NATIONAL OPEN UNIVERSITY OF NIGERIA

SCHOOL OF SCIENCE AND TECHNOLOGY

COURSE CODE: ANP 321

COURSE TITLE: GENETICS AND BREEDING

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                                     NOUN, LAGOS.

TABLE OF CONTENT

MODULE 1:   CELL ORGANISATION

Unit 1: Historical background and Cell Structure
Unit 2: Types of cells
Unit 3: Cell components and their functions

UNIT 1:   DEFINITION OF CELL AND HISTORICAL BACKGROUND

1.0:   Introduction
2.0:   Objectives
3.0:   Main Content
3.1   Historical background to the study of cells and cell structure
4.0:   Conclusion
5.0:   Summary
6.0:   Tutor Marked Assignment
7.0:   References/Further Readings

1.0   INTRODUCTION

The study of living things begins with the study of cells. A proper understanding of the cell is essential for us to be able to understand the characteristics and functions of the different tissues and organs in any living organism.

2.0   OBJECTIVES

At the end of this unit, the student is expected to be able to:
1.   Define the term "Cell".
2.   State the relationship between cells and tissues.
3.   Name the early proponent of cell studies.
4.   Draw and label the different parts of the cell.

3.0   MAIN CONTENT:

3.1   HISTORICAL BACKGROUND TO THE STUDY OF CELLS AND CELL STRUCTURE

The cell is the simplest or basic functional unit of an organism. Cells were first described by Robert Hooke, a British Architect and microscopist in 1665. Robert Hooke designed one of the earliest optical microscopes with which he examined thin sections of corks. He discovered that corks were made up of numerous box- like structures which we now know to be cells. Although, Hooke coined the word cell for these structures, he did not realize their significance. In 1675, Marcello Malpighi published an "Anatomy of plants," the first systematic study of cell structure. In 1772, Corti observed the jelly-like material in the cell that was later called protoplasm.

In 1839, Mathias Schleiden, a German botanist and Theodor Schwann, an animal anatomist formulated the "cell theory "which states that "the elementary parts of all tissues are formed of cells in an analogous though very diversified manner, so that it may be asserted that there is one Universal principle of development for the elementary parts

of organisms, however different and that this principle is the formulation of cell". Cells are thus, the unit of life. Twenty years later, Rudolf Virchow suggested that cells originate only from pre- existed cells – *omnis cellulae cellula.* All living organisms, the diversity not withstanding are composed of cells which are similar in structure, function and organisation. Below is a typical diagram of a cell.
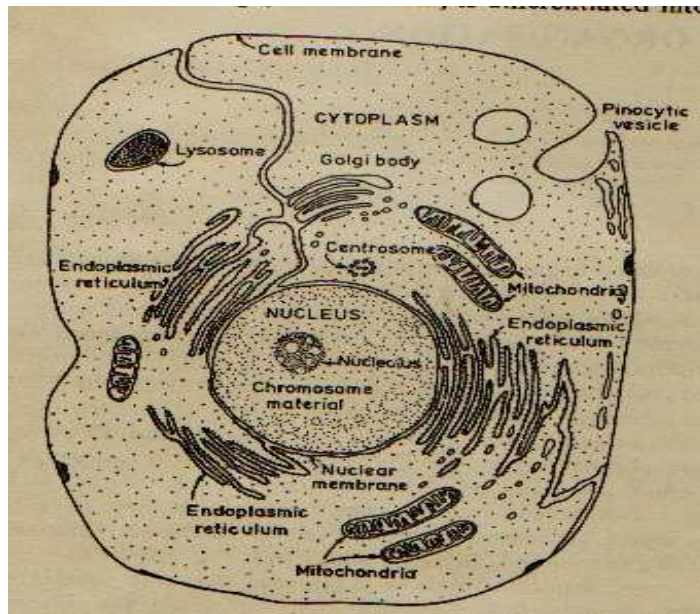

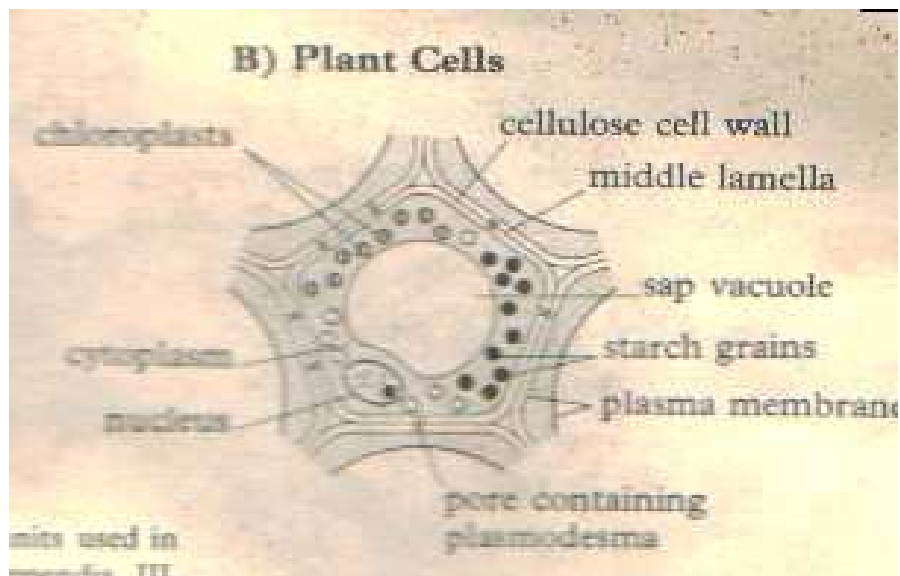Fig. 1: A diagram of a typical animal cell

Fig. 2: A diagram of a typical plant cell (Roberts, 1980)

Cells have many things in common but that vary to some extent in size, shape, structure and function.

4.0   CONCLUSION
The cell is the simplest functional unit of an organization. Robert Hooke was the first Scientist to describe the cell. The first systematic study of cell structure was carried out by Marcello Schleiden, who formulated the Cell Theory.

Cells are alike but vary to some extent in size, shape, structure and function.

5.0   SUMMARY
Cells are the basic functional unit of life. The elementary parts of all tissues are form of cells in an analogous though very diversified manner. Cells have many things in common but they vary to some extent in size, shape, structure and function.

6.0   TUTOR MARKED ASSIGNMENT
1.   What is a cell?
2.   What is the relationship between cells, tissues and organs?
3.   Name four scientists that initiated the study of cells and their functions
4.   Draw and label the different parts of the cell

7.0   REFERENCES AND FURTHER READINGS
George Acquaah (2007) Principles of Plant Genetics and Breeding, Blackwell, United Kingdom.

Roberts, M.B.V. (1980) Biology: A Functional Approach, 4th Edition, ELBS and Nelson, Hong Kong.

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UNIT 2:   TYPES OF CELLS

1.0:   Introduction

2.0:   Objective

3.0:   Main Content

4.0:   Summary and Conclusion

5.0:   Tutor Marked Assignment

1.0   INTRODUCTION

Multicellular organisms are made up of cells with different shapes and sizes. Animal cells are capable of changing their shape but plant cell is fixed due to the presence of cellulose. In this unit we shall be examining their different types of cells and their characteristics.

2.0   OBJECTIVES

At the end of the unit, the student is expected to be able to:

1.   Differentiate between plant and animal cell.
2.   List the different types of cell.
3.   State the diameter of the different types of cells.

3.0   MAIN CONTENT

The diameter of most cells ranges between 0.5 μ and 20μ (μ or micron = 0.001 mm) Table I shows the range of size variation of different kinds of cells. Cells vary widely in shape and depend upon the environmental conditions, surroundings, function and need of the organism.

Table 1: Range of size variation of different kinds of cells

_____

Cell type	Size
Egg of ostrich	170 x 135 mm
Egg of hen	60 x 45 mm
Human egg	0.1 mm= 100 μ
Amoeba	100 μ
Sea urchin egg	70 μ
Red blood corpuscle	7 μ

Typhoid bacillus	2.4 X0.5 μ
Escherichia coli	1.5 x 0.7 μ
Diplococcus pnemoniae	200 x 100 mμ
Influenza virus	100 mμ
Tobacco mosaic virus	300 X 15 mμ
T_3 bacteriophage	45mμ

Cells of multicellular organisms have different shapes. The red blood cells of human beings are round, whereas muscle cells are long and with pointed ends. Animal cells are capable of changing their shape. But the shape of plant cells is fixed due to the presence of a cellulose walls. Figure II, shows the diversity in cell shapes.
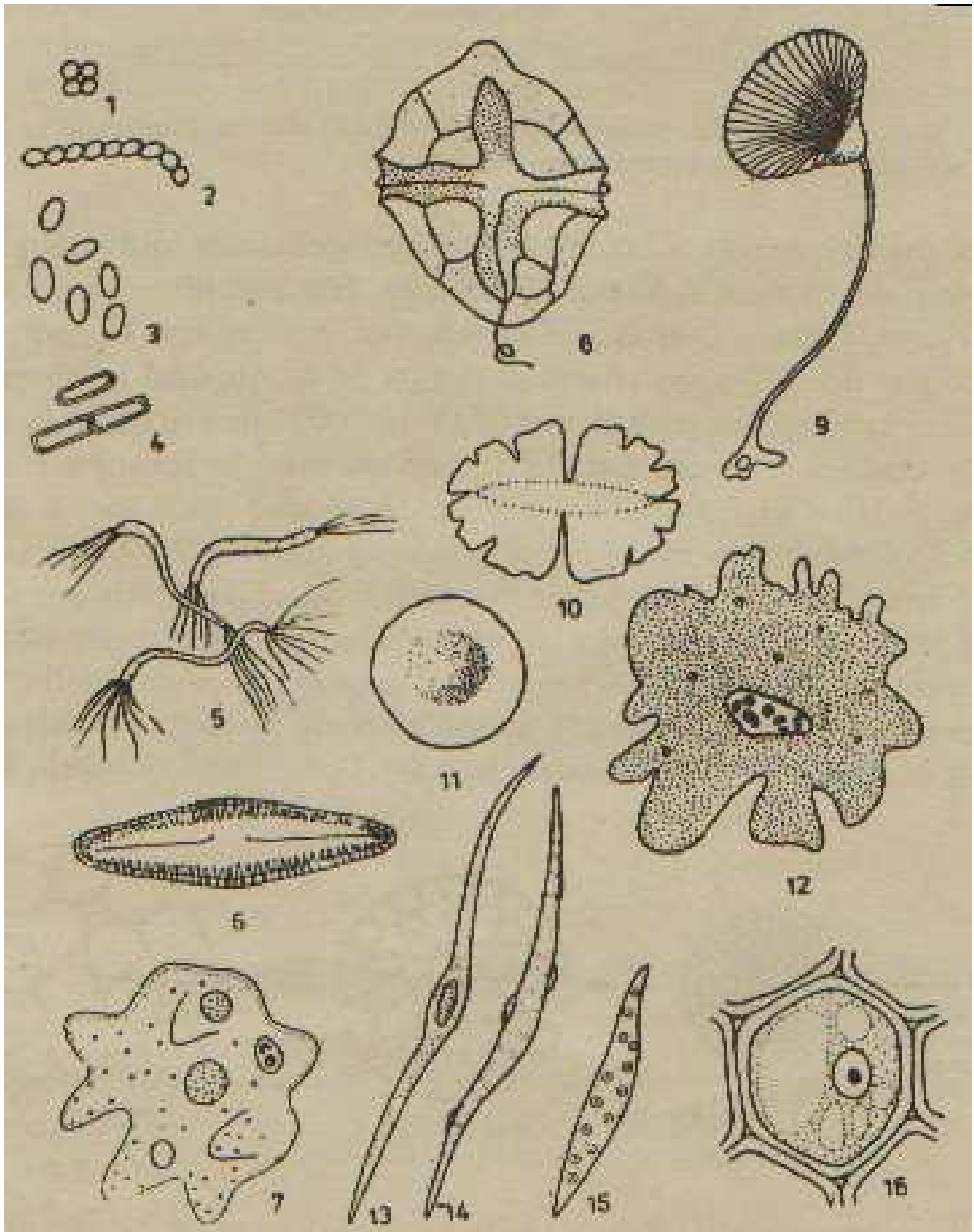
Fig. 3: Variation in cell shape (Sinha and Sinha,1982)

1. Tetracoccus, 2. Streptococcus, 3. Micrococuss, 4. Bacillus, 5. Spirillum, 6. Diatom, 7. Amoeba, 8. Dinoflagellate, 9. Acetabularia, 10. Desmid, 11. Human red blood cell, 12. Melanocyte, 13. Smooth muscle cell, 14. Striated muscle cell, 15. Tracheidal cell, 16. Parenchymatous cell.

