INSTITUTE OF ADULT EDUCATION

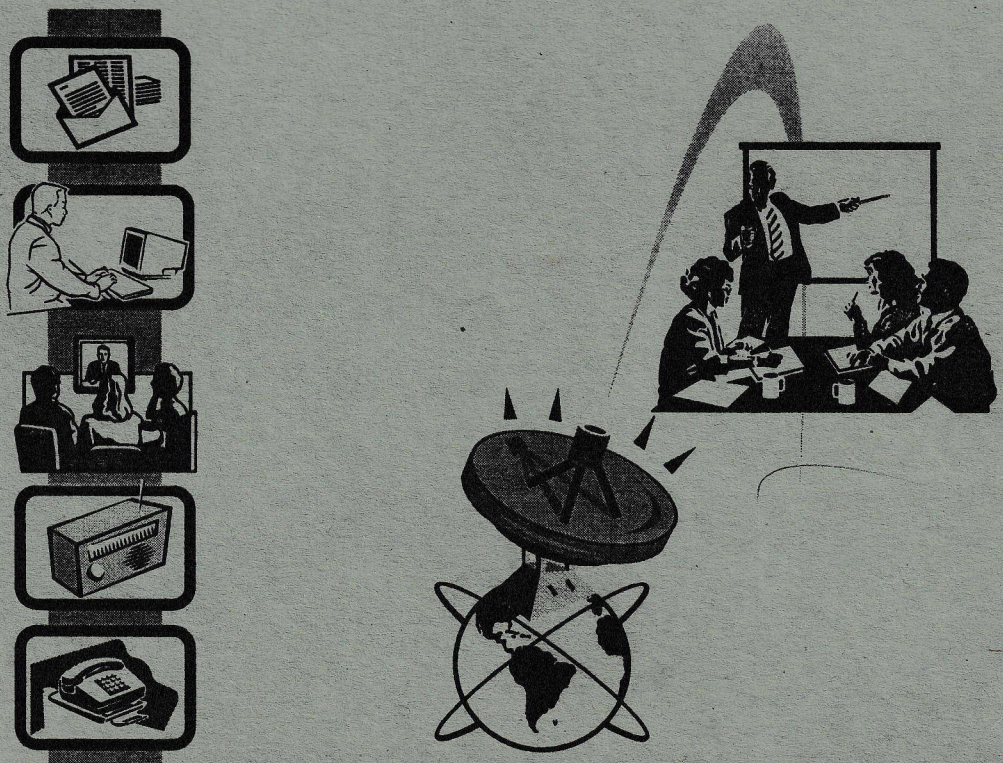
OPEN AND DISTANCE LEARNING

BIOLOGY

TEWW B_2

MODULE 8

Growth, Genetics and Evolution



Unit 8:1 Growth
Unit 8:2 Genetics
Unit 8:3 Evolution

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MODULE 8
Growth, Genetics and Evolution

Unit 8.1: Growth
Unit 8.2: Genetics
Unit 8.3: Evolution

BIOLOGY

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MODULE 8
Growth, Genetics and Evolution

Unit 8.1: Growth
Unit 8.2: Genetics
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Institute of Adult Education ODL Study Materials

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8.0.1 INTRODUCTION TO THE MODULE

Dear learner welcome to the last module of this wonderful subject i.e. Biology. We believe you have enjoyed the previous modules and you have developed great interest in this subject.

In this module you will learn how organisms grow i.e. change in size and weight. You will also learn genetics which, will tell you much on how organisms inherit characters from their parents and evolution.

It is my great hope that you will enjoy this module the previous ones.

8.0.2 OBJECTIVES OF THE MODULE

At the end of this module you should be able to:

- Explain the concept of growth and mitotic division.
- Describe human postnatal growth and development
- Explain growth in plants
- Describe the concept of genetics and variation
- Explain the Mendelian laws of inheritance
- Describe the Non-Mendelian laws of inheritance
- Outline sex determination characters and their causes
- Explain genetic disorders and their causes
- Explain the application of genetics
- Describe the concept of organic evolution and its evidence
- Explain the theories of the origin of life
- Describe theories of organic evolution (Lamarckism and Darwinism).

UNIT 8.1
GROWTH

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8.1.0.1 INTRODUCTION

Dear learner, I hope you are doing very well in Biology. In the previous module you learnt about reproduction and how organisms start. You learned that organisms (especially mammals) start by the fission of the nuclei of two sex cells; one from each parent (male and female) producing a single cell called a zygote. But do you know how this cell develops and attains a size and weight you have today? If the answer is yes congratulations because you are becoming a master in Biology, but, if not relax for the answer is in this unit.

This unit will explain to you what growth is and where and how it takes place.

I hope you are still enjoying learning this wonderful subject "BIOLOGY".

8.1.0.2 OBJECTIVES

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

- Explain the concept of growth and factors affecting it.
- Explain the stages of mitosis and its significance.
- Describe the stages of human post-natal growth and development and its psychological and behavioural changes associated with each stage.
- Explain meaning of localized growth in plants.
- Draw a seed and describe the functions of each part.
- Explain apogeal and hypogeal germination.

8.1.1 GENERAL CONCEPT *AND* FACTORS AFFECTING GROWTH

Growth

Life starts as a single cell. For example in human beings the sperm fuses with the ovum to form a zygote. The process whereby the sperm fuses with the ovum to form the zygote is called *fertilization*. The size of the zygote is normally smaller than anything you can see by naked eye. However, along with time it develops to form an embryo. The embryo starts to develop different organs such as brain, eyes, ears and limbs.

When the embryo has developed all organs and systems of the body, its size become big. We say it has increased in size and form. Scientists have given such kind of the embryo another name. It is now called the *foetus*. The foetus continues to increase in size and complexity until it is born as a baby.

Dear learner, I believe that you are now in a position to estimate the size of the baby since it is out of the mother's body and can be seen clearly without using any instrument. The young baby can neither sit, crawl nor stand up. Furthermore he/she cannot serve himself/herself in anyway. Did you also pass through these changes at one stage of your life? With time the baby sits, crawls and stands up without any support. The processes go on until it reaches the stage you are now. A lot of changes including increase in weight, change in the shape and form of an organism happen. In biology we call these changes growth and development.

Definition

Growth is an irreversible increase in body size and involves changes in weight, shape and form of an organism.

Causes of growth

Growth is caused by:

- Synthesis of new organic material, plant cellulose and carbohydrates by photosynthesis.
- Cell division follows nucleus division of a single cell producing millions of body cells.
- Cell enlargement; occurs by formation of large vacuoles in plants.
- Cell differentiation; occurs in multi cellular organisms to form tissues, organs and systems of the complete body.

Factors affecting growth

Dear learner, I believe you know that babies born on the same day do not necessarily possess the same growth rate. Growth in them differs to a large extent. For example, some will grow faster while others slower than their age mates. Do you remember at least two children who were born on the same day and date? If you compare their sizes, weight and forms, are they exactly similar in every respect? If not what makes them differ in the way the grow? The above questions bring us to a very important aspect of growth termed as factors which affect growth in living organisms.

Factors which affect growth are grouped into two as follows.

- Internal factors
- External factors

(i) Internal factors

Internal factors include the functions of hormones. In both plants and animals, hormones affect growth in one way or more. In plants the axing influences the cell division, cell elongation, regeneration of tissue at cut surfaces and growth of ovaries into fruits. In animals hormonal secretion of some glands has influence on growth. In its absence growth is impossible, i.e. no growth without hormones.

(ii) External factors

- Nutrients availability:
  Adequate supply of food is needed to provide new raw materials and energy so that an organism can repair, replace and build new cells and tissues. Lack of essential foods such as proteins leads to poor growth.

- Light energy:
  Light is required by plants during photosynthesis where by food is manufactured.

- Temperature:
  Temperature is very important in controlling growth in plants and cold blooded animals. In general low temperature slows down growth whereas, high temperatures (but not more than body temperature) accelerate growth.

- Accumulation of By-Products of Metabolism:
  Growth may be inhibited by the toxic substances formed as by products of metabolism. If an increase concentration of waste products is allowed to continue, it will soon retard growth.

8.1.2 MITOSIS

In the introduction of the concept of growth, we learnt that the size of the zygote is normally smaller than anything you can see by the naked eyes. However, we say that it later changes into embryo, foetus and born as a baby. Its size increases until it reaches the size you have at this time. How does the zygote increase in size over time until it reaches the big size you have now?

The answer is that its body cells divide over time to increase the size and weight. For example, the zygote is normally a single cell. The singe cell divides to form two cells which divide to form eight cells until millions of cells are obtained. The process whereby the body cells divide into several many cells is called mitosis.

Mitosis is the process by which the cell nucleus divides into two identical daughter cells. Two identical daughter cells are formed from one parent cell. Cells involved in this kind of division are all somatic (body) cells.

The time taken for mitosis of a nucleus varies with the species of organism and prevailing temperature, e.g. drosophila fly takes 7 minutes, and man takes 100 minutes.

Areas in which mitosis takes place

(a) IN PLANTS

Plants unlike animals have special areas in which mitosis takes place. These areas include the apex of shoots and the cambium. These areas contain meristematic tissues. Meristematic tissues are capable of dividing constantly.

(b) IN ANIMALS

Mitosis in animals takes place in the somatic cell i.e. all body cells except sex cells which divide by meiosis. Mitosis is a continuous process but four main phases are recognized:

(i) Interphase

Any cell under going division passes through preparatory stage before it divides. This stage is known as interphase. During this stage, chromosomes (coloured thread-like or beard) in the nucleus become visible. Chromosome is a Greek word which means *chromos*= colour and *soma*= body (coloured structure in the body). Chromosome consists of a protein and a substance called DNA which is a double helical strand capable of zipping i.e. can unzip-replicate. Centriole

separate and radiate to form protoplasmic strands which spindles. Chromosome is held by the centromere. Each chromosome is made up of two chromatids. Generally before it undergoes division, it absorbs water and nutrients which enlarge them.

(ii) Prophase

During this stage the following events occur:

- The nuclear membrane disappears.
- Chromosomes become visible after they have shortened and thickened.
- Chromosomes make their replicate called chromatids held together at the centromere.
- The nucleoli disappears.
- Centrioles in animal cells separate and start moving to the poles. Spindle fibres radiate as they move.

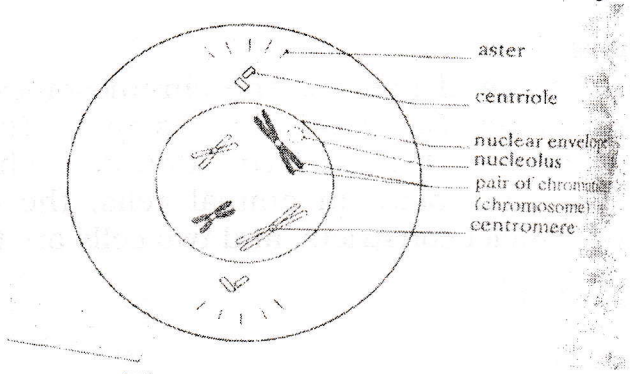

Figure 8.1.1: Prophase stage

(iii) Metaphase

Chromosomes arrange themselves on the equatorial position or midline. Centrioles arrive at the poles and spindles fully formed. Chromatids attached on spindles by their centromeres are moved to the poles by the activities of spindles.

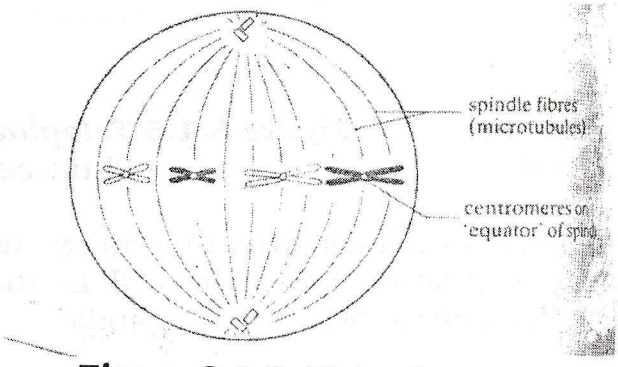

Figure 8.1.2: Metaphase stage

(iv) Anaphase

The chromatids are separated, after the splitting of the centromes. The chromatids move towards the opposite poles along the spindle fibre as chromosome.

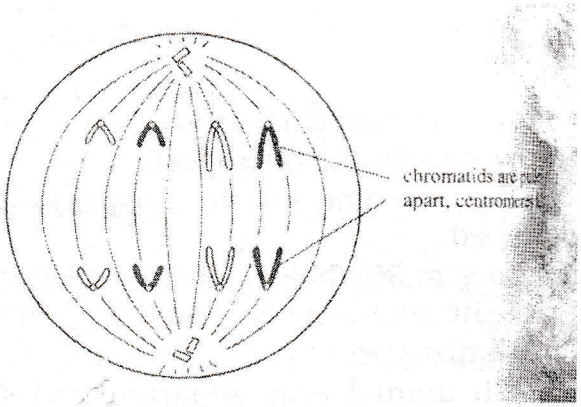

Figure 8.1.3: Anaphase stage

(v) Telophase

This is the last stage of mitosis. The chromosomes lengthen and become indistinct. The spindle breaks apart. The muscles reappear. Nuclear membranes form around each mass of chromosomes. At this point in animal cells, the cytoplasm between the two nuclei constricts, and two cells are formed.

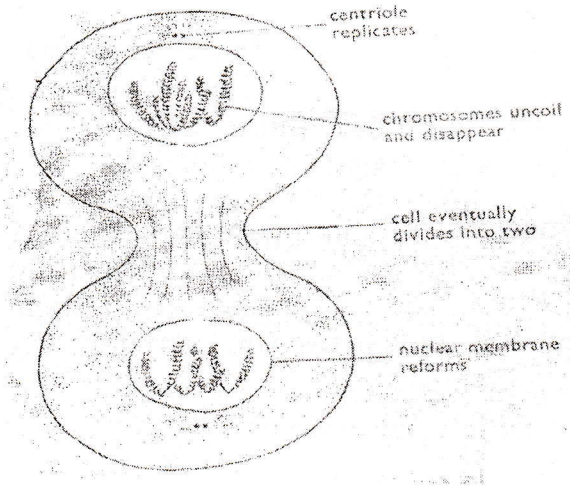

Figure 8.1.4 Telophase in Animal cell

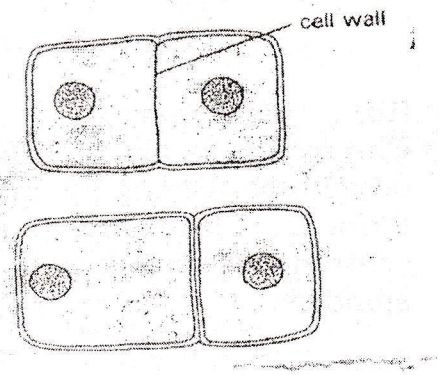

Figure 8.1.5 Telophase in Plant cell

In plant cell, the cytoplasm does not constrict to form two new cells. Instead a new cell wall is formed across the cell in the region originally occupied by the equatorial plane of the spindle.

Significance of mitosis

Significance of mitosis is that:

Growth; increase in body size due to formation of new cells and tissues.

- Repair of damaged and wounded tissues.
- Renewal of blood and epidermal cells in skin.
- Asexual reproduction is essentially a division or multiplication by mitosis.
- The replacement of lost body parts in some animals (regeneration).

Dear learner, after discussing the general process of cell division, let us now study plant growth.

8.1.3 GROWTH IN PLANTS

Growth in plants and development are localized and take in specific regions called *meristems.* It is caused place by active cell division in meristemic regions (or cell division regions). The principal meristematic regions are roots and shoot apex.

