_1R_2r_2}$ **(Medium red)**

F_1 (selfed) = $\mathbf{R_1r_1R_2r_2}$ x $\mathbf{R_1r_1R_2r_2}$

⇩

F_2 =

G	$\mathbf{R_1R_2}$	$\mathbf{R_1r_2}$	$\mathbf{r_1R_2}$	$\mathbf{r_1r_2}$
$\mathbf{R_1R_2}$	$\mathbf{R_1R_1R_2R_2}$ Dark red	$\mathbf{R_1R_1R_2r_2}$ Medium dark red	$\mathbf{R_1r_1R_2R_2}$ Medium dark red	$\mathbf{R_1r_1R_2r_2}$ Medium red
$\mathbf{R_1r_2}$	$\mathbf{R_1R_1R_2r_2}$ Medium dark red	$\mathbf{R_1R_1r_2r_2}$ Medium red	$\mathbf{R_1r_1R_2r_2}$ Medium red	$\mathbf{R_1r_1r_2r_2}$ Light red
$\mathbf{r_1R_2}$	$\mathbf{R_1r_1R_2R_2}$ Medium dark red	$\mathbf{R_1r_1R_2r_2}$ Medium red	$\mathbf{r_1r_1R_2R_2}$ Medium red	$\mathbf{r_1r_1R_2r_2}$ Light red
$\mathbf{r_1r_2}$	$\mathbf{R_1r_1R_2r_2}$ Medium red	$\mathbf{R_1r_1r_2r_2}$ Light red	$\mathbf{r_1r_1R_2r_2}$ Light red	$\mathbf{r_1r_1r_2r_2}$ White

Conclusion

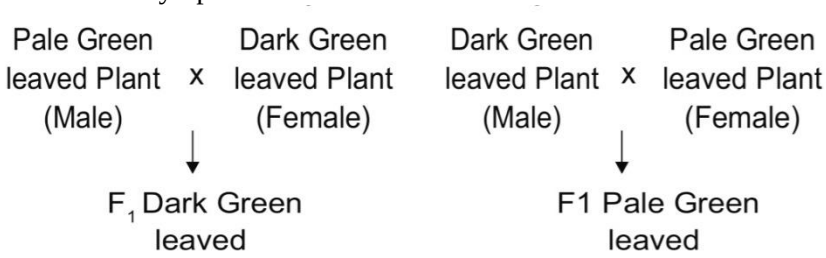
- Finally the loci that was studied by Nilsson – Ehle were not linked and the genes assorted independently.
- Later, researchers discovered the third gene that also affects the kernel colour of wheat.
- The three independent pairs of alleles were involved in wheat kernel colour.
- Nilsson – Ehle found the ratio of 63 red : 1 white in F_2 generation.
- 1 : 6 : 15 : 20 : 15 : 6 : 1 in F_2 generation.

15. Bring out the inheritance of chloroplast gene with an example.

- DNA is the universal genetic material. Certain traits are governed either by the chloroplast or mitochondrial genes.
- Cytoplasmic organelles such as chloroplast and mitochondrion that act as inheritance vectors, it is also called Cytoplasmic inheritance.
- It is found in 4 O' Clock plant (Mirabilis jalapa).
- There are two types of variegated leaves

- Dark green leaved plants
- Pale green leaved plants.

- When the pollen of dark green leaved plant (male) is transferred to the stigma of pale green leaved plant (female) and pollen of pale green leaved plant is transferred to the stigma of dark green leaved plant.
- The F1 generation of both the crosses must be identical as per mendelian inheritance.
- But in the reciprocal cross the F_1 plant differs from each other.
- In each cross, the F_1 plant reveals the character of the plant which is used as female plant.
- This inheritance is not through nuclear gene.
- It is due to the chloroplast gene found in the ovum of the female plant
- It contributes the cytoplasm during fertilization. Since the male gamete contribute only the nucleus but not cytoplasm.



Additional Questions

16. What is lethal allele ?

- An allele which has the potential to cause the death of an organism is called lethal allele.
- Ex : Snapdragon.

17. What are alleles ?

- Alternate forms for the same trait is called alleles.

18. What is Co dominance?

- The phenomenon in which two alleles are both expressed in the heterozygous individual is known as co dominance.

19. What is test cross?

- Crossing an individual of unknown genotype with a homozygous recessive is called Test cross.

20. What is a Atavism ?

- Atavism is a modification of a biological structure.
- An ancestral that reappears after having been lost through evolutionary changes in the previous generation.

21. What is incomplete dominance ?

- When one allele is not completely dominant to another allele it shows incomplete dominance.

22. Name the three types of phenotype observed in plants in snapdragon.

- Green plants with chlorophyll (cc)
- Yellowish green plants (Cc)
- White plants without any chlorophyll (cc)

23. What is reciprocal cross

- The tall pea plants were pollinated with the pollens from a dwarf plants, the result was all tall plants.
- When the parental types were reversed, the pollen from a tall plant was used to pollinate a dwarf pea plant which gave only tall plants. The result was the same.
- So it was concluded that the trait is not sex dependent.

24. Explain about dihybrid cross.

- The crossing of two plants differing in two pairs of contrasting traits is called dihybrid cross.

