HEREDITY

1. INTRODUCTION ::

"**Like begets like**" i.e., an organism produces organisms of its own kind. A generation of a species resembles its own ancestors, like offspring of humans are humans, offspring of dog are always dogs never cats or rats. Likewise a seed of mango will give rise to a mango only not banana or grape.

Thus science of "Genetics" refers to the similarities and differences between different individuals and different species.

Definition :

- **Heredity :** Heredity is the transmission of traits from one generation to the following generation.
- **Genetics :** Genetics is the branch of Biology that deals with the study of heredity and variation.
- **Variation :** Variations are the differences among a kind of organisms.

2. TERMS USED IN GENETICS ::

- **Gene –**
  - Mendel used the term factor for a gene. A gene is the part of DNA responsible for the appearance and inheritance of character or a unit of inheritance, a part of DNA located in a fixed location in the chromosome.
- **Genome –**
  - Total set of genes in the haploid set of chromosomes and inherited as unit from parents to offspring.
- **Allelomorph or Allele –**
  - Allelomorphs or Alleles are a pair of genes that control the two alternatives of the same character and located at the same locus in the homologous chromosomes.
- **Karyotype –**
  - A set of chromosomes of an individual or species is called karyotype.
  - It is the genetic constitution of an organism which determines the characters.
- **Phenotype –**
  - Phenotype of an individual refers to the expressed or observable structural and functional traits produced by interaction of genes and enviornments.
- **DNA –**
  - DNA is the abbreviated form of deoxyribose nucleic acid. It is the main nucleic acid in the chromosomes of the nucleus of a cell.
- **Chromosome –**
  - Chromosomes are thread-like bodies found in the nuclei of all cells. They contain DNA (RNA in some viruses) and protein. The chromosomes of cells contain genes.
- **Haploid and Diploid –**
  - The cells with one set of chromosomes in their nuclei are called **haploid**. On the other hand, the cells with two sets of chromosomes in their nuclei are called **diploid**.

- **Gene Locus –**
  - It is "A position on a chromosomes where an allele is located".
- **Heterozygous –**
  - The prefix hetero means different and zygous means a pair the organism in which both the genes of a character are unlike is said to be heterozygous or hybrid. Such organisms do not breed true on self fertilization.
- **Homozygous –**
  - The prefix homo means "the same" and zygo means "a pair" the organism in which both the genes of a character is said to be homozygous or genetically pure for that character. It gives rise to offsprings having the same character on self breeding.
- **Dominant and Recessive –**
  - A heterozyote possesses two contrasting genes or alleles but only one of the two is able to express itself, while the other remains hidden. The gene which gains expression in F_1 hybrid is known as **dominant gene**, while its allele is unable to express itself in presence of the dominant gene is **recessive gene**.
- **Back Cross –**
  - When an individual is crossed with a parent, it is called back cross.
- **Test Cross –**
  - When an individuals is crossed with a recessive parents, it is described as test cross.
- **F_1 Generation –**

  It is the generation of hybrids produced from a cross between two true breeding parental forms. 'For example, "Aa" hybrid individuals are produced in F_1 generation from a cross between "AA" and "aa" parents.
- **F_2 Generation –**
  - It is generation of individuals, which arises as a result of inbreeding (self breeding) of individuals of F1 generation. 'For example, AA (pure dominant), Aa (impure dominant or hybrid) and aa (pure recessive) individuals are produced in F_2 generation from self breeding of Aa hybrids of F_1 generation.

3. MONOHYBRID CROSS ::

'It is a cross between two individuals of a species which is made to study the inheritance of a single pair of factors or genes of a trait.

4. DIHYBRID CROSS ::

It is a cross between two individuals of a species which is made to study the inheritance of two pairs of factors or genes.

5. MENDELISM ::

- **Mendel was a monk in Austria.**
- Mendel performed a number of experiments on the gardan pea plants (**Pisum sativum**).

