UNIT 4: GENETICS : HEREDITY IN LIVING THINGS

INTRODUCTION

Genetics is a biological science that is concerned with the study of heredity and variation. You may have been wondering why members of your nuclear family differ or look exactly as your mother or father and possibly like any of your grandparents.

In unit 3 you looked at the differences among living things. In this unit, you will be looking at the basic component of the cell and the type of cell division that takes place in the living cells which makes heredity possible. The nucleus of every living cell has several thread-like structures called chromosomes. Human cells each contain 46 chromosomes. Other living organisms, each has it own peculiar number of chromosomes present in each of their body cells.

The presence of chromosomes in the nucleus makes the nucleus the most important component of your body cells. The chromosomes are made up of DNA and proteins. The DNA is a set of instructions to the cell. These instructions tell the cell what proteins to make.

OBJECTIVES

By the end of this unit you should be able to:

1. describe the stages of mitotic division;
2. describe the stages of meiotic division;
3. explain terms used in genetics;
4. state Mendel's laws of Heredity; and
5. explain the stages of a Monohybrid cross.

HOW TO STUDY THE UNIT

1. In this unit, you will come across many unfamiliar terms. Learn to spell the words correctly and make sure you understand what they mean. Try to explain them in your own words.
2. When you understand the terms, then you can readily follow the science of genetics.
   Carry out all activities and assignment

NOTE : ALL ANSWERS TO ACTIVITIES AND ASSIGNMENT ARE AT THE END OF THIS BOOK.

WORD STUDY

Genetics is a biological science concerned with the study of heredity and variation.

Heredity is the tendency of an offspring to possess certain features/characteristics similar to either of or both parents.

The **nucleus** is that part of the cell that is concerned with reproduction and with transmission of characters from parents to offspring.

Chromosomes are threadlike structures contained in the nucleus. They are made up of DNA and protein.

DNA Stands for deoxyribose nucleic acid. The molecules contains instructions for making different kinds of proteins.

Protein is substance made up of carbon, hydrogen, oxygen and sometimes contain sulphur.

RNA stands for ribose nucleic acid.

Genes are part of the DNA molecule which gives instructions for the making of a particular protein. There are more than one type of gene in a particular chromosome.

Homologous chromosomes a pair of identical chromosomes.

Heterozygous chromosomes a pair of unidentical chromosomes

Zygote is a single cell formed as a result of the union of a male sex cell with a female sex cell during sexual reproduction. It is a fertilized egg, containing diploid number of chromosomes.

A **gamete** is a mature sex cell which takes part in sexual reproduction. It may be a male (sperm cell) or a female (egg cell). Each gamete contains haploid number of chromosomes.

Allelomorphs are a pair of genes responsible for a pair of contrasting characters, like the red and white flower colour in the common garden pea plant.

A pair of Allelomorphs is also known as an **allelic** pair, in which case each member of the pair of allelomorphs resides on the same position, or locus of homologous chromosomes.

An individual is said to be **homozygous** if the two members of a pair of gene controlling a given pair of constrasting characters are identical.

An individual is said to be **heterozygous** if the two members of a pair of genes controlling a given pair of constrasting characters are different

A **dominant** character is a character that produces its effect even though the opposite, or contrasting character is present.

A **recessive** character is a character which does not produce its effect in the presence of a dominant gene.

A dominant character is controlled by a dominant gene.

A recessive gene s controlled by a recessive gene.

Phenotype is used to describe the individually expressed traits.

Genotype is used to describe the individual's total genes inherited from both parents These include both the individual's genes that are dominant and recessive genes that are not expressed.

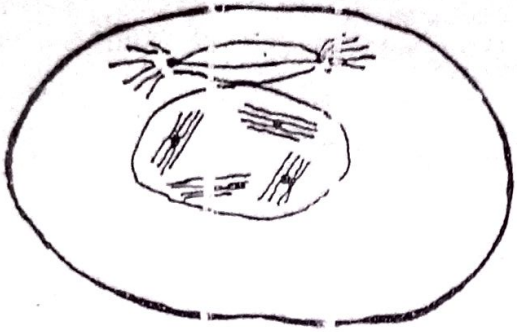
Filial generations are the offspring of the parent generation. First, second and third generations and a represented by the symbols F_1, F_2, F_3 respectively.

STAGES OF MITOSIS

Mitosis is the type of cell division that takes place during growth and development. This type of cell division also occur in a sexual reproduction.