Parent **Round Yellow** **Wrinkled Green**
RRYY **rryy**

Gametes **RY** **ry**

⇩

F_1 (selfed) **RrYy**

RrYy x **RrYy**

Gametes : Ry Ry rY ry **RY Ry rY ry**

⇩

F_2 =

	RY	**Ry**	**rY**	**ry**
RY	**RRYY** R.Y	**RRYy** R.Y	**RrYY** R.Y	**RrYy** R.Y
Ry	**RRYy** R.Y	**RRyy** R.G	**RrYy** R.Y	**Rryy** R.G
rY	**RrYY** R.Y	**RrYy** R.Y	**rrYY** W.Y	**rrYy** W.Y
ry	**RrYy** R.Y	**Rryy** R.G	**rrYy** W.Y	**rryy** G.W

- **Phenotypic ratio : 9 : 3 : 3 : 1**

- Yeelow Round (YR) – 9 / 16
- Yellow Wrinkled (Yr) – 3 / 16
- Green Round (yR) – 3 / 16
- Green Wrinkled (yr) – 1 / 16

25. Why did mental choose pea plants for his experiments ?

- It is an annual plant.
- It has clear contrasting characters that are controlled by a single gene separately.
- Mendel used both self-fertilization and cross-fertilization.
- The flowers are large hence emasculation and pollination are very easy for hybridization.

26. Name the four major subdisciplines of genetics.

Transmission Genetics

- Deals with the transmission of genes from parents to off springs.
- Th e foundation of classical genetics came from the study of hereditary behaviour of seven genes by Gregor Mendel.

Molecular Genetics

- Deals with the structure and function of a gene at molecular level.

Population Genetics

- Deals with heredity in groups of individuals for traits which is determined by a few genes.

Quantitative Genetics

- Deals with heredity of traits in groups of individuals where the traits are governed by many genes simultaneously.

27. State the laws of inheritance proposed by Mendel

Law of independent Assortment

- When two pairs of traits are combined in a hybrid, segregation of one pair of characters is independent to the other pair of characters.

Law of segregation

- Though the parents contain two alleles during the gamete formation, the factors or alleles of a pair segregate from each other, such that the gamete receives only one of the two factors.

28. Why is mendel called as father of genetics ?

- Mendelian genetic concepts are basic to modern genetics. Therefore, Mendel is called as Father of Genetics.

29. Gametes are never hybrid – Justify.

- A homozygous parent produces similar gametes and a heterozygous parent produces two kinds gametes each having one allele with equal proportion.
- During the formation of gametes, the alleles of a pair separate and segregate from each other.
- Each gamete receives only one of the two factors.

30. What is incomplete dominance ? In 4 O' clock plant shows incomplete dominance for flower colour.

- When one allele is not completely dominant to another allele it shows incomplete dominance.
- Carl correns's experimented in 4 o' clock plant Mirabilis jalapa.
- The homozygous red (R^1R^1) parent is crossed with white (R^2R^2).
- The F_1 phenotype differs from both the parental phenotype.
- The F_1 generation produces an intermediate colour pink (R^1R^2).
- Here one allele is not completely dominant to another allele. Such allelic interaction is known as incomplete dominance.
- The pink coloured plants of F_1 generation were interbred.
- In F_2 both phenotypic and genotypic ratios were found to be identical as 1 : 2 : 1.
- R^1 allele codes for an enzyme responsible for the formation of red pigment.
- R^2 allele codes for an enzyme responsible for the formation of white pigment.
- R^1 and R2 genotypes produce only enough red pigments to make the flower pink.
- In F_2 both phenotypic and genotypic ratios are 1 : 2 : 1.

Parent **Red** R^1R^1 **White** R^2R^2

Gametes R^1 R^2

F_1 = R^1R^2 **(pink colour)**

F_1 (Selfed) = R^1R^2 x R^1R^2

F_2 =

Gametes	R^1	R^2
R^1	R^1R^1 Red	R^1R^2 Pink
R^2	R^1R^2 Pink	R^2R^2 White

Phenotypes : R^1R^1 R^1R^2 R^2R^2

Phenotypic Ratio : 1 : 2 : 1

31. Mitochondrial Inheritance - Explain.

- DNA is the universal genetic material. Certain traits are governed either by the chloroplast or mitochondrial genes.
- Cytoplasmic organelles such as chloroplast and mitochondrion that act as inheritance vectors, it is also called Cytoplasmic inheritance.
- Male sterility found in pearl maize (Sorgum vulgare) is the best example for mitochondrial cytoplasmic inheritance.
- Male sterility found in this pearl maize so it is called cytoplasmic male sterility.
- The gene for cytoplasmic male sterility is found in the mitochondrial DNA.
- There are two types
    - One with normal cytoplasm (N) - Male fertile.
    - The other one with aberrant cytoplasm (S) - Male sterile.
- These types also exhibit reciprocal differences as found in Mirabilis jalapa.
- Recently it has been discovered that cytoplasmic genetic male sterility is common in many plant species.
- This sterility is maintained by the influence of both nuclear and cytoplasmic genes.
- There are commonly two types of cytoplasm
    - N (normal)
    - S (sterile)
- The genes for these are found in mitochondrion.there are also restores of fertility (Rf) genes.
- Even though these genes are nuclear genes, they are distinct from genetic male sterility genes of other plants. Because the Rf genes do not have any expression of their own, unless the sterile cytoplasm is present.
- Rf genes are required to restore fertility in S cytoplasm which is responsible for sterility.
- So the combination of N cytoplasm with rfrf and S cytoplasm with RfRf produces plants with fertile pollens, while S cytoplasm with rfrf produces only male sterile plants.