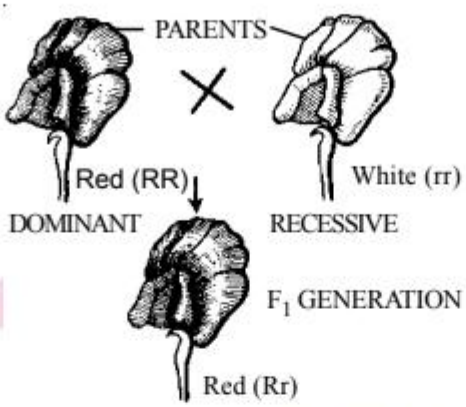
5.1 Mendel's Law :

- The theoretical explanation of mendel's results are now firmly establisas Mendel's laws of inheritance.

➤ These are as follows :

5.2 Mendel's law of Dominance :

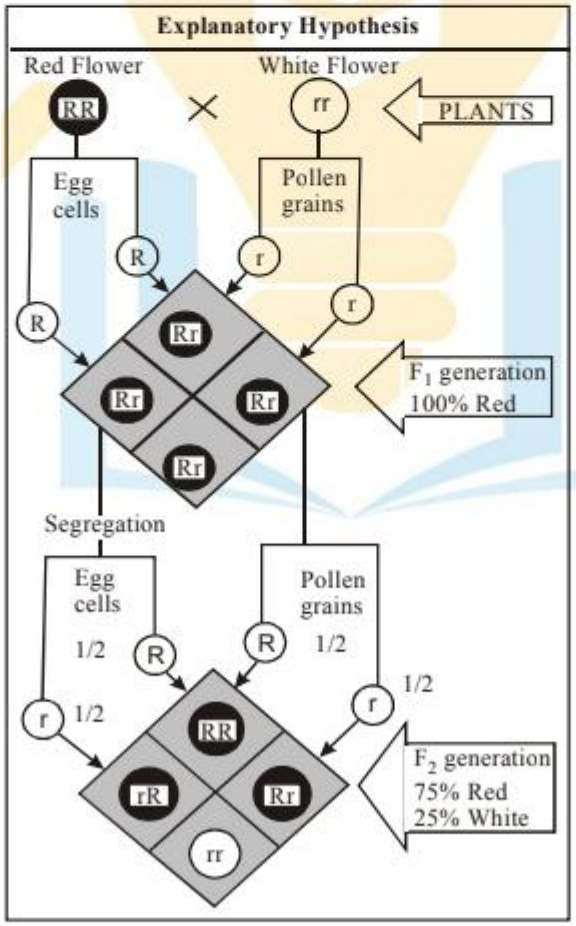
➤ According to this law, if a cross is made between plants with contrasting pair of charactess, the character that appears in the first generation is dominant and the other is recessive.



Mendel's monohybrid cross between a homozygous red flowered (RR) and a homozygous white flowered (rr) plant to show that red colour is dominant over white (recessive)

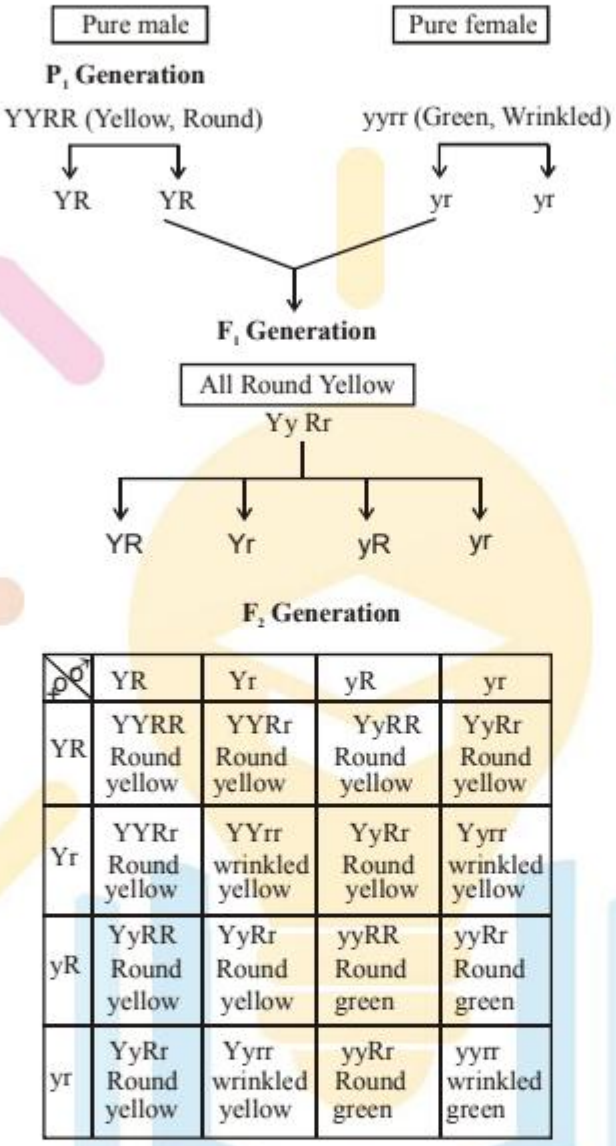
5.3 Mendel's law of segregation (or law of purity of gametes) :