In these regions, cells retain the power of dividing. These regions are also called apical meristems and the type of growth taking place in these regions is called **apical. Growth** a characteristic feature of plants.

How apical growth takes place

Cells of the extreme tips of roots and shoot apex are constantly undergoing cell division. Further behind the region of cell elongation, the cells start to differentiate into various tissues and take up various functions in the plant. The meristematic regions are distinguished by three regions or zones.

Zone of cell division
Zone of cell elongation
Zone of cell differentiation.

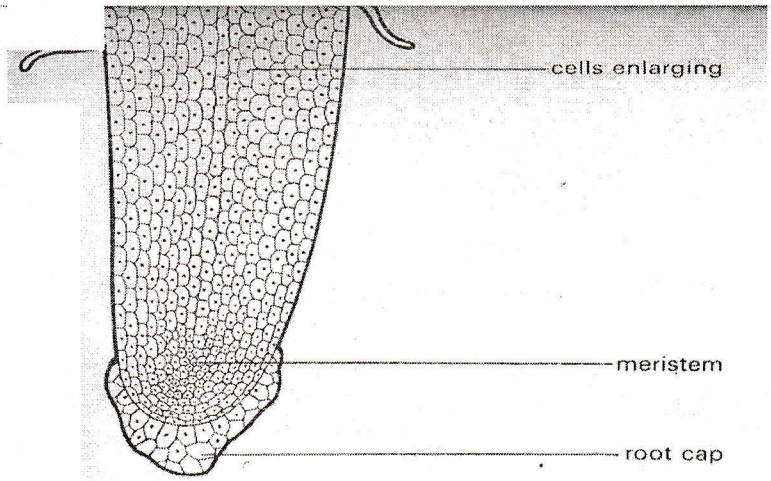

Figure 8.1.6 Longitudinal section through a root showing region of cell division and cell elongation

Protection of delicate meristemic tissue

- Root apical meristems are protected by a cap made up of spongy cells which are constantly being worn up as the roots push their way through. Root cap cells are replaced by meristemic cells.

- Shoot apical meristems (in buds) are protected by folding of soft leaves layers called premordia. This fold envelops the apex.

Dear learner, can you tell us the source of plants?

This question brings us to the concept of a seed.

Seed and Seed Germination

A seed is a fertilized ovule. A seed usually consists of the following parts.

- Testa:This is the seed coat which covers the seed.
- Hillum: This is a scar which marks the place where the seed broke from the wall of the ovary.
- Endosperm: It is the part of the seed in which the seed food is stored e.g. in castor oil and maize.

In other plants there is no separate food storage tissue and the food is stored in the cotyledons. Such seeds are said to be non-endospermic. E.g. bean seeds. A seed with two cotyledons is called dicotyledonous seed e.g. beans, castor oil seed, and groundnuts. Cereals including maize, wheat and millet have only one cotyledon hence monocotyledonous seeds.

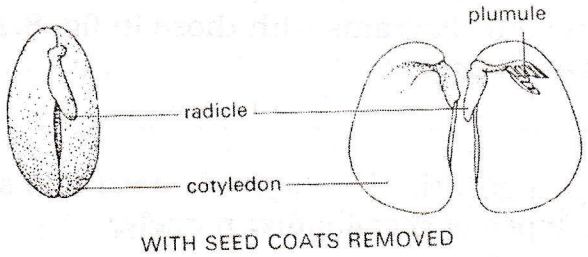

Figure 8.1.7: Structure of a seed

The Empbryo

This is a growing part of a seed when supplied with all essential conditions made up of highly meristematic cells.

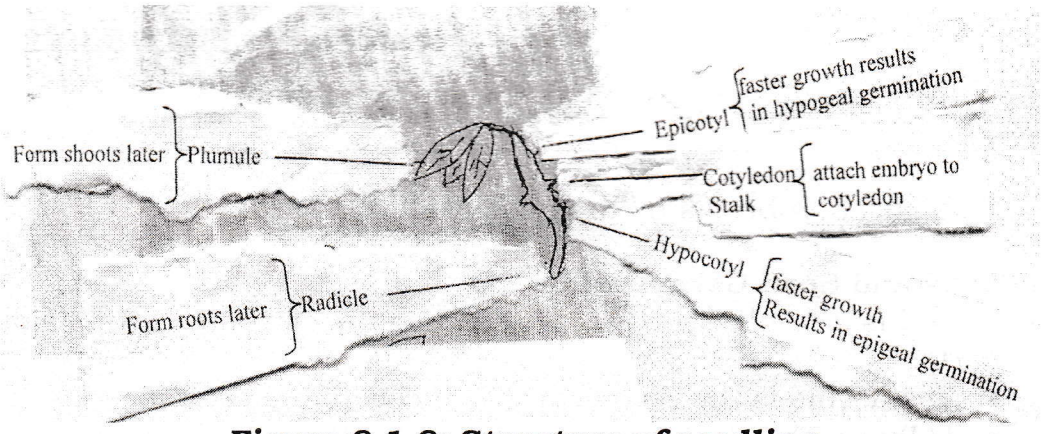

Figure 8.1.8: Structure of seedling

Germination

ACTIVITY 1

Observation of germination in peas and maize

- Germinate some peas and maize grains in two separate pots.
- Make sure that all conditions necessary for germination are available.
- Observe the seeds daily for about seven days.
- Seedlings are emerging from the soil.
- Compare your diagrams with those in fig. 8.1.9 and 8.1.10
- Label your diagrams.

Germination is a growth of embryo of a seed into seedling.
There are two types of germination namely;

i.) Epigeal germination
ii.) Hypogeal germination

Epigeal germination

This is caused by faster growth of hypocotyls. This is the type of germination whereby cotyledons are pulled upward above the ground level as germination proceeds. This type of germination is common in dicotyledonous plants e.g. beans. A few dicotyledons, however exhibit this type of germination.

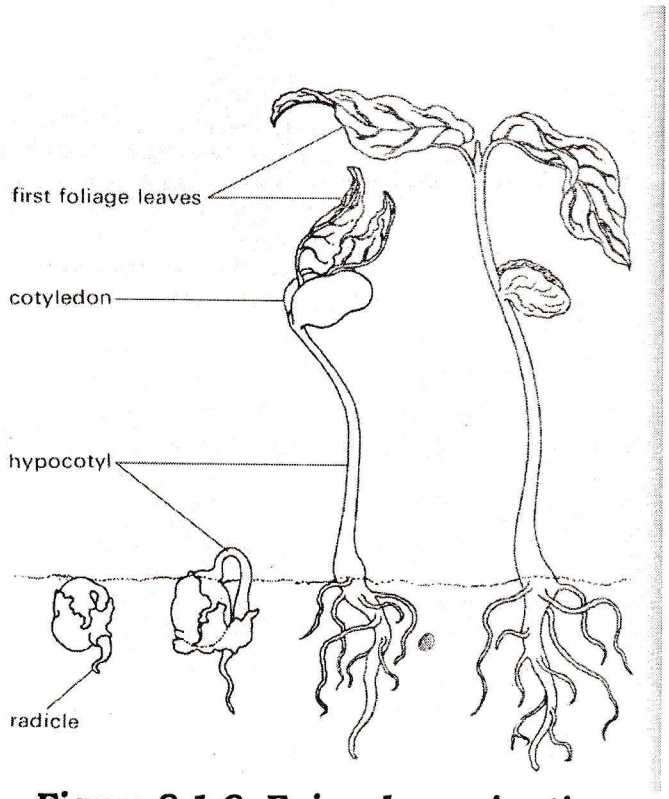

Figure 8.1.9: Epigeal germination

Hypogeal germination

Caused by faster growth of epicotyls:

This is the type of germination in which the cotyledons remain below the ground level as germination proceeds. This type of germination is common in most monocotyledons and few dicotyledons.

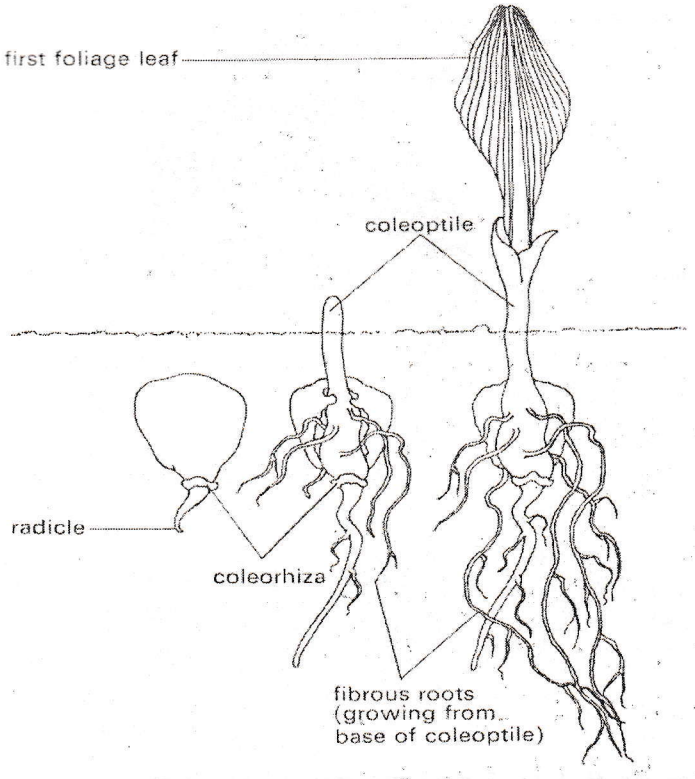

Figure 8.1.10: Germination of maize grain

Conditions necessary for germination

ACTIVITY 2

Find out conditions necessary for seed germination

- Obtain four medium size tubes (test tube or any relevant tube). Label them a – d;
- At the bottom of each tube, put some cotton wool;
- Place a few mature maize grain in each of the tube;
- In tube a and b add just enough water making sure that cotton wool is completely soaked;
- In tube c, add enough water to completely flood the seeds.
- Don't add any water in tube 4;
- Place the tubes a, c and d under room temperature;
- Place tube b in a very cold place such as a refrigerator. The experimental set up should be kept for at least seven days.
- In which tube did the germination take place and why?
- Why did due germination not take place in other tubes?

A seed can only germinate if certain conditions are present. These conditions are:

- Supply of water
- Supply of oxygen
- Suitable temperature
- Seed viability
- Maturity of seed
- Enzymes.

Water

Dry seeds contain only 10 – 20% water molecules, and as long as they are kept dry, they will not germinate unless some water is added. If it is placed in water a seed will rapidly increase in weight and size owing to the absorption of water (imbibition) through the micropyle.

Water dissolves stored food and softens the taste. Due to this and increasing pressure of absorbed water through micropyle, the taste burst to permit the embryo to emerge (radicle first). The process of water absorption by seed is known as imbibition.

Oxygen availability

All seeds need oxygen for germination in order to release energy by the process of Respiration.

Temperature

A certain minimum temperature is required for a seed to germinate. The requirement of amount of temperature varies according to the species of plants: e.g. those growing in tropical countries require a higher temperature whereas those in temperate regions require low temperatures. These influence enzymes to control biochemical reactions in a seed.

Seed viability

Seed must be alive in order to germinate. Seeds vary in length of life span.

Maturity of seeds

Seed must be fully ripened and not dormant. Some seeds fail to germinate immediately after their formation even though other conditions are available (seed dormancy). Seeds of this kind must be treated or crushed first.

Enzymes

Enzymes are needed for breaking down stored food.

DORMANCY

ACTIVITY 3

Collect seeds of different species such as maize, grain millet, coconut, mango and cashew nuts. If those seeds are not available select any other provided they are seeds that belong to different species.

Germinate them at the same time and record the germinating of each seed. Did they germinate at the same time/date? If not why? This brings us to the concept of seed dormancy.

Dormancy is a persisting stage or condition with a very low rate of metabolism in which growth ceases. It is seen in seeds, spores, buds, fruits and organs such as bulbs, corns, rhizomes and tubers.

Dormancy is the means to survive adverse conditions of low temperatures, lack of moisture in drought and winter conditions.

Causes of seed dormancy

Dormancy in seeds can be caused by:

(a) Restrictions

The seed may fail to germinate due to the restriction imposed by seed coat. The restriction may be purely mechanically imposed by seed coats which allow water and gases to penetrate but prevent expansion, until broken. Also restriction may be due to formation of extra layer on the coat.

(b) Rudimentary embryo

In certain plants such as orchids, the seeds are shed before the embryo has reached its maturity. Such seeds will fail to germinate until the embryo completes its development.

(c) Chemical inhibitors

These are chemical substances which inhibit internally in the seed. They prevent germination by preventing cell division.

After covering plant growth let us now see animal growth.

8.1.4 GROWTH IN ANIMALS

Human Postnatal Growth and Development

Growth in animals takes place in all body cells. This is caused by the type of cell division called mitosis. This type of growth which involves the whole body is called *diffused growth*. The human growth and development passes through a life cycle which leads to old age and ultimately death. Each stage of the life cycle has its unique characteristics and health needs.

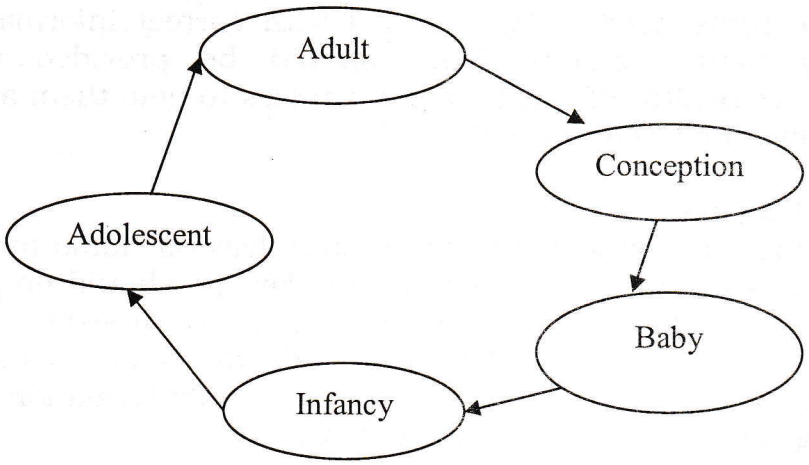

Figure 8.1.11: Life cycle of human being

Stages of Human Postnatal Growth and Development

Infancy: 0 – 5 years

- At this stage, children start to be curious about how babies are; may play with their genitals. They become interested in self-learn/self-identify.

- At this stage, adequate nutrition is very important for the baby to promote physical and intellectual development. Breast feeding is necessary up to two years if possible.

Children: 6 – 10 years

- These are school going age children. They try to adjust to school settings.

- At this stage the children want to look like emanate and act like peers. During the late years of this stage of growth, the pubertal changes may be noticed. At this stage the children should be informed about changes in their bodies, especially girls should be prepared for onset of menstruation. Both boys and girls should be provided with information on STDs and HIV/AIDS

Adolescence: 11 – 19 Years

- At this stage, puberty occurs. The biological changes occurring at puberty, clearly define males and females reproductive roles. For instance, menstruation occurs in the girls at puberty indicating that the girl can conceive if she meets a man sexually. Also, the boys have their first emission of semen (sperms) especially during wet dreams. As a result puberty triggers interests and desire in the opposite sex and curiosity to know them better.

- The adolescents need to be provided with correct information regarding their sexuality. They should be provided with reproductive health information and services to help them avoid getting unwanted pregnancies.

Adult: 20 – 55 years

- At this stage, the grown up people start leaving home during early adult stage to start their own life. Parents should prepare their minds for this period to prevent uncle mortal stress. This is because, at this stage of growth, individuals are ready to assume great responsibility like marriage, family formation and parenting, which includes rearing of children.

