

Major Concept



6.1 Introduction

It is a matter of common observation that the offspring of all organisms resembles their own parents. Man has long been aware that "like beget like" i.e. it is one of the characteristics of living things to reproduce their own kind. Frog always produces frogs, whereas of garden pea produces garden pea plants. These offspring's would show similarities to their parents. The characteristics of the offspring's to resemble their parents is called **heredity**. The branch of biology which deals with the study of heredity and Variations is called **genetics** whereas the process by which characters are transmitted from parents to off springs is called **inheritance**.

Living things when reproduce sexually, their offspring differ somewhat from their parents. They show resemblance with one another as well as with their parents but they are not their exact copies, even than the brothers and sisters of one parent, neither resembles exactly with one another nor with their parents. Similarly puppies of the same litter are not exactly alike. The same is true about plants, such differences are called **variations**.



Fig. 6.1 variable offspring of some parents.

Genes control inheritance of characters:

Life of every organism; every character of his structure; function and behavior, at all levels of biological organization is programmed and controlled by a set of instructions. These instructions are in the form of coded biological information called **genes**. This biological information to offspring is passed through egg and sperm (gametes)

which are the sex cells. You have also received your genes from your parents and they received their genes from their parents. Thus you and your brother and sisters share many genes of your parents and even of your grandparents. So the inherited characters are determined by genes which are transmitted from generation to generation. Therefore we can say that “Heredity is the way by which genes transmit characters from parents to offspring”.

As we know that each kind of organism has specific number of **chromosomes**. These numbers and shapes remain constant in all individual of a species generation after generation.

All human contains two sets of 23 chromosomes. One haploid set ($n=23$) is paternal in origin, which is contributed by sperm while the other haploid set ($n=23$) is maternal which comes from egg. The genes are located at chromosomes and inherited through chromosomes during sexual reproduction. The two chromosomes which are similar in their shape, size and position of centromeres present in a cell make one **homologous** pair of chromosome. These homologous sets of chromosomes provide the physical basis of heredity of an organism.

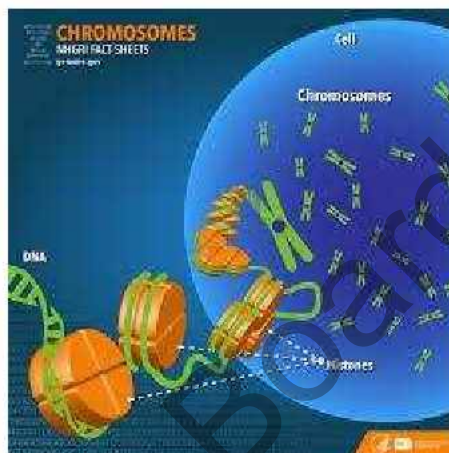


Fig. 6.2 Chromosome

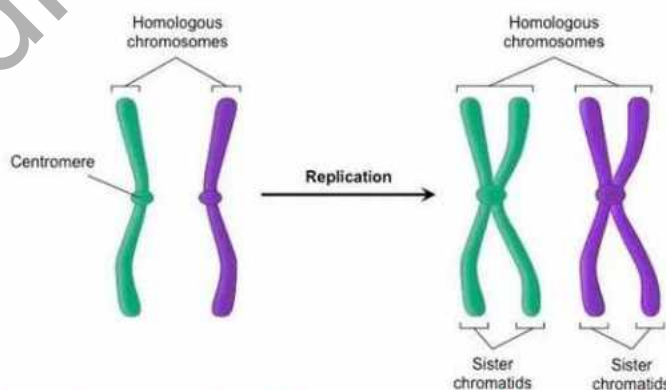


Fig. 6.3 homologous pairs of chromosomes of an organisms

6.2 CHROMSOMES AND GENES

As we know that the chromosomes are fixed in number and shape in the members of a species. These chromosomes contain many genes. Now the question arises what is the composition of chromosomes and genes?

Chemical Composition of chromosome:

The chemical material of chromosome is called **chromatin**, which is basically a **nucleo-protein** (Deoxyribo Nucleoprotein). It is composed of DNA (40%) and special protein i.e Histone (60%). DNA (Deoxyribo Nucleic Acid) is made up of billions of units called Deoxyribo Nucleotides. Each nucleotide is made up of deoxy ribose sugar ($C_5H_{10}O_4$), phosphoric acid (H_3PO_4) and Nitrogenous bases as shown below

3 Parts of a Nucleotide

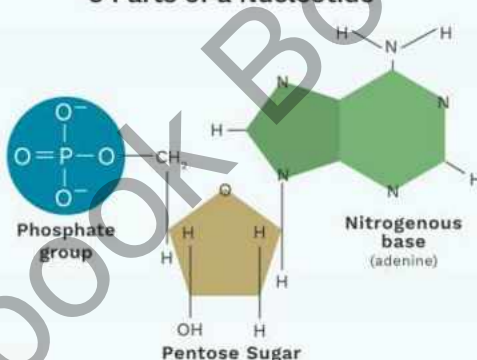


Fig. 6.4 Chemical structure of a nucleotide

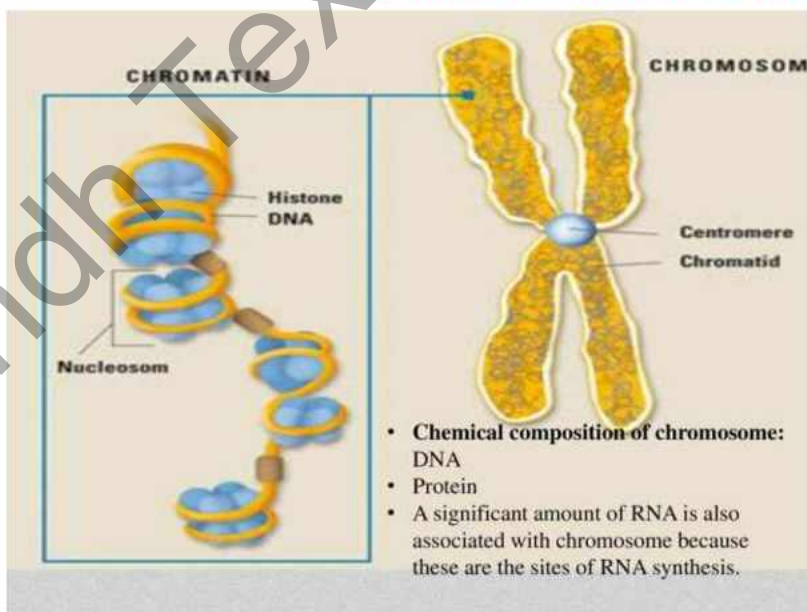


Fig. 6.5 Chemical Composition of



The DNA of a chromosome exists as one very long double stranded fiber, a duplex, which extends unbroken through the entire length of the chromosome. This long DNA is coiled to fit into a much smaller spaces.