➤ Both parental allels (i.e. dominant as well as recessive) segregate or separate and are



expressed phenotypically in F_2 generation, and this is called mendel's Law of segregation.

➤ **Mendel's Law of Independent Assortment**, which states that most of the characters of parents can appear in any combination in their offsprings.



♀ / ♂	YR	Yr	yR	yr
YR	YYRR Round yellow	YYRr Round yellow	YyRR Round yellow	YyRr Round yellow
Yr	YYRr Round yellow	YYrr wrinkled yellow	YyRr Round yellow	Yyrr wrinkled yellow
yR	YyRR Round yellow	YyRr Round yellow	yyRR Round green	yyRr Round green
yr	YyRr Round yellow	Yyrr wrinkled yellow	yyRr Round green	yyrr wrinkled green

Fig : Result of Dihybrid cross between pea plants having round yellow seeds and wrinkled green seeds

8. VARIATION ::

The differences or dissimilarities shown by numbers of a species and children to their parents, is termed as variation.

➤ Variations are of **two types** :

❑ **Somatic variations :**

➤ The variation in external appearance, are called somatic variations. These variations are not transmitted to next generation.

➤ Somatic variation are produced due to environmental changes, light and continuous efforts.

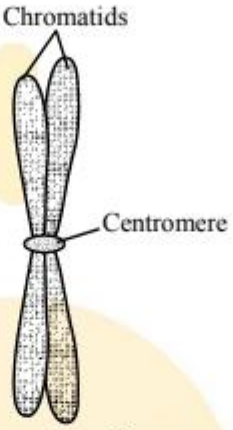
❑ **Germinal variations :**

➤ The variations which affect the germ cells, are called germinal variations. Germinal variations are transmitted from one generation to next generation.

9. STRUCTURE OF A CHROMOSOME ::

Each chromosome is divided along its length into two identical strands called the **chromatids.** which remain joined at some point by a structure called **centromere.**

The physical appearance of chromosomes of an individual or species as seen at metaphase stage of mitotic cell division is called **karyotype**.



Structure of a Chromosome (diagrammatic)

❑ **Chromosome Number :**

➢ Each species has a fixed number of chromosomes in each of its cells, and this is called **chromosome number**. For example, each body cell in human beings possesses 46 chromosomes (22 pairs of autosomes = 44 and 2 sex chromosomes = 46).

10. DEOXYRIBONUCLEIC ACID (DNA) :

Is a chemical in the chromosomes which carries the hereditary characters or traits in a coded form from one generation to the next in all the organisms. DNA is a macromolecule or polymer which is made up of large number of smaller units called 'nucleotide' units. So, DNA is a polynucleotide.

❑ **Nucleotide :**

➢ It is the basic structural unit of DNA. Nucleotide is a compound made up of **three components :**

(i) a nitrogen containing base

(ii) a pentose sugar (deoxyribose) and

(iii) a phosphate group.

❑ The **nitrogenous bases** present in DNA are of **two type** — Purine and Pyrimidines.

➢ The two **purines** in DNA are Adenine (A) and Guanine (G).