4.0   SUMMARY AND CONCLUSION

Cells of multicellular organism have different shapes and sizes. Animal cells are capable of changing shape but the shape of plant cell is fixed due to the presence of cellulose wall.

5.0   TUTOR MARKED ASSIGNMENT

1.   What is the difference between plant and animal cell?
2.   List the different types of cells
3.   State the diameter of the different types of cells

6.0   REFERENCES/FURTHER READINGS:

George Acquaah (2007) Principles of Plant Genetics and Breeding, Blackwell, United Kingdom.

Roberts, M.B.V. (1980) Biology: A Functional Approach, 4th Edition, ELBS and Nelson, Hong Kong.

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Sinha, U. and Sinha, S. (1982) Cytogenetics, Plant Breeding and Evolution, 2nd Edition, Vikas, New Delhi.

UNIT 3: CELL COMPONENTS AND THEIR FUNCTIONS

1.0 INTRODUCTION

Cells are made up of different components. In this unit we shall examine the different components of the cell and highlight their functions

2.0 OBJECTIVES

At the end of this unit, the student should be able to:

1. List the different components of the cell

2. State the function of the different component of the cell

3.0   MAIN CONTENT

CELL COMPONENTS AND THEIR FUNCTIONS

3.1   The Cell Wall

The cell wall is the outer boundary of the cell. It is made up of cellulose, lignin, salts and fatty substances. The cell wall of a young cell has a thickness of 1-3μ, which increases in both length and girth during cell growth. After a while, the primary or initial wall stops growing, and a secondary wall is laid inside it. The thickness of the secondary wall ranges from 5μ to 10μ and it's rigid. It is not flexible like the primary wall. Adjacent cells are cemented together by an intercellular substance or a middle Lamella in multicellular organisms. The middle lamella is composed primarily of calcum pectate. Animal cells lack a cell wall. Hemicellulose make up 50 percent of the dry weight of the cell wall, while cellulose make up 25 percent,: the rest 25 percent consist of protein, pectic substances and fats. Water make up 90 – 95 percent of the fresh weight of the cell wall. Hemicellulose, celluloses, and pectins are all polysaccharides and are built up of linked chains of sugars or uronic acid residues.

Cellulose is made up about 3000 glucose units, which are arranged parallel to one another to form microfibrils. Unto 400 microfibrils are bundled together to form a macrofibril or fibril. Macrofibrils are irregularly and loosely arranged and the gaps are filled with carbohydrates, cutin, suberine, pectin, lignin etc. The macrofibrils of secondary wall are relatively compact and the gaps are filled mainly by lignins. Cell walls gives a definite shape and protection to the cell and provides mechanical support. It is permeable and hydrophilic and contains enzymes which are concerned with the synthesis, transport and degradation of cell wall macromolecules, digestion and modification of extracellular metabolites and other metabolic functions.

3.2   Cell membrane

Inside the cell wall is the cell membrane, plasma membrane, plasmalemma or cytomembrane. The plasma membrane is the most important, as others are not essential

for life. The plasma membrane cannot be removed or damaged without killing the cell. The cell membrane has three properties namely:

(a)   Preferential permeability to lipid-soluble substances

(b)   High electrical resistance

(c)   Low tension

It has been proposed that a single membrane layer consist of a continous film of lipids molecules, such as phosphatides, sterols and fats, of which the outermost two layers are so oriented that the hydrated polar groups are in the water- oil interface, with a layer of protein molecules absorbed on both of these interfaces. There is considerable freedom of movement of constituent molecules within the membrane. This is necessary if the membrane is to be a dynamic structure capable of charging its composition and function according to the exigencies of the situation. Cell organelles are also bounded by membranes.

Membranes, thus bring about compartmentalization within the cell which is necessary for division of labour at the sub cellular level. Membranes are fluid and dynamic functional systems.

They are the sites of active transport, oxidative and photosynthetic phosphorylations, immunological response, cell-cell interaction and many other vital physiological activities.

3.3   Protoplasm

This is a colloidal mixture of organic and inorganic material enclosed inside the cell wall. Plasma membrane surrounds the protoplast. When cell wall is remove, the protoplast rounds off and sometimes breaks up into pieces.

3.4   Cytoplasm

Cytoplasm is that part of the cell which is enclosed by the plasma membrane and surrounds the nucleus. In many plants, the cytoplasm of adjacent cells is connected by cytoplasmic strands which pass through plasmodesmata. Sometimes, the cytoplasma can

be divided into an outer ectoplasm, a middle mesoplasma and an inner endoplasma. In the cytoplasm are suspended the various organelles such as the nucleus, endoplasmic reticulum, plastids, mitochondria, golgi bodies etc. Also present in the cytoplasm are many soluble and insoluble molecules which participate in various metabolic reactions of the cell.

3.5   Endoplasmic reticulum

The endoplasmic reticulum is made up of a system of tubes or flattened sacs located in the cytoplasm. The endoplasmic reticulum or ergastoplasm appears to be continous with the cell membrane on one hand and the nuclear membrane on the other. Sometimes endoplasmic reticulum is expanded to form flat and sac like cysternae which may occur singly but more often are aggregated to form parallel lamellae. Beside tubules and cysternae, there may be isolated vesicles which may be formed due to pinching off of cysternae.

The endoplasmic reticulum divides the cytoplasm into two parts: one part which is outside the tubules and vesicles and other which is enclosed by them. In cells that can synthesise protein, part of the endoplasmic reticulum is studded with granula particles, which are known as microsomes or ribosomes. Endoplasmic reticulum covered by ribosomes are known as rough endoplasmic reticulum, while those without ribosomes are called smooth endoplasmic reticulum.

In cells where smooth endoplasmic reticulum predorminates, the enzymes concerned with the synthesis of fatty substance are associated with the endoplasmic reticulum. Ribosomes are the sites of protein synthesis, and can be stung together by messenger RNA to form polysomes or polyribosomes. Endoplasmic reticulum thus, provides a situable surface for various metabolic reactions. It also helps in the transport and storage of various metabolites and compartmentalization of cytoplasm.

3.6 Golgi body

The golgi bodies usually appear as a series of flattened membranous sac (2 to 20) which lies parallel to each other near the nucleus. It was named after its discoverer, Camillio

Golgi (1898). The golgi body is also know as dicytosome. Each of the sac or cysternae are enclosed by smooth double membranes which are often dilated and fenestrated at the ends. Vesicles are constricted off the branched cysternae from time to time. The aggregation of dicytosomes along with vesicles derived from them is known as the "Golgi complex" or "Golgi apparatus". It has been suggested that golgi complex is concerned with the storage and transformation of lipids and lipid-like substances and participates in cell wall formation and secretion. It is also involved in inter and intra-cellular transport and formation of primary lysosomes in animal cells.

3.7   Lysosomes

Lysosomes are sac like structures, which are found in animal cells. They are derived from smooth endoplasmic reticulum. Lysosomes measures 0.25μ to 0.05μ in diameter and contain hydrolytic enzymes. They are composed of a homogenous matrix which is bounded by a single lipo-proteinaceous membrane. They can be separated and purified by centrifugation. They have been implicated with intra digestion, autophagy and autolysis as they contain enzymes which control the breakdown of large molecules such as protein and fat, both of intra- and extra- cellular origin.

3.8 Microbodies

These are also known as cytosomes. They are sac like organelles found in both plant and animal cells. These organelles are supposed to arise from the endoplasmic reticulum and are enclosed by a single membrane. Their matrix is fibrillar or granular.

Cytosomes were first discovered in rat liver and kidney cells where they carry out various oxidative reactions involving the formation and further degradation of hydroperoxide. Microbodies contain specific enzymes, depending on the type of cell and stage of differentiation. Microbodies that contain glycolytic enzymes are know as peroxisomes. They are found near the chloroplasts as they contain enzymes of the photosynthetic cycle. Microbodies containing enzymes of the glyoxylate cycle are known as glyoxysomes. Glyoxysomes are involved in the degradation of fatty acids to form

15

carbohydrate. They are common in fatty seeds and qradually disappear after the germination of the seedling.

3.8 Microtubules:

Microtubules are tubular structure made up of glubolar protein and get aggregated to form the spindle fibres. Generally, two centrally located microtubules are surrounded by a ring of nine pairs of microtubules and the whole thing is embedded in a matrix which is enclosed by an extension of the plasma membrane.

Microtubules are present in all eucaryotic cells and are responsible for the orderly movement of chromosomes during cell division. They are also found in places where new cell wall is to be synthesized, for example at the time of cytokinesis or at the time of cell elongation. Cilia and flagella of motile gametes or cells contain microtubules which are arranged in an orderly and definite fashion. Centrioles of animal cells possess a similar pattern of microtubules. Microfilaments are also present in cells. They are smaller than microtubules and help in photoplasmic streaming, cell mortility, changes in cell shape and muscle contraction.

3.9 Mitochondria

Mitochondria are bean-shaped, free floating organelles in the cytoplasm. They were discovered by Benda in 1898. Their shape, size, internal structure and number differ from cell to cell and measured 1 to 10µ long and about 0.5µ wide. The mitochondrion is bounded by a double membrane, the outer is smooth and has many round granules attached to its surface while the inner one is folded and involuted inside the mitochondrial matrix to form the cristae. The mitochndrial matrix is homogerous and many granular and fibrous structures are surrounded in it. It contains ribosomes, nucleic acids and proteins. Mitochondria are capable of oxidizing various organic acids, thereby librating energy. They are the seats of respiration and contain respiratory enzymes. The reaction of the krebs cycle take place in the matrix of mitochondria. Mitochondria are often referred to as the "power house" of the cell due to their major role in respiration and liberation of energy. It should be noted, however, that mitochondria are absent in red

blood corpuscles, bacteria and blue green algae. Bacteria has smaller organelles known as mesosomes and are the sites of respiratory activity.

3.10   Plastids

Plastids are discoid organelles found free floating in the cytoplasm of cells except in animals and a few primitive plants. The may be coloured or colourless and measured about 3-6µ in diameter and 1-3µ in thickness. Leucoplasts and chromoplasts are the major plastids found in cells. Leucoplasts are white plastids which serve the purpose of storage. Leucoplasts which store starch are term amyloplasts. Chromoplast on the hand are coloured. They determine the various colours of petals and other plant parts. Plastids have the potential of interconversion e.g. In the presence of light, the leucoplast of potatoes become green. Chloroplasts are made up of grana, which are interconnected by stroma lamella (stroma thylakoids). There may be 2 to 100 thylakoids per granum and 25-100 grana per cell. Thylakoids are the sites of light reaction of photosynthesis (photo phosphorylation). The dark reaction is completed in stroma. Stroma contains ribosomes, DNA etc. The chemical composition of chloroplasts is as follows:

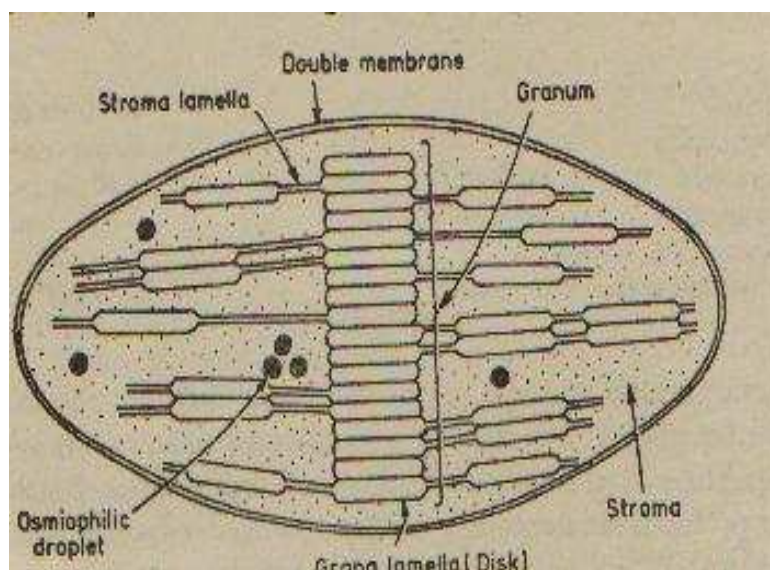| Component	Percentage Composition
Protein	40-50
Phospholipids	25
Chlorophyll	5-10
Carotenoids	1-2
Ribose nucleic acid (RNA)	5
Deoxyribose nucleic acid (DNA)	1

Fig. 4: Diagram of the structure of a chloroplast.

Photosynthetic bacteria and blue green algae have chromatophores or synthetic lamellae instead of chloroplasts. It should be noted however, that simple and undifferentiated proplastids develop into mature and differentiated chloroplasts in the presence of proper stimuli. For instance, when plastic are germinated in the dark, its cells contain smelled colourless double membraned structures which become green in light.