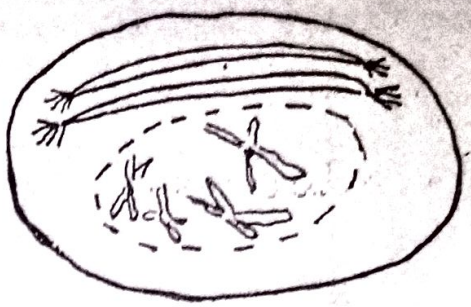
Located inside the cytoplasm of the cell is the nucleus. Animal cells and some simple plant cells have structures called centrosomes along side of the nucleus. The centrosomes are composed of two parts at right angles to the other. In mitotic cell division you are concerned with what happened to the chromosomes inside the nucleus.

Early Prophase



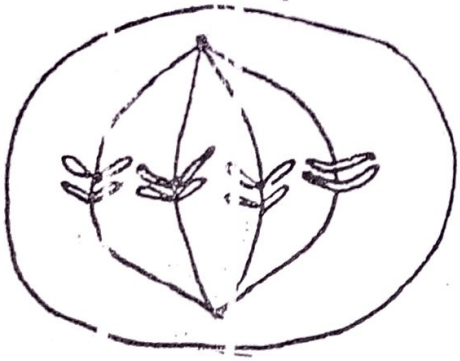
The centrosomes move to opposite sides of the cells from each centrosome spindle fibres develop.

Late Prophase



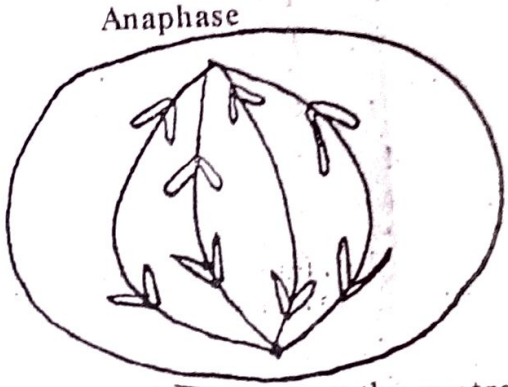
The chromosomes become more pronounced.

Metaphase



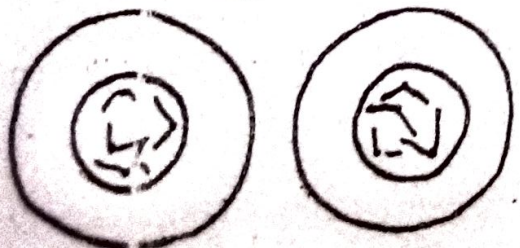
The chromosome move to centre of the cell and line up in pairs

Anaphase



Chromatid separate at the centromere. Each pair move to the opposite pole of the spindle thread.

Late Anaphase



Telephase

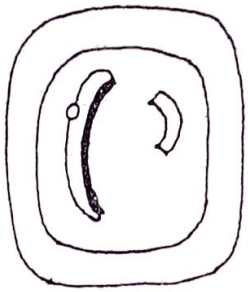
Two sets of chromatids become indistinct. Nuclear membrane reforms and parent cells constrict and divide into two daughter cells. Each cell contain the diploid number of chromosomes.

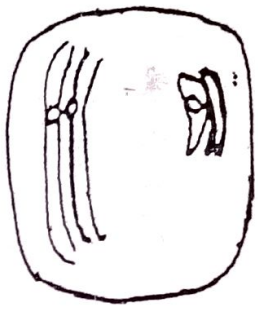
THE STAGES OF MEIOTIC DIVISION

Meiosis cell division only takes place during the formation of gametes before sexual reproduction. The cells present in the reproductive organs which gives rise to sperms and ova undergo mitotic cell divisions. The final cell division which gives rise to the gametes is a meiotic division.

In meiosis, there are two divisions of cells quickly following one another. These division is accompanied by only a single duplication of chromosomes. The result is that haploid nuclei are formed.

Stages of Meiotic Cell Division



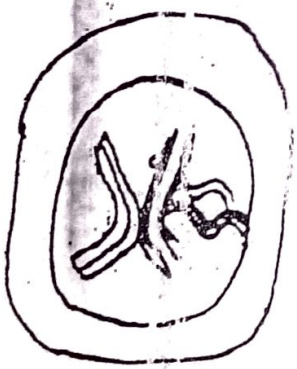


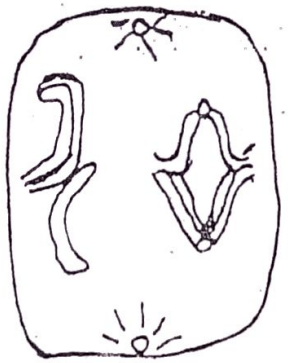
Prophase

(a) A deploid number of chromosomes appear

(b) Homologous chromosomes pair with each other, and then shorten and thicken

(c) Replication has occured and the chromatids become visible.





