1. Genetics of Life

Class 10 biology Notes by **Rasheed Odakkal**

- Gene, DNA, Nucleotide, Chromosome.
- Protein synthesis of gene and role of RNA.
- Monohybrid-Dihybrid crosses, Laws of Inheritance
- Non-Mendelian Inheritance.
- Variations: Crossing over & Mutation.

Unit Summary:

Heredity and some variations in offspring occur through genes received from their parents. Genetics is the branch of science that deals with genes, heredity, and variation. Gregor Johann Mendel is known as the father of genetics because of his hybridization experiments on *Pisum sativum*, and made some inferences, which made the foundation of genetics.

Genes located in the DNA molecule, inside the chromosome, in cell nucleus. A gene is a specific sequence of nucleotides in DNA (Deoxyribo nucleic acid). Proteins, which are synthesised in ribosomes, according to the instructions of genes, are responsible for the formation of characteristic features and for controlling metabolic activities.

DNA and histone proteins are the primary components of a chromosome. Chromatids are the parts of a chromosome which are connected by means of centromere. There are 23 pairs of chromosomes in the nucleus of each human cell. Of these, 22 pairs are somatic chromosomes, which control physical characteristics, and one pair is sex-determining chromosome. The genetic constitution of a female is 44+XX, and that of a male is 44+XY.

Nucleotides are the basic building blocks of DNA. Each nucleotide is composed of a deoxyribose sugar, a phosphate group, and a nitrogen base. DNA contains the nitrogen bases adenine, thymine, guanine and cytosine. DNA, which is a double-stranded, helical structure, contains adenine paired with thymine and guanine paired with cytosine. James Watson, Francis Crick, and Maurice Wilkins were awarded the Nobel Prize in 1962 for their contributions on the discovery of the double helix model of DNA.

Cells also containsanother nuceic acid, RNA (Ribonucleic Acid). Most of the RNA are single-stranded and consist of nucleotides, made up of ribose sugar, phosphate group, and nitrogen bases such as adenine, uracil, guanine, and cytosine.

Different types of RNA are involved in the protein synthesis of DNA. **Transcription**, the first stage of protein synthesis, is the formation of mRNA, from a specific nucleotide sequence (gene) in DNA, with the help of various enzymes. When this mRNA reaches the ribosome, tRNAs transfer specific amino acids to the ribosome according to its message. The rRNAs in the ribosome join the amino acids together to form proteins. This process is called **translation**. Thes proteins are responsible for the formation of characteristic features and for controlling metabolic activities.

Through his experiments on pea plants, such as monohybrid crosses and dihybrid crosses, Gregor Mendel discovered that certain *factors* are passed from parents to offspring through their gametes. These factors were later discovered to be genes.

One of the two forms (alleles) of a gene, inherited from parents to offspring is expressed. According to the dominant allele, the observable characteristics of an organism are called **phenotype** and the genetic constitution responsible for these characteristics are called **genotype**.

When Gregor Mendel conducted hybridisation experiments in pea plants considering the opposite traits (tallness and dwarfness) of one character (ie,height), the phenotype of all the offspring in the first generation (F_1) was taller. When this generation was self-pollinated, the second generation (F_2) produced tall and short offspring in a ratio of approximately **3:1**. Through this type of monohybrid cross, Mendel arrived at some conclusions.

- A trait is controlled by two factors.
- When a pair of contrasting traits is subjected to hybridisation, only one of the contrasting traits is expressed (dominant trait) in the offspring of the first generation and the other remains hidden (recessive trait). The trait hidden in the first generation reappears in the second generation.
- When gametes are formed, the factors that determine trait gets separated without mixing.
- The ratio of dominant to recessive traits in the offspring of the second generation is 3:1.

When dihybrid crosses were performed on plants with two pairs of contrasting traits of the same plant such as height of the plant and shape of seed, the same phenotype was obtained in the first generation (F_1). When these were self-pollinated to produce the second generation (F_2), phenotypes different from the parent plants were obtained. The offspring were obtained in a ratio of approximately **9:3:3:1**. The hypothesis that Mendel arrived at through such dihybrid crosses is given below.

- When two or more different traits are combined, each trait is inherited independently to the next generation without mixing each other.

In 1865, Gregor Mendel presented his conclusions to the scientific world, but they were ignroed. Later, in 1900, Hugo de Vries, Carl Correns and Erich Von Schermak recognized the importance of Mendel's Laws of Inheritance and since then Mendel became known as the father of genetics.

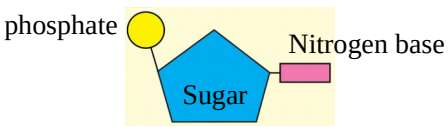
Some later studies have revealed some limitations to Mendel's laws, which is known as **Non-Mendelian Inheritance**. (Examples include incomplete dominance, codominance, multiple allelism, and polygenic inheritance.and polygenic inheritance.).