If the strands of DNA from a single set of chromosome in nucleus were laid out in a straight line, it would be more than 7 feet (2 meter) long. This is too long to fit into a cell.

How coiling of this long DNA is coiled in very small chromosome and nucleus of cell?

If we gently disrupt a eukaryotic nucleus and examine the DNA with an electron microscope, we find that it is because the histone is positively charged while DNA is negatively charged. This beads of histone and DNA is called nucleosome, when the string of nucleosomes wraps up into high order coil called super coil. This super coiled chromomers form chromosome.

6.2.1 GENE A LOCALISED PART OF DNA

To understand the nature and composition of gene we must know about structure of DNA because gene is the localized part of DNA which has a coded information to synthesize a protein which works as enzyme.

Brief structure of DNA

The model of DNA was suggested by Watson and Crick in 1953. This model is based on X-Rays Photographs and chemical analysis of DNA. According to this model

- DNA is a double helical structure.
- Each helix is a polynucleotide chain which are twisted around each other.
- The outer part is called **Upright**, which are made up of deoxyribose sugar and phosphate. The inner part called **Rungs**, made up of paired nitrogenous bases.

- Both helix are complementary to each other which are held together by hydrogen bonds.
- The complementary helix have complementary base pairs i.e Adenine pairs with Thymine and Cytosine always pairs with Guanine.

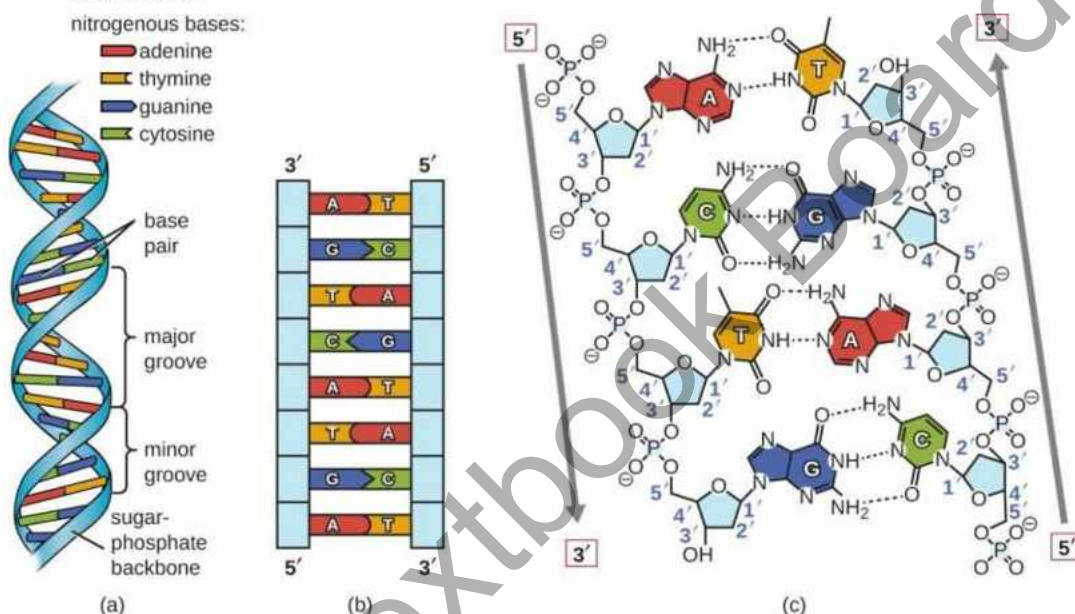


Fig. 6.6 Structure of DNA

Gene:

Gene is the small segment of DNA which has genetic information in the form of code to synthesize a protein. It is the basic unit of biological information. Each gene is located at specific position on chromosome, this position of gene on chromosome is called **Gene locus (loci)**. Each gene has a specific function e.g. a gene determines the height of plant; another gene determines the colour of their petals etc.

The coded information may change due to any reason which is called genetic variation caused by mutation. This genetic variation among offspring leads to tremendous variety in their traits. This variation in the genes of a trait gives rise to two or more than two alternative forms of a gene. These alternative forms of a gene are called



alleles or **allomorph**. Some genes may have as many as 300 alleles. A diploid cell thus any two of these multiple allele while a haploid have one allele.

Gene is a Unit of inheritance which is copied and Inherited to the next Generation

The complementary arrangement of nucleotide is of great importance in DNA molecule. If the sequence of bases in one strand is known, the sequence of bases in the other strand will be automatically known due to specific base- pairing. This property of the two strands of double helix makes DNA a unique molecule best suited to store, copy and transfer genetic information from generation to generation.

DNA is able to make its exact copy itself in nucleus of cell before cell division. This process of duplication of DNA is called **replication** of DNA. Gametes are haploid cells, carry one copy of replicated DNA. This copy carry genes from parents to offspring through these gametes.

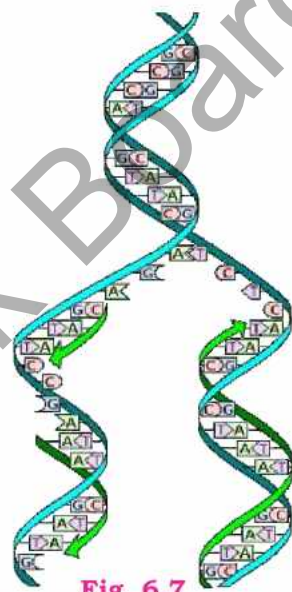


Fig. 6.7
Replication of DNA

The Watson and Crick model of DNA ideally proposed the mechanism of self replication. The hydrogen bond that hold together the double helix of DNA are broken up from one end to another end like a zip. The double helix gradually “unzip” along its length and each new nucleotide of the complementary nucleotide would be added to separate chains sequentially.