Anaphase

d) Homologous Chromosomes move apart except at the chiasma where the chromatids have exchanged portions

e) A spindle has formed and homologous chromosomes move to opposite ends taking exchanged portions with them.

f) Homologous chromosomes separated but not enclosed in nuclear membrane.

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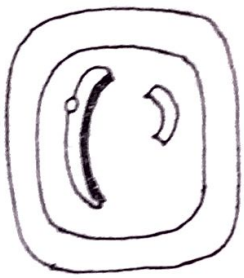

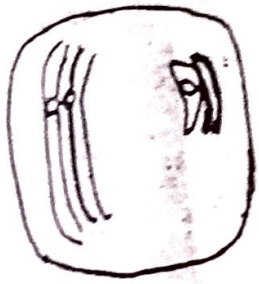

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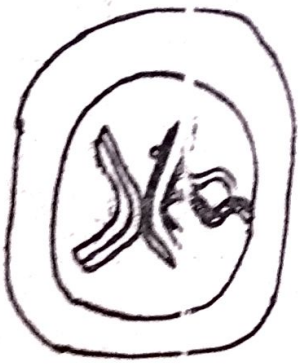

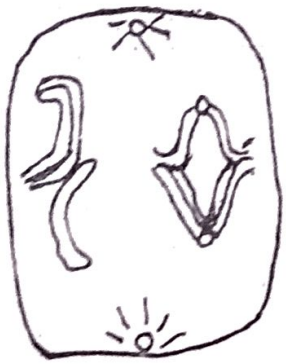

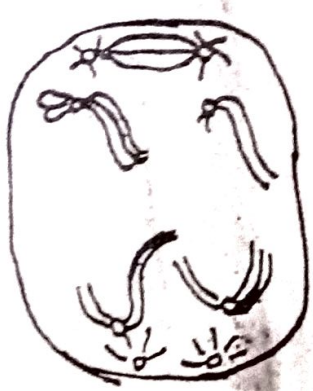

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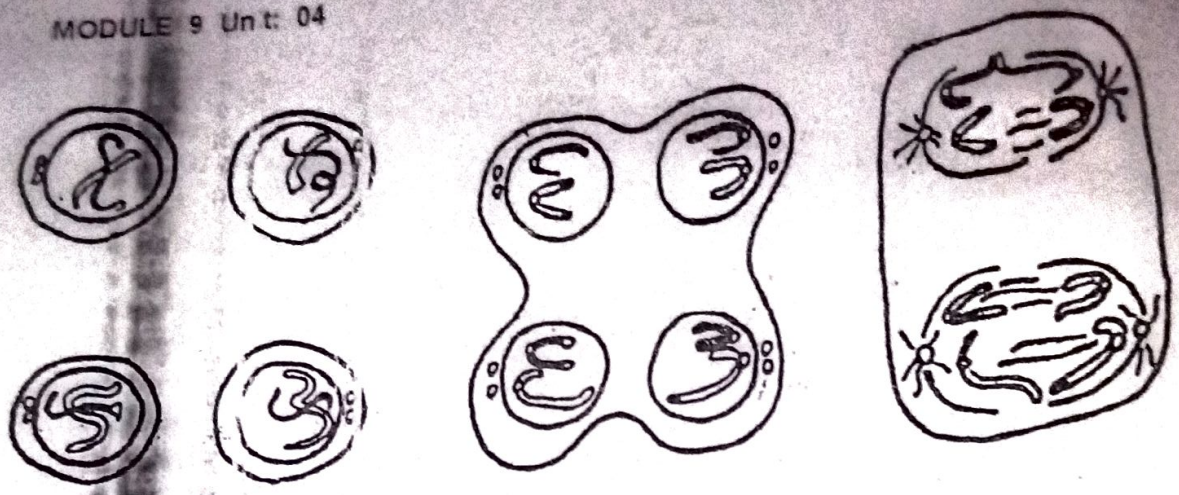


Second Meiotic Division

(g) Spindles form at right angles to the first one and the chromatides separate.

(h) Four nuclei appear, each enclosing the haploid number of chromosomes.

(i) Cytoplasm divides to form four gamete cells.

MENDELS IDEAS ON HEREDITY

Gregor Mendel was the first to work on genetics in 1856. His work on genetics was carried out with plants and he tried to find out how hereditary characteristics were transmitted in the plants he studied. Mendel was mainly concerned with garden pea and he worked on various inherited characteristic such as the length of plant, colour of seed, surface of seed coat. As a result, he was able to produce offsprings of these plants, both by self-pollination and by cross pollination. From his experiments he came out with two laws of Heredity.