3.11 Vacuoles

Vacuoles are sacs of various kinds of solids and liquids found in the cytoplasm of cells. Vacuoles are surrounded by a unit membrane know as tonoplast. Vacuoles are common in old cells, as little or no vacuoles are found in young cells. They are considered as storage organs and they increase the cytoplasm surface. They sometimes help in maintaining the turgor pressure of cells. In some plants, vacuoles serve as reservoirs of waste material and may serve as lysosomes. Vacuoles contain cell sap with atmospheric gases, sugars, mineral salts, organic acids and sometimes anthocyanin pigments. The dissolved pigments of vacuoles are responsible for different colours of petals. In lower organisms the contractile vacuoles are excretory in function.

3.12 Nucleus

The nucleus is a spherical body suspended in the cytoplasm. It was discovered by Brown in 1883. The nucleus is surrounded by two lipo-proteinaceous membranes. The space

18

between the two membrane is known as the perinuclear cisterna. The nuclear membrane has many pores through which the cytoplasm communicates with the nuclear matrix (also known as nucleoplasm or nuclear sap). The nucleus also contains chromatin and nucleolus. The chromatin network is composed of DNA and histone whereas the nucleoplasm contains RNA and protein. Ribosomes have also been found in the nucleoplasm.

The nucleus is the most vital part of the cell and contains the information for various characters of the organism. It also controls its growth and differentiation. During cell division the nucleus divides into two identical and complete halves. When the nucleus is not dividing, metabolic activities of the cell continues and they are regulated and controlled by the nucleus. A non- dividing nucleus is often referred to as a "resting" nucleus. The nucleus contains the genetic material of the cell: chromatin in the dividing cell and chromosomes in the non-dividing cell. The nuclei of somatic cells contain information necessary for determining the structure of new cells and the nuclei of sex cells contain the information necessary for determining the characteristics of a new individual.

4.0   CONCLUSION
Cells are made up of similar components which carry out varied but specified functions.

5.0   SUMMARY
The cell is made up of cell wall, cell membrane, protoplasm, cytoplasm, endoplasmic reticum, golgi bodies, microbodies, lysosomes, microtubules, mitochondria, plastids, vacuoles and nucleus.

6.0 TUTOR MARKED ASSIGNMENT

1. List the different components of the cell

2. State the function of any five components of the cell

3. Which component of the cell is referred to as the "Power house" of the cell and why?

7.0 REFERENCES/FURTHER READINGS

George Acquaah (2007) Principles of Plant Genetics and Breeding, Blackwell, United Kingdom.

Roberts, M.B.V. (1980) Biology: A Functional Approach, 4th Edition, ELBS and Nelson, Hong Kong.

Simmonds, N.W. and Smatt, J. (1999) Principles of Crop Improvement, 2nd Edition, Blackwell Science, United Kingdom.

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MODULE 2: CHEMICAL COMPOSITION OF CELL, BASICS OF HEREDITY AND CELL DIVISION

UNIT 1:   Chemical Composition of Cells

UNIT 2:   Basics of Heredity

UNIT 3:   Cell Division

UNIT 1: CHEMICAL COMPOSITION OF CELLS

1.0:   Introduction

2.0:   Objectives

3.0:   Main Content

      a. Water

      b. Protein

      c. Carbohyrate

      d. Lipids

      e. Inorganic salts

4.0:   Conclusion

5.0:   Summary

6.0:   Tutor Marked Assignment

7.0:   References/Further Readings

1.0   INTRODUCTION

Cells are made up of different chemical component, performing different functions within the cell.

2.0   OBJECTIVES

At the end of this unit, student should be able to:

1.   Enumerate the different chemical component of the cell

2.   State the functions of the different chemical components of the cell

3.   Give example of different classes of chemical constituents of the cell

3.0   MAIN CONTENT CHEMICAL COMPOSITION OF CELLS

The major chemical constituents of the cell are water, protein carbohydrates, lipids and inorganic salts.

(a) Water: Water is the largest constituent of the cell (about 85 percent). The protoplasm is largely a colloidal solution in water. Water also acts as a solvent for inorganic substances and enters into many reactions that occur in the cell. Water occur in the cell as free water, and is available for use in metabolism and as bound water , which is absorbed to the surface of protein and other molecules.

(b) Protein: After water, protein is the next largest constituents of the protoplasm (about 10 percent). Proteins and related substances are involved in many activities of the protoplasm and the cell. The large size of many protein molecules (the molecular weight varies from $10^3 – 10^6$) makes them an important factor in maintaining osmotic pressure in cells, so that the water level in the cell remains a relatively constant.

All enzymes which catalyses chemical reactions in cells are proteins. All cell membrane are partly protein and proteins are associated with the genes involved in the transmission of genetic information from cell to cell and generation to generation.

When proteins are digested with acids, alkalies or enzymes they break up into small pieces and upon complete hydrolysis gives rise to amino acids. Many proteins combine with other molecules to form the cellular components. Nucleoproteins for example are products of nuclei acid while lipoproteins are products of lipids and protein

(c) Carbohydrates: Carbohydrates are found in the cell and may occur in soluble or insoluble form and as reserve food or as integral part of protoplasm or cell wall. Sugars, starch, resins etc are examples of carbohydrate. Carbohydrates can be broadly classified into sugars and polysaccharides. Polysaccharides are formed due to condensation of large number of sugar molecules. Cellulose is a regular polymer of glucose. Starch is complex polysaccharide and are mixed or irregular polymers of sugars.

Carbohydrates in the cell have a high turnover and utilization as energy. Carbohydrates are also essential components of the DNA and RNA. (DNA= deoxyribose nucleic acid and RNA= ribonucleic acid). The sugar, deoxyribose in combination with base (purine or

purimidine) and a phosphate form DNA- which is the carrier of all genetic information and ribose combine with a base and a phosphate to form RNA, which is associated with all proteins.

(d) Lipids

Lipids are important in forming part of the plasma membrane and other membraneous substances. Lipids are either esters of fatty acids or hydrolytic products of such esters. Fats are the most important lipids. Fats are esters of glycerol and fatty acids. Lipids are insoluble in water but soluble in organic solvents like alcohol, ether, chloroform etc, hence they easily aqqregate in the aequeous environment of the cell and thus form a bimolecular layer which is a major components of various membranes. Lipids are also utilized in the cells for the release of energy. Lipids can also be found in combination with other substances such as phosphate (phospho-lipids) or nitrogenous base (as in lecithin)

(e) Inorganic salts

The organic components of the cell account for 99 percent of the cell weight while the inorganic components is about 1 percent of the dry weight of the cell. The inorganic salts found in the cell include, sodium, potassium, magnesium, calcium, phosphorus, iodine, copper, zinc, cobalt, selenium, chlorine, fluorine, molybdenum, silicon, and vanadium. Inorganic salts and their ions aid in maintaining a constant pH and help to regulate osmotic pressure in the cell. Phosphorus joined with adenosine to form ADP or ATP is vital for energy release in the cells.

4.0 SUMMARY AND CONCLUSION:

The major chemical constituents of the cell are water, protein, carbohydrate, lipids and inorganic salts.

5.0   TUTOR MARKED ASSIGNMENT

1.   What are the chemical components of the cell?

2.   Briefly discuss the functions of any four chemical constituent of the cell.

3.   What are inorganic salts?. Give examples of six inorganic salts found in the cell.

6.0   REFERENCES/FURTHER READINGS

Banerjee, G.C. (2005) A Textbook of Animal Husbandry, 8th Edition, Oxford &Ibh, New Delhi.

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UNIT 2: CHEMICAL BASIS OF HEREDITY

1.0: Introduction

2.0: Objective

3.0: Main Content

4.0: Conclusion

5.0: Summary

6.0: Tutor Marked Assignment

7.0: References/Further Readings

1.0 INTRODUCTION

The hereditary materials in living organisms are nucleic acids. Nucleic acids are polymers of nucleotide. They are involved in the transmission of character or trait in living organisms.

2.0 OBJECTIVES

At the end of the unit, the student should be able to:

1. Name the types of nucleic acids

2. Describe the structure of DNA and RNA

3. Explain the arrangement of the four bases which are the building block of nucleic acid.

4. List the different types of RNA

3.0 MAIN CONTENT

3.1 CHEMICAL BASIS OF HEREDITY

Nuclei acids are not protein and are the hereditary material in living organisms. There are two types of nuclei acids involved in the transmissions of character or trait in living

organisms. They are the DNA (deoxyribose nucleic acid and RNA (ribose nucleic acid). Generally the DNA is endowed with the capacity to transmit genetic information from one generation to another. However when DNA is not present (as in some viruses) RNA assumes this roles.

Nuclei acids are polymers of nucleotides. Each nucleotide is composed of a nucleotide base, a five carbon sugar and phosphoric acid. The nucleotide of DNA are known as deoxyribonucleotides or deoxyribotides, while those of RNA are known as ribonucleotides or ribotides. The sugar of DNA is deoxyribose sugar whereas that of RNA is ribose sugar. RNA has one hydrolyl group (- OH) attached to its second carbon atom whereas DNA has only one hydrogen atom attached to its second carbon atom.

DNA has four bases: adenine, thymine, guanine and cytosine. Adenine and thymine are purines, whereas guanine and cytosine are pyrimidines. RNA on the other hand, has uracil instead of thymine, while the other three bases are the same as in DNA. Below are the structure of purines and pyrimidaie bases of nuclei acid.

3.2 STRUCTURE OF DNA

DNA molecule according to Waston and Crick has two long anti- parallel polynucleotide chains, helically coiled around the same axis. The right handed helices are held together by their bases which are paired together by covalent hydrogen bonds. Purine one polynucleotide chain pairs with pyrimidine of the other- adenine with thymine and guanine with cytosine. See fig 1 and 2 below:………
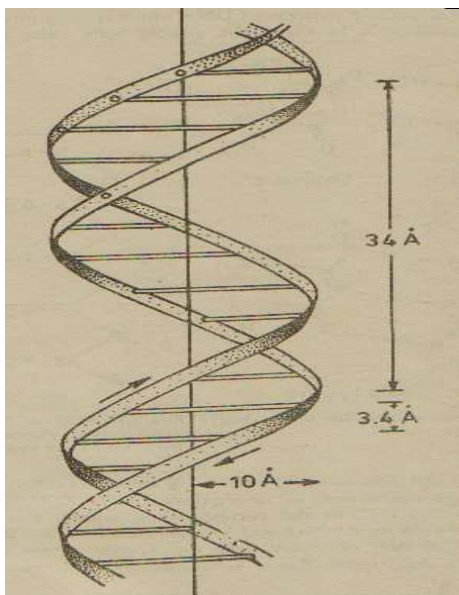
Fig. 5: The double helix model of DNA

3.3   STRUCTURE OF RNA

RNA is a polynucleotide chain of ribonucleotides. The RNA connterpart of thymine is uracil. Thymine of DNA is the 5- methyl derivative of uracil of RNA . see structure below:
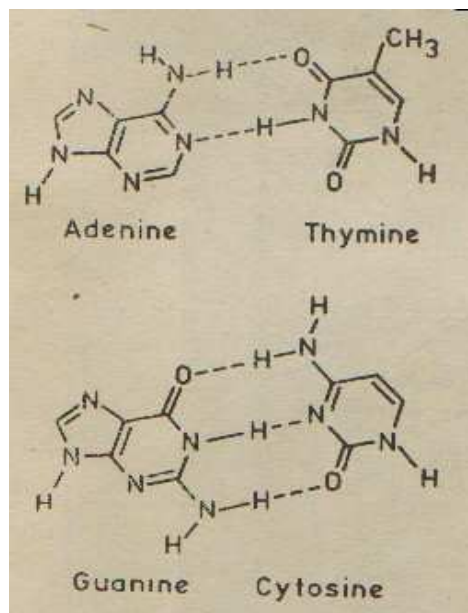
Fig 6: Pairing of bases due to covalent hydrogen bonds

There are three types of RNA found in cells. These are:

(a)   Ribosomal RNA (r RNA) – It is stable and is a major component of ribosomes. It is the most abundant RNA (80 percent) in the cells.

(b)   Messenger RNA (mRNA)- It is usually short lives and functions as the carrier of genetic information from DNA to proteins. It is about 10 percent of the total cell RNA.