➢ The two **pyrimidines** in DNA are Cytosine (C) and Thymine (T).

❑ The **sugar** present in DNA is a five carbon atom sugar or pentose sugar which is deoxyribose; and is represented in the DNA structure by the letter S in a pentagon as Ⓢ, where S stand for 'sugar'.

❑ The **phosphate group** contains one phosphorus atom and four carbon atoms ; and is represented in the DNA structure by writing the letter P in a circle as Ⓟ where P stands for 'phosphate'

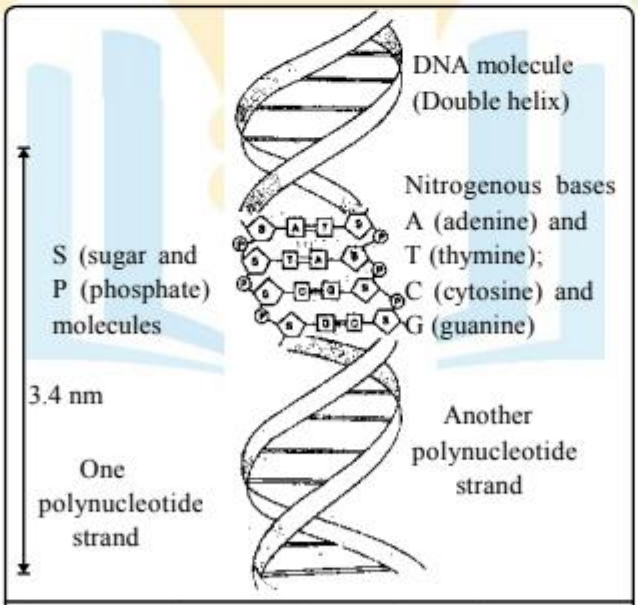
10.1 Structure of DNA :

- Watson and Crick (1953) proposed the **'Double Helix' model** of DNA molecule.
- The DNA molecule consists of two polynucleotide chains or strands of deoxyribose series twisted about each other in the form of a double helix or spiral.
- Each helical turn has a length of 3.4 nm in which ten nucleotides are present.
- Each polynucleotide strand of DNA has a backbone of sugar and phosphate molecules joined with each other through strong chemical bonds. The nitrogenous base are attached to the sugar molecules.
- The two polynucleotide strands of the DNA molecule are joined through nitrogenous bases.
- The nitrogenous base present on one polynucleotide strands forms weak hydrogen bonds with the nitrogenous base of the opposite polynucleotide strand, and these hydrogen bonds hold them together.
- One nitrogen base of one DNA strand pairs up with a specific nitrogenous base of the opposite DNA strand. For example,

(i) Adenine (A) of one DNA strand pairs with Thymine (T) of the opposite DNA strand by 2 hydrogen bonds.

(ii) Cytosine (C) of one DNA strand pairs with Guanine (G) of the opposite DNA strand by 3 hydrogen bonds.

- The structure of a DNA molecule is like that of a spiral staircase in which both the railings of the staircase are made of alternating sugar and phosphate molecules whereas the steps of the staircase are made of complementary nitrogenous bases.



Structure of Deoxyribonucleic Acid (DNA)

11. GENETIC ENGINEERING ::

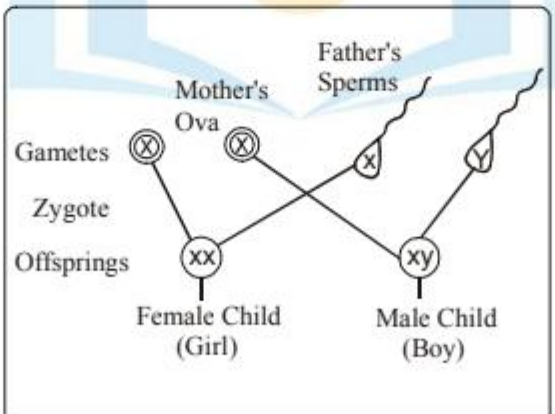
It is the technique for altering an organism's genetic make up by inserting genes from other organism (foreign gene) into its chromosome.