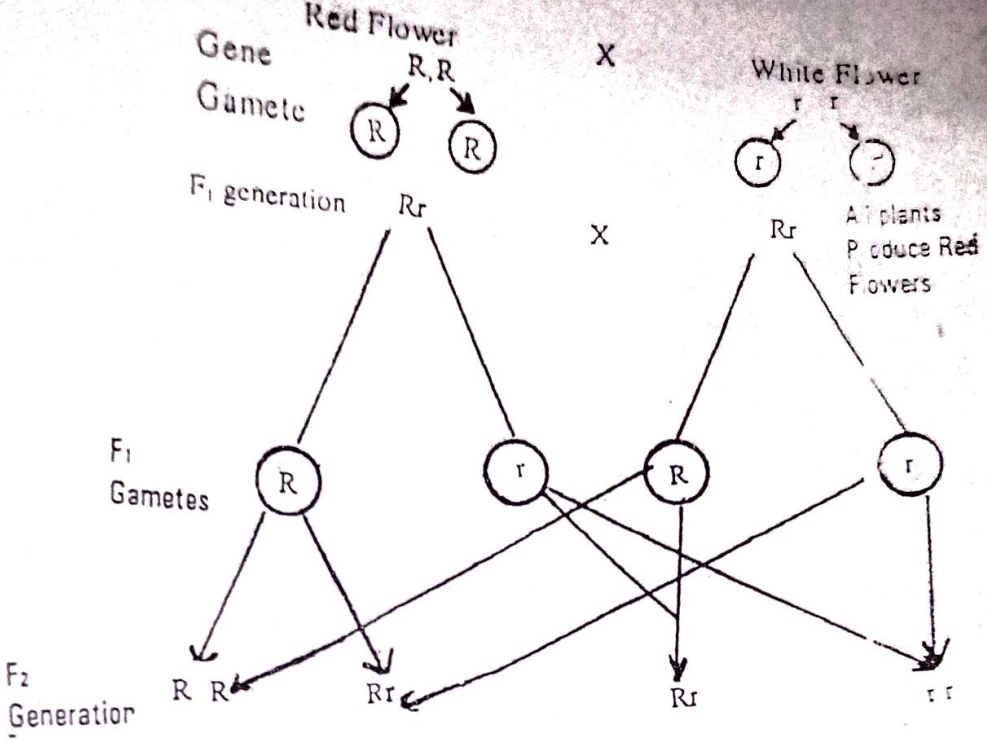
The First Law of Mendel is the law of segeration of genes. The law states that genes are responsible for the development of the individual and they are independently transmitted from one generation to another without undergoing any change.

The Second Law of Mendel is the law of independent assortment of genes. the second law of Mendel states that each character behaves as a separate unit and is inherited independently of any other character.

Mono-hybrid Cross - Complete Dominance

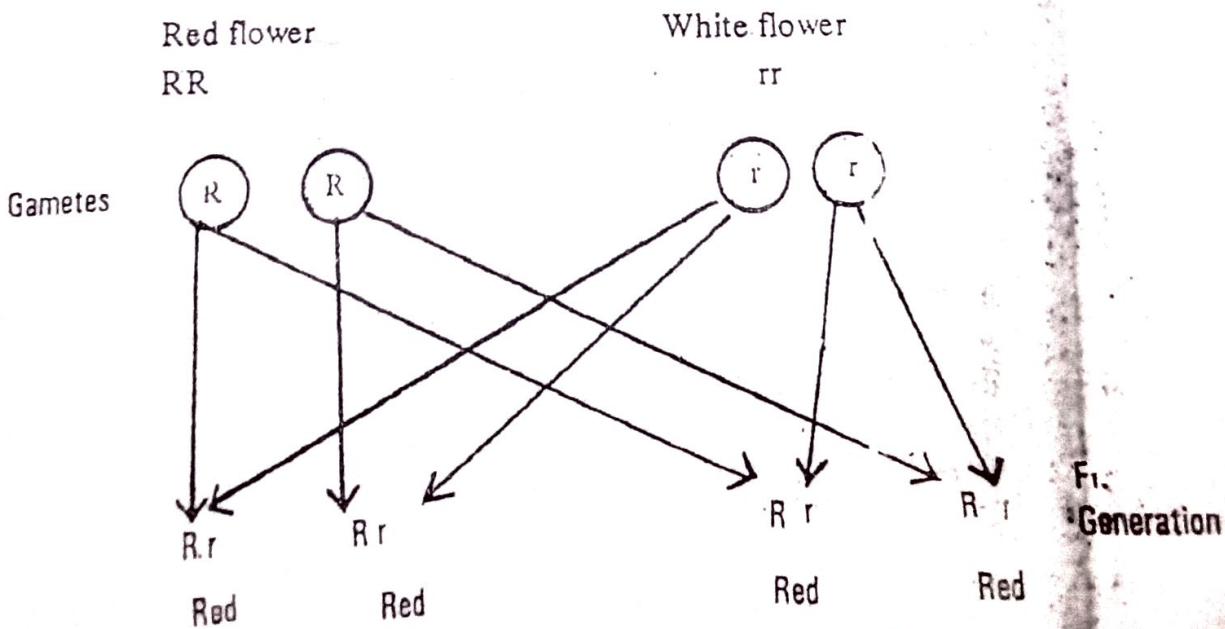
A good example of a Mono-hybrid is the flower colour of the garden pea plant. A pure stock of red-flowers when crossed among themselves will always produce pure red flowers only. In the same way, a pure stock of white flowered pea will also produce only white flowers. We can say that both the pure red and pure white pea flowers are true breeds. In his experiment, Mendel crossed the red-pure breed flower with a pure - white breed flower. The result of Mendel crossing is shown below.