(c)   Transfer or soluble RNA (tRNA)- It is stable and acts as the amino acid receptor

and carries amino acid from the pool to the site of protein synthesis. It represents about 10- 15 percent of the total cell RNA.
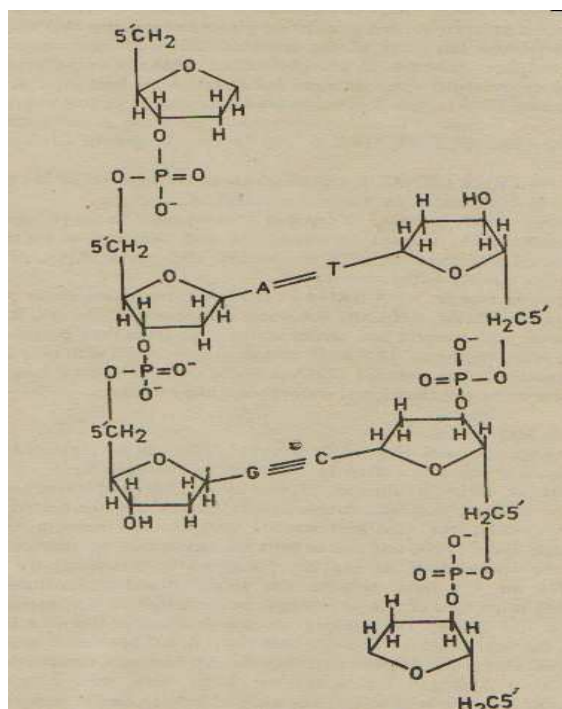
Fig. 7: A section of the double helix of DNA showing opposite polarity of two strands which have opposite directions of sugar –phosphate linkages.

4.0   CONCLUSION:
Nucleic acid are the hereditary materials found in the cells of the living organism and are responsible for the transmission of characters and traits.

5.0   SUMMARY:
DNA and RNA are the nucleic acids responsible for the transmission of genetic information from one generation to another. DNA has four basis: Adenine, thymine, guanine and cytosine. In the structure of RNA, however, thymine is replaced by uracil.

There are three types of RNA. These are: ribisoma RNA, messenger RNA and transfer RNA.

6.0   TUTOR MARKED ASSIGNMENT

1.   What are nucleic acids?

2.   Name the two major types of nucleic acid found in the cell?

3.   What is the major role of nucleic acids in the transmission of traits?

4.   Briefly describe the structure of DNA and RNA.

7.0   REFERENCES / FURTHER READINGS

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UNIT 3:   CELL DIVISION

1.0:   Introduction
2.0:   Objectives
3.0:   Main Content
        3.1   Cell Division
        3.2   Mitosis
        3.3   Meiosis
4.0:   Conclusion
5.0:   Summary

INTRODUCTION

Living organisms grow and multiply by cell division. The process of cell division varies with organisms and even the various tissues of the same organism. The basic process is the same for all living organisms.

OBJECTIVES

At the end of this unit, the student should be able to:

1.   Describe the process of cell division

2.   Define mitosis and meiosis

3.   Explain the various stages of cell division

3.0   MAIN CONTENT

3.1   CELL DIVISION

Living organisms grow and multiply by cell division. The process of cell divisions varies with organisms and even the various tissues of the same organisms. The basic process is however, the same. The process of cell division is a complex cyclical process in which cell division of the organism is preceeded by a division of the nucleus. During cell division, the nucleus and its chromosomes divides with great precision. During cell multiplication, the somatic cells divide equationally (mitosis), so that daughter cells contain the same number of chromosomes as their mother cells. But during gamete formation, the cells undergo a reductional division (meiosis), so that the gametes receive half the number of chromosomes from their mother cells. It should be noted, however, that during cell division chromosomes maintain their identity and individuality to a remarkable extent.

3.2   MITOSIS

Mitosis is a dynamic process and has four different stages which are short lived. The sub-stages are: Prophase, Metaphase, Anaphase and Telophase.

The net result of mitosis is that two identical nuclei emerges from the division of a single nucleus.
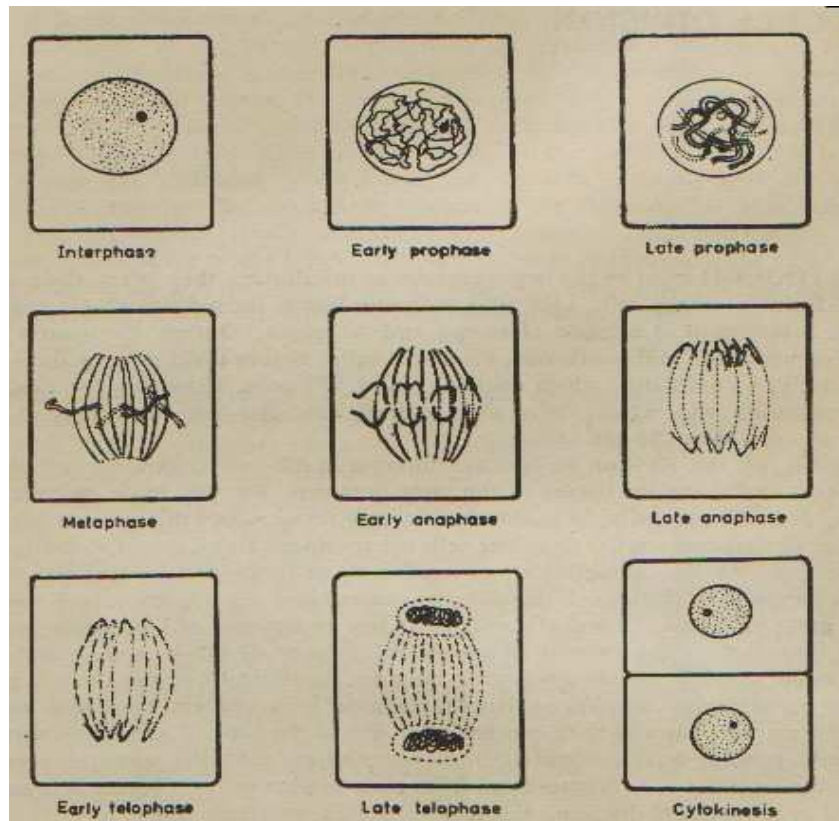
Fig. 8: Diagrammatic representation of different stages of mitosis (Sinha and Sinha, 1982)

Cytokinensis

Nucear division is generally followed by cytokinensis. Cell plates sometimes starts in the center of the cell soon after the anaphasic separation of daughter chromosomes. The cell plate gradually enlarge and ultimately touches the cell wall, thus separating the two nuclei and dividing a single cell into two. Spindle fibres and cytoplasmic membranes help in the organization of the cell wall. There are however some variation in the process in different organisms . In animal cells, there is a star like body known as centrosome,

which divides into two during the prophase and the daughters get situated at the two poles. They get connected by spindle fibers as soon as the nuclear membrane disappears.
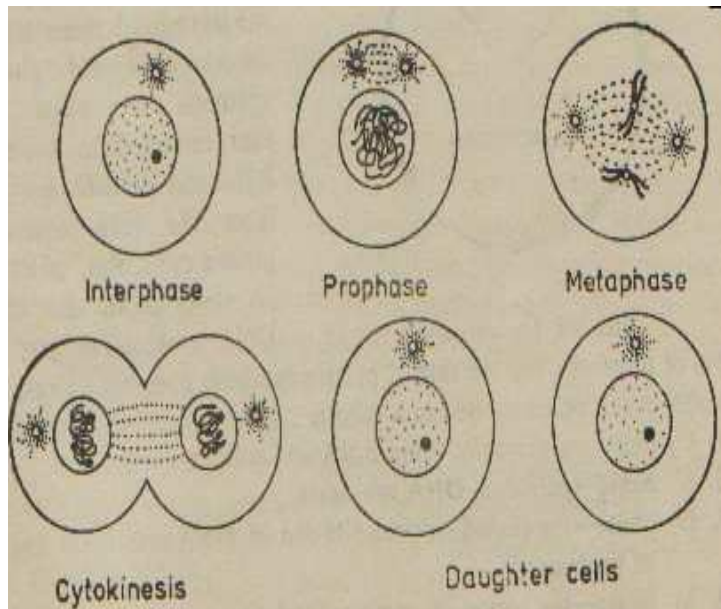
Fig. 9: Some stages of cell division in an animal cell showing the behaviour of centrosome and cytokinesis by furrowing, (Sinha and Sinha, 1982)

The pattern of cytokinesis in animal cell is also different from that of plant cell. In animal cell, a furrow starts in the middle of the cell wall and gradually deepens or extends up to the middle of the cell, thereby dividing the cell into two halves. Furrows do not, however, appear in plant cell because the cell wall is rigid.

Significance of mitosis

Inclusive mitotic division of a single cell gives rise to a group of cells with identical genetic make known as clone. Mitosis is essential to maintain a particular nucleo-cytoplasmic ratio. Proper nucleo- cytoplasmic ratio is necessary for proper functioning of the nucleus. Also if DNA synthesis continues without cell division, different cells will contain different amounts of DNA and this amount will continue to rise.

Cell division is therefore necessary to maintain the constancy of quality and quantity of the hereditary material in different cells of an organism as well as in its different generations. It also ensures the coordinated growth and function of various organs of an individual. Cell division also helps in the survival of a species, as every cell has a definite life span. Before an individual dies, it produces offspring by cell division.

3.3   MEIOSIS

Meiosis is the process by which sexually reproducing organism produce their gametes. During sexual reproduction, two gametes unite to form a zygote, which divided mitotically to form an individual. It results in the blending of characters from two parents into an individual (offspring) and ensures variation, which is important for evolution. Gametes contain half the number of chromosomes as compared to somatic cells. The union of two gametes restores the somatic number of chromosomes in the zygote.

During meiosis, or the time of gamete formation, the amount of chromosomes or DNA is halved. This is achieved by two successive divisions of nuclei (meiosis I and meiosis II) and cytoplasm accompanied by only one replication of chromosomes. For example, each somatic cell of pea (*Pisum sativum*) has 14 chromosomes, but each gamete (male or female) contains only 7 chromosomes.

Meiosis in plants can be studied at the time of gamete formation which occur in specialized organs (i.e the embryo and the pollen sac. A single cell undergoes meiosis in the embryo while large number of spore mother cells divides meiotically to produce haploid in the pollen grains.
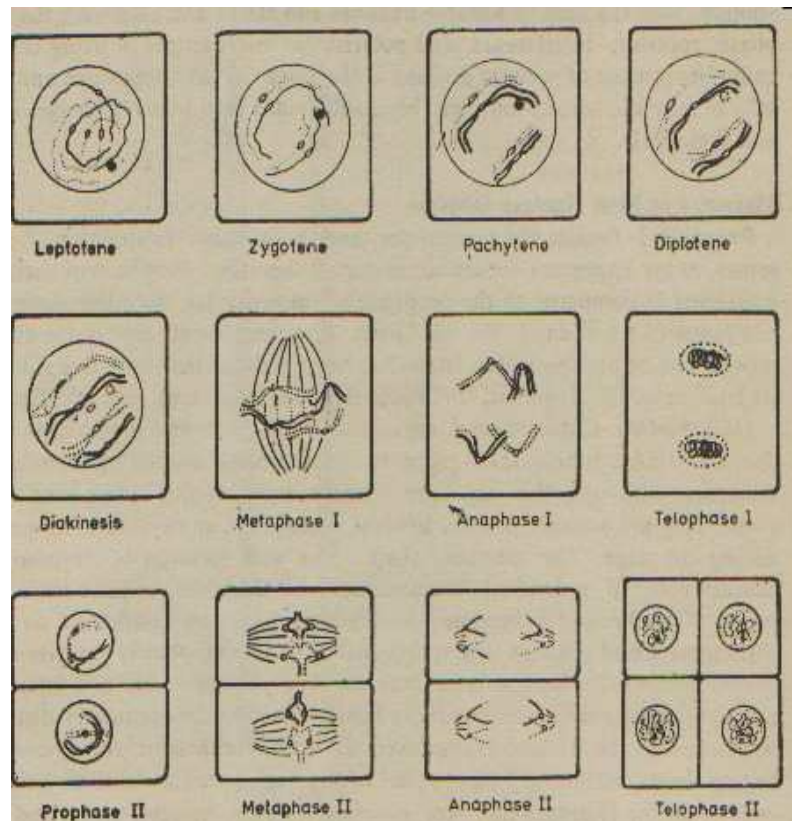
Fig. 10: Diagrammatic representation of different stages of meiosis, (Sinha and Sinha, 1982)

In sexually reproducing organism, the gametes are haploid and two gametes fuse together to form a diploid zygote. But in order to main a particular diploid number through successive generations, a reduction in chromosomes number through the process of meiosis is essential at the point of gamete formation or else, the chromosomes number will continue to double after every generation. Fertilization brings the paternal and maternal chromosomes together and the process of meiosis separates them after reassortment. In this way, new associations of chromosomes are established. Chiasmata help in exchanging parts of chromatids between homologue chromosomes, thus ensuring new combination of characters. Meiosis therefore helps in brining about variation in population.

4.0 CONCLUSION

Cell division is necessary to maintain consistency of quality and quantity of the hereditary materials in different cells of an organism as well as ensures the coordinated growth and function of various organs of an individual

5.0   SUMMARY
Living organisms grow and multiply by cell division. During cell division, the nucleus and its chromosomes divide with great precision. The somatic cells divide equationaly (Mitosis) so that daughter cells containing the same number of chromosomes as their mother cells. During gamete formation, the cells undergo reductional division (Meiosis) so that the gamete receives half the number of chromosomes from the mother cell.