- The reproductive health needs such as family planning are very important to help married couple space the birth of their children and limit the sizes of families.

Old age: 60 Years and above

At this stage, some physical changes take place;

- The skeleton shrinks, skin loses elasticity and become wrinkled
- Hair loses pigmentation and become grey
- Generally there is a decline in sexual activity

The old men and women need education about their sexual changes, unrealistic expectations of one's sexuality may create unnecessary emotional difficulties.

8.1.5 THE GROWTH PATTERN IN ANIMALS AND PLANTS

Growth Pattern in Plants

The curve of plants always shows the sigmoid shape e.g. then intact annual plant shows that weight of very young plant tends to decrease slightly as the food reserves in the seed are used up. This loss is made up when the first leaves develop and function photo synthetically. Gradually the rate of increase in weight becomes more and more rapid until it becomes fairly constant at a high value. This high rate is maintained until maturity is approached and then the rate declines slowly.

This kind of growth can be plotted on a graph and appears as follows:

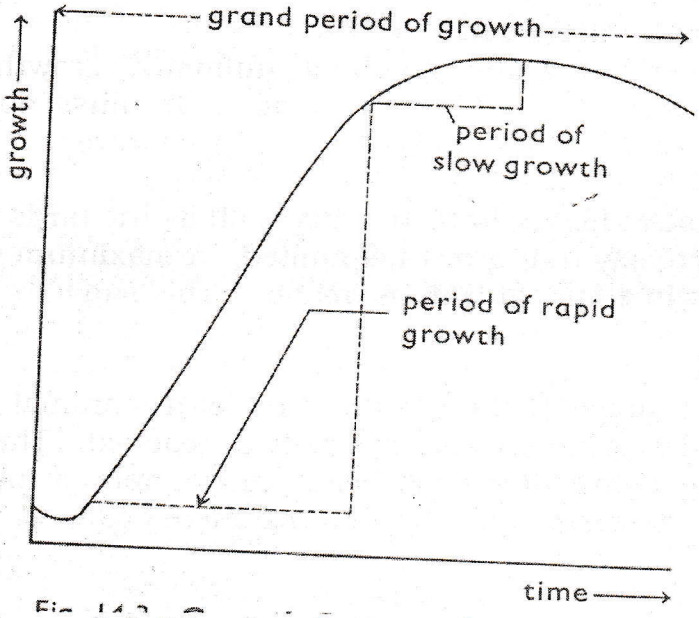

Figure 8.1.12: growth curve for annual plant

Perennial or woody plants

These plants never reach maximum size, but each year they add to the previous yearly growth. This shows a curve corresponding to a series of sigmoid curves added together (i.e. the top of the sigmoid curve is never quite flat). This kind of growth is described as unlimited growth.

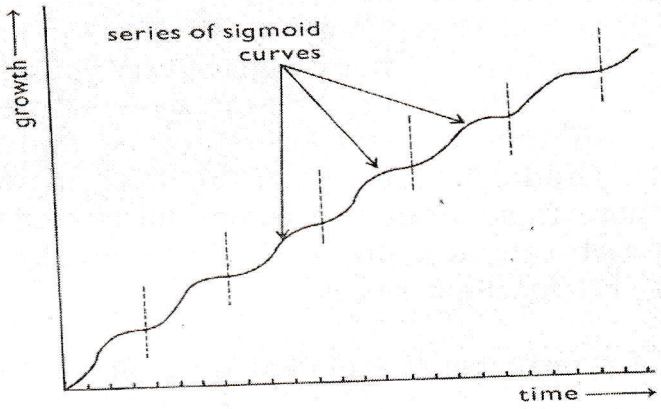

Figure 8.1.13: Perennial Growth curve

The Growth Pattern in Animals

Many layers of animals exhibit unlimited growth, though the growth rate is diminished with age. It must not be thought, however, that such animals can or do live forever.

In the case of higher land animals such as the birds and mammals it is true to say that growth is limited. A maximum size is reached beyond which no growth is made. The same is true to some insects.

The exact shape of the growth curve of a mammal depends upon the speed at which sexual maturity is reached. The growth curve of human being after birth being an example of mammals shows two distinct phases as shown on the curve below.

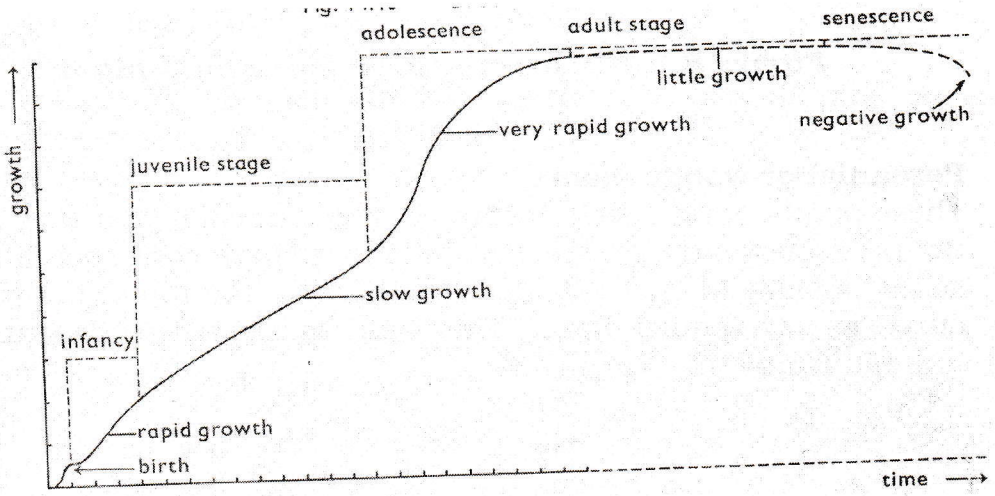

Figure 8.1.14: Human growth curve

Interpretation of above pattern of man growth curve:

1. The child grows very fast for the three years of its life, and doubles its height from 5 to 100cm.

2. It then stops growing for a period. During this time a child fills out, that is the body becomes broader.

3. Growth starts again, and continues fairly steadily until the onset of puberty (about 13 years).

4. During puberty (from about 13 to 15 years), growth at first almost stops for a short time, and then accelerates.

5. After puberty, growth gradually slows down and stops altogether at about the age of 18.

Growth pattern of Animals which Moults e.g. some insects

The animal shows rapid growth in a period immediately after moulting (ecdysis) before hardening of exoskeleton. These animals which moult exhibit a STEP – LIKE Pattern of growth.

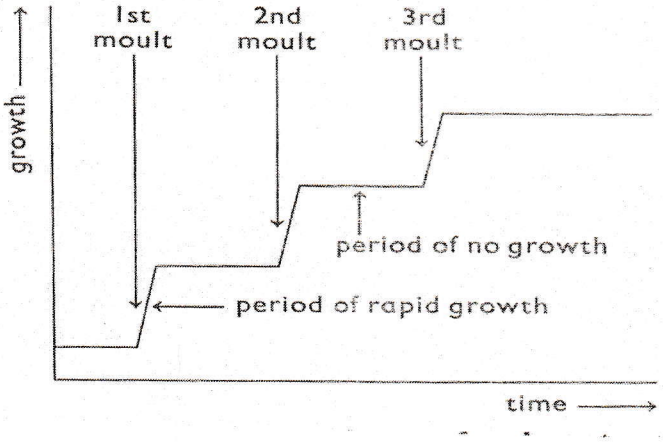

Figure 8.1.15: Step - like Growth curve for insects

8.1.6 SUMMARY OF THE UNIT

Growth is an irreversible increase in body size and weight in an organism caused by synthesis of new organic materials, cell division, cell enlargement and cell differentiation.

Mitosis is the division of the cell (somatic cells). Growth in plants occurs in localized areas called meristematic tissues found at the tip of roots and shoots (Apical growth).

Growth in animals occurs in all cells of the body (diffuse growth). A seed is a fertilized ovule. Germination is a growth of an embryo of a seed into a seedling. Two types are recognized i.e. Hypogeal and Epigeal germination.

Seed dormancy is a resting stage or condition of a seed with very low rate of metabolism in which growth ceases.

Plant exhibits a type of graph called sigmoid while animals like insects exhibit a step – like pattern.

Before proceeding further, complete the following exercise.

Interpretation of above pattern of man growth curve:

1. The child grows very fast for the three years of its life, and doubles its height from 5 to 100cm.

2. It then stops growing for a period. During this time a child fills out, that is the body becomes broader.

3. Growth starts again, and continues fairly steadily until the onset of puberty (about 13 years).

4. During puberty (from about 13 to 15 years), growth at first almost stops for a short time, and then accelerates.

5. After puberty, growth gradually slows down and stops altogether at about the age of 18.

Growth pattern of Animals which Moults e.g. some insects

The animal shows rapid growth in a period immediately after moulting (ecdysis) before hardening of exoskeleton. These animals which moult exhibit a STEP – LIKE Pattern of growth.

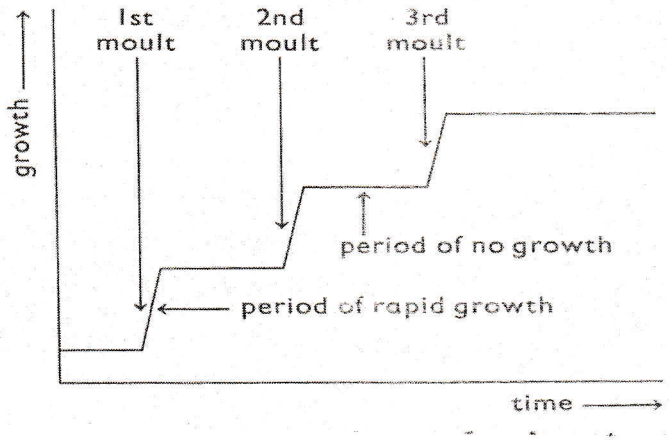

Figure 8.1.15: Step - like Growth curve for insects

8.1.6 SUMMARY OF THE UNIT

Growth is an irreversible increase in body size and weight in an organism caused by synthesis of new organic materials, cell division, cell enlargement and cell differentiation.

Mitosis is the division of the cell (somatic cells). Growth in plants occurs in localized areas called meristematic tissues found at the tip of roots and shoots (Apical growth).

Growth in animals occurs in all cells of the body (diffuse growth). A seed is a fertilized ovule. Germination is a growth of an embryo of a seed into a seedling. Two types are recognized i.e. Hypogeal and Epigeal germination.

Seed dormancy is a resting stage or condition of a seed with very low rate of metabolism in which growth ceases.

Plant exhibits a type of graph called sigmoid while animals like insects exhibit a step – like pattern.

Before proceeding further, complete the following exercise.

8.1.7 SELF CHECK EXERCISE

1. Explain the following terms
   (i) Growth.....
   (ii) Mitosis.....
   (iii)Apical growth.....

2. In which two parts of the plant body does growth take place?
   .....
   .....

3. (a) Define the term germination
   .....
   .....
   .....

   (b) Mention the types of Germination
   .....
   .....
   .....

   (c) List down the conditions necessary for germination
   .....
   .....
   .....

Compare your answers with those at the end of this unit.

8.1.8 TUTOR MARKED ASSIGNMENT

1. (a) Explain the term seed
   (b) Take two seeds of bean and soak them in water over night, cut one seed in longitudinal section (LS)
   (i) Draw and label one half containing an embryonic plant
   (ii) State the function (S) of each part you labeled.

   (25 Marks)

2. (a) Differentiate between growth and development

   (b) Explain the meaning of the following
   (i) Meristems
   (ii) Apical growth
   (iii) Localized growth
   (iv) Seedling

   (c) Outline four roles of water to the germinating seed

   (25 Marks)

3. (a) With well labeled diagrams differentiate between hypogeal germination and epigeal germination.

   (b) Explain how growth in insects differs from that of other animals like a human being.

   (25 Marks)

4. Outline the events which occur at these stages of human growth:
   (a) Infancy
   (b) Adolescence
   (c) Adult stage
   (d) Senescence

   (25 Marks)

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   .....

   (c) List down the conditions necessary for germination
   .....
   .....
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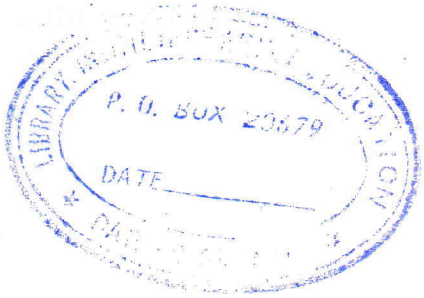
Compare your answers with those at the end of this unit.



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   (a) Infancy
   (b) Adolescence
   (c) Adult stage
   (d) Senescence

   (25 Marks)

8.1.9 KEY ANSWERS TO SELF CHECK EXERCISE

1. (i) Growth is the irreversible increase in body size and weight of organisms.

   (ii) Mitosis is a somatic (body) cell division. It results in the formation of new cells with the same number of Chromosomes

   (iii) Apical growth is a localized growth which takes place in apex of plant roots and shoots.

2. (i)
Shoots (tip)
   (ii) Roots (tip)

3. (a) Germination is the growth of an embryo of a seed into a seedling.

   (b) (i) Hypogeal germination
   (ii) Epigeal germination

   (c) (i) Water
   (ii) Oxygen
   (iii) Temperature
   (iv) Seed viability
   (v) Maturity of a seed
   (vi) Enzymes.

UNIT 8.2
GENETICS

CONTENTS

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8.2.0.1 INTRODUCTION

Dear learner, Biology as stated earlier is the study of living things. So far you have discussed all characteristic of living things. In each topic you have learnt how organisms exhibit them and their role. In general they enable organism to grow and develop. Neither of those characteristics explained why some people are tall while others are short or why some people can roll their tongue while others can't.

Genetics will answer these and many others. Genetics deals with characteristics of organisms. It tells you how these characteristics are transmitted to offspring from parents and to successive generations. This unit will give you knowledge on different diseases which are genetically transmitted. It will also give explanation on its application in improving our crop and animals production.

8.2.0.2 OBJECTIVES

At the end of this unit you should be able to:-

- Explain the meaning and importance of genetics
- Outline various terms used in genetics
- Describe genetic materials and their roles
- Mention types of variation and their causes
- State Mendels 1st inheritance
- Describe monohybrid and crosses of contrasting traits and its ratio
- Explain inheritence of albinisms, tongues rolling, and sickle cell anaemia.
- Explain complete and incomplete dominance.
- Explain the concept of incomplete dominance and codominance.
- Illustrate patterns of inheritance that deviate from Mendels first law of inheritance.
- Explain the meaning of sex and mechanism of sex determination, inheritance and development
- Explain sex linked characters.
- Name the common genetic disorders and their causes.
- Explain inbreeding and outbreeding and give advantages and disadvantages.

8.2.1 CONCEPT OF GENETICS AND VARIATION

In reproduction we have learnt that there are two types of reproduction; sexual reproduction and asexual reproduction. In asexual reproduction the newly formed organisms are exactly equal to the parent i.e. total resemblance. However, in sexually reproducing organisms, the offspring resembles their parents but not in total as they share characters of two parents (male and female). Resemblance is due to the fact that in each genetic nucleus there are genetic materials responsible for transmitting or passing characters from parents to the offspring.

Differences seen in offspring of the same parents are a result of different arrangement of genetic material components (genes) and the external environmental factors. The study of how characters are passed from parents to the off springs and successive generation together with the differences in the off springs is called genetics. Therefore genetics is the study of heredity and variations.

Variations

Dear learner, it is obvious that no two organisms look exactly the same. Even identical twins can have little variations due to environmental influences.