- The organism which has been genetically altered by introducing the genes from other organisms into it is known as **'transgenic organism'** or **'Genetically Modified Organism' (GMO)**.
- This technique allows genetic engineers to 'program' an organism to make useful substances by introducing the necessary genes into it.
- For example, a harmless bacteria *Eacherichia coli* (*E coli*) found in the human intestine has been genetically altered for mass production of insulin hormone for diabetes.

12. SEX DETERMINATION ::

It is a process by which the sex of a person is determined. Genetics is involved in the determination of the sex of a person, which is explained as follows :

- A male has one X chromosome and one Y chromosome, i.e., half of the male gamete or sperms will have X chromosome and the other half will have Y chromosome.
- A female has two X chromosomes, i.e., all the female gametes or ova will have only X chromosomes.
- Sex of a child depends on what happens at fertilisation.
- If a sperm carrying **X** chromosome fertilises an ovum which carries **X** chromosome, then the **child born** will be a **girl**.
- If a sperm carrying **Y** chromosome fertilises an ovum which carries **X** chromosome, then the **child born** will be a **boy**.
- Thus, the sperm determines the sex of the child.
- Sex determination is also controlled by the environmental factors in some animals.
- For example, in some reptiles like **turtle**, high incubation temperature leads to the development of female offsprings, while in case of **lizard**. high incubation temperature results in male offsprings.



Determination of Sex in Humans

EXERCISE - 1

A. VERY SHORT ANSWER TYPES QUESTIONS

Q.1 Define a gene.

Q.2 Write the expanded form of DNA.

Q.3 Name the plant on which mendel performed his experiments.

Q.4 Where is locus ?

Q.5 Name the scientist who proposed the laws of inheritance.

Q.6 What is diploid condition ?

Q.7 Write the number of chromosomes in human beings.

Q.8 Name the two purine bases.

B. SHORT ANSWER TYPES QUESTIONS
(About 30–40 words)

Q.9 How many types of purines and pyrimidines are there in a DNA molecule ? Name them.

Q.10 Define variations.

Q.11 What is heredity ?

Q.12 What is monohybrid cross ?

Q.13 What is dihybrid cross ?

Q.14 What is GMO.

C. LONG ANSWER TYPES QUESTIONS
(More than 60–70 words)

Q.15 Who was mendel ? why was he called the "father of Genetics" ?

Q.16 What is variation ? what is significance of variation ?

Q.17 Define law of segregation.

Q.18 What is genetic engineering ? Give an application of genetic engineering ?

Q.19 What do you understand by double helical structure of DNA ? Who proposed this structure ?

Q.20 What is the law of dominance, and law of independent assortment.

D. FILL IN THE BLANKS

Q.21 Mendel performed his experiments on .....

Q.22 According to modern concept, mendel's factor is called a.....

Q.23 A human female has.....sex chromosomes.

Q.24 .....is called the science of heredity and variation.

Q.25 Gene is a segment of a large molecule of.....

Q.26 Gamete have a set of.....chromosomes

Q.27 Mendelian factors or genes as well as chromosomes are present in.....

E. TRUE OR FALSE

Q.28 J.P. Watson and F.H.C. Crick has proposed double helical model of DNA.

Q.29 47 chromosomes are present in human being.

Q.30 Each chromosome consists of two units called chromatids.

Q.31 Adenine and guanine are the pyrimidines.

Q.32 Guanine and cytosine are pyrimidines.

Q.33 Gene or DNA molecules are the components of a chromosome.

Q.34 Full form of DNA is Ribosenucleic acid.

Q.35 Heredity is defined as the transmission of traits from parents of offsprings.

Q.36 Sutton is the father of genetices.

Q.37 The variation which affect the germ cells are called somatic variation.

F. OBJECTIVE TYPE QUESTIONS

Q.38 Dissimlarity shown by members or offsprings is called –
(A) Heredity (B) Variation
(C) Mutation (D) Fusion.

Q.39 Mendel worked on –
(A) Wild pea (B) Edible pea
(C) Garden pea (D) All the above.