6.0   TUTOR- MARKED ASSIGNMENT

1.   Why is the study of cell division necessary?
2.   Define the term mitosis and meiosis
3.   How many stages are involved in mitosis and meiosis?
4.   What is cytokinensis?
5.   In which part of the plant can meiosis be studied?

7.0   REFERENCES/FURTHER READING

George Acquaah (2007) Principles of Plant Genetics and Breeding, Blackwell, United Kingdom.

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MODULE 3: PRINCIPLE OF INHERITANCE

UNIT 1:   LAW OF INHERITANCE

1.0   INTRODUCTION

Characters are transmitted from one generation to another without much change by inheritance. In this unit, we shall examine the historic background of our understanding of the principles of inheritance and the various Laws of Inheriance.

2.0   OBJECTIVES

At the end of this unit students will be able to:

1.   Explain the historical background of the principle of inheritance

2.   State the Laws of inheritance

3.   Explain the principles governing inheritance of various traits in plants and animals.

3.0   MAIN CONTENT

3.1   PRINCIPLES OF INHERITANCE

It has been observed over time that plants and animals beget their lives. Characters are transmitted from one generation to another without much changes. Although men have made this observation, they never understood the basis of inheritance until 1866. Different ideas were put forward at different times about the mode of transmission of character from one generation to another. One of such idea was that the factors responsible for character transmission were fluid in nature and during the process of reproduction, the fluid from both parents were mixed or blended to bring an offspring with intermediate character. Some other workers believed that in animals, inheritance is by the way of the blood and so offspring's are brought by a combination of the blood of both parents. A well known philosopher, Aristletoes has a different idea, he postulated that the male and female contributions are not equal, and that, while the female contributed the matter, the male contribution the emotion. Also, attempts at improving paddy by ancient Chinese farmers are well documented but these ancient people were unaware of the basic principles of inheritance. They depended mainly on hybridization and selection for their crops and animals.

The reports of various studies carried out by scientist such as Knight (1799), Goss (1824) and Mendel (1866) laid the formation for modern day understanding of the principles of inheritance.

Knight crossed a pea plant with green stem, white flowers and colourless seed-coat with another one which had purple stem, purple flowers and brown seed-coat. A cross between coloured and colourless plants yielded only coloured plants in the first filial generation. On self-fertilization, this F_I progeny segregated into pigmented and unpigmented plants (both type of seeds where found in the same pod) and concluded that there was a stronger tendency to produce pigmented than unpigmented plants. In another experiment, he pollinated a tall variety and a dwarf one and vice versa, and observed that only tall plants are produced and the two crosses are the same. He therefore discovered that reciprocal crosses give the same result.

Goss in 1824, reported that when he pollinated a green-seeded pea plant with the pollen from a yellow-seeded one, he found that the seeds of the first generation progeny (F_I) were yellow like those of the male parent. When the F_I progeny were crossed (self fertilization), it yielded pods, some of which had only green seeds, , some had only yellow seeds and some had both yellow and green seeds. And when the second generation seeds were sown, the green seeds produced plants which bore only green seeds but the yellow seeds yielded plants with only yellow seeds as well as with mixed pods.

The works of Knight and Goss were flawed, because they did not keep proper statistical record and did not pay adequate attention to the relative frequencies of different types of plants.

The first empirical study which gave rise to our present day understating of the principles of inheritance was carried out by an Augustinian Monk by name Gregor Mendel, who in 1866 published papers that reported on data from eight years of crossing breeding experiments using common garden peas. It should be noted however, that the significance of his works was not appreciated until De Vries, Correns and Von Tschermark published their papers in 1990. Although the significance of most of his works was not realized until his death in 1884, he was given the credit as the father of genetics. Based on Mendel's conclusions from his studies, later workers were able to deduce three basic laws of inheritance.

These are:
1.   The law of dominance.
2.   The law of segregation and
3.   The law of independent assortment.

1.   **The Law of Dominance.**
This law states that "when a pair of contrasting characters (allelic pair) are crossed, one allele behaves as dominant while the other as recessive. This is termed complete

dominance but in the case of incomplete dominance or partial dominance, both alleles interact with each other and an intermediate character is expressed.

Mendel crossed his red-flowered plants, either on self-pollination or crossed with another red-flowered plant, the progeny were all red flowered plants for many generations. He however, observed that when he crossed a tall plant with a dwarf one, all offspring or F_I progeny were tall. But when the F_I progeny were crossed, it yielded some tall and some dwarf plants. Indicating that some of the dwarf character was not expressed – the first generation but it remain recessive, whereas the tall character was dominant.

2.   **The Law of Segregation.**

This law states that "each character is conditioned by genes which occur in pairs and only one of the pairs can be carried in a single gamete".

Mendel observed that when red-flowered plant was crossed with a white flowered one, all the F_I plants were red-coloured, but when the F_I progeny were crossed, red and white colours appeared in the F_I generation in a ratio of 3:1 (red : white).

Mendel not satisfied with this result, decided to raise the third generation plants with F_2. He found out that the 3:1 ratio was resolved into 1:2:1 ratio in which 25 percent of the first group is true-breeding for the dominant character, 25 percent plants of the third group was true breed of the recessive character while the rest 50 percent were hybrid containing both character but expressed only the dominant one.

Mendel also carried out other studies using tall and dwarf varieties of peas and obtained similar results. The results of Mendels experiment formed the basis for the law of segregation.

3.   **The Law of Independent Assortment.**

In another study Mendel made a cross between plants, which differed in two characters instead of one. (a dihybrid cross). He crossed a round and yellow-seeded plant with a wrinkled and green-seed one. He found F_I that plants bore only round and yellow seeds

(Round and yellow were dominant). When F_2 generation was raised from these seeds, he observed that four types of plants were produced in a definite ratio of 9:3:3:1. Of the 556 plants (F_3), the phenotypic expressions were: 315 round and yellow-seeded plants; 108 round and green-seeded plant, 101 wrinkled and yellow-seeded plants and 32 wrinkled and green-seeded plants.

The law of independent assortment was derived from the results of these studies. And it states that "each member of a pair of allele may combine randomly with either of another pair". In order words, no matter the number of character been considered at a time, each gene maintains its identity and may combine with or assort from others independently.

3.2 APPLICATION OF MENDELIAN GENETICS TO ANIMAL IMPROVEMENT

The practical significance of the first two laws of Mendelian theory are of extreme importance when man is selecting for specific traits in plants and animals. I shall now examine them with reference to examples from domestic livestock.

A germ cell consists of a pair of like chromosomes, known as homologues. Each homologue contains identical genes that occur in the same order. These identical genes are known as alleles. Although the opposite genes are identical in that they affect the same phenotypic characteristic or development process of a character, they do not necessarily influence it in the same way. If both alleles have the same influence on a characteristic, the individual possessing them is said to be homozygous for that characteristic, but if they differ in that influence, the individual is said to be heterozygous for the character. If the effect of one alleles is stronger than that of the other to the extent that it masks the effect of the other, the masking alleles is said to be dorminant, while the allele that has been masked is said to be recessive.

For example, in cattle the polled or absence-of-horns trait is dominant over the horned trait. Thus when homozygous horned cattle are mated with homozygous polled cattle, the offspring possess one gene for the presence of horned and another for the absence of

horns i.e. they are heterozygous for the character. Since the polled gene is dorminant, all offspring are polled. If the genotype of the homozygous horned individual is designated as hh, the homozygous individuals resulting from the mating as Hh. The situation could be expressed in the following manner

HH   x   hh

Polled | horned

Hh
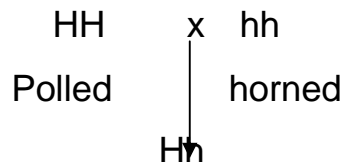
The phenotypes of the HH and Hh individual will be the same but their genotype will be different.

If the heterozygous offsprings are inter mated, then, as both parents produce equal numbers of germ cell carrying either allele, the chances of any sperm cell from the male fusing with any egg of the same type or of a different type are equal and so four combinations of the genes are possible. There combinations are HH, Hh, hH and hh.

H h   H h

HH   Hh   hH   hh

Polled   Polled   Horned
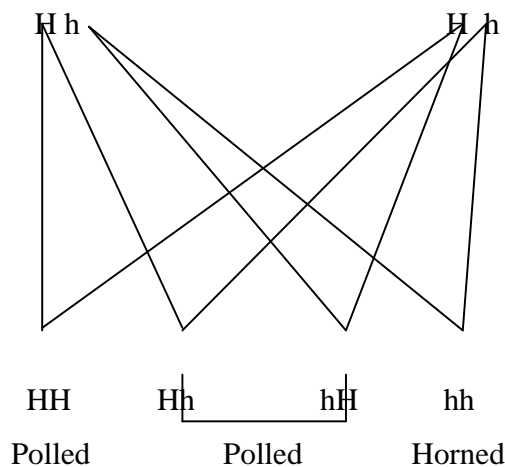
The penotype grouping is therefore three polled to one horned animal, but since fertilization is at random, it must not be expected in practice that among every four progeny of such matings the result will be 3 polled and one horned animal. This will occur only when a very large number of matings are evaluated.

An example of what happens when dominance is lacking in alleles can be demonstrated by reference to the inheritance of coat colour in short horn cattle. If a red–coated short horn is represented by RR and a white–coated short horn by rr, then when red and white short horns are mated, the offspring are of a Rr type and their coat is roan rather than either red or white. This may be represented as follows:

RR   x   rr
Red coat   white coat

                          Rr
                    Roan coat
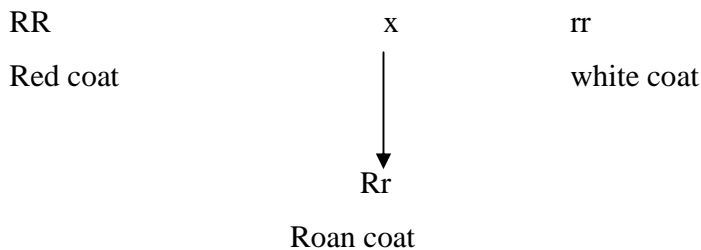
If the roan offsprings are intermated then segregation takes place as in the previous example. This may be represented as follows:

Rr   x   Rr

RR   Rr   rR   rr
Red coat   roan coat   roan coat   white coat

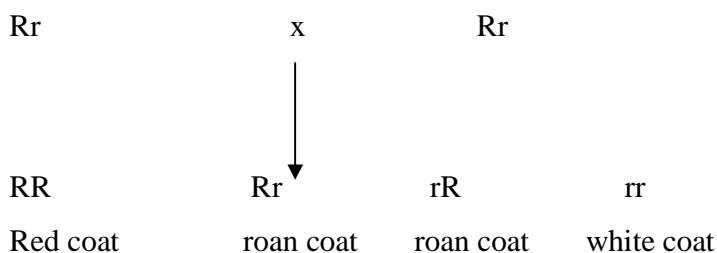The above examples demonstrate the operation of the 1st Mendelian law on the segregation of inherited characteristics.

The second law, that of independent assortment can be demonstrated in an example where the inheritance of two pairs of genes are consider at the same time. For example we can consider two dorminant traits polledness and dwarfism in Hereford cattle. If a homozygous polled, non – dwarf individual with the genotype HHDD is mated to a homozygous horned, dwarf individual with the genotype hhdd, the F1 progeny will be phenotypically polled and non–dwarf but genotypically HhDd. If the F1 progeny are then intermated, the resulting offsprings (F2) will exhibit four different phenotypes in the ratio

of nine polled non–dwarf, to three polled dwarf, to 3 horned non dwarf, to 1 one horned dwarf individual (9:3:3:1). This can be represented as follows:

HHDD   X   hhdd

Polled : non dwarf   horned : dwarf

Gametes HD   hD
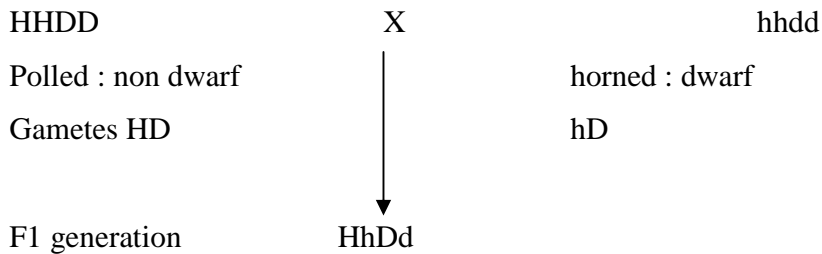
F1 generation   HhDd

HhDd   X   HhDd

Polled: non dwarf   polled: non dwarf

F2 gametes: HD.Hd.Hd.hd. X HD.Hd.Hd.hd.