Differences in appearance shown by organisms belonging to the same species are called *variation*. Phenotypic appearance of any characteristic is determined by certain gene(s). The extent to which certain characteristics develop may be influenced more by the environment.

Types of variations

There are some characteristics within a population which exhibit, a limited form. Variation in this case shows clear – cut differences with no intermediates between them. This kind of variation is known as **Discontinuous variations** or qualitative inheritance.
Example: Blood groups and tongue rolling etc. A person is group A or AB forever. It will never change.

The second type of variation is known as **continuous variation.** These are variations which show a complete graduation from one extreme to another without any break. For example mass, weight, shape, skin colour.

Characteristics exhibiting continuous variations are produced by the combined effect of many genes (polygenes) and environmental

factors. Individually each of these genes has an effect on the phenotype but their combined effect is significant.

Sources/cause of variation

Asexually reproducing organisms show very little or no variation due to DNA replication being nearly perfect.

Variation occurs even in identical twins. I believe you know that if twins are subjected to different environment e.g. very cold and very hot they will physically look different.

You also know that If one is given enough balanced diet and the other starved or just given food to sustain life, they will look different. This gives an example of environment as one source of variation.

Other sources are:

- Crossing over during meiosis may result in variation. These groups move as whole in a certain chromosome without being passed to the other (homologous chromosomes).

- Independent assortment/orientation of chromatids during interphase 1. That is, each chromatids decides the direction of movement freely.

- Random fusion of gametes e.g. X'X" * XY
  X' can fuse with X or Y
  X" can fuse with X or Y
  X'Y looks different from X'X
  Even X'Y looks different from X"Y
  However, gene reshuffling becomes major source of variation.

- Mutation
  This may be due to change in chromosome or gene number. Gene arrangement may be disturbed by x-ray or any other ultra-rays or strong chemicals.

Heredity

Heredity is the transmission of characters from one generation to the next, that is, from parents to their offspring. Because of heredity, offspring resemble their parents. It is owing to heredity or self-reproduction that we commonly observe the phenomenon of "like begets like" that is a seed of orange develops into an orange tree or the offspring of a dog is a puppy, and that of human beings is a human being only. This resemblance is due to the fact that in

each nucleus of a cell there is a genetic material known as DNA found in the chromosomes. The genetic constitution depends on these genetic material DNA (and RNA).

RNA – (Ribonucleic acid) – is a simple strand made up nitrogenous bases. This is mainly for protein synthesis and not for heredity. DNA – Deoxyribonucleic Acid is a double helical strand (ladder like) polynucleotide chain in which the two strands are joined together by hydrogen bond. DNA is purely hereditary material.

DNA is capable of zipping up. This enables it to replicate. DNA and RNA are parts of chromosomes. They are giant macromolecules which are longer than any kind of protein in the body.

NB: Nucleic acid is made up of nucleotides or monomers of nitrogen bases. These combine together to form chain of nucleic acid.

DNA is made up of phosphate group, pentose sugar (five-carbon sugar) and nitrogenous bases. There are four nitrogenous bases. These are adenine, guanine, cytosine and thymine.

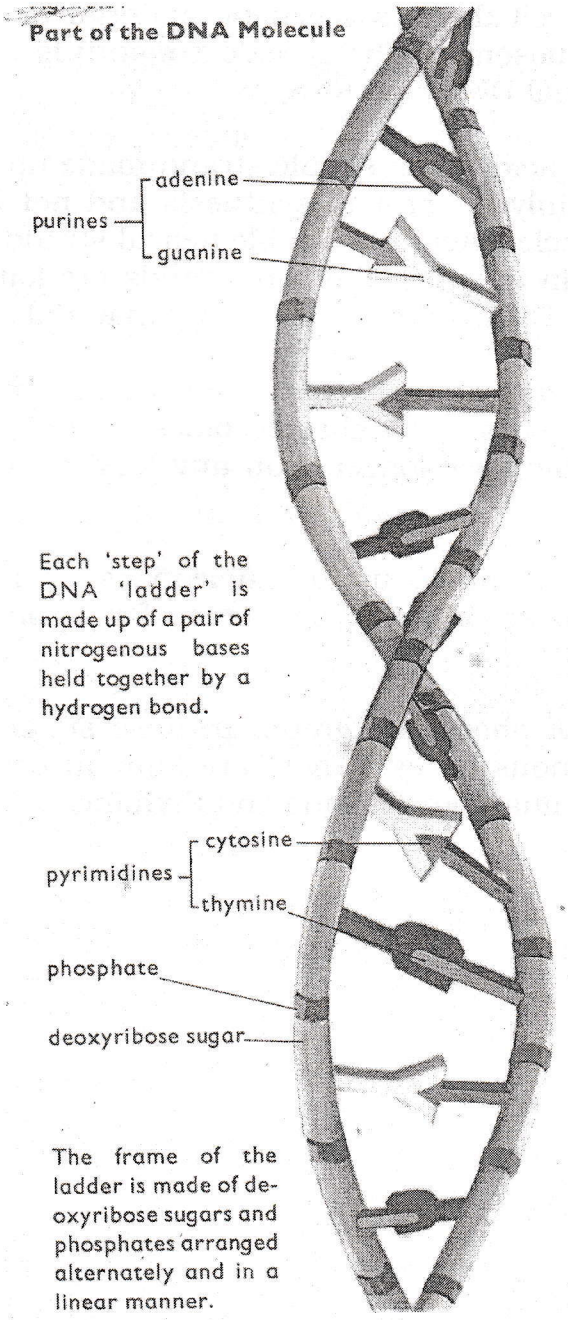


Figure 8.2.1: DNA molecule in a form of double helix

Genetic Terms

- **Gene:** The basic unit of inheritance for a given character.
- **Allele or Allelomorph:** one of the alternative forms of the same gene responsible for determining contrasting characteristics.
- **Locus:** position of allele within DNA molecule.
- **Phonotype:** The external (morphological) appearance of an individual for any trait or traits is called the phenotype, example for seed – round or wrinkled, animals being short or tall.
- **Genotype:** The genetic constitution of an organism with respect to the alleles under consideration.
- **Dominant:** The trait which expresses in F1 or is the allele which influences the appearance of the phonotype even in the presence of alternative allele.
- **Recessive:** The allele which is suppressed (does not appear) in the F1 (it appears only in homozygous form i.e. in the presence of other recessive).
- **F1** – The first filial generation. The generation produced by crossing homozygous parents.
- **Homozygous:** The diploid condition in which the alleles at a given locus are identical e.g. AA, TT, GG, SS, BB.
- **Heterozygous:** The diploid condition in which the alleles at a given locus are different e.g. Aa, Tt, Gg, Ss, Bb.

8.2.2 MENDEL'S LAW OF INHERITANCE

Gregory Johann Mendel was born on July 22, 1822 in Moravian, Austria. He died in 1884. He was a monk, and a teacher of Physics and Natural Science. He did a lot on genetics by performing several experiments perceptively with precision and thoroughness. However, his work was not recognized at that time. 16 years later, scientists confirmed that Mendel's law of inheritance is applicable to other organisms as well and not plants he used only. His experiments form a basis of modern genetics. For that reason Mendel is called the **father of genetics.**

Mendelian 1st Law of Inheritance states that:

The characteristics of an individual or organisms are determined by internal factors which occur in pairs. Only one of a pair of such factor (allele) can be expressed in a single gamete" or "genes and are responsible for the development of the individual and that they are independently transmitted from one generation to another without undergoing any alteration, that is a pair of constructed allelomorphs are separated or segregated when gametes are formed and only one will be expressed by a single gamete.

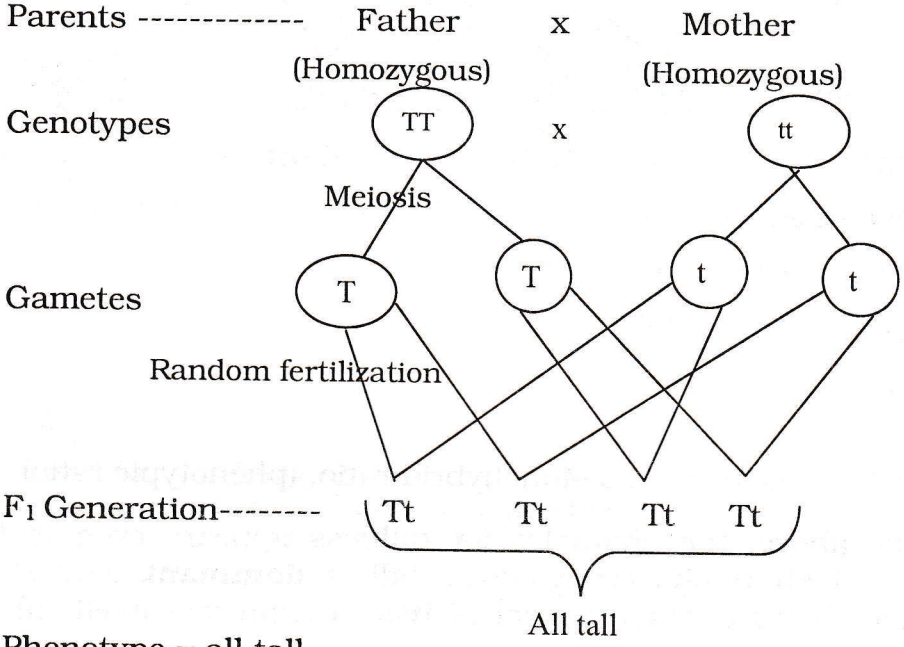
For more information on this law carefully read the table below.

Table 8.2.1 Mendelian work – experiments

S/No.	Characters	Contrasting pairs (Allelic pairs)	
		(Dominant)	Recessive
1	Form of seed	Round	Wrinkled
2.	Color of cotyledons	Yellow	Green
3.	Color of seed coat	Colored	White
4.	Form of pod	Inflated	Constricted
5.	Color of pod	Green	Yellow
6.	Position of flower	Axial	Terminal
7.	Height of plant	Tall	Dwarf

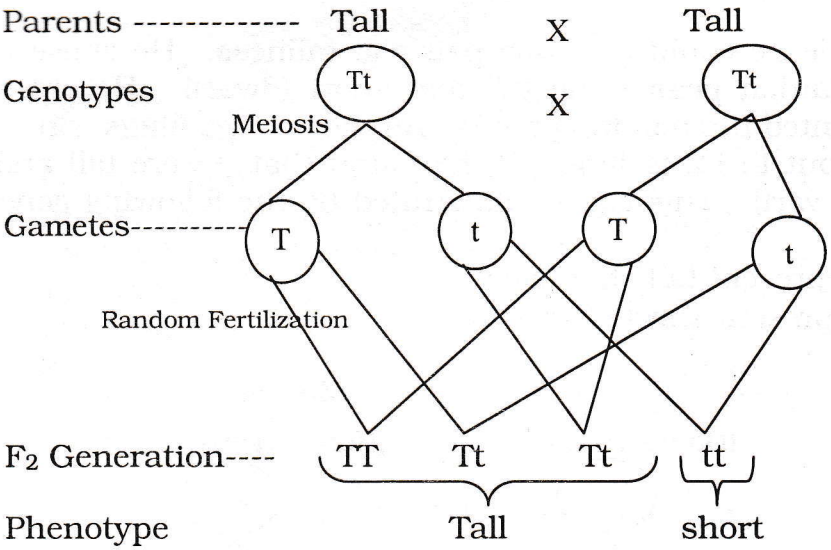
From the table he could pick one pair e.g. tallness. He chose two varieties of garden peas – the tall and short (dwarf). He crossed them and planted the resulting seeds. All the seedlings in F1 were all tall but in F2 (selfing F1), he found that ¾ were tall and ¼ were short (dwarf). This can be illustrated by the following genetic diagram.

- Let T represent tall character
- Let t represent short character



Phenotype = all tall
F_1 offspring are hybrids.

On allowing F1 offspring self pollination and planted, results were as follows:



Phenotypic ratio	$^3/_4$		¼
Monohybrid ratio	3	:	1
Genotype	TT	Tt	tt
Genotypic ratio	1 :	2 :	1

NB: 3:1 Ratio is known as Monohybrid ratio, (phenotypic ratio)

From the above, the character for tallness appears even in the presence of short character, hence tall is **dominant** over short character. Short character is **recessive.** It expresses itself only in homozygous.
Tall= Dominant
Short = recessive

Dominant characters are represented by capital letter while recessive is represented by small letter.

Calculations on Genetics
Crossing ratio can be obtained by counting number of offspring produced.

For example: in a cross between tall and dwarf stem, 787 were tall while only 277 offspring were short. Find the ratio of tall to short.

Answer: Tall : short
787 277
Ratio $\frac{787}{277}$ $\frac{277}{277}$
= 2.87 : 1
= 3 : 1

Remember

(i). 3:1 ratio is obtained from two heterozygous parents with complete dominant character.

(ii) Heterozygous are obtained by crossing two homozygous parents

Assignment

Assign letter and make cross to show how the following results were obtained.

1. Shape of seed round x wrinkled (5474, 1850) (meaning – 5474 were round and 1850 were wrinkled.
2. colour of seed yellow x green (6022,2001)
3. shape of pod inflated x constricted (682, 229)
4. Position of flour axial x terminal (651, 207)
5. Colour of flower red x white (705, 224)

In solving these problems do not use confusing letters e.g. C and S unless instructed.

Assignment 3 is done as an example for you

Assignment 3

Inflated x constricted (682, 229)

(i) Is this a monohybrid ratio?

Answer: inflated: constricted

682 : 229

= 3 : 1 (monohybrid ratio)

(ii) How do we get 3:1 ratio?

Answer: From a cross between Two heterozygous parents.

(iii) Which character is dominant

Answer: since inflated are more (3/4 of total offspring) then is dominant and constricted (1/4) is recessive.

(iv) How do we get heterozygous?

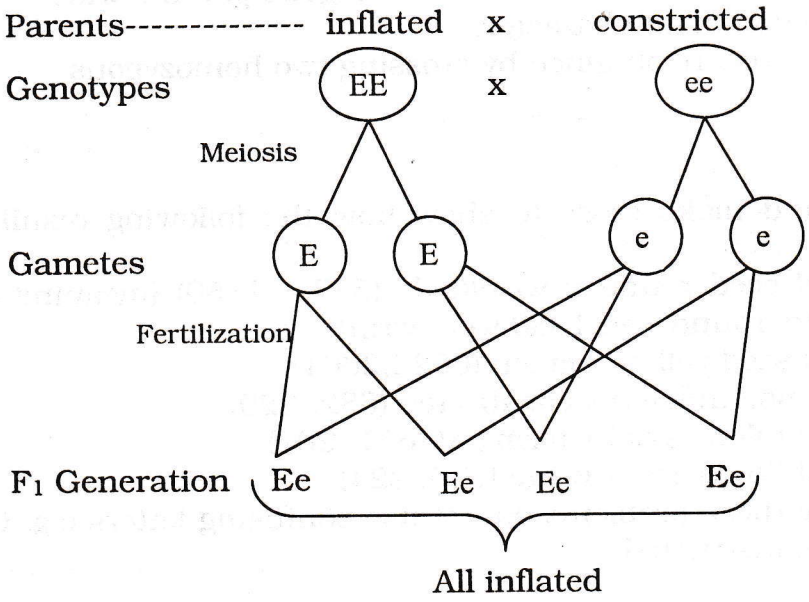
Answer: By crossing two homozygous parents i.e. TT and tt.