Q.40 Double helical model of DNA was proposed by–
(A) Sutton and Baveri
(B) Griffth and McCarty
(C) Watson and Crick
(D) Avery and Mcleod

Q.41 The Nitrogenous basis of two strands of a chromosome joined together by a chromosome joined together by a –
(A) Covalent bond
(B) Ionic bond
(C) Hydrogen bond
(D) None of the above

Q.42 Guanine pairs with –
(A) Adanine (B) Cytocine
(C) Thymine (D) None of these

Q.43 Chemically a nucleotide has a –
(A) Pentose sugar (B) Nitrogenous base
(C) Phosphate group (D) All the above

Q.44 The chemical unit of DNA molecule is –
(A) Nucleotide (B) Nucleoside
(C) Gene (D) None of these

G. MATCH THE COLUMNS

Q.45 Match the words of column I and column II.

Column - I	Column - II
1. An organism or cell having only one complete set (n) of chromosomes of one genome -	a. Somatic variation
2. The variation in external appearance are called are called	b. Germinal variation
3. The variations which affect the germ cells	c. Human beings
4. The diploid number of chromosome is 46 or 23 pairs in the cells of	d. Haploid

H. FILL THE BOX WITH APPROPRIATE WORD

Q.46 Test cross is across between recessive parent and – ☐

Q.47 The chemical unit of DNA molecule is – ☐

Q.48 How many autosomal pair of chromosome present in a human cell – ☐

I. PASSAGE BASED QUESTIONS

PASSAGE (Q.49 TO Q. 51)

If two organisms are crossed for a single distinguishing characeter (say tall (D) and short (r))

Q.49 What is the type of cross ?

Q.50 What will be the phenotypic ratio is F_1 and F_2 generation.

Q.51 What will be the genotpc ratio in F_2 generation ?

J. ASSERTION AND REASON TYPE QUESTION

The following questions consist of two statement each : assertion (A) and reason (R). To answer these question, mark the correct alternative as described below :

(A) If both **A** and **R** are true and **R** is the correct explanation of **A**.

(B) If both **A** and **R** are true but **R** is not correct explanation of **A**.

(C) If **A** is false but **R** is true.

(D) If both **A** and **R** are false.

Q.52 **A :** Common garden pea was experimental material of Mendel.

R : Garden pea has well defined contrasting characters with bisexual and predominantly self fertilised flowers.

Q.53 **A :** Heredity is not the transmission of traits from one generation to following generations.

R : Mendel selected six traits in garden pea for his experiment.

Q.54 **A :** Chromosomes which do not contribute to determination of sex are known as autosomes.

R : Inserting new genes from one organism to another for beneficial purposes is known as genetic engineering.

ANSWER

EXERCISE -1

A. VERY SHORT ANSWER TYPES QUESTION

1. Gene is the hereditary determinant or unit of a specific, biological function.
2. DNA = Deoxyribonucleic acid.
3. Mendel performed his experiment on garden pea (pisum sativum)
4. Locus is point on homologous chromosome where allele are situated.
5. Gregor Johann Mendel.
6. The paired condition of chromosomes is called diploid condition.
7. 46
8. Two purines are adenine and guanine.

D. FILL IN THE BLANKS

21. Garden pea **22.** Gene
23. XX **24.** Genetics
25. DNA **26.** Haploid
27. Pairs

E. TRUE OR FALSE

28. T **29.** F **30.** T **31.** F
32. F **33.** T **34.** F **35.** T
36. F **37.** F

F. OBJECTIVE TYPE QUESTIONS

38. B **39.** C **40.** C **41.** C
42. B **43.** D **44.** A

G. MATCH THE COLUMNS

45. 1 - d, 2 - a, 3 - b, 4 - c

H. FILL THE BOX WITH APPROPRIATE WORD

46. F_1 generation
47. Nucleotide
48. 22 pair

I. PASSAGE BASED QUESTIONS

49. Monohybrid
50. F_1–All tall, F_2 - 3 : 1
51. F_2 – 1 : 2 : 1

J. ASSERTION AND REASON TYPE QUESTION

52. A **53.** D **54.** B