F2 generation: (polled: non dwarf) 9:, (polled: dwarf)

3:, (horned: non dwarf) 3:, (horned: dwarf)1

the cross can be better presented with a Punnet sqrare as follows.

	HD	Hd	hD	Hd
HD	HHDD polled:non dwarf	HHDd polled: non dwarf	HhDD polled: non dwarf	Hh Dd polled: non dwarf Hhdd
Hd	HHDd polled: non dwarf	HHdd polled: dwarf	HhDd polled: non dwarf	Hhdd polled: dwarf
hD	HhDD polled: nondwarf	HhDd polled: non dwarf	HhDD horned: non dwarf	HhDd horned: non dwarf
Hd	HhDd polled: non dwarf	Hhdd polled: dwarf	HhDh horned: non dwarf	Hhdd horned: dwarf

It should be noted that the number of possible combinations increase rapidly with an increase in the number of gene pairs. Thus in domestic animals where the number of heterozygous gene pairs is very large, it is not surprising that no two individuals, with the exception of identical twins, are genotypically or phenotypically completely alike.

4.0   CONCLUSION

Our understanding and application of the Mendelian Laws are of extreme importance when man is selecting for specific traits in plants and animals.

5.0   SUMMARY

Different ideas were put forward at different times about mode of transmission of character from one generation to another. The first empirical study which gave rise to our present day understanding of the principles of inheritance was carried out by Gregor Mendel. Based on Mendels's conclusion from his studies, later workers are able to deduce three basic Laws of Inheritance. These are the Law of Dominance, Law of Segregation and Law of Independent Assortment.

6.0 TUTOR MARKED ASSIGNMENT

1.   Why is Gregor Mendel referred to as the father of genetics?
2.   What are the basic laws of inheritance?
3.   Briefly explain the practical significance of the laws of Mendel.

7.0   REFERENCES /FURTHER READINGS

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UNIT 2: TYPES OF CROSSES AND GENES

1.0   INTRODUCTION

There are different types of crosses and terms used by breeders to achieve their objectives. The various terms are used to describe observed variations in characters as conditioned by genes. In this unit we shall be explaining the following:

Test cross, Back cross, Multiple alleles, Pleiotropism, Lethal genes, Complimentary gene, Additive gene, Epitasis and Mutation.

2.0   OBJECTIVES

At the end of this unit the students should be able to:

1.   Define the various term stated above that was used to describe observed variations in characters a conditioned by genes.

2.   Explain the basic principles behind these observed phenomena

3.   Discuss the causes of mutation of genes and its significance.

3.0   MAIN CONTENT

3.1   TEST CROSS AND BACK CROSS.

The cross of an individual of unknown genotype to a completely recessive individual is known as a test cross. In this case, the type of progeny will depend on the types and frequencies of gametes produced by the parent of unknown genotype and can help in determining the genotype of unknown individual.

Back cross involves crossing a progeny to one of the parents.

3.2   MULTIPLE ALLELES

This is used to describe a situation where, a single gene may have more than only two possible kinds of alleles. For example B may give rise to B^I, B^2, B^3, B^4 ………., such a group of alternatives is called a series of multiple alleles. Multiple alleles are present in eye colour of Drosophila. ABO blood group system of animals is controlled by a series of seven multiple alleles.

3.3   PLEIOTROPISM

Pleiotropism is a special phenomon and it used to describe a situation, where a gene has multiple phenotype effects. Such a gene is known as pleiotropic. Many studies have revealed that many genes are pleiotropic. For example the seed coat colour of sweet peas control flower colour and also red spots in leaf axils.

3.4   LETHAL GENES

Lethal genes are genes that cause the death of an organism during early stages of development. Dominant lethal genes are often lost from the population because they cause death of the organisms even in a heterozygous condition. For example, aurea is a

lethal gene discovered in *Antirrhinum majus*. Aurea homozygous causes death of seedlings or sometimes before germination due to lack of ability to produce chlorophyll.

3.5   COMPLIMENTARY GENE

Complimentary genes are dominant alleles which are located at two different loci and segregate independently of each other. Their presence or activities produces complimentary phenotypic effect. For example flower colour in *Lathyrus adoration* is determined by two genes. Bateson and Punnett made a cross between two white flowered plants and found that the F_I progeny were purple-flowered, F_2 progeny aggregated into 9 purple and 7 white flowered plants. On selfing the white flowered plants it yielded only white flowered plants. The purple flowered plants when selfed did not produce all purple flowered plants. (They did not breed true). It produced purple and white coloured flower plants in a ratio of 3:1. The F_3 progeny did not follow the normal ratio of 9:3:3:1 where the last three have the same phenotype, rather, it produced a phenotypic ratio of 9:7. The above phenomenal can be explained if we assume that the colour purple is controlled by two dominant genes C and P. If either or both of the dominant genes are absent, the flowers become white. This can be illustrated as follows:

P1   White   x   White
               CCpp   ccPP

P1 gametes   Cp   purple   cP
F1   CcPp

F1 gametes → CP   Cp   Cp   cp

	CP	Cp	Cp	cp
CP	CCPP Purple	CCPp purple	CcPP purple	CcPp purple
Cp	CCPp Purple	CCpp white	CcPp purple	Ccpp white
Cp	CcPP Purple	CcPp purple	ccPP white	ccPp white
Cp	CcPp Purple	Ccpp white	ccPp white	ccpp white

F2

Fig 11. Inheritance of flower colour in Lathyrus odoratus. Due to complementary genes the F2 phenotypic ratio of 9:7 is obtained, (Sinha and Sinha, 1982)

The gene C and P are complimentary to each other and they control the synthesis of anthocyanin. White colour appears because of the absence of complementation. Aleurone colour in maize is also controlled by complementary genes.

3.6   ADDITIVE GENES

Additive genes are also known as polymeric genes. This is a situation where two pairs of genes determine a character. For example, in *Cucurbita pepo* plants, crossing two plants with spherical fruits, yielded only discoid-fruited progeny (F_I). When F_I are crossed, discoid, spherical and long progeny are produced. In this example, the F_I progeny are not like any of the parents, and in F_2, a third phenotype appears. In pigs, coat colour also follows the same inheritance pattern.

3.7   EPISTASIS:

This term is used to describe a modification of normal gene expression in which a particular gene at one locus masks the expression of at least one other gene at a different chromosomal location. For example coat colour in mice follows this pattern of inheritance. Coat colour in mice is controlled by two genes: C and A. In agonti mice both genes are dominant. When only gene C is dominant, the mice are black. When only C is homozygous recessive or both C and A are homozygous recessive, albino mice are produced. The recessive gene C can thus be said to be epistatic over gene A and does not allow its expression.

3.8   MUTATION

Mutation can be defined as a random heritable change in DNA that introduce a new alleles into the gene pool. Gene mutation occurs within a gene (as opposed to chromosomal mutations). Substituting one nucleotide for another results in point mutation. The present concept of mutation includes only the hereditary changes that involve alternations in gene or Mendelian factors.

The activities of genes are normally lost due to mutations. This explains why the original or wild-type genes are dorminant and the mutant gene are recessive.

In a diploid organism, the chances of simultaneous mutations in both genes controlling a particular character are very remote because mutation is a random process. If mutation occurs in one of the genes, it leads to heterozygosity because the other allele remains unaffected. Recessive mutations are often not expressed immediately but may be expressed in later generations in only a few individual, which become homozygous for the mutant gene. In haploid organisms, with only one copy of the gene, each gene mutation is often expressed. Undesirable mutations are usually selected against by the environment. The chances of mutations been lost or eliminated from a population are greater with haploids than in diploids.

Mutation is however useful for evolution because the environment keeps on changing.

3.9   TYPES OF MUTATION.

There are various types of mutation. Mutation can either by dominant or recessive, sex link or autosomal, germinal or somatic, lethal or non lethal, useful or deleterious, or neutral. Neutral mutations often go unnoticed.

Mutations which occur in the germplasm are known as germinal mutations while those that occur in the somatic cells are called somatic mutations. Often, mutations in somatic cells fail to get transmitted to the progeny through gametes with the result that they are lost with the death of the organism. However, in vegetatively or asexually reproducing organisms, somatic mutations are transferred to the progeny and thus perpetuated. Many flowers and fruits of commercial importance today have arisen due to somatic mutations.

4.0   CONCLUSION:

Our knowledge of test cross and back cross, as well as the various types of genes and their effect on phenotypic variations is necessary to enable the breeder select appropriate breeding techniques.

5.0   SUMMARY:

Test cross and back cross are the major type of crosses used by breeders to unfold the genetic type of unknown individual. The terms such as multiple alleles, pleiotropism, additive genes, lethal genes, complimentary genes, epistatis and mutation and the basic principles behind these observed phenomena were properly explained in this unit.

6.0   TUTOR MARKED ASSIGNMENT

1.   Define the following: Test cross, Back cross, Multiple alleles, Pleiotropism, Lethal genes, Complimentary gene, Additive gene and Epitasis
2.   What is Mutation?
3.   Name the various types of Mutation
4.   Why is the study of Mutation necessary?

7.0   REFERENCES/FURTHER READINGS

Banerjee, G.C. (2005) A Textbook of Animal Husbandry, 8th Edition, Oxford &Ibh, New Delhi.

Simmonds, N.W. and Smatt, J. (1999) Principles of Crop Improvement, 2nd Edition, Blackwell Science, United Kingdom.

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MODULE 4: METHODS OF CROP BREEDING

Introduction

 In this module the student is expected to learn the various methods used by crop breeders to develop new varieties of crops or to maintain desirable characteristics within a population.

Plant breeding is the act of improving economically important plants on a scientific basis. Plant breeding is as old as man. Early men were wonderers and depended on forest products for food. As time went on, he learnt to cultivate the more useful plants and selected the seeds from healthier plants for sowing the next year. Selection was the earliest method of crop breeding. As knowledge advanced, sexuality was discovered in plants which led to the application of hybridization. Modern plant breeding requires a thorough knowledge of the principle of cytogenetics, physiology, embryology, biochemistry, agronomy, statistics, entomology e.t.c. A plant breeder should thus be a good biologist and should know his plants thoroughly. In order to develop varieties that respond to alter conditions, plant breeders should know the fundamental of farm management and mechanization.

A plant breeder strives to get a group of plants with suitable combinations of genes that will give a better yield and improved quality under a particular set of environment conditions.

Various methods of breeding exist depending on the reproduction. There are methods for self-pollinated, cross-pollinated and vegetatively propagated plants.

The module is divided into three units namely:

Unit 1: Method of breeding self-pollinated crops
Unit 2: Method of breeding cross-pollinated crops.

Unit 3: Method of breeding asexually propagated crops

UNIT 1: METHODS OF BREEDING SELF-POLLINATED CROPS

1.0:   Introduction

2.0:   Objective

3.0:   Main Content

3.1   Methods of breeding Self-pollinated crops

4.0:   Conclusion

5.0:   Summary

6.0:   Tutor Marked Assignment

7.0:   References/Further Readings

1.0   INTRODUCTION:

Pollination is the transfer of pollen grains from the open anthers to the stigma of a flower. When the pollen grains fall unto the stigma of the same flower, the plant is said to be self-pollinated.

2.0   OBJECTIVES:

At the end of the unit the student should be able to:

1.   List the different methods used in breeding self-pollinated plants

2.   Explain the different methods used in breeding self- pollinating plants

3.   State the advantages and disadvantages of the different methods used in breeding self-pollinated crops

4.   Give examples of self-pollinated crops

3.0 MAIN CONTENT

3.1 METHODS OF BREEDING SELF-POLLINATED CROPS

Introduction, selection and hybridization are the major methods of breeding self-pollinated plants.

(a). **Introduction:** This involves growing a crop in an environment where it did not originate from. For example tobacco, potato, maize etc. where introduced to Asia only a few decades ago from America. Also crops like cocoa, rubber, tomatoes, maize, rice etc. were introduced to Nigeria from other countries. For a well-planned introduction programme, the breeder must have a good knowledge and collection of diverse genotypes of a species that can be used as a source material for desirable genes and characters. The germ plasm collection should include local as well as exotic strains of the plants and its related species.

(b). **Selection:** This involves sorting out from a mixed population a plant or a group of plants with desired characters. Selection can be natural or artificial and it is possible only when there are variations. Two types of selection are often practiced in breeding self-pollinated plants. Namely: mass selection and pure line selection.

i. **Mass selection:** In mass selection, plants are selected on the basis of their phenotypes and their seed are composited without progeny testing. In mass selection, a few or several hundreds of plants with similar phenotype are selected in the first year and their seeds are composited. These seeds are grown – the second year for a preliminary yield test and their performance is compared with the standard varieties. These procedures are repeated in the third, fourth, up to the seventh year. In subsequently years, the seed multiplication and distribution is then done commercially.