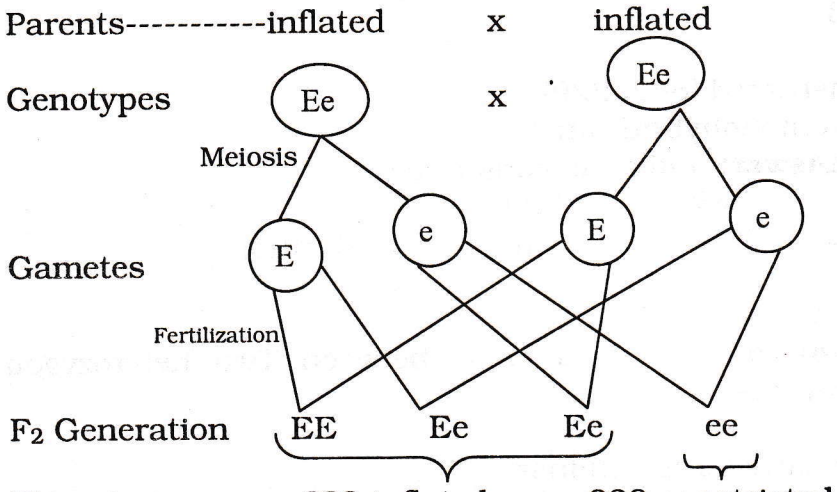
From above answers let us now assign symbols to represent inflated and constricted.

Let E represent inflated

Let e represent constricted.

From question iv – parents were





Phenotypic ratio 682 : 229

3 : 1

Genotypes EE Ee Ee ee

Genotypic ratio 1 : 2 : 1

Now use this example to work on the remaining questions.

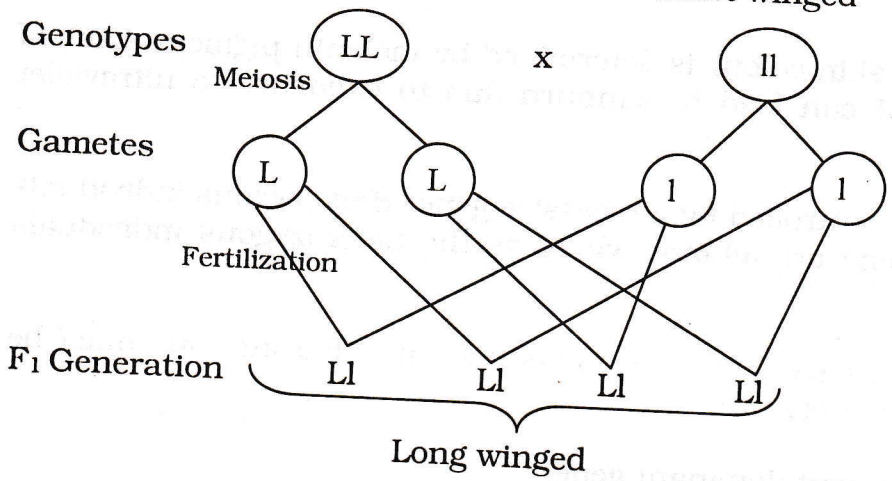
Test Cross

Crossing of an organism having an unknown genotype with a homozygous recessive organism.

Example: Genotype of long winged drosophila may be LL or Ll. To establish correct genotype, the fly is test crossed with a double recessive ll.

If the unknown genotype is LL, then the cross will be as follows:

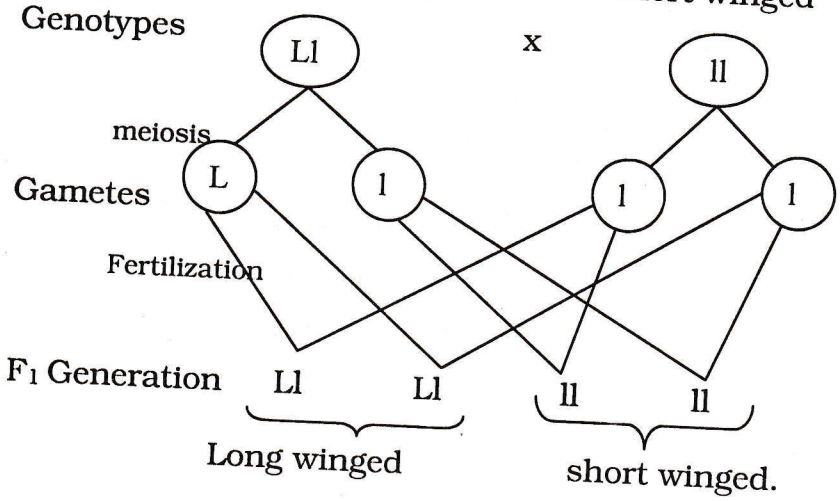
Parents----------long winged x short winged



Since F1 all are long winged the parents of unknown genotype is LL (Homozygous dominant).

If the unknown genotype is Ll the cross will be as follows:

Parents----------long winged x short winged



Genotypes Ll Ll ll ll

Genotypic ratio 2 : 2

1 : 1

Since half is long winged and half is short winged, therefore parents genotype is L1 (Heterozygous dominant).

Patterns of Inheritance That Follow Mendel's First Law
Worked examples above, e.g. Albinism and sickle cell anemia.

Albinism
This is hereditary condition which is characterized by complete or nearly complete absence of melanin pigment in the skin, hair and eyes.

The human skin colour is determined by melanin pigment. Lack of this pigment can lead to sunburn due to exposure to ultraviolet radiation.

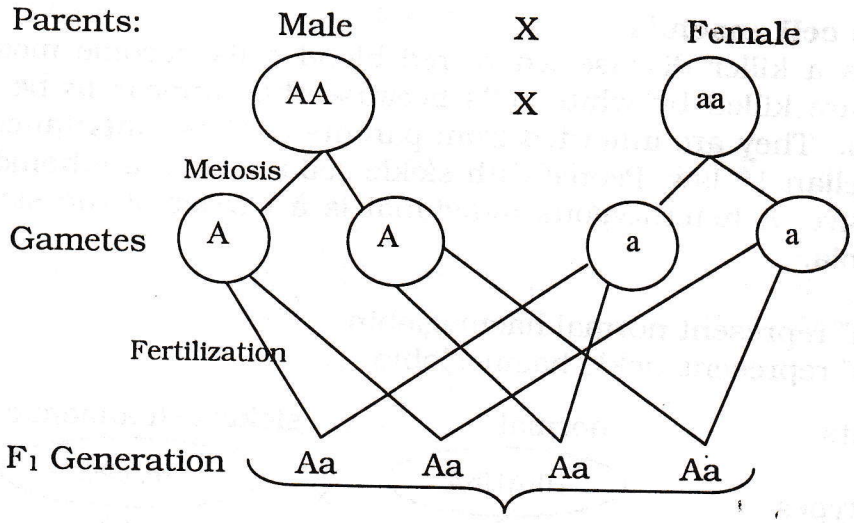
Albinism is controlled by a recessive gene. Homozygous individuals for these gene are albinos where as the heterozygous individuals are normal

For any recessive gene to express itself in offspring, one must be homozygous recessive.

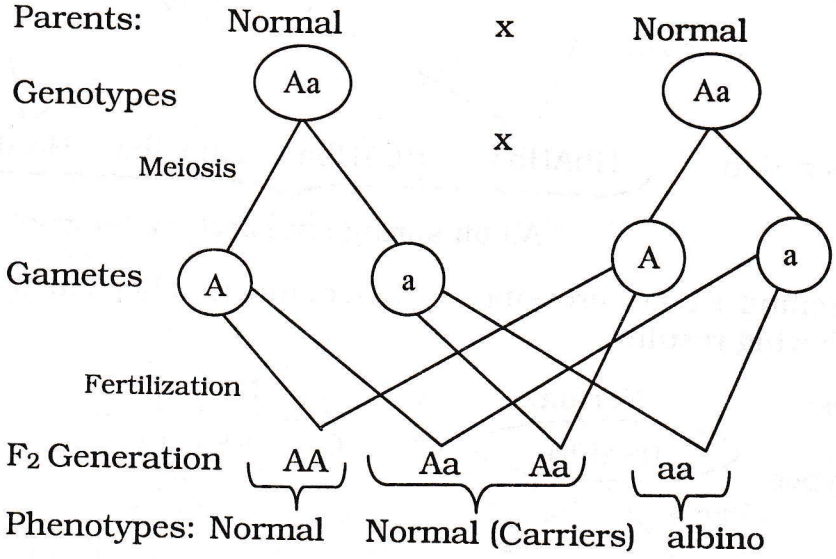
Let "A" represent dominant gene.

Let "a" represent recessive gene.

If normal man marries homozygous woman then all offspring will be normal but carries.



If crossing between F1 occurs, the following are the results



Phenotypic ratio: 3:1

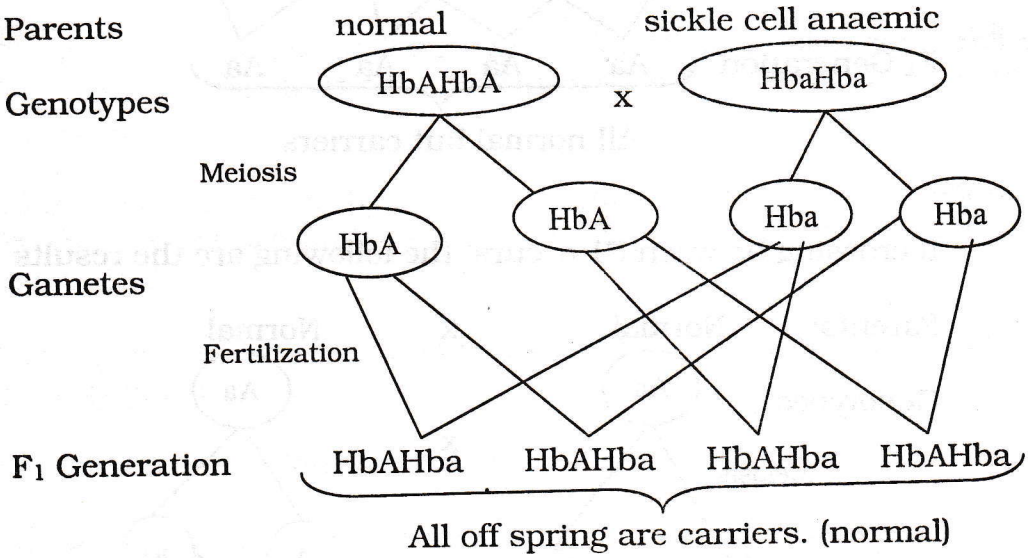
Genotypes: AA Aa Aa aa

Genotypic ratio: 1:2:1

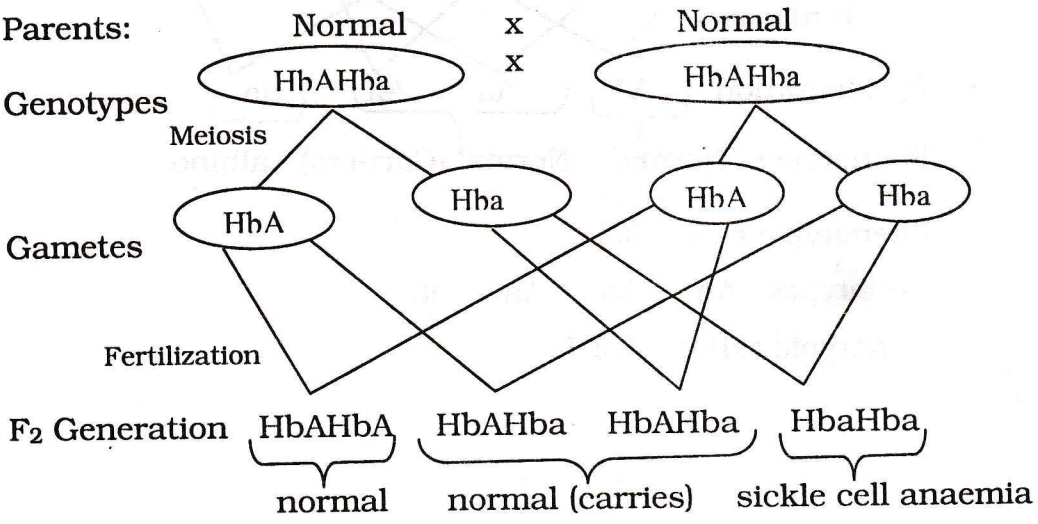
Sickle cell anaemia

This is a killer disease where red blood cells become moon like. They are killed by white cells because they appear to be foreign bodies. They are inherited from parents and its inheritance obeys Mendelian 1st law. People with sickle cell anaemia are homozygous recessive. A heterozygous individual is a carrier of the sickle cell aneamia.

Let "A" represent normal haemoglobin
Let "a" represent sickle haemoglobin



Then selfing F1 i.e. crossing a carrier and another carrier shows the following results:



Phenotypic ratio: 3:1
Genotypic ratio: 1:2:1

Symptoms of sickle cell anaemia

- A person becomes anaemic
- The red blood cells tend to change shape to sickle at low oxygen concentration
- Since they are sickle like they tend to jam and in the blood capillaries and small blood vessels hence preventing normal blood flow.
- Blocking of blood vessels causes pain in the arm, legs, back and stomach.
- Haemoglobin of suffered person is Hba while the normal persons is HbA.

Sex Linkage

It has been found out that the sex chromosomes carry genes other than those concerned with sex. They are known as sex–linkage genes because such genes are carried on the sex chromosome but have nothing to do with sex. Thus, genes located on sex chromosomes and have nothing to do with sex are called sex–linked genes. They tend to be inherited together because they are located on the same chromosome.

If sex–linked genes are carried on the Y-chromosomes they will follow the pattern of inheritance of the Y-chromosomes. If they are carried on the X-chromosome they will also follow strictly the pattern of inheritance of the X-chromosomes. Traits whose expressions are governed by sex-linked genes are called sex linked traits. The gene for colour vision in human beings is a sex linked trait since it is located on the X-chromosomes. The X-chromosome carries many such genes than the Y-chromosome i.e. the Y-chromosome has very few. Example of sex-linked characteristics in human being are:

- Colour blindness
- Haemophilia

Haemophilia

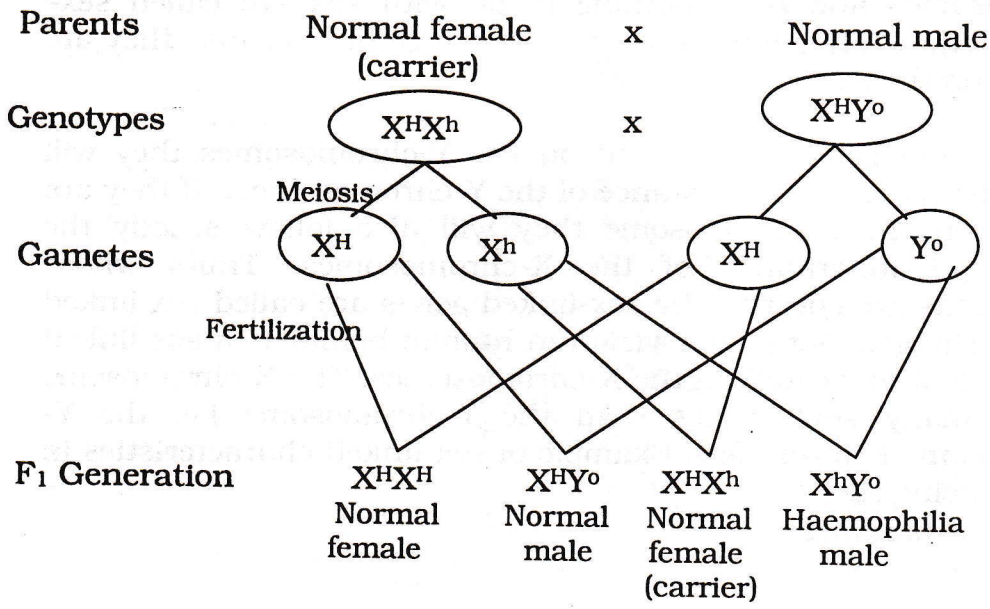
Haemophilia or bleeders disease is a sex–linked recessive condition which prevents the formation of factors Viii. These factors are important in increasing the rate of blood clotting. Haemophilia is characterized by delayed blood clotting resulting in prolonged bleeding. Even a small skin injury can lead to death due to prolonged bleeding. It is controlled by a recessive gene which is located on the X-chromosome. It can appear in two allelomorphic forms i.e. normal (dominant) and mutant (recessive).