Monohybrid Cross

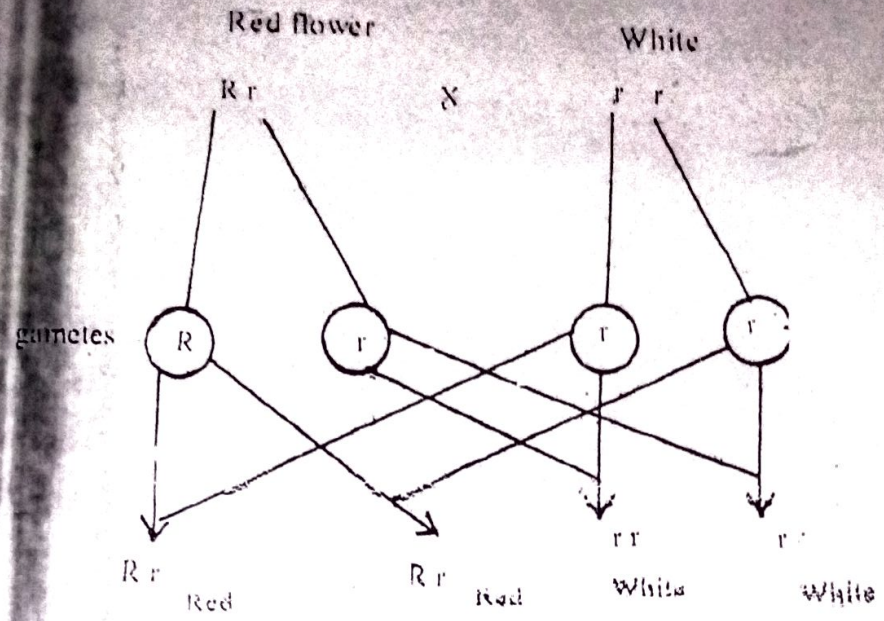


The result of the crossing showed that the first generation of pea flowers were all red flowers. the crossing of the F_1 generation flowers with two types of genotypes and two phenotypes. The genotypes appear in the ratio of 1:2:1 or RR homo zygyous white flowers. The phenotype appear in the ratio of 3:1 that is three red flowers to one white flower.

Back-cross is always done to confirm the genotype of the red flowers in the F_2 generation. This is done by crossing the red flowers (genotypes Rr or RR) with a true breeding (genotype rr). The Back-cross is shown below.



A red flower homozygous genotype was used so the offspring's were all red Flowers.



When the heterozygous red is crossed half the number (2) flowers were red and the remaining 2 flowers were white.

SUMMARY

In this unit you learnt that:

- The nucleus is the most important structure of the cell.
- The chromosomes are housed in the nucleus and control the activities of the cell.
- The chromosomes are made of DNA and proteins.
- DNA is a set of instructions to the cell.
- The cell undergoes 2 types of division: mitosis and meiosis.
- In mitotic division, the cell divides to give 2 daughter cells. They are diploid.
- In Meiotic division 4 daughter cells are produced and they are haploid.
- When pure breed red pea flowers were crossed with true breed white flowers, the phenotype ratio was 3 red flowers to 1 white flower.
- The genotype ratio was 1 red (pure breed) to 2 red flower (heterozygous) to 1 white pure breed (homozygous.)
- Back cross of red homozygous flower with white (homozygous) flowers from F_2 generation produced all red flowers.
- Back cross of red heterozygous flower with white (homozygous) flowers produced 2 red flowers and 2 white flowers