This method of selection has two major limitations. Because selection is done on the basis of phenotypic appearance, sometimes homozygous and heterozygous plants are composited together and the heterozygous ones segregations during

subsequent   generations. Also, hereditary and environmental variations are not distinguished at the   time of selection.

ii.   **Pure line selection:** A pure line is a collection of plants from a single homozygous individual, as a result of self-pollination. In pure line selection, up to a 1000 plants are selected from a genetically mixed population of a particular variety in the first year. In the second year, the progeny of each plant are grown in separate rows and seeds of superior plants within each row are composited to form experimental strains. For the next five years, different strains are grown in replicated plots, superior strains are selected and their yields are compared. In the eight-year the best strain are multiplied for commercial distribution.

Varieties developed by pure line selection are often more homozygous genetically than varieties developed by mass selection. It should be noted, that once a pure line is established there will be no need of selection again. Results of several studies have revealed that variations observed in plants between pure line are environmental. New genotypes are not created by this method of selection as selection is limited to the isolation of the best genotype that exists in a population. Pure line selection thus, narrows the genetic base and may be undesirable because genetic variability is essential for adaptation in a variety of environmental conditions.

(c).   **Hybridization:**

This involves crossing different plants. The desirable characters of two or more species, varieties or lines are combined together or transferred from one to the other. Artificial crossing is necessary for hybridising self-pollinated plants and the process involves the removal of the anther before it dehisces and collection and transfer of pollen from the male parent to the stigma of the emasculated plant.

Cross fertilization result in heterozygous progeny but in subsequent generations, the percentage of homozygosity increases as result of self-fertilization. To get a wider range of genetic segregation, a large number (about 10,000) of the F2 progeny (desirable progeny or genotype) are then selected using the pedigree selection or bulk population method. In pedigree selection, plants with desirable genotypic are selected from the segregants in the second and subsequent

generation until genetic purity in reached. Whereas in bulk population method, selection is delayed until a later generation, (until the fifth and sixth generation) where there is plenty segregation and variation in population. Majority of this plant at this stage becomes homozygous and breed true.

When a few simply inherited characters are to be transferred from one parent to the other, repeated back-crosses are made with the parent with most of the desired characters. A scheme of such a series of crosses can be illustrated thus:

A X B $\longrightarrow$ B X C $\longrightarrow$ B X D B X E B X F

C D E F G
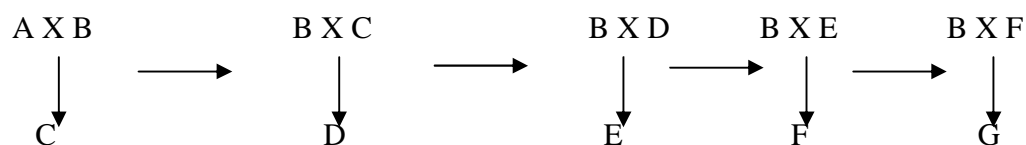
The parent A is known as the non-recurrent parent whereas B is known as the recurrent parent. The offsprings contain most of the genes and character of the recurrent parent. In the recurrent back-cross method, selection is necessary after each cross and the desirable hybrids are back-crossed to the recurrent parent.

Hybridization brings about a combination of genes from many strains and thus generates great variations, some of which may turn out to be useful.

4.0   SUMMARY AND CONCLUSION

Introduction, selection and hybridization are the method of breeding self-pollinated plants

5.0   TUTOR MARKED ASSIGNMENT

1.   What are the different methods used in breeding self-pollinated plants?

2.   Give two advantages and limitations of the methods used in breeding self-pollinated plants

3.   List four crops that are self-pollinated

6.0   REFERENCES /FURTHER READINGS

George Acquaah (2007) Principles of Plant Genetics and Breeding, Blackwell, United Kingdom.

Simmonds, N.W. and Smatt, J. (1999) Principles of Crop Improvement, 2nd Edition, Blackwell Science, United Kingdom.

Sinha, U. and Sinha, S. (1982) Cytogenetics, Plant Breeding and Evolution, 2nd Edition, Vikas, New Delhi.

UNIT 2: METHOD OF BREEDING CROSS-POLLINATED CROPS

1.0   INTRODUCTION

During pollination when pollen grains of a flower are conveyed by wind, insects or some other agents to the stigma of another flower, the crop is said to be cross pollinated.

Cross-pollinated plants exhibit great variations in floral organization and mode of reproduction.

In this unit the different methods used in breeding cross-pollinated crops will be examined.

2.0   OBJECTIVES

At the end of the unit the student will be able to:

1.   List the different methods used in breeding cross-pollinated plants

2.   Explain the different methods used in cross-pollinated plants

3.   State the advantages and limitations of the different methods

4.   Give examples of cross-pollinated crops

3.0 MAIN CONTENT

3.1 METHODS OF BREEDING CROSS POLLINATED CROPS

Cross- pollinated plants exhibit great variations in floral organisation and mode of reproduction. As a result, diverse methods are employed for their breeding. The methods popularly used are Introduction, selection, development of synthetic varieties and hybridization

(a) **Introduction:** This is the same as with self pollinated plants. It involves introducing a source of desirable genes into the population. Here suitable crosses are made with the new variety.

(b) **Selection:** Mass selection is more commonly used in cross-pollinated plants, unlike self-pollinated plants. This is because cross- pollinated plants are highly heterozygous and individual plants are unable to maintain their purity due to segregation and cross-pollination. In mass selection, a large number of individual plants with improved phenotypic characteristics are selected and bulked together, their seeds harvested and grown the following year. However, plants such as castor, sunflower, Colton and jute give better results with progeny selection rather than mass selection because they are often harvested and evaluated as individuals.

If genes for a particular quantitative character are to be concentrated, recurrent selection is used. In the first step, plants with improved yield are selected and their progeny obtained after setting and grown in separate rows. Plants of different rows are then crossed in all possible combinations, hybrid. Seeds are composited and population is established for the first recurrent selection cycle. The entire process is repeated until improvement is shown in the character under investigation.

(c) **Development of synthetic varieties:** This entails the development of new variety of plants by compounding seeds of individual plants or strains into a synthetic variety. The success of this exercise however depends on the combination abilities of the component strains. New varieties of crops such as maize and sugar beets have been developed using

this method. It has been observed, however, that synthetic varieties of maize are not as good as hybrids seeds but are superior to open pollinated varieties.

(d) **Hybridization :** This involves inter varietal or interspecific crosses of crops with desirable genotype or characters. Many are normally heterozygous and this heterozygosity is maintained from one generation to the other through cross – pollination. Cross – pollination often leads to the development of hybrid vigour.

Hybrids plants with improved characteristics are selfed for a few generations to achieve homozygosity for a desirable character. Thereafter, the hybrid population is subjected to progeny selection and desirable lines are selected and multiplied. For example, in the production of hybrid maize seeds, homozygous inbred lines are first established. Then, these inbred lines are crossed in suitable combinations to give better yield. Simple cross hybrids are than crossed together to give better double – cross hybrids. It should be noted, however, that where hybrid vigor is lost, it can be restored by out – crossing.

4.0   SUMMARY AND CONCLUSION:

Diverse methods are employed for the breeding of cross-pollinated crop. The methods popularly used are introduction, selection, and hybridization.

5.0   TUTOR-MARKED ASSIGNMENT

1.   What methods are used by breeders to breed cross-pollinated crops?
2.   What are the advantages and limitation of the various methods used in breeding cross-pollinated crops?
3.   Give five examples of crops that are cross-pollinated
4**.**   Briefly describe the procedure for producing hybrid maize seeds.

6.0   REFERENCES/FURTHER READINGS

George Acquaah (2007) Principles of Plant Genetics and Breeding, Blackwell, United Kingdom.

Simmonds, N.W. and Smatt, J. (1999) Principles of Crop Improvement, 2nd Edition, Blackwell Science, United Kingdom.

Sinha, U. and Sinha, S. (1982) Cytogenetics, Plant Breeding and Evolution, 2nd Edition, Vikas, New Delhi.

UNIT 3: METHOD OF BREEDING ASEXUALLY PROPAGATED CROPS

1.0: Introduction

2.0: Objectives

3.0: Main Content

3.1   Methods of breeding Asexually propagated crops

4.0: Summary and Conclusion

5.0: Tutor Marked Assignment

6.0: References/Further Readings

1.0   INTRODUCTION:

Asexual propagation entails the production of new individuals from the same plant. It does not involve the participation of two individuals. Asexually propagation results in the formation of clone of identical individuals.

In this unit, we shall examine the different methods of breeding asexually propagated crops.

2.0   OBJECTIVES:

At the end of the unit the student will be able to:

1.   List the different methods used in breeding asexually propagated crops

2.   Explain the different methods used in breeding asexually propagated crops

3.   State the advantages and limitations of the different methods

4.   Give examples of asexually propagated crops.

3.0   MAIN CONTENT

3.1   METHOD OF BREEDING ASEXUALLY PROPAGATED CROPS

Asexual propagation results in the formation of clone of identical individuals. Plants that really produce seeds, except under special conditions are usually reproduced asexually or vegetatively. Some crops such as banana, plantain, sugar cane, potatoes and tea are examples of crops that reproduce asexually. Vegetatively propagated crops are usually highly heterozygous.

There are two methods often used in breeding asexually propagated crops. These are clone selection and hybridization.

(a) **Clone selection:** In this method, selected improved variety of plants from a mixed population are multiplied asexually to give rise to a clone. This selection is made on the basis of phenotypic appearance.

One of the limitations of this method is that new genotypes are not created, as the genotype of a clone does not charge unless mutations or chromosomal aberrations occur.

(b) **Hybridisation:** In this method, improved clones of asexually propagated plants are selected and allowed to grow under conditions which favour flowering and seed setting. These plants are then crossed and hybrid of selected plants are multiplied by cloning. Selfing is not desirable at any stage because it leads to a reduction in hybrid vigour. However, where back cross has to be done in order to reduce or eliminate undesirable genes, different varieties are used as the recurrent parent.

4.0   SUMMARY AND CONCLUSION:

Plants that really produce seeds, except under special conditions are usually reproduced asexually. Clone selection and hybridization are two methods often used in breeding asexually propagated crops.

5.0   TUTOR-MARKED ASSIGNMENT

1.   Give five examples of asexually propagated crops

2.   What are clones?

3.   What is the major limitation of clone selection method?

4.   What are the major methods used by breeders for multiplying asexually propagated crops?

6.0   REFERENCES/FURTHER READINGS

George Acquaah (2007) Principles of Plant Genetics and Breeding, Blackwell, United Kingdom.

Simmonds, N.W. and Smatt, J. (1999) Principles of Crop Improvement, 2nd Edition, Blackwell Science, United Kingdom.

Sinha, U. and Sinha, S. (1982) Cytogenetics, Plant Breeding and Evolution, 2nd Edition, Vikas, New Delhi.

MODULE 5:   ANIMAL BREEDING

INTRODUCTION

Animal breeding is a field of the biological science which deals with application of genetic principles in farm animal production. Essentially it entails the incorporation of genes for desisrable characteristics in animals not already possessing such characteristics, increase in gene frequency of such genes in population in which they already exist and removal of or decrease in the frequency of genes responsible for undesirable characteristics in animals.

This module is divided into two units:

Unit 1:   Aims of Animal Improvement Programmes and Selection.

Unit 2:   Systems of Animal Breeding.

UNIT 1 :   AIMS OF ANIMAL IMPROVEMENT PROGRAMMES AND SELECTION.

1.0:   Introduction

2.0:   Objectives

3.0:   Main Content

       3.1   Aims of Animal Improvement

       3.2   Selection

4.0:   Conclusion

5.0:   Summary

6.0:   Tutor Marked Assignment

7.0:   References/Further Readings

1.0   INTRODUCTION

In this unit, we shall study the aims of Animal Improvement Programmes and the different methods of Selection.

2.0   OBJECTIVES

At the end of this unit, the student is expected to be able to:

1.   State the aims of Animal Improvement Programmes

2.   Define the term "Selection"

3.   Explain the various method of selection

3.0   MAIN CONTENT

3.1   AIMS OF ANIMAL IMPROVEMENT PROGRAMMES

Animal improvement programmes are aimed at producing improved animal with more easily transmissible or highly heritable desirable characteristics and less of undesirable characteristics. More specifically, animal improvement aims at increasing animal productivity by producing animals that yield more in terms of meat, milk, eggs, hair etc. it also aims at decreasing the quality of some animal products e.g. percentage butterfat content of milk, carotene content of egg yolk, carcass quality, egg shell color, egg hatch-ability etc and at producing animals that are resistant to diseases prevalent in the environment.

Adaptability to prevailing climatic conditions may also be an aim of an improvement program; alternatively an improvement programme, may be concern with the production of stronger, hardier work animals or animals with reduced mortality during growth or animals with better reproductive ability.

Production of animals with good mothering ability is another concern of animal breeding. Animal breeders may sometimes be concerned with increased rate of gain and better efficiency of food conversion in animals. Sometimes emphasis is placed on esthetic rather than productive characteristics, e.g. a breeder may be interested in producing polled cattle, coloured milk, colour tinted eggs, or in producing good looking animals with proper physique for exhibition.

Besides trying to improve desirable characteristics in animals, a breeding program may also aim at detection and removal of undesirable characteristics or at reduction of such characteristics in animals. Some examples of such characteristics are dwarfism in cattle, crooked legs, and buck teeth in rabbits.

Generally, improvement exercises may be carried out by introduction of animals or the semen of animals with desirable characteristics into one's stock, selection of individual within the stock that posses more of the desirable characteristics and mating of such individual to produce more of the desired animals.

3.2   SELECTION

Selection is the non – random production of offsprings from the parent generations or a situation in which some individuals in a population have an advantage over other individuals in transmitting their genes to the next generation. Random production of offsprings is a condition in which all the members of a generation are allowed to mate at random to produce the next generation. The gene frequencies of the two generations are equal.   In non–random production of offsprings or selection, however, the gene frequencies of the next generation are different from those of the first since genes determine the performance of an animal, a change in gene frequency in favour of the gene or genes that conditions desirable characteristic will improve animal performance. This essentially is what selection seeks to achieve. In order words, selection is done to increase the number of gene that affect the desired trait and to reduce those gene that are undesirable. The relative frequency of the gene or genes of the desirable trait in question, therefore, increases from generation to generation with selection.

Selection may be natural or artificial. Natural selection results from the action of natural forces and leads to the elimination of unfit individuals in a population in favour of the fittest individual.

Artificial selection on the other hand is a deliberate attempt by man to ensure the continued transmission of a desirable trait (s) or the removal of undesirable one by allowing only animals with the desired trait to produce offspring of the next generation.

There are various types of artificial selection:

(1) **Individual selection:**- This involves selection of animals for breeding purposes on the basis of their individual performances. It is usually used where heritability is high i.e. when the proportion of observed variance that affects the character is predominantly due to the effect of gene. It should be noted however, that some traits are sex limited e.g. egg production and milk yield. Generally, highly heritable trait that can be measured in both sexes are not easily improved through individual selection. Individual selection may also be employed in eliminating undesirable recessives that are highly heritable.

(2) **Family selection:**- This is selection that is based on the performance an entire family. In order words a family is picked or rejected on the basis of what the farmers need is in respect to the desired trait. When heritability is low, the phenotypic value of an individual is a poor indication of its genetic value. The mean value of a population is therefore a more accurate indication of the genotype of any one member of the family.

Family selection is therefore used when heritability is low and environmental effect is high and when environment effect common to members of the same family is not high. The larger the family size the more reliable the results.

There, are however some variations of family selection. These are:

(a) Sib selection:- an individual in this case is selected on the basis of its sibs i.e. brother, sister and half brother and sister. The merits of this method will however depend on the number of sibs used in accessing the individual, the heritability of the trait being considered, the average genetic relationship between members of the family and the mean generation interval.

Selection for relevant sex limited trait can be done through this method e.g. milk yield. Sib selection has been widely used in poultry because of the relatively short generation span in birds.

(b) Progeny testing:- Here the progeny (off springs) of the individual are evaluated to estimate the genetic value of the individual. The average value of several sample of a gene from the same parent is believed to give a true value of the parent's genetic make up.

It is useful where habitability of a character is low, where the character is sex limited or where the trait to be determined can only be measured after slaughter e.g. loin eye in pigs and carcass weight.

It is widely used in determining sire with desirable but moderately or weakly inherited character in beef cattle.

(3) Within family selection:- This is used when heritability is low and when environmental condition common to members of the family are high. The best member of the family is assumed to be the best genetically.

(4) Pedigree selection:- In this method, individuals are selected on the basis of their ancestors. This method is useful when little or no information are available on the

animals themselves because of their age or sex. Such record must contain sufficient and relevant information to be of any use.

FACTORS AFFECTING EFFECTIVENESS OF SELECTION

(1) Adequacy of selection criteria. The extent to which what is measure is related to what is desired affect the effectiveness of selection e.g. if back fat thickness is related to leanness in pig, it may be used as a basis for selection.

(2) Heritability of the trait. Progress is fast if the heritability of the trait under considerable is high and vice – versa.

(3) Intensity of selection. The number of animal one can afford to select or discard affect selection effectiveness.

(4) Number of traits selection for at a time. Progress is faster when one trait is considered than when two or more traits are worked on at the same time. However, in dealing with one trait one may unavoidable deal with other traits, e.g. egg size and egg weight cannot be divorced.

(5) Consistency of the breeder. The more consistent the breeding programme, the more successful it is likely to be, if the selection criteria and mating system adopted are appropriate.

4.0   CONCLUSION

Improvement exercises may be carried out by introduction of animals or the semen of animals with desirable characteristics into ones stock. It involves the selection of individuals within the stock that possess more of the desirable characteristics and mating of such individuals to produce more of the desired animals.

5.0 SUMMARY

Animal improvement programme is aimed at producing animals with more easily transmissible or highly heritable desirable characteristics and less of undesirable characteristics.

Selection and mating are the major tools used in animal improvement programmes. Selection can be natural or artificial. Artificial selection can be grouped into individual and family selection. Family selection is further subdivided into: sib selection, progeny testing, within family and pedigree selection.

6.0 TUTOR MARKED ASSIGNMENT

1. What are the major aims of Animal Improvement Programmes?
2. What is Selection?
3. Briefly discuss the various methods of Selection.

7.0 REFERENCES/FURTHER READINGS

Banerjee, G.C. (2005) A Textbook of Animal Husbandry, 8th Edition, Oxford &Ibh, New Delhi.

Payne,W.J.A. and Wilson, R.T (1999) An Introduction to Animal Husbandry in the Tropics, 5th Edition, Wiley-VCH, Germany.

UNIT 2: SYSTEMS OF ANIMAL BREEDING

1.0: Introduction
2.0: Objectives
3.0: Main Content

    3.1 Introduction
    3.2 Inbreeding
    3.3 Line breeding

1.0   INTRODUCTION

After selection, mating or breeding follows. This unit will deal with the various systems of breeding employed by Animal breeders.

2.0   OBJECTIVES

At the end of this unit, the student is expected to be able to:

1.   List the various systems of breeding

2.   Explain in detail the three breeding systems

3.   Discuss the uses of the various breeding systems

4.   Define artificial insemination

5.   Explain the benefits and limitations of artificial insemination

3.0   MAIN CONTENT

SYSTEM OF BREEDING

3.1   INTRODUCTION

After selection mating or breeding follows, there are three main breeding systems. These are Inbreeding, out breeding and crossbreeding.

3.2   INBREEDING

Inbreeding is a mating system in which the male and female mated are closely related than the average of the population from which come e.g. mating brother and sister. Inbreeding makes more pairs of genes in the population homozygous. The more closely related the individuals, the greater the degree of inbreeding. Mating individuals with unrelated ancestry would amount to zero inbreeding.

The degree of inbreeding or the probability that genes received by an offspring are from the same ancestor when two related parents are mated is known as inbreeding coefficient. Thus an inbreeding coefficient of 10% means that the probability of the gene of the resulting offsprings is from the same ancestor is 10%.

Inbreeding has also been observed to lead to the production of individuals that are less vigorous than the original parent, a phenomenal known as inbreeding depression. Generally some trait are associated with inbreeding for example a 10% increase in inbreeding has been shown to depress egg production by about 6.2%, milk production by about 3.2%, litter size of pig about 4.6%, litter size of mice by 8%, while a decrease of about 0.8% was observed for body weight (a non reproductive trait) in poultry.

A third consequence of inbreeding is that it uncover deleterious (undesirable) trait e.g. dwarfism in cattle. Deleterious traits are often recessive. It should be noted that increase in homozygosity is achieved in inbreeding with respect to dominant and recessive trait.

Uses of inbreeding

(1) Inbreeding is usually employed for the development of pure lines where such lines are associated with dominant desirable trait.

(2) It can be used to uncover undesirable gene for elimination. For example, suspected carrier of undesirable trait can be crossed with known heterozygote or with their own offsprings. It will bring out all the recessive genes the sire may be carrying and will give some indications of the desirable genes as well. This will thus help the farmer to known the actual genetic worth of his animals. Also it helps him to identify and cull undesirable recessive genes.

(3) In laboratory animals, highly inbreed lines are useful in many experiments and tests.

3.3   LINE – BREEDING

Line breeding is essentially inbreeding. But it involves mating individual not more closely related than half brothers and half sisters.

The objective of line breeding is not to increase homozygosity but to maintain a high relationship to an outstanding ancestor. Any homozygosity taking place in such a case is only incidental.

When the herd average is high and introduction of a new sire is expected to lower the merit of the herd, line breeding is very desirable. At least two sires are necessary in the herd to practice line breeding; otherwise, inbreeding will rise to such a level that many recessive genes which are usually deleterious may surface and produce defective individuals.

3.4   OUTBREEDING

Outbreeding is the mating of members of the same breed that are less related than the average of the population. It has the effect of increasing heterozygosity. It is useful in maintaining certain outstanding characteristics of the bred.

Upgrading

This is a form of out crossing. In up-grading the pure breed male is mated constantly to the female and the resulting female off springs of the low breed. The idea is to bring about a change of character in the low quality breed. This method is useful in developing new breed that are adapted to the environment.

3.5   CROSS BREEDING

This involves mating individuals from different breeds to obtain a hybrid since desirable gene often show dominance, the first progeny of such crosses often combine the good qualities of both breeds so that theses offsprings tend to be more vigorous than either of the parent breed. This phenomenal is known as hybrid vigor or heterosis.

3.6   ARTIFICIAL INSEMINATION

Artificial insemination (AI) is the technique in the technique in which semen with living sperms is collected from the male and introduced into the female reproductive tracts at the proper time with the help of instruments.

Artificial insemination involves the following steps:- collection of semen from the male, examination of semen quality, semen dilution, insemination or deposition of semen in the respective female reproductive tract.

 Some of the benefits derived from Artificial insemination include:

(1) It allows the maximum exploitation of the best sires.

(2) If properly organised, it reduces breeding costs, as there is a reduction in the total number of sires that have to be maintained.

(3) As Artificial insemination demands that the farmer should closely monitor his female stock, it also probably improves general standard of management.

(4) Artificial insemination also minimise the spread of veneral and other diseases.

(5) Artificial insemination is very useful where it is desired to import exotic livestock for cross breeding and or upgrading purposes, and where it is doubtful whether exotic sires will thrive.

Several factors, however, militates against the use of Artificial insemination technique in the tropics. Some of these are:

(1) In most countries the low level of farm recording has been a major

    handicap in the testing of Artificial insemination bulls.

(2) Many livestock owners in the tropics rear all their animals to maturity

    for meat purposes, so that the use of artificial insemination does not

    reduce their costs in bull maintenance.

(3) The females of many tropical breeds in particular the females of Zebus or humped cattle breeds, have short heat period and often difficult to identify, as it usually occurs at night. Under these circumstances many heat periods may be missed and this seriously reduces the efficiency of the artificial insemination operation. Short and silent heats are also very frequent in the females of exotic dairy breeds managed in the tropics, and in consequence artificial insemination in many exotic dairy herds has tended to become an uneconomic operation.

4.0   CONCLUSION

In order to achieve meaningful animal improvement, the breeder must adopt appropriate breeding systems.

5.0   SUMMARY

There three main breeding systems. These are inbreeding, outbreeding and cross breeding. Each of the breeding systems has its limitations. Artificial insemination is the technique in which semen with living sperms is collected from the male and introduced into the female reproductive tract at the proper time with the help of instruments. In carrying out artificial insemination the proper procedure should be followed. Artificial insemination, however, has its limitations.

6.0   TUTOR MARKED ASSIGNMENT

1.   What is the difference between inbreeding and out breeding?
2.   What are the uses of inbreeding?
3.   What is heterosis?
4   What is the major advantage of cross breeding?
5.   What are the steps involved in artificial insemination?
6.   List four factors that is militating against the effective use of artificial insemination in Nigeria

7.0   REFERENCES/FURTHER READINGS

Banerjee, G.C. (2005) A Textbook of Animal Husbandry, 8th Edition, Oxford &Ibh, New Delhi.

Payne,W.J.A. and Wilson, R.T (1999) An Introduction to Animal Husbandry in the Tropics, 5th Edition, Wiley-VCH, Germany.