Genotype	**Phenotype**
X^HX^H	Normal female
X^HX^h	Normal female carrier
X^HY^o	Normal male
X^hY^o	haemophilic male
X^hX^h	haemophilic female

"H" – Represents normal gene for blood clotting (dominant).

"h" – represents recessive gene for haemophilia.

Let us see a cross between normal male, $X^H Y^o$. and a heterozygous female, X^HX^h .



Colour blindness

It is a hereditary trait characterized by the inability to detect certain colours of the spectrum.

The commonest colour blindness is the inability to distinguish red from green.Colour blindness is controlled by recessive gene located in x-chromosome. It is more likely to occur in males than in females. For a male to be colour blindness, he needs to receive only one X–chromosome from his mother who is heterozygous. On the other hand, a female to be colour blind, she must receive the trait from both parents.

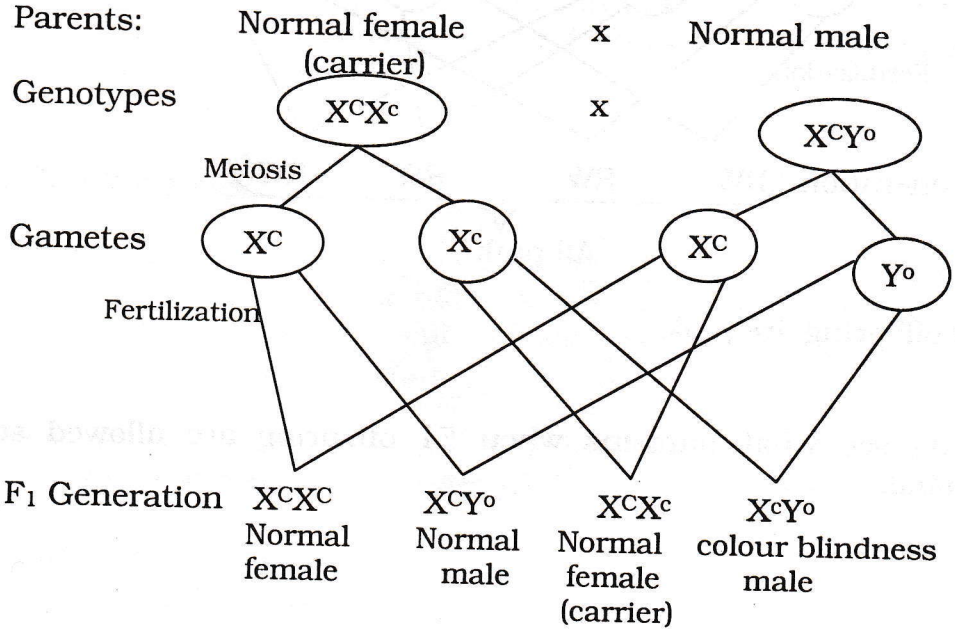
In females, homozygous individuals are colour blind; whereas heterozygous individuals are normal but carriers of the trait:

If a heterozygous woman marries a normal male, the results will be as follows:

Solution:

Let "C" represent the gene for normal colour vision. Let "c" represent the gene for colour blind.

Let a heterozygous woman be "$X^C X^c$" and normal male "$X^C Y^o$"



8.2.3 NON – MENDELIAN INHERITANCE

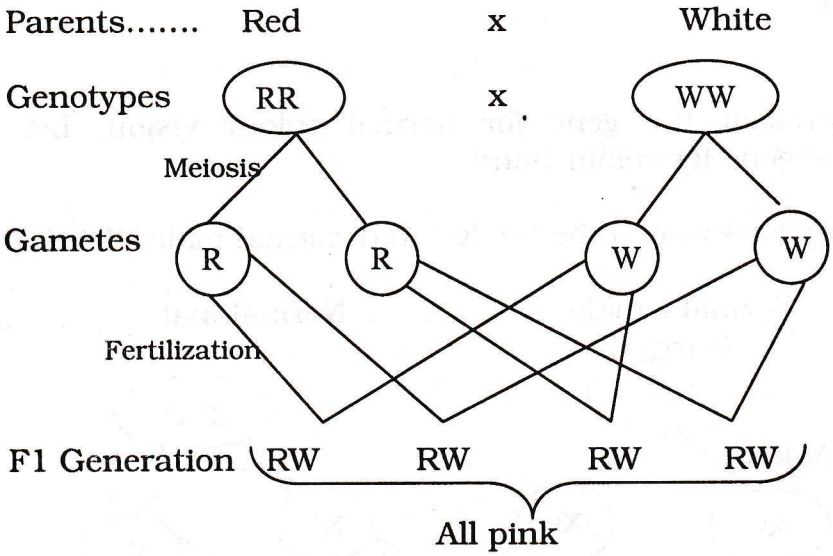
Incomplete dominance and co – dominance:

Incomplete Dominance

Studies have shown that some characters may blend or mix with others to form intermediates. These will appear in F1. When this happens, Mendelian 1st law does not apply.

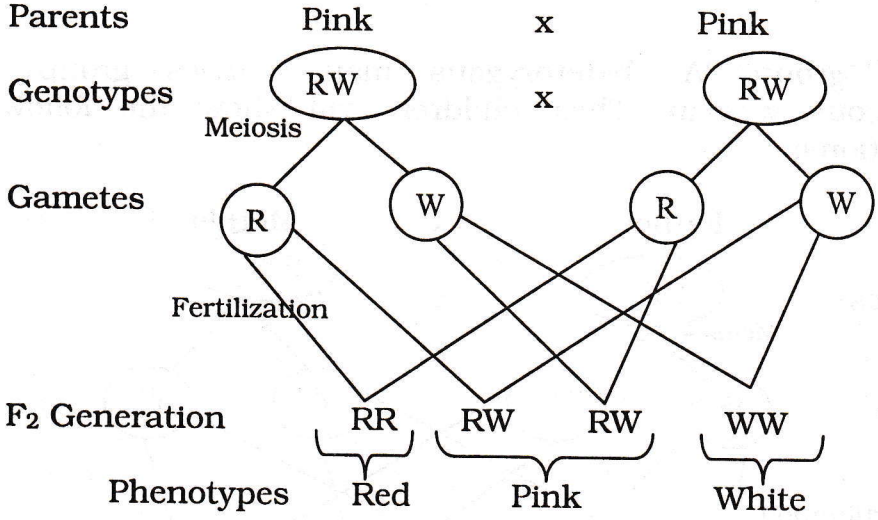
Example: When red flowers are crossed with white flowers, pink flowers are observed in F_1.

Let "R" represents red
Let "W" represents white



All offspring are pink

Let us see what happens when F1 offspring are allowed self-crossing.



Phenotypic ratio 1 : 2 : 1

This is not 3:1 since there is blending i.e. pink.

Genotype: RR RW RW WW

Genotypic ratio 1 : 2 : 1

From above it is clear that red colour is not dominant over white, also white is not recessive to red. This condition is known as incomplete dominance.

Co-Dominance

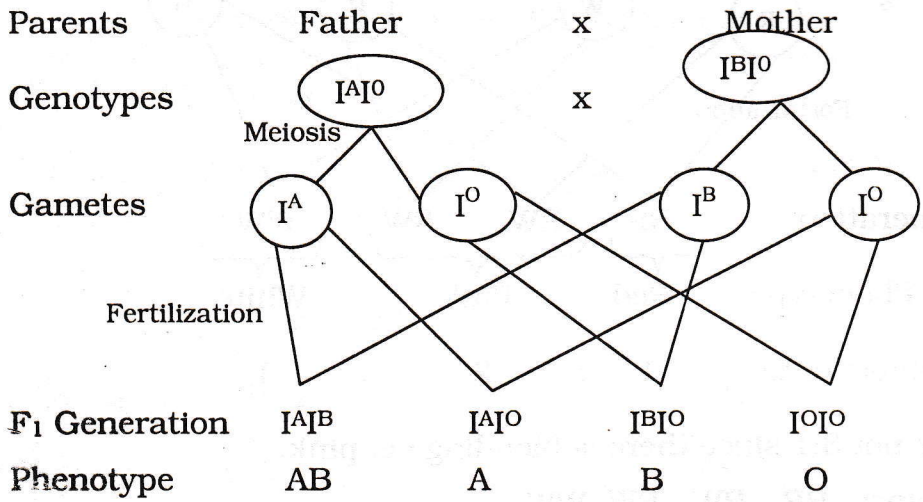
Sometimes, when two alleles are present, both are fully expressed, such a situation is known as Co-dominance. The characteristics are determined by several forms of an allele which are called multiple alleles.

E.g. In human beings blood groups there are three alleles A,B, and O. A and B are dominant while 'O' is recessive.

These occur as follows:

Genotypes	**Blood groups**
I^AI^A or I^AI^O	group A
I^BI^B or I^BI^O	group B
I^BI^B	group AB
I^OI^O	group O

Suppose group "A" heterozygous man marries group "B" heterozygous woman. Their children will show the following combinations;



NB: Co-dominance = parents characters are shared but also appear in F_1

8.2.4 SEX INHERITANCE AND DETERMINATION

We are the products of our parents; mother and father. Therefore what we have originate from them. This includes our sex. Sex is either being a female or a male.

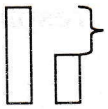
Sex Determination

Human cell (nucleus) is composed of 46 chromosomes (2n). In the gonads, these are reduced into a half (n) or 23. During fertilization, male will supply (n) 23 chromosomes and female (n) 23 chromosomes. Combination of (n+n) if successive, resembling organism will be produced. Out of 23 pairs involved, one pair is a sex pair. The remaining 22 are autosomes. A sex pair in woman contains two identical chromosomes, XX while a sex pair in a man contains non identical chromosomes XY.

During fertilization male supply only one sex chromosome – either X or Y. Female supplies only X. When combination takes place, a boy or a girl will be formed X +Y = XY (a boy) or X + X = XX (a girl). Therefore the father is responsible for children sexes. If they are imbalanced i.e. only girls or only boys or more girls than boys, he is responsible because his Y will form a boy while his X will form a girl. The mother is innocent on these problems.

NB: X is longer than Y. Y is faster than X. X has longer life span compared to Y.

From above it is clear that male may encounter problems especially when recessive harmful gene is carried by X. It may express itself in male if it falls on that area where no Y as shown below.



Any recessive gene will have effect in male if harmful.

Recessive gene will have no effect as the other X suppresses its occurrence.

8.2.5 GENETIC DISORDERS

Genetic Disorder

Certain genes cause diseases more likely in adulthood; examples are breast cancer, coronary heart diseases and diabetes. This is because gene can undergo mutation: some mutation is fatal. Some cause varying degrees of harm, generally referred to as genetic disease. But some mutations are harmless.

Genetic disorder can be caused by chromosomal abnormalities: Chromosomal abnormalities means entire chromosomes or large segments of them are missing, duplicating or alleviated. Examples of this kind are the Down syndrome, Turner's syndrome and Klinefeltres syndrome.

Down syndrome

This is due to non-functional chromosomes 21 during anaphase of the meiosis. It is more common during the female egg production. It is a failure of whole chromosomes to separate hence in meiosis II chromotids fail to separate. This is the type of mutation known as *translocation.* But can also be caused due to mother's age. Down syndrome is also correlated with the mother's age. Most children with Down syndrome show typical facial features which include;

- Eyelids which apparently start upwards.
- The face is typically flat and round.
- Mental retardation.
- Short stature and relatively small skull due to poor skeletal development.
- Heart defects occur in about one–quarter of Down's syndrome.
- Increased risk of infections, particularly respiratory and ear infections
- Course, straight hair.

Klinefelter's syndrome

This is due to extra X chromosomes. Genetically an individual is therefore XXY instead of XY and the sufferer has 47 chromosomes instead of 46. This is an example of trisomy. Characteristic of the disorder is as follows;

- Infertility – sperms are never produced, although erection and ejaculation are possible.

- Usually taller than average.

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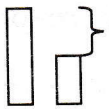

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- Infertility – sperms are never produced, although erection and ejaculation are possible.

- Usually taller than average.

- Some breast development, although this is not necessarily obvious.

- Higher than usual FSH secretion for males. FSH is follicle stimulating hormone produced by the pituitary glands in both men and women.

- Truck may show signs of obesity.

- Little facial hair.

- Voice pitches higher than normal.

- Educational difficulties and behavioural problems are fairly common.

Turner's syndrome

Turner's syndrome is due to missing X chromosomes. The genotype is therefore Xo, instead of XX.

Person suffering from Turner syndrome has the following symptoms:

- Infertility – ovaries are absent
- Averaging
- Short
- Small uterus
- Webbed neck may occur
- Puffy fingers with deep set finger nails which are more convex than normal.
- The hair at the back of the head is lower than normal

NB: Some disorder results when mutation causes the protein product of single gene to be altered or missing. Example is the sickle cell anemia.

Inbreeding and Outbreeding

Inbreeding

This involves crossing closely related individuals to maintain desirable traits.

Advantages of inbreeding: Desirable characters are maintained.

Disadvantages of inbreeding:

- **Incase** of any change i.e. environmental changes, members of **this** group will be unable to adapt.
- **There** is quality loss and poor produce

Outbreeding

This is the crossing of distantly related varieties. Such hybrids **may** show hybrid vigour.

Hybrid Vigour refers to the superiority reached in the offspring **having** the desirable traits of both parents. Example of a hybrid **produced** by out breeding is a variety of cattle called zebu

Advantages of outbreeding:

- **Quality** is improved.
- **Desirable** characters are shared.
- **New** species can be formed.

Disadvantage of outbreeding: Bad gene can be introduced

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Disadvantage of outbreeding: Bad gene can be introduced

8.2.6 GENETICS IN USE

Application of Genetics

Dear learner, can you tell me where do we apply genetics?

The main application of the genetics is to produce a new breed by crossing over two individuals of different quality characters. Therefore the inborn qualities of plants and animals can be improved by selective breeding. This is called *cross – breeding.* This process can produce new breeds of animals and plants which posses desirable characteristics of each parent.

Example

C = large grain. High production but very poor in draught resistance and diseases.

c = small grain. Poor production but very resistance to draught and diseases.

Parents CC X cc

Hence C c

Cc Hybrid

Character shared

Cc – High production

- Large seed.
- Resistance to disease.
- Resistance to drought.
- Improved seed hybrids

Animals can be crossed the same way.

Boran x Jersey/Fresian

qq QQ

q Q

Qq improved breed

Qq is improved breed with required qualities

8.2.7 SUMMARY OF THE UNIT

Genetics is the study of how characters are passed from parents to the offspring and how they are expressed. It also deals with differences in individuals of same species. Genetics is divided into heredity and variation. Heredity deals with character transmission while variation means differences in individuals. Variations are of two types;

- Discontinuous variation shows character differences with no intermediates between them e.g. blood groups.
- Continuous variation shows complete gradation from one extreme to another without any break e.g. skin colour.

Heredity is controlled by genetic material DNA which is a double helical strand made up of genes – character carrying units.
Mendel Johann G. is the father of genetics. He formulated laws of inheritance.