The Central Dogma of Protein Synthesis by Gene:

The term central dogma means a set of beliefs where a gene expresses by synthesizing a protein. This protein work as an enzyme, which carry down a chemical reaction to produce a metabolic product. This metabolic product either develops a character or lead to develop a character.

DNA is located in the nucleus of eukaryotic cell while most of the synthesis and metabolic reactions occur in cytoplasm under the instructions of DNA (genes). Therefore DNA requires some other molecules to carry its genetic information from nucleus to cytoplasm. These molecules are different type of **Ribo Nucleic Acids** or **RNAs**.

Genetic information flows in a cell from DNA to mRNA than to ribosome in cytoplasm, which is two step process for protein (enzyme) synthesis.

1. Transcription:

The step of protein synthesis where information which contained in a specific segment of DNA (gene) is copied in complimentary form (genetic codes) i.e. RNA. This RNA carry information of DNA sequences to ribosome from nucleus to cytoplasm called messenger RNA or **mRNA**. The process of copying DNA information to mRNA is called **Transcription**.

2. Translation:

In the second step two other types RNA: transfer RNA (tRNA) and ribosomal RNA (rRNA) translate the information of messenger RNA into the specific sequence of amino acids which help to synthesize the protein.

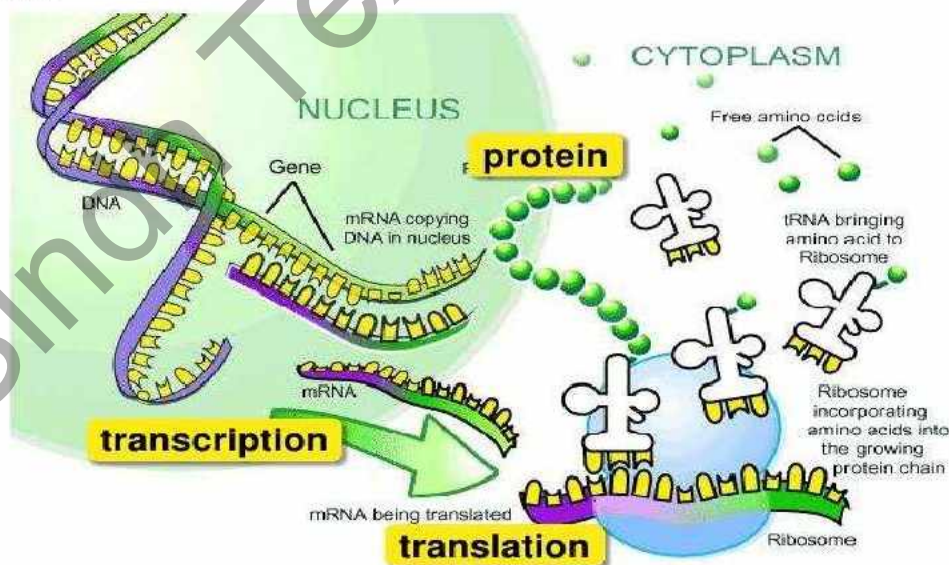


Fig. 6.8 Translation from gene to protein

6.3 MENDEL AND HIS LAWS OF INHERITANCE

Gregor John Mendel, an Austrian Monk carried out breeding experiment with garden pea (*Pisum sativum*). He explained the mechanism of heredity. He is known as **Father of Genetics**. He studied seven traits (characters) in pea plants one by one i.e. height, seed shape, pod shape, seed colour, flower colour, flower position, pod colour. He has chosen to study the contrasting pairs of these above traits because they were easily distinguishable like Tall and Dwarf. These varieties continued to produce offspring identical to their parents generation after generation, as long as they were self-pollinated such varieties are called true breeders and their offspring are pure-breeds.



Fig. 6.9
Gregor John Mendel

Pure-breed means that if an organism is self fertilized, the offspring always look exactly like parents e.g. if a parent pea plant is tall and have purple flowers perform self pollination to produce next generation, the offspring will always be tall and have purple flowers.



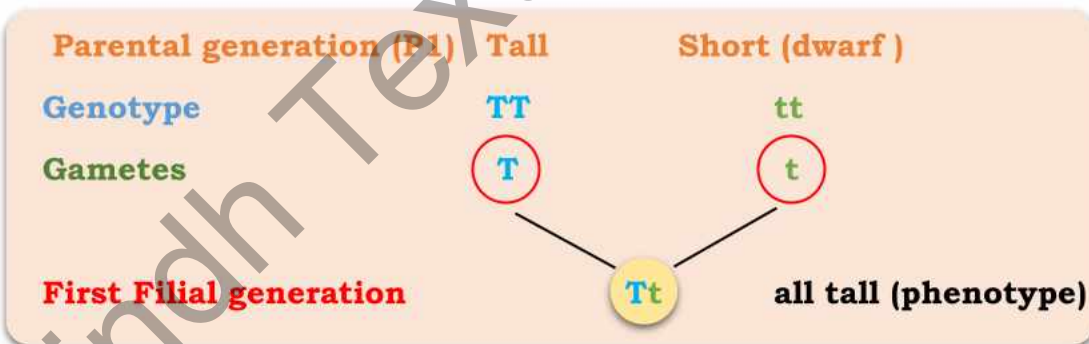
Fig. 6.10 Pea plant

Mendel's study was based on these seven pairs of contrasting characters but considering the inheritance of single pair of contrasting characters at a time. He counted and recorded the parents and offspring of each of his cross. His keen interest in mathematics led him to the formulation of certain hypotheses which led him to present laws of Genetics.

6.3.1 Mendel's experiment and Law of Complete Dominance:

Mendel took gene as factor; he told that both parents donate one factor of a trait. If both the parents donate same factor of the trait, the organism is pure or **homozygous** for this trait like pure Tall i.e. TT, same as the pure short (dwarf) i.e. tt is also **homozygous**. On the other hand if both parents donate different factors (allele) of a trait, the organism is **hybrid or heterozygous** for the trait i.e. Tt for tall.

In one of his experiments, he took pure tall stem and short stem varieties and crossed them. All the seeds were collected and allowed to grow. He founded that all the plants were of tall stem, no plant with intermediate stem were found to grow in this generation. He repeated his experiment on pea plants with different traits having contrasting characters, found same result than he presented the **law of dominance**. According to this law, when a pair of contrasting characters (heterozygous) is brought together in a cross, only one factor will express in the offspring while other will be masked. It means that in heterozygous condition one factor is completely dominant over other.



From above experiment some terms came into light which are commonly used in genetical studies.

6.3.2 Common terms used in Genetics:

Dominant:

The factor (gene) which express and masks the expression of other factor in heterozygous condition is said to be Dominant factor. Mendel represent it with capital letter like T for tall.

Recessive:

The factor which is unable to express or masked in heterozygous condition is said to be recessive. It represents by small letter of same alphabet like t for small (dwarf).

Phenotype:

It is the physical appearance of the trait on the basis of inherited genes like tall, dwarf, round seed, wrinkled seed etc.

Genotype:

The genetic makeup or genic constitution of a trait like TT, Tt, tt etc.

Homozygous:

An individual having same factors (allele) of a trait called **homozygous**. For example, TT (factor for tallness).

Heterozygous:

An individual having different factors of a trait called **heterozygous**. For example, Tt (factors of tallness and dwarfness both).

Parental generation (P1):

The original true breeding organisms were called **parental generation** or **P1** by Mendel.

Filial one generation or F1:

the offspring of true breeding organism were called **First Filial Generation** or **F1**.

Second Filial generation or F2:

The offspring of filial one generation produced by crossing self fertilization were called **Second Filial generation** or **F2**.

6.4 MENDEL'S LAW OF SEGREGATION OR LAW OF PURITY OF GAMETES

Mendel when crossed pure tall and dwarf plant and got all tall plant in F₁ generation but unlike the P₁ tall, these plants of F₁ generation were heterozygous. Mendel did not stop his experiments here. He planted all the seeds of F₁ generation and allowed them to self pollinate. He observed that in the next generation (F₂), both the parental types, i.e. tall and dwarf stem varieties were produced. When he counted these, he found that in F₂ generation, the two types of the individuals were present in a ratio of 3:1 tall and dwarf respectively. Mendel perceived from these results that when the plants of F₁ generation form their gametes, the factors (allele) separate or segregate again in such a way that only one of the two alleles enters each gamete. On the basis of these observation he presented the “Law of segregation” this is also called **law of purity of gametes**. This law states that in an organism, the factors (genes) exist in pairs but during gametes formation these factors segregate cleanly from each other, so each gamete has only one factor of a trait.

Alleles separate during gamete formation.

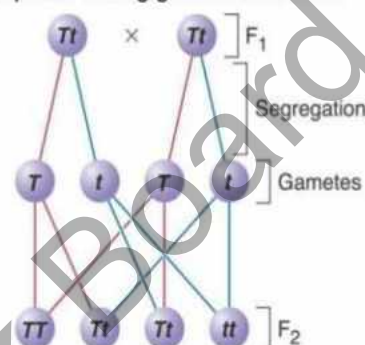


Fig. 6.12 Alleles separation during gamete formation

6.5 MENDEL'S LAW OF INDEPENDENT ASSORTMENT:

Mendel's experiments on garden peas were not limited to a single trait as explained in law of segregation, but sometimes involved two or even more characters. He crossed between two individuals (pea plant) differing in two traits which he called Dihybrid –Cross and the ratio obtained in F₂ generation called Dihybrid-ratio. The results achieved as a consequence of dihybrid-cross is known as Inheritance of two traits.

When Mendel crossed yellow cotyledon and rounded seed containing plant with green cotyledon and wrinkled seed containing plant. The F₁ generation had all plants with yellow cotyledon and

round seeds. This proved Mendel previous findings that allele for round seed is dominant over wrinkled while yellow cotyledon over green.

Mendel self fertilized the F₁ generation, expecting either of the two following possibilities:

(a) If the genes for round seed and yellow colour are inseparable (dependent on each other), as well as those for wrinkled shape and green colour, then in F₂ generation $\frac{3}{4}$ of the seeds will be round and yellow and $\frac{1}{4}$ will be wrinkled seed and green.

(b) If the genes for seed shape and cotyledon colour are separable (independent) and distributed to the gametes independent to each other, then in F₂ generation some plants produce round seeds with green cotyledon and some have wrinkled seeds with yellow cotyledon will also be expected along with parental combinations.

Mendel actually obtained four different kinds of phenotype in F₂ generation. Out of a total 556 seeds, he obtained four different phenotypes i.e

Round and Yellow seeds = 315, Wrinkled and Yellow seeds = 101

Round and Green seeds = 108 Wrinkled and Green seeds = 32

Genotypes for round and yellow seeds RRYY, RRYy, RrYY, RrYy

Genotypes for round and green seeds RRyy, Rryy.

Genotypes for wrinkled and yellow seeds rrYY, rrYy.

Genotypes for wrinkled and green seeds rryy.

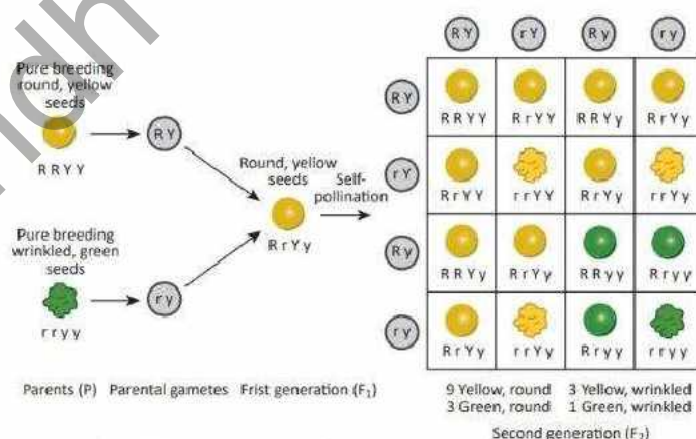


Fig. 6.13 Expected ratio in dihybrid cross.

These numbers are in a ratio of about 9:3:3:1 for the four phenotype it showed that the genes for seed colour and shape are independent in their inheritance. They do not necessarily stay together in the combination in which they occurred in parents.

This observation led to the formation of **Mendel's law of Independent assortment**. It is stated that the genes of assorted traits are independent in their inheritance

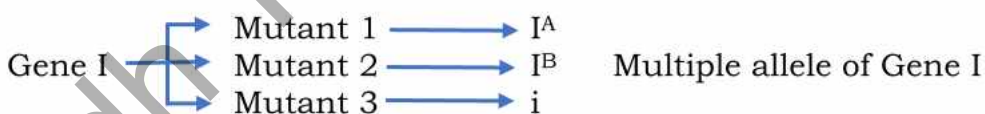
OR

“Members of one pair of genes separate from each other during gametes formation”.

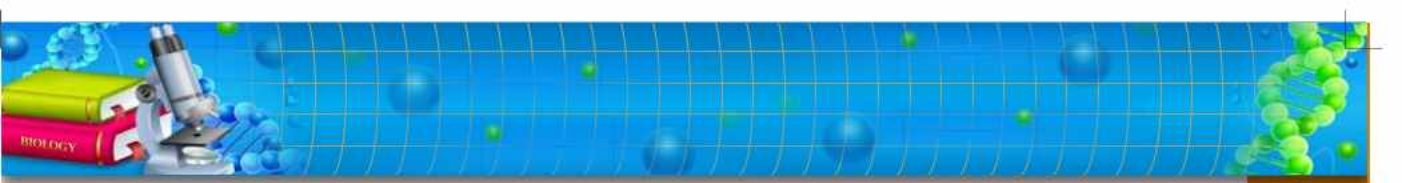
Multiple Allele (Blood Groups in human as an example)

According to Mendel's finding that each trait has two alternative forms (allele). Later it was found that some trait has more than two and more alternative forms. These traits are called **Multiple Allelic Trait** or **Multiple alleles**. ABO blood group system in human population was the first discovered multiple allelic trait. Karl Landsteiner in 1901 discovered ABO blood group system. There are four phenotypes due to presence or absence of two specific antigen on the surface of RBC.

The genetic basis of ABO system was explained by Bernstein in 1925. This system is controlled by a polymeric gene I on chromosome 9, contain three alleles i.e. I^A , I^B and i .



Blood Group	Genotype	Phenotype & Antigen
Group A	$I^A I^A$	A-Homozygous A
	$I^A i$	A-Heterozygous
Group B	$I^B I^B$	B-Homozygous B
	$I^B i$	B-Hetrozygous
Group AB	$I^A I^B$	AB-Heterozygous AB
Group O	$i i$	O-homozygous NO



R^h blood type (R= Rhesus):

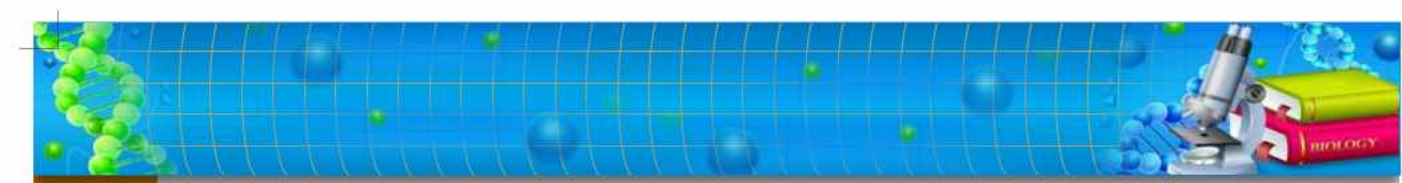
This protein was first time observed in rhesus monkey the another mendalian gene found in human. This gene produce a protein which is found on the surface of R.B.C as well. This trait has 2 allele a dominant R^h and r^h recessive. The Rh protein produce R^h protein therefore person called R^h+ve where as r^h gene is unable to produce R^h protein so the person called R^h-ve person will be r^hr^h.

Role of antibodies for AB and R^h in blood transfusion:

It is already known that the chemicals cells or organs of an organism can work as antigen to other organism. When these antigens enter in the body of other organism. This organism produce defense protein against this antigens to protect itself. These proteins are called antibodies.

The blood group alleles (I^A, I^B, i) starts their expression at embryonic stage and keep expressing till death. The person also produce anti-A, anti-B antibodies during first few months after birth. The person of A-blood group produce anti-B antibodies while person of B-blood group produce both anti-A and anti-B antibody while person with AB blood group do not produce any of the while person with AB blood serum containing antibodies called antibody. The blood serum containing antibodies called antiserum.

The person of A blood group which contain anti-B antibodies if given blood of B-group. The R.B.C of this B-blood group will work as antigen in the person of A-blood group it anti-B antibodies will work against the donor R.B.Cs of B-blood group and clumped cells called agglutination. Which lead to serious problem, this clumped cells can not pass through fine capillaries. Therefore during transfusion of blood the people must be careful about blood group.



Blood group	Blood group recipient	Reason
A	A and AB	Recipient donot have antibodies A.
B	B and AB	Recipient donot have antibodies B
AB	AB only	Recipient neither have antibody A or antibody B
O	O,A,B,AB	• Blood group have antibody A and antibody so it can receive only O blood group. • O blood can be donated to A, B and AB because donor's antibodies are quickly absorbed by other. Tissue or diluted in recipient blood. Therefore O blood is called universal donor

On the other hand side the R^h factor has different phenomena: unlike the naturally occurring anti-A and anti-B antibodies of ABO system, anti- R^h antibodies do not produce automatically. The production of anti- R^h antibodies require stimulus which is R^h human protein itself. It works as antigen. If an R^h -ve person receive R^h protein (antigen) through wrong R^h +ve blood transfusion, he will begin to produce anti- R^h antibodies against R^h antigens. R^h -ve blood person does not contain any R^h protein (antigen) can be transferred to R^h +ve person (recipient).

Co-Dominance:

According to Mendel's law of dominance only one factor expresses in heterozygous condition but it was also found that some trait has alleles that are both expressed in a heterozygous condition independently. This phenomenon of inheritance where both alleles are dominant and expressed equally called Co-Dominant e.g. AB blood group, where both alleles I^A and I^B express and produce antigen A and B both.

Incomplete Dominance:

Carl Correns in 1899 crossed a pure breed red flowered Japanese 4 O' clock plant with pure breed white flowered. He found pink flowered plant in F₁, these results were against the Law of dominance. This new phenotype was intermediate between those parents. When Correns self-pollinated F₁ pink flowered plant, the F₂ showed all three phenotypes of flowers in the ratio of 1 red; 2 pink: 1 white. Red and white are homozygous for their respective alleles. It was also found that when alleles for red and white were present together (heterozygous) in the same plant, neither of them masked the effect of other, therefore expression of both genes blended to produce new phenotype.

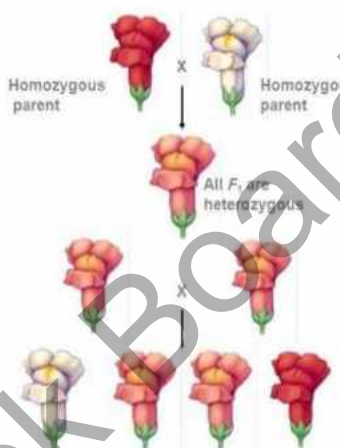


Fig. 6.13. 4 O'clock plant

This phenomenon of inheritance where both alleles of a trait express in heterozygous condition and their expression get blended to produce new phenotype called **incomplete dominance** or **partial dominance**.

6.6 VARIATIONS AND EVOLUTION

From previous discussion we have learnt that living things exist in great variety. They have many features in common. For instance there are fundamental similarities in their chemical structure. Not only in chemistry, there exist similarities in morphology also such as rats with mice, turtle with tortoise, frog with toad etc.

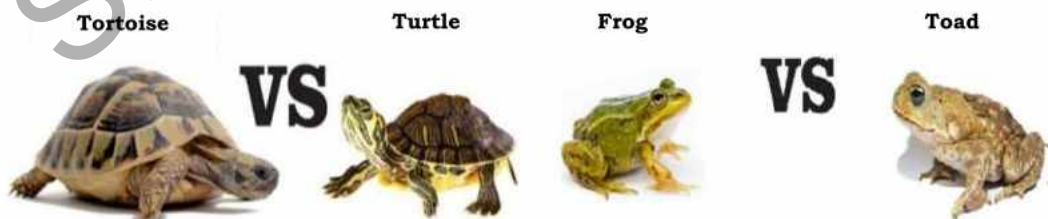


Fig. 6.14 Similarities in animals

Similarities discussed above and yet numerous other similarities suggest that species are more closely interrelated in some ways, some species are more closely interrelated than the others. The great variety of forms leads to many questions such as: How living things vary from each other? Have they always been like this? Did the great variety of life forms appear with time?

To account for the answers of these question, first of all we will see the variation and its causes:

6.6.1 Variations and their causes:

The differences in characters such as height, colour, etc. among individuals of same species are called **variations**. Variations may be caused either by the effect of environment or by the changes in the genetic material.

a) Environmental variation:

Variation caused by environmental factors among the members of same species, it is not inherited to the offspring e.g development of muscles in athletes, loss of some body parts due to accident or diseases etc.



Fig. 6.15 Muscles development

b) Heritable variation:

The variation caused due to changes in genetic material called genetic or **heritable variation**. This type of variation is considered as raw material for evolution.

On the basis of effects there are other two types of variation

c) Continuous variation:

These variations refers to small differences in characters of the members of a species i.e. Height, Skin colour, Intelligence, Eye colour etc such variations are neither purely genetical nor purely

environmental. They appear to be the combination of both factors.



Fig. 6.16 Variation in skin colour and height

d) Discontinuous variation:

These are sudden and sharp differences among the members of same species. They are heritable as they are purely caused by genetic material. Blood groups, six fingers in hand or foot, tongue rolling etc are common examples in man.



Hexadactyl Hand



Tounge Rolling

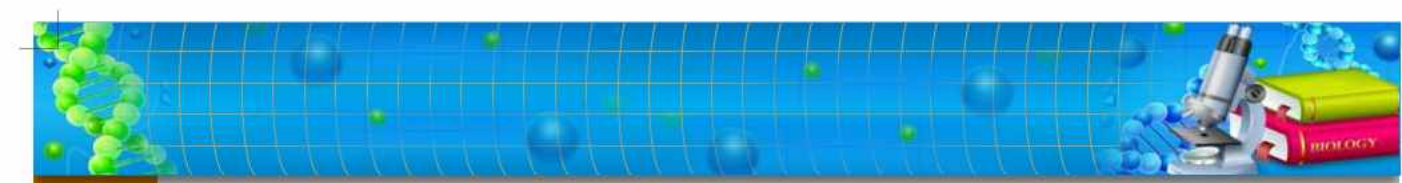


Attached Earlobe



Detached Ear lobe

Fig. 6.17 Discontinuous Variation



6.6.2 Causes of variations

some important causes of variations are as follows

i) **Mutation:**

It has been a common observation that some strikingly different characters than the others e.g. some person has six fingers in hands or feet. This phenomenon of producing sudden changes is called **mutation**. It can be defined as the sudden changes in the genetic material (genome) of an organism. It is the major source of heritable variation among the organisms which is considered as the starting point of new species.

ii) **Crossing over:**

It is the process of mutual exchange of segments of chromatids between non-sister chromatids of homologous pair of chromosome. It occurs during prophase of 1st meiotic division. Due to crossing over maternal and paternal alleles are mixed and segregated. So the indefinite combinations of alleles are made. Due to this crossing over and segregation, offspring of same parents become variable.

iii) **Environment:**

Number of environmental factors affect the body cells to cause variations e.g. the changes in the pigmentation of skin due to extent of exposure to sun light or the development of muscles due to exercise etc.

iv) **Independent assortment of chromosome:**

During metaphase of first meiotic division homologous chromosome come together in the form of pairs and subsequently segregate during anaphase I into the daughter cells independently. This produces a wide variety of different gametes.



v) **Fertilization:**

The set of alleles carried by chromosomes of each gametes is unique and always differ from each other. There are number of male gametes available to fertilize a single female gametes. Thus different combination of characters in an individual are possible as a result of fertilization.

This all painstaking scientific work of biologist leads to the idea of evolution especially organic evolution. Evolution is the process where descends become better than ancestors, while the organic evolution explains that present day living things are modified from simple ancestral forms during the course of time through a gradual and continual process of modification.

Theories of organic evolution not only explain how living things have become so varied, it also explains their basic similarities as well.

Several theories have been proposed to explain the mechanism of evolution, we are going to discuss some of them here.

6.6.3 Theory of Natural Selection or Darwanism:

Charles Darwin (1809-1882) was an Englishman. He studied different plants and animals, collected new specimens and categorized them. In the year 1859, he published a book "**Origin Of Species**" where he proposed the theory of Natural Selection, in which he presented simple evidences in favour of evolution and proposed the mechanism of origin of species.

The main points of the Darwin's theory are as follows:

- i) **Over Production:** living organisms reproduce rapidly so that the number of their offspring could increase rapidly.
- ii) **Struggle for Existence:** Due to the limited available resources of food, shelter, etc. the offspring of species compete not only with each other but also with the members of different species to share these resources. In this struggle a large number of

individuals of each species are eliminated. As a result the population remains stable.

iii) Heritable Variation: Individuals of a species differ from each other in their ability to obtain resources, withstand environmental extremes, etc. These differences in characters are called **minor variations**. Darwin concluded that survival in struggle for existence is not random but depends upon in part on the heredity constitution of the surviving individuals. Those individuals whose inherited characters fit them best to their environment would survive and produce more offspring than less fit individuals who will vanish.

iv) Natural selection: Nature selects the fittest individuals to survive and reproduce. As a consequences, the favourable variations are preserved through their inheritance to new young ones.

Over millions of years of variations, natural selection and inheritance might have led to the accumulation within the species a number of characters with survival value. As a result, a species may slowly changes to a better new species. Darwin was very much convinced by Artificial selection.



Fig. 6.18 Darwins finches as a result of natural selection

Number of evidences are reported in support of evolution from comparative anatomy, homologous organs, analogous organs, vestigial organs and fossils.

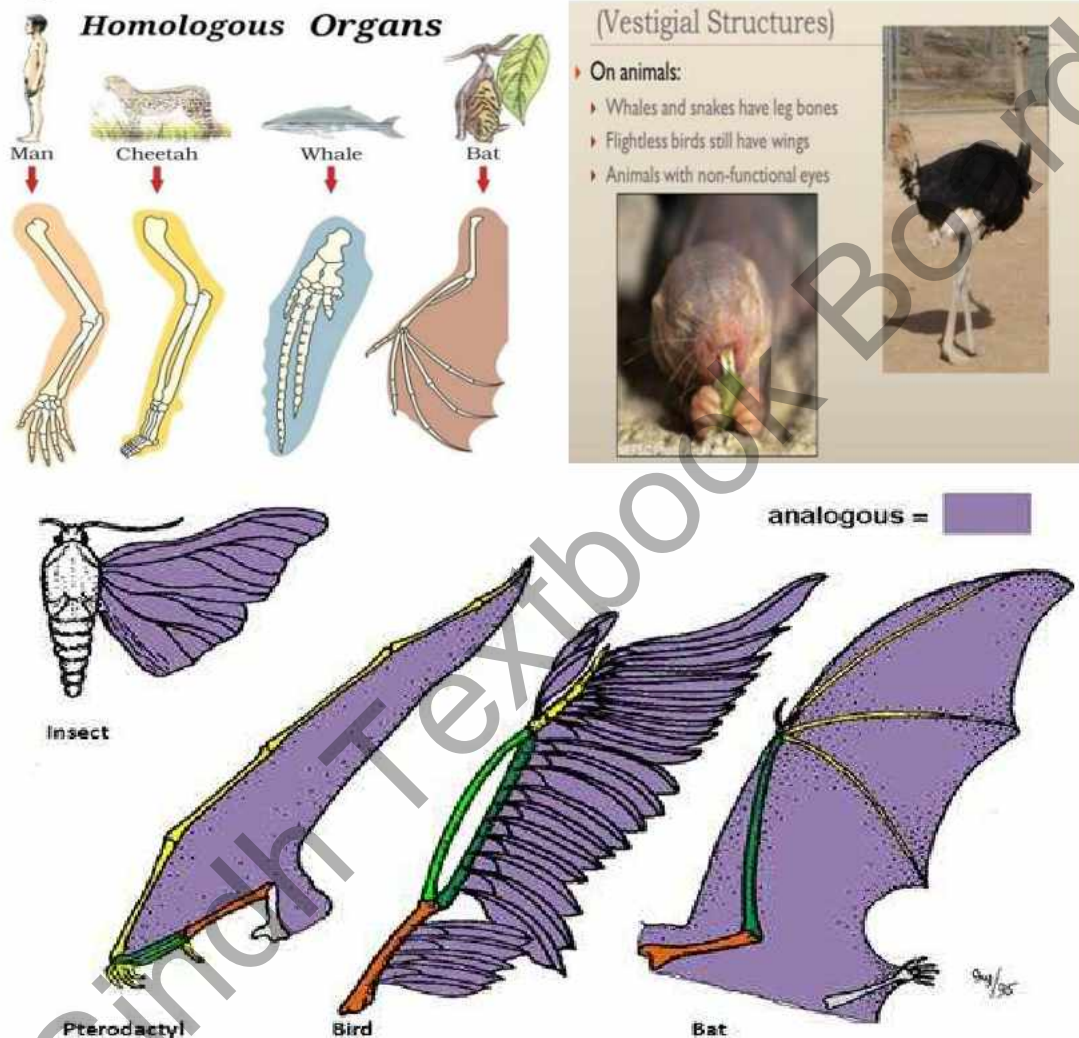


Fig. 6.19 Homologous, Analogous and Vestigial organs

6.6.4 Evidences from Artificial Selection:

Artificial selection is the cross breeding of domestic animals and plants to produce specific desirable features. Various breeds of dogs, pigeons, sheep, horse, cattle, cow, buffalo, hen etc. among the animals,

have been developed through artificial selection. Darwin convinced biologists that the process of artificial selection could produce so many changes in a species in relatively short period of time, then natural selection should be capable of considerable modification of species over thousands of generations

A



B

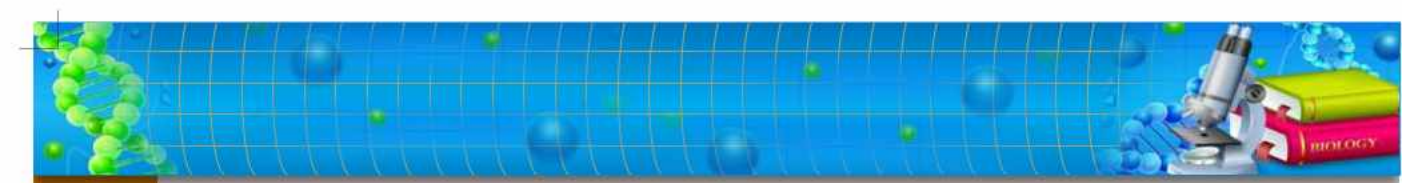


Fig 6.20 Different breeds of (A) Goats, (B) Horses by artificial selection



SUMMARY

- ◆ The branch of biology which deals with the study of heredity and variations is called **genetics**
- ◆ The process by which characters are transmitted from parents to offsprings is called **inheritance**.
- ◆ Living things when reproduce sexually their offspring differ somewhat from their parents, such differences are called **variations**.
- ◆ Heredity is the way by which genes transmit characters from parents to offspring.
- ◆ All human contains two sets of 23 chromosomes.
- ◆ Haploid set ($n=23$) is paternal in origin, which is contributed by sperm while the other haploid set ($n=23$) is maternal which comes from egg.
- ◆ The genes are located at chromosomes and inherited through chromosomes during sexual reproduction.
- ◆ Two chromosomes which are similar in their shape, size and position of centromeres present in a cell make one **homologous** pair of chromosome.
- ◆ The chemical material of chromosome is called **chromatin**.
- ◆ Deoxyribo nucleoprotein is composed of DNA and special protein i.e Histone. DNA(Deoxyribo Nucleic Acid) (H_3PO_4)
- ◆ Eukaryotic chromosome are composed of **chromatin**, a complex of DNA and protein i.e. 40% and 60% respectively.
- ◆ DNA is a double helical structure.
- ◆ Each helix is a polynucleotide chain which are twisted around each other.
- ◆ Both helix are complementary to each other which are held together by hydrogen bonds.
- ◆ Gene is the small segment of DNA which has genetic information in the form of code to synthesize a protein.
- ◆ The process of duplication of DNA is called **replication** of DNA.

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- ◆ A gene expresses by synthesizing a protein. This protein works as an enzyme, which carry down a chemical reaction to produce a metabolic product.
 - ◆ Genetic information flows in a cell from DNA to mRNA than to ribosome in cytoplasm, which is two step process for protein (enzyme) synthesis.
 - ◆ Transcription: DNA (gene) is copied in complimentary form. The process of copying DNA Information to mRNA is called **Transcription**.
 - ◆ Translation tRNA and rRNA translate the information of mRNA into the specific sequence of amino acids.
 - ◆ Gregor John Mendel is known as **Father of Genetics**, He studied seven traits (characters) in pea plants one by one.
 - ◆ Pure-breed means that if an organism is self fertilized, the offspring always look exactly like parents
 - ◆ Mendel took gene as a factor; if both the parents donate same factor of the trait, the organism is pure or Homozygous for this trait like pure Tall.
 - ◆ If both parents donate different factors (allele) of a trait, the organism is hybrid or Heterozygous for the trait
 - ◆ The factor (gene) which express and masks the expression of other factor in heterozygous condition is said to be Dominant factor.
 - ◆ The factor which is unable to express or masked in heterozygous condition is said to be recessive.
 - ◆ **Phenotype** is the physical appearance of the trait on the basis of inherited genes like tall.
 - ◆ **Genotype** genetic makeup or genic constitution of a trait like TT, Tt
 - ◆ In an organism, the factors (genes) exist in pairs but during gametes formation these factors segregate cleanly from each other, so each gamete has only one factor of a trait.
 - ◆ Some trait has more than two and more alternative forms. These traits are called multiple allelic trait or **multiple alleles**.
 - ◆ The phenomenon of inheritance where both alleles are dominant and expressed equally called **Co-dominance**.



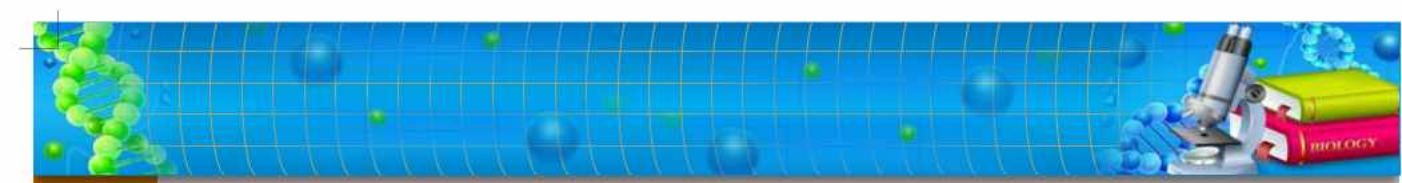
- ◆ The phenomenon of inheritance where both alleles of a trait expressed in heterozygous condition and their expression get blended to produce new phenotype called **incomplete Dominance** or **Partial Dominance**.
- ◆ The differences in characters such as height, colour, etc. among individuals of same species are called Variations. Variation may be caused either by the effect of environment or by the changes in the genetic material.



A. MULTIPLE CHOICE QUESTIONS

Choose the correct answer:

- i) Branch of biology deals with the study of heredity and variation is called:
 - (a) Inheritance
 - (b) Heredity
 - (c) Genetics
 - (d) Evolution
- ii) The way by which gene transmits characters from parents to offspring is
 - (a) Genetics
 - (b) Inheritance
 - (c) Heredity
 - (d) Allele
- iii) Two similar chromosomes in a cell which are similar in shape, size and position of centromere called
 - (a) Chromatids
 - (b) Arms
 - (c) Homologous
 - (d) Homology
- iv) The chemical material of a chromosome is called
 - (a) Chromatin
 - (b) Chromeres
 - (c) Chromonema
 - (d) Chromatid
- v) The outer part of DNA helix made up of sugar and phosphate is called
 - (a) Nucleoprotein
 - (b) upright
 - (c) Rungs
 - (d) Phosphoester

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- vi)** The small segment of DNA which has information to code one protein is called
(a) Nucleotide (b) Polynucleotide
(c) Gene (d) Exon
- vii)** The exact duplication of DNA is called
(a) Duplication (b) Replication
(c) Transcription (d) Translation
- viii)** If both the parents donate same factors of a character is called
(a) Homologous (b) Heterologous
(c) Homozygous (d) Heterozygous
- ix)** The Genetic constitution of a trait is called
(a) Genotype (b) Phenotype
(c) Genome (d) Phenyl

B. SHORT QUESTIONS:

- i)** What is gene and how it works?
- ii)** Define following terms
(a) Homologous Chromosome (b) Heterologous Chromosome
(c) Dominant allele (d) Allele
(e) Recessive allele (f) Homozygous
(g) Heterozygous
- iii)** Which of the phenomena of inheritance is there where both factor express in heterozygous condition.