It is now possible to alter the characteristics of organisms through gene editing, which makes desirable changes to certain genes in DNA. Jennifer A. Doudna and Emmanuel Carpentier were awarded the 2020 Nobel Prize in Chemistry for developing the CRISPR-Cas9 technology for gene editing.

Variations are characters expressed in offspring, that differ from their parents. The genetic processes that cause variations are crossing over, which occurs in the first stage of meiosis, and mutation, which is the sudden heritable change in the genetic structure. Mutations play a crucial role in the process of evolution.

Questions and Answers:

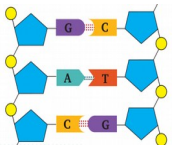
1. What is gene editing? Name a technology used for gene-editing? Who were introduced this technology?
   Gene editing is the process of making desired changes to certain genes in DNA.
   CRISPR-Cas9 is a technology used for gene-editing. Jennifer A. Doudna and Emmanuel Carpentier introduced this technology.
   (They were awarded the 2020 Nobel Prize in Chemistry for this).
2. What are the benefits of gene editing?
   Gene editing is expected to make revolutionary advances in genetic disease therapy, treatment of cancer and in the production of disease and pest resistant varieties of crops or vaccines.
3. What is a gene? Where is this located?
   A gene is a specific sequence of nucleotides in DNA (Deoxyribo nucleic acid). Proteins, which are synthesised according to the instructions of genes, are responsible for the formation of characteristic features and for controlling metabolic activities. Genes are located in the DNA molecule, inside the chromosome.
4. Who proposed the double helical model of DNA? What helped them discover this structure?
   James Watson and Francis Crick.
   They were able to derive the double helix model from DNA X-ray diffraction studies of Rosalind Franklin and Maurice Wilkins, especially from the 'Photo 51' taken by Rosalind Franklin.
   (James Watson, Francis Crick and Maurice Wilkins were awarded the Nobel Prize in Medicine in 1962.)
5. What are nucleotides? Name the components of a nucleotide?
   Nucleotides are the basic structural units of DNA and RNA. A nucleotide is composed of a 5 carbon sugar, a phosphate group, and a nitrogen base.



6. What are the sugars and nitrogen bases in DNA?
   Deoxyribose sugar.
   DNA contains the nitrogen bases adenine, thymine, guanine and cytosine.

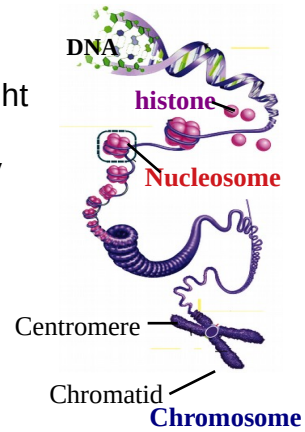
7. Structure of DNA?

DNA, which is a spiral double stranded structure, has strands of deoxyribose sugar and phosphate, and rungs of paired nitrogen bases, namely adenine, thymine, guanine, and cytosine.
Adenine pairs with thymine and guanine pairs with cytosine.



8. Number of chromosomes in a cell nucleus?
46 (23 pairs from mother and father each).

9. How does chromosome form?
DNA and histone proteins are the major components of a chromosome. Eight histone proteins join together to form a histone octamer. DNA strands wind around this octamer to form a **nucleosome**. The chromosome is formed by packing and coiling numerous nucleosomes and recoiling the chains of nucleosomes.

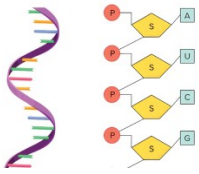


10. Structure of a chromosome?
A chromosome is formed by the contraction of a chromatin network.
Its wings-like parts, connected by the centromere, are called chromatids.

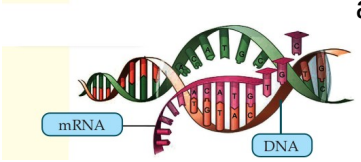
11. Two types of chromosomes in humans? Compare them.
Somatic chromosomes (22 pairs) and the Sex chromosomes (1 pair).
Somatic chromosomes control physical characteristics. These are known as the homologous chromosomes because of identical pairs. Sex chromosomes are involved in sex determination. (**XX** in females and **XY** in males). The Y chromosome is smaller than the X and contains **SRY gene**, which is responsible for the development of testis in the embryo.

12. Female genetic structure: 44+XX, Male genetic structure: ------- ?
44+XY

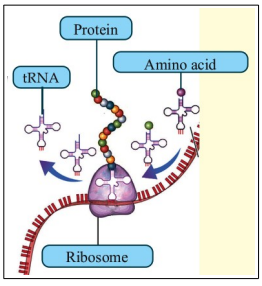
13. From DNA, how is RNA different?
Most of the RNA are single-stranded and long. The nitrogen bases are adenine, uracil, guanine, and cytosine, but are not found in pairs.



14. How do a gene act? Describe the stages of this process.
Gene acts by synthesising proteins with the help of RNA.
Transcription and translation are the two stages of protein synthesis.



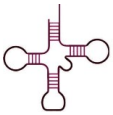
a. **Transcription** is the formation of mRNA from a specific nucleotide sequence (gene) in DNA with the help of various enzymes. The mRNA contains messages for protein synthesis. Transcription occur inside the nucleus.



b. mRNA reaches the ribosomes. According to the message in mRNA, tRNAs carry amino acids to the ribosome. The rRNAs in the ribosome join the amino acids together to form proteins. This process is called **translation**.

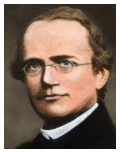
15. The cell organelle for protein synthesis? Which RNA is seen in it? Function of that RNA?
Ribosome.
rRNA (ribosomal RNA). Helps in the formation of bonds between amino acids.

16. Identify this RNAand mention its function in gene action.
tRNA (transferer RNA).
Bring specific amino acids to the ribosome, according to the message in mRNA.



17. Define the 'alleles'?
The different forms of a gene that determins a character are called **alleles**. Since offspring inherit genes from their parents, a gene usually has two alleles.

18. Genetics? Who is regarded as ithe father of genetics? And why?



Genetics is the branch of science that deals with genes, heredity, and variation.
Gregor Johann Mendel is known as the father of genetics.
The conclusions (the Laws of Heredity) he made from his hybridization experiments on the garden pea plant, Pisum sativum, later became the basis for genetics.

19. Who recognized the importance of Mendel's 'laws of inheritance' and presented to the world?
Hugo de Vries, Carl Correns, and Erich von Schermak. (in 1900)

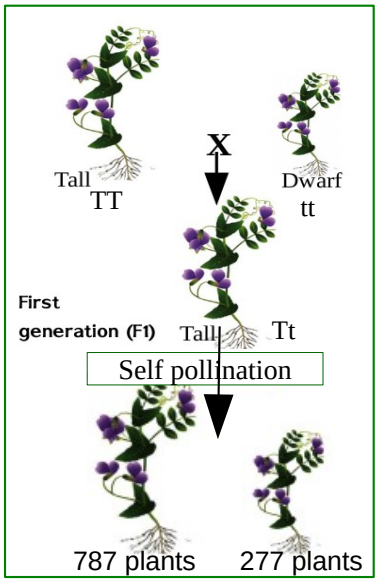
20. Heredity? Variations?
Heredity refers to the transmission of characteristics from parents to their offspring.
Variations are characters expressed in offspring, that differ from their parents.

21. Who had postulated that a trait is controlled by two factors, only one of the contrasting traits is expressed in the offspring and the other remains hidden and when gametes are formed, the factors that determine trait gets separated without mixing?
Gregor Johann Mendel.

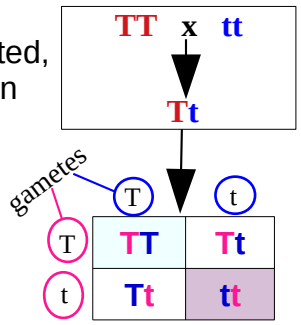
22. According to the dominant allele, the observable characteristics of an organism are called ------- and the genetic constitution responsible for these characteristics are called **genotype**.
Phenotype.

23. What is a monohybrid cross? How does a dihybrid cross differ from it?
A monohybrid cross is the crossing of pairs of opposite traits of a single trait) and a dihybrid cross is the crossing of pairs of opposite traits of two traits.

24. Describe the hybridisation of Mendel, considering the opposite traits of the character, height (Monohybrid cross).
When tall and dwarf parent plants were selected and crossed, the phenotype of all the offspring in the first generation (F_1) was tall.



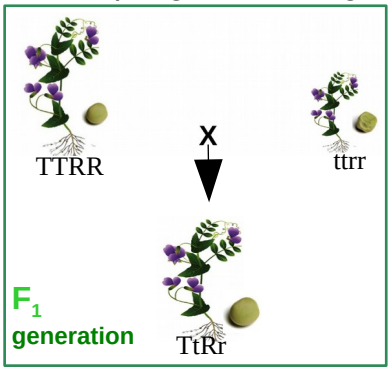
However, when this generation was self-pollinated, to find out the hidden trait,the second generation (F_2) produced both tall and dwarf offspring in a ratio of approximately **3:1**.



First generation (F_1): Genotype: Tt
Phenotype: Tall.
Second generation (F_2): Genotype: Tt TT, Tt, **tt**
Phenotype: Tall & Dwarf - (in a ratio 3:1)

25. The conclusions arrived by Mendel through monohybrid crosses?
- A trait is controlled by two factors.
- When a pair of contrasting traits is subjected to hybridisation, only one of the contrasting traits is expressed (dominant trait) in the offspring of the first generation and the other remains hidden (recessive trait). The trait hidden in the first generation reappears in the second generation.
- When gametes are formed, the factors that determine trait gets separated without mixing.
- The ratio of dominant to recessive traits in the offspring of the second generation is 3:1.

26. Describe the hybridisation, considering the opposite traits of two characters (Dihybrid cross).
When a tall, round-seeded pea plant was crossed with a dwarf, wrinkled-seeded pea plant, all the offspring in the first generation (F_1) were tall and round seeded.



When F_1 generation was self-pollinated, the second generation (F_2) produced 4 types of plants in a ratio **9:3:3:1**

Gametes	TR	Tr	tR	tr
TR	TTRr Tall, Round	TTRr Tall, Round	TtRR Tall, Round	TtRr Tall, Round
Tr	TTRr Tall, Round	TTrr Tall, Wrinkled	TtRr Tall, Round	Ttrr Tall, Wrinkled
tR	TtRR Tall, Round	TtRr Tall, Round	ttRR Dwarf, Round	ttRr Dwarf, Round
tr	TtRr Tall, Round	Ttrr Tall, Wrinkled	ttRr Dwarf, Round	ttrr Dwarf, Wrinkled

F_2 generation

First generation (F_1): Genotype: TtRr
Phenotype: Tall and Round seeded.
Second generation(F_2): Genotype: TTRR, TTRr, TtRR, TtRr, Ttrr,Ttrr, ttRR, ttRr, **ttrr**
Phenotype: Tall and Round seeded, Tall and Wrinkled seeded, Dwarf and Round seeded, Dwarf and Wrinkled seeded.
- (in 9:3:3:1 ratio)

27. The postulations arrived by Mendel through dihybrid crosses?
- When two or more different traits are combined, each rait is inherited independently to the next generation without mixing each other.

28. The hereditary factors identified by Mendel were later identified as ----.
Genes.

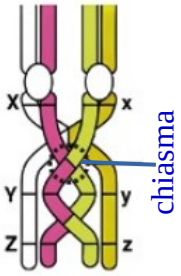
29. What is Non Mendelian Inheritance?
Later studies about the complex interaction among genes, environment and other factors revealed some of the limitations of Mendel's laws. This gave rise to the concept of **Non-Mendelian Inheritance**.

30. Examples for Non Mendelian Inheritance?
Co-dominance : A condition in which both alleles are expressed.
Incomplete Dominance : Shows a different character by the combination of both alleles.
Multiple Allelism : Dominance of more than two alleles.
Polygenic Inheritance : More than one gene controls a character.

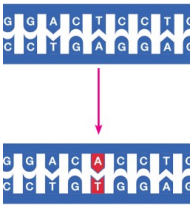
	Peculiarity	Reason
1. Incomplete dominance	Pink coloured flower appears when a red flowered 4 o'clock plant is hybridised with a white flowered one	The dominant allele cannot fully hide the allele of the recessive trait.
2. Co-dominance	Roan coat pattern, found on some cattle and horses.	Both alleles exhibit their traits at the same time.
3. Multiple Alleles	ABO blood group in humans	More than two alleles (I^A, I^B, i alleles) determine the blood group.
4. Polygenic Inheritance	Difference in skin colour.	More than one gene controls the production of melanin.

31. Why are traits (variations) different from those of parents seen in offspring?
Processes like crossing over and mutation.

32. What is crosssing over? How does this cause variation?
During the first phase of meiosis, pairing of homologous chromosomes occur and chromatids at the chiasma region exchange the broken segments each other. This exchange is known as **crossing over**.
Through this exchange of genes, a recombination of alleles occur resulting the appearance of new traits in offspring.



33. Mutation? Reason? What is the importance of mutation?
Mutation is a sudden heritable change in the genetic constitution.



Mutation can be caused by errors during DNA replication, exposure to certain chemicals, radiations etc.
Mutation causes changes in genes leading to variations in characters in next generation. Mutations play a crucial role in the process of evolution.

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Video Class Links:
Part 1 : https://youtu.be/twR6DxxrqFw?si=gJfLH4fWHC0jpClS
Part 2 : https://youtu.be/pdPOa7wmKA0?si=-GbMgAlu-L4BsHf6
Part 3 : https://youtu.be/__VmnEDG6a8?si=4jmFZvnllGAgaqmN