First law of Mendel states that "*Genes are responsible for the development of the individual and that they are independently transmitted from one generation toe another without undergoing any alteration*"; that is a pair of contrasted allelomorphs are separated or segregated when gametes are formed and only one will be expressed by a single gamete e.g. when tall and short flowers are crossed, offspring will be either tall or short.

First law gives phenotypic ratio 3:1. Incomplete dominance is one of the non Mendelian pattern giving 1:2:1 phenotypic ratio instead of 3:1 ratio.

Genetics help in determining blood group of off springs. Genetical diseases like haemophilia and sickle cell is due to sex linked character (character carried by x chromosome).

Genetics is applied in animal breeding and crop production. Improved breeds (hybrids) are produced.

Before proceeding complete the following exercise.

8.2.8 SELF CHECK EXERCISE

1. Explain the following terms
   (a) Heredity

   (b) Gene

   (c) Genotype

   (d) Recessive.

   (e) Homozygous

   ---

2. Explain the term co-dominance and give one example.

   ---

3. Mention 4 types of genetic disorders.

   ---

4. A woman with blood group "A" claims that a man with blood group "AB" is the father of her child. A blood test reveals that the child's blood group is "B". Is it possible that the woman's claim was correct? Explain you reason.

Compare your answer with those given at the end of the unit.

8.2.9 TUTOR MARKED ASSIGNMENT

1. Distinguish between these terms
   (i) Heredity and variation
   (ii) Gene and allele
   (iii) Discontinuous variation and continuous variation
   (iv) Test cross and back cross
   (v) DNA and RNA

(20 Marks)

2. In the experiment, a pure black mouse was crossed with a pure white mouse. The offspring resulted in F1, were all black. After selfing F1, 120 black mice and 40 white mice were obtained.
   (a) Identify the colour which was
      (i) Dominant
      (ii) Recessive
   (b) Show clearly how the results above were obtained.
   (c) What was the phenotypic ratio and genotypic ratio in F2?
   (d) In the results of F2, what is the probability that
      (i) The offspring were homozygous black?
      (ii) The offspring were heterozygous black?
      (iii) The white offspring and black were obtained
      (iv) The white offspring or black were obtained?

(30 Marks)

3. (a) Define the following:
      (i) Mendelian 1st law of inheritance
      (ii) Sex linked characteristics
      (iii) Sex inherited characteristics

   (b) There is a dispute in a newly wed couple. The mother has given her first birth to a baby girl who is albino. The father sues his wife for divorce on grounds on infidelity. If you happen to come across such a dispute could your genetics help to solve the dispute? Explain your reason.

(25 Marks)

4. (a) Describe the term genetic material
   (b) Discuss the importance of genetics in our daily life.
   (c) (i) Define the term cross breeding
      (ii) What are the advantages and disadvantages of cross breeding?

(25 Marks)

8.2.10 KEY ANSWERS TO SELF CHECK EXERCISE

1. (a) Heredity – is the transmission of characters from one generation to the next generation that's from parents to their offspring

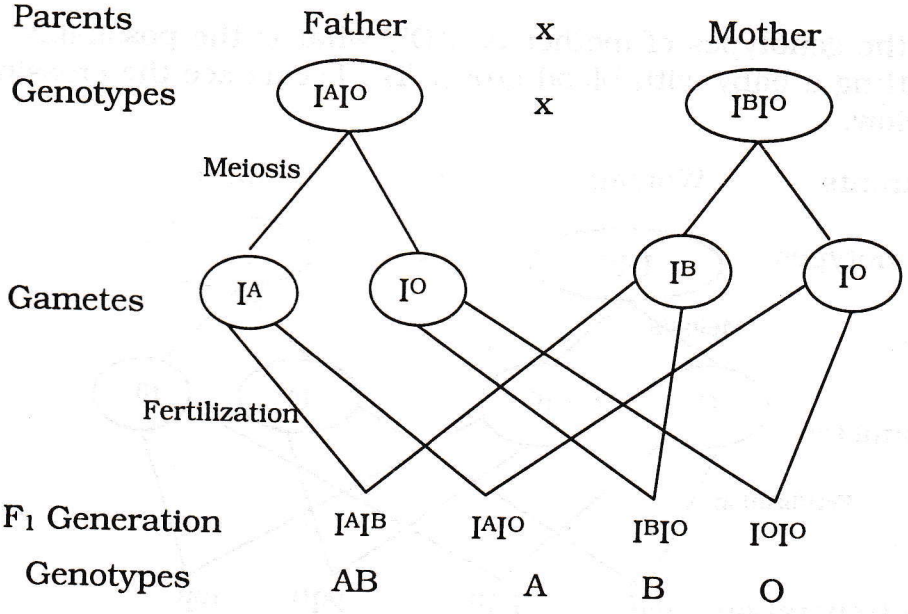
   (b) Gene is the basic unit of inheritance allele for a given character.

   (c) Genotype – is the genetic constitution of an organism with respect to the alleles under consideration.

   (d) Recessive – the allele which is suppressed (do not appear) in the F1 generation

   (e) Homozygous: the diploid condition in which the alleles at given locus are identical.

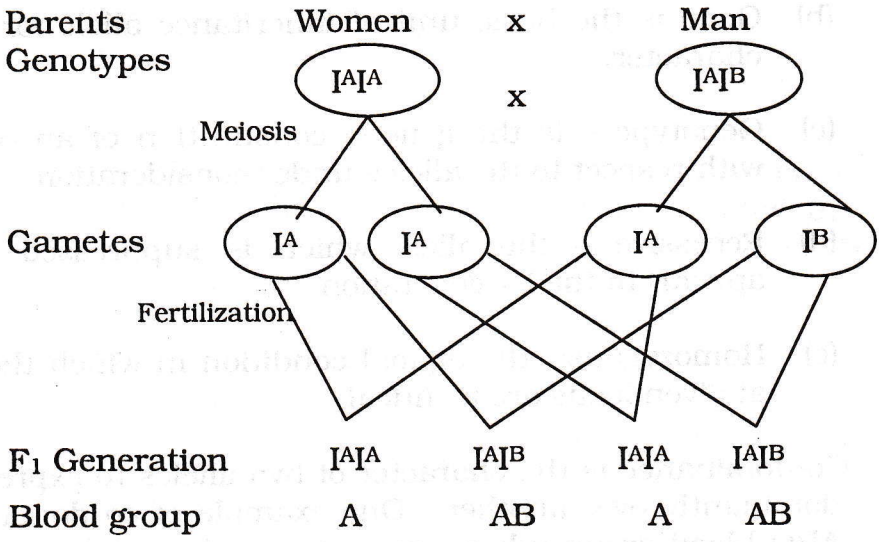
2. Co-dominance is the character of two alleles to express itself dominantly over another. One example of co dominance is ABO blood group inheritance. Parent characters are shared but also appear in F1. Suppose group A heterozygous man marries group B heterozygous woman then children will show the following combination.



3. Albinism, sickle cell anaemia, Down syndrome, turner's syndrome, Klinefelter's syndrome.

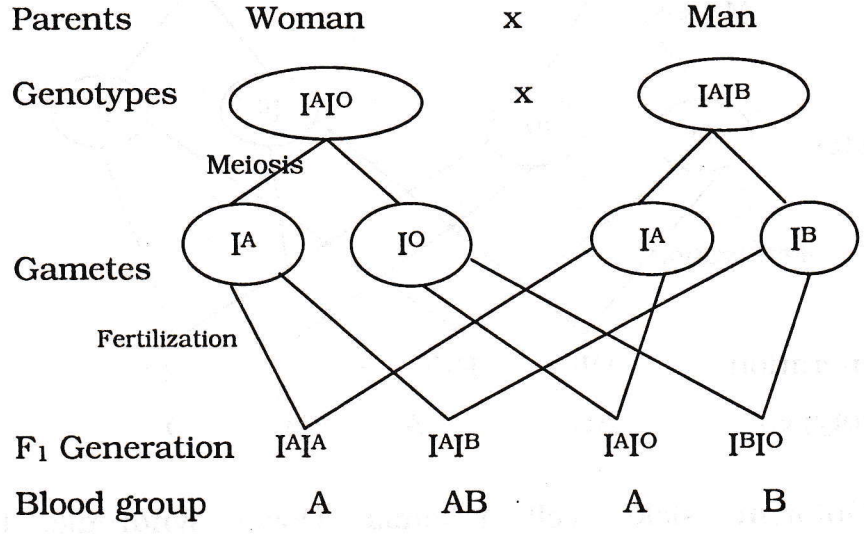
4. The genotypes of blood group "A" will be "AA" or "AO". Genotypes of blood group "AB" is "AB".

Let us see the possibility of getting a baby with blood group "B" if the genotypes of mother is "AA".



From the crossing above, the possibility of getting a baby with blood group "B" if the genotypes of mother is "AA" is zero.

If the genotypes of mother is "AO", what is the possibility of getting a baby with blood group "B". Let us see the crossing below:



From the crossing above it is possible that woman's claim was correct since among the offspring produced ¼ has blood group "B".

UNIT 8.3
EVOLUTION

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8.3.0.1 INTRODUCTION

The Earth we live on is full of different organisms. Do you know where they came from or originated? Were the past/previous organisms exactly the same as we see them today? Why individuals in a population belonging to the same species (e.g. humans) vary so much in characteristics across the continents?

These questions and others will be answered in this unit, called EVOLUTION. Evolution is the last unit in the series of the Biology course modules. Therefore, I wish you all the best in your biological life cycle.

8.3.0.2 OBJECTIVES

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

- Explain the concept of organic Evolution.
- Mention sources of evidence which support organic evolution.
- Investigate evidences and application of organic evolution in the real life situation.
- Outline the basic ideas about the origin of life.
- State the theories of the origin of life.
- State Lamarck's and Darwin's theories of Evolution.
- Outline the merits and demerits of Lamarck's and Darwin's theories.
- Explain the theory of natural selection in relation to the mechanism of evolution.

8.3.1 CONCEPT OF ORGANIC EVOLUTION

In the previous unit you learnt how characteristics are passed from the parents to the offspring. This tells us why sometimes the child looks like a photocopy of either the father or mother. He/she real looks similar to them.

In this unit you are going to learn about where organisms originate. The question like where did life originate. What was the source of life? And the theories which support evolution will be answered. You will see that people differ in this view. However, scientific evidence will always remain true since it can be proved or tested. For more information relax and join us this interesting unit.

Evolution is the development of differentiated or complex organisms from pre-existing less differentiated or simpler organisms over the course of time (millions of years) or Organisms evolve/change from simple pre – existing ones to more complex organisms over a long period of time.

8.3.2. THEORIES OF THE ORIGIN OF LIFE

There are different theories that try to explain the origin of life on Earth. The major theories are:

Special creation
States that; "life was created by a supernatural being/God at a particular time". The created organisms remain the same throughout the years despite the changes in the environment.

Spontaneous generation
States that "Life arose from non-living matter (life-less objects) on numerous (many) occasions."

Steady State Theory
Life has no origin that is, the Earth had no origin and undergoes little changes if at all. Likewise, species had no origin. That is the Earth has always been able to support life.

Cosmozoan Theory
"Life arrived on this planet (the Earth) from elsewhere in the universe."

Biochemical Evolution Theory
"Life arose according to chemical and physical laws." Despite all these theories, no single theory was certain/sure to justify how life originated on Earth. They were just speculations (no truth in them). With further studies, biologists came up with a new theory to explain the origin of life on Earth.

The Theory of "organic evolution"
Organic evolution is the gradual (progressive) development of organisms from pre – existing simple forms to more complex forms over time. This process of change in structure (form) and function is determined by gradual change in the genetic composition of a population over time through the generations. The mechanisms of organic evolution involve natural selection. Let us now learn how Lamarck's and Darwin's theories support organic evolution.

8.3.3. LAMARCK'S THEORY OF ORGANIC EVOLUTION

One of the biologists who tried to explain organic evolution was Jean Lamarck. He formulated a theory known as Lamarkism. "The theory of use or disuse of body parts and inheritance of acquired characteristics." Lamarck arrived at his theory of organic evolution through the following deductions:

- The environment in which organisms live is constantly (always) changing.
- A change in the environment creates new needs in the organisms living in it.
- The new behavour leads to use or disuse of certain organs in the organisms.
- Frequent uses of a body part/structure leads to greater morphological (structural) and functional development (the structure)
- Disuse of organs makes them become small in size and sometimes disappear altogether.
- The organs acquire new characteristics which are passed to the next generation i.e. are inherited.

Example 1

The ancestor of giraffes had short necks and short legs. Because the land was so dry with no grasses, these giraffes had stretched their necks and legs in order to feed leaves on tall trees. The long necks and legs characteristics were passed (inherited on to the next generations up to the present giraffes.

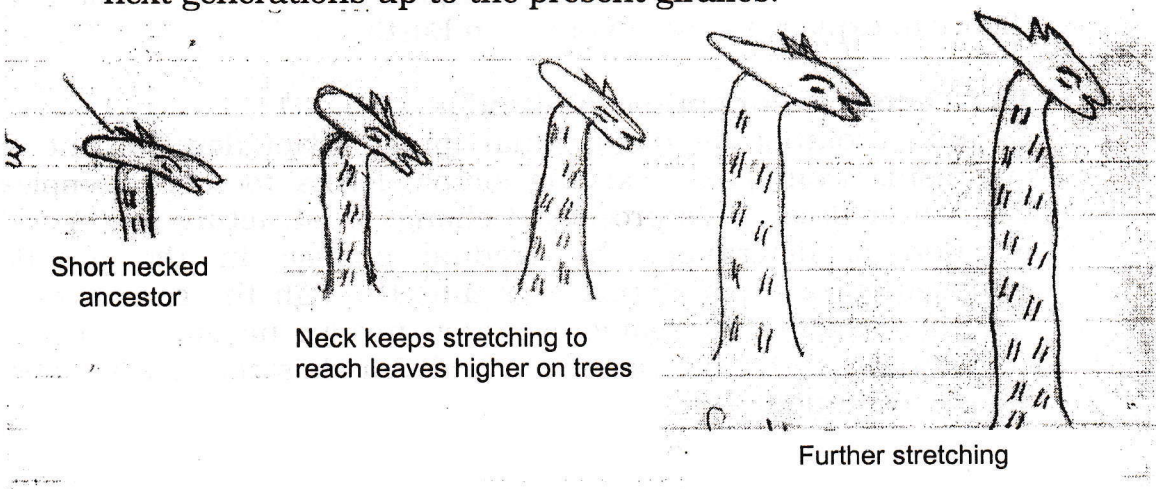

Figure 8.3.1: ***Development of a Modern long necked giraffe as explained by Lamarck***

Example 2

The web between the toes of aquatic birds e.g. ducks, developed due to frequent spreading of the skin between the toes in order to swim and search for food in water and escape (run away) predators/enemies.

Merits of Lamarckism

- The law of use or disuse of organs (structures) is correct.
- Eg. Body building exercises, increase the size of muscles.
- Lamarck was also correct to say that environmental changes cause changes of the phenotypic characteristic in organisms.

Demerits of Lamarcksim

- Acquired characteristics (traits) or characters learned from the environment are non-genetic and do not influence the genotype. Therefore, cannot be inherited by off springs.

E.g. If you cut off the tails of parent rats over generations, the new born rats always will have long tails. It means that body cell do not transmit characteristics to the next generations.

8.3.4. DARWINS THEORY OF ORGANIC EVOLUTION

Another great biologist on organic evolution was Charles Darwin. He came up with the theory of organic evolution by natural selection to explain the origin of life (species).

Natural selection is the mechanism by which new species arise. He based his theory on the following observations in the environment.

Observation 1
Individuals within a population have a high rate of reproduction (high reproductive potential) i.e. they over reproduce.

Observation 2
The numbers of individuals in a population remain more or less constant. From the two observations, Darwin deduced that;

Deduction 1
- Many individuals fail to survive or reproduce.
- There is struggle (competition) for existence (survive) with a population for resources like food, space (plants) and mates

Observation 3
There is variation of individuals within all populations.
E.g. the human populations are not exactly the same in characteristics. They vary in height, type of hair, skin colour, type of nose, sex etc.

Deduction 2
During the struggle for existence, individuals with variations best adapted to their environment are able to reproduce offspring than those less well adapted organisms. The offsprings of these naturally selected organisms will inherit many of their parents' favourable characteristics and continue to reproduce.

Merits of Darwinisms:
- He was right to say that species arise from pre-existing ones over time.
- Individuals within a population vary so much.
- Individuals of a population struggle/compete for survival for resources like food, space and mates and only those who win in the struggle are able to survive and reproduce i.e. the environmental conditions have favoured them (natural selection).

Demerits of Darwinism:

- Darwin failed to explain how life originated on the Earth. He just tried to explain how new species originate.

- He did not understand how organisms keep on varying in each generation on which natural selection could act. In other words, he had no knowledge in genetics.

- Natural selection is not always negative/destructive/ damaging but can be a positive (good) mechanism) of adjustments within a population.

- He was wrong to say that humans descended from apes because up todate, apes have remained the same while evolution takes place in each population. This is the descent the theory humans posses of special creation which is believed by the people in religions.

8.3.5 EVIDENCE OF ORGANIC EVOLUTION

How do you know that evolution is taking place?

Observations have shown that the process of evolution is slow. Dear learner it takes millions of years for any significant change to be noticeable as an evolutional change. This means that organic evolution can not be easily proven by experiments. Thus scientists approach the subject by referring to the evidences that support the idea that evolution is taking place.

The following are the evidences of organic evolution:-

- Fossil record
- Comparative embryology
- Comparative physiology
- Comparative anatomy
- Geographical isolation
- Vestigial organs
- Behaviour affinities
- Classification.

Evidence from fossil record or palaeontology

Fossils are the remains of plants and animals that lived millions of years ago. These remains are usually of bones or teeth of animals and roots, leaves or stems of plants. When fossils are arranged on a time scale from the earliest to the most recent forms, the following are revealed,

- The more recent the fossils, the more complex and the more they tend to resemble the living species.
- Older fossils, in general differ more from the present day organisms.

This means that organisms have been changing with time. The extinct organisms represent the ancestors from which the organisms living today originated.

Comparative anatomy

Comparative study of the anatomy of groups of animals or plants reveals that certain structural features are basically similar.

For example, the fore limb bones of nearly all the vertebrates (animals) are built basically on the same pattern with similar bones arrangement in about the same order and position. This similarity implies that those organisms arose from a common ancestor which had that basic plan.

For example: - Forelimbs of whale, human being, birds, horse, bat. See fig 8.3.2 for more details.

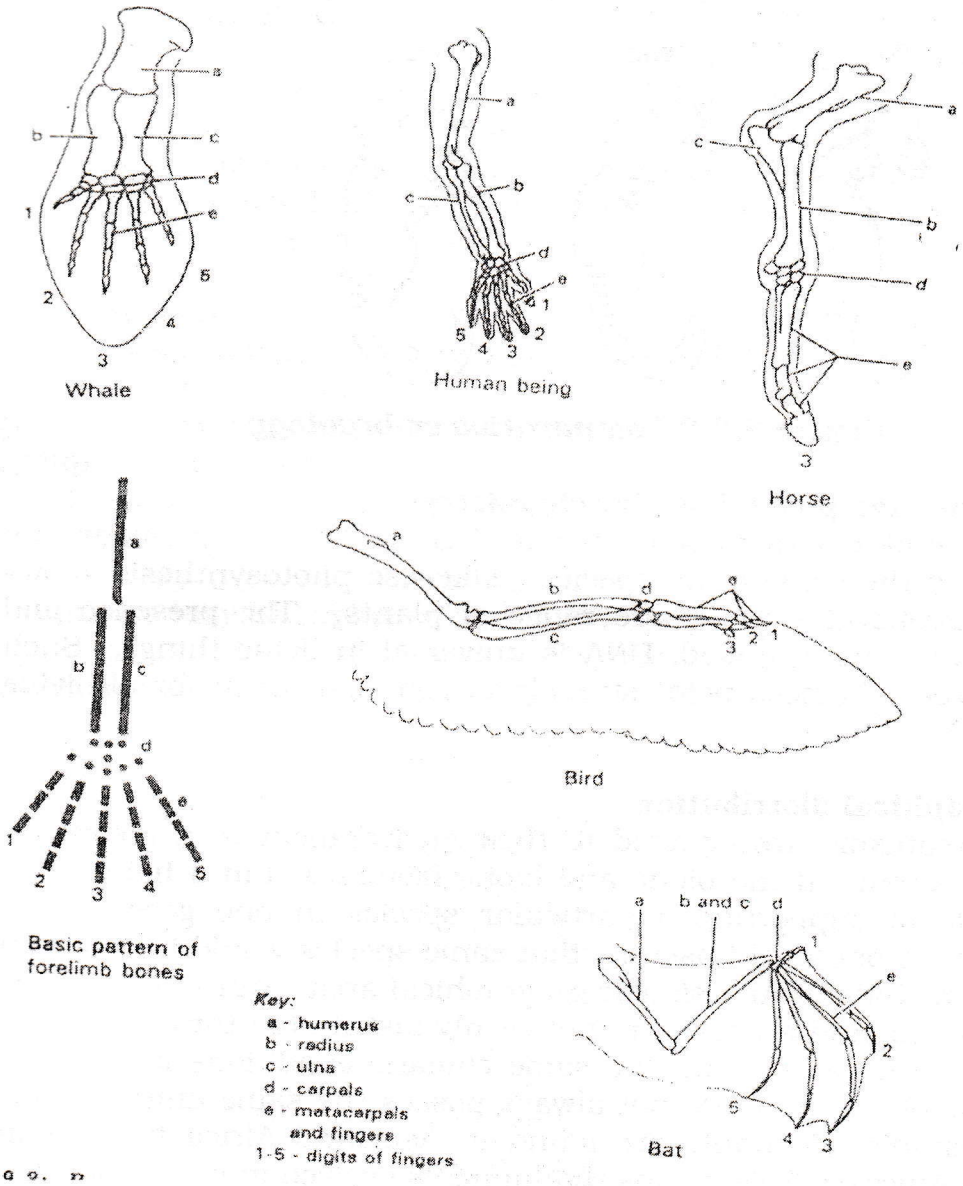

Figure 8.3.2: Bone arrangement in the forelimbs of man, horse, bird, bat and whale

Comparative embryology

The study of the development of the embryos of related animals shows great similarities. For example, at certain stages of embryonic development some groups of animals (vertebrates) look very similar. For example the embryos of fish, frog, reptiles, birds and mammals are very similar at early stages of development. This suggests that all vertebrates arose from a common ancestor (see fig 8.3.3.).

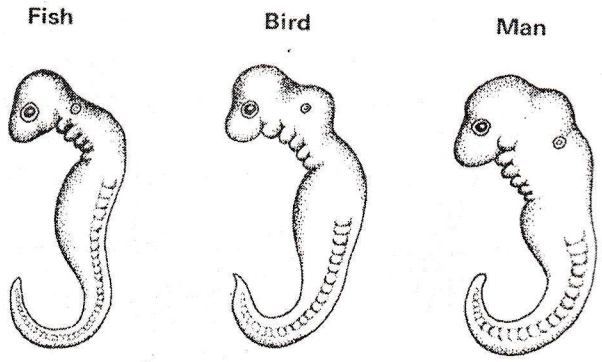

Figure 8.3.3 Comparative embryology

Comparative physiology (biochemistry)

The complex reactions of respiration in living organisms are basically the same in all species. Likewise photosynthesis shows great similarities in a wide range of plants. The presence and function of nucleic acid, DNA is universal in living things. Such basic resemblances point strongly to common origin for all living things.

Geographical distribution

The organisms are adapted to their environment to a greater or lesser extent. If the biotic and biotic factors within a habitat are capable of supporting a particular species in one geographical area, then one might assume that same species would be found in a similar habitat in a similar geographical area. But studies show that plants and animals are not evenly distributed throughout the world. The places with the same climatic conditions in different regions of the world do not always posses the same animal forms for example, elephants are found in Asia and Africa but not in South America. This means that animals evolved in certain locality and spread into those habitats which they could reach.

Vestigial organs

These are small or non-functional imperfectly developed organs. Many organisms have obvious structures which seem to serve no useful purpose but which continue to be developed from one generation to the next. For example in man the caecum appendix and coccyx.

Behaviour affinities

This shows that organisms whose patterns of behaviour are similar are more likely to be closely related than those whose behaviour is very different. For example, a young chimpanzee is held by its parents in a way comparable to the way in which human babies are held or nursed. This shows that chimpanzees and humans have common ancestry.

Classification

Most classifications we use today are natural and phylogenetic. A phylogenetic classification is one based on evolutionary relationships. In such a system organisms belonging to the same groups are believed to have a common ancestor. The structural similarity between organisms which forms the basis of a natural system of phylogenetic classification, suggests the existence of an evolutionary process. These similarities and differences between organisms may be explained as the result of progressive adaptation by organism within each taxonomic group to particular environmental conditions over a period of time.

8.3.5. SUMMARY OF THE UNIT

- Evolution is defined as the gradual change of organisms from simple pre-existing ones to more complex ones over a long period of time (millions of years).

- Different theories explain the origin of life e.g Special creation, spontaneous generations, steady state, cosmozoan and Biochemical evolution theories.

- Organic evolution incorporates gradual change in genetic make up of pre-existing organisms to get more complex organisms over time.

- Lamarck explained organic evolution basing on use or disuse of body parts and the influence of the environment on organism basing on inheritance of acquired characteristics.

- Darwin explained organic evolution basing on natural selection through observations and deductions. Organisms over reproduce and struggle for existence.

- There is also variation among individuals belonging to the same population. Those with favourable variations adapt while those with unfavourable adaptations are wiped out. Both Lamarck's and Darwin's theories have merits and demerits.

The following give evidence to organic evolution;

- Palaeontalogy/fossil record.
- Comparative embryology
- Comparative physiology
- Comparative anatomy
- Vestigial organs
- Classification
- Geographical isolation
- Behaviour affinities

Before proceeding complete the following exercise.

8.3.6. SELF CHECK EXERCISE THREE

1. What is organic evolution?

---

2. State the main ideas of special creation.

---

3. What is natural selection?

---

4. List down the evidences of organic evolution.

---

5. Explain in terms of natural selection how aquatic birds developed webbed toes.

Compare your answers with those given at the end of this unit.

8.3.8 TUTOR MARKED ASSIGNMENT

Now answer the following questions in the workbook provided and send to your Tutor for marking and commenting.

1. (a) Explain the meaning of organic evolution
   (b) Outline three theories which explain the origin of life
   (c) Among the theories you have outlined in (b) above which one is true? Give reasons.

(25 Marks)

2. (a) Write down the main points of Darwin's theory of organic evolution
   (b) How could Darwin explain the long neck of giraffes in relation to evolution?
   (c) Explain the observation and deductions of Lamarkism theory of organic evolution.

(25 Marks)

3. With examples explain how the following support the theory of organic evolution:
   (a) Comparative embryology
   (b) Comparative anatomy
   (c) Serology
   (d) Cell biology.

(25 Marks)

4. With examples distinguish between
   (a) Homologous and analogous features
   (b) Convergent and divergent evolutions
   (c) Survival for the fittest and natural selection
   (d) Vestigial organ and paleontology
   (e) Speciation and species

(25 Marks)

8.3.9 KEY ANSWERS TO SELF-CHECK EXERCISE

1. Organic evolution is the gradual change of organisms from pre-existing simple focus to more complex focus over time (millions of years).

2. The main idea of specials creation is that, "life was created by a supernatural being/God at a particular time."

3. Natural selection is a selection force which operate on variations.

4. - Evidence from fossil records
   - Palaeontalogy/fossil record
   - Comparative embryology
   - Comparative physiology
   - Comparative anatomy
   - Vestigial organs
   - Classification
   - Geographical isolation
   - Behaviour affinities

5. Due to lack of food on the dry land, some birds had to look for food in water. In order to swim, they developed the web between their toes. These birds were naturally selected. They passed on the webbed toes characteristics to their off springs up to date.

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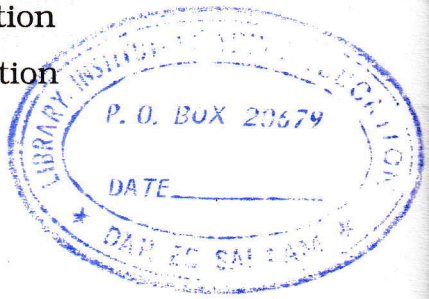

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OPEN AND DISTANCE LEARNING

BIOLOGY

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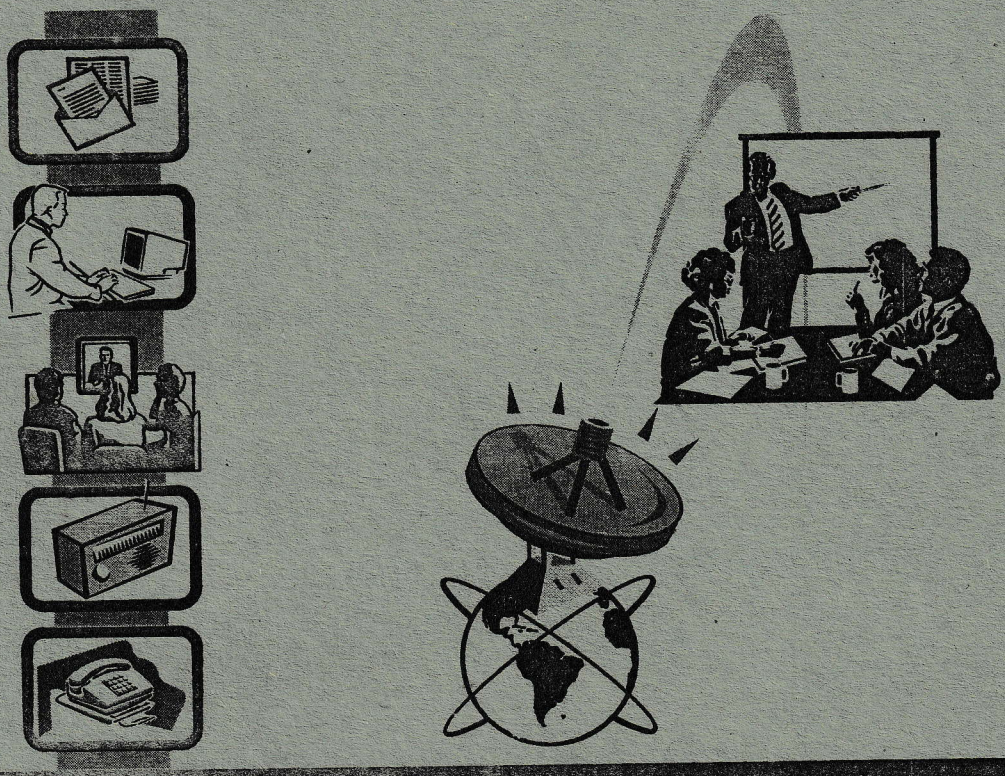
MODULE 6

Movement, Coordination and Regulation



Unit 6:1 Movement
Unit 6:2 Coordination
Unit 6:3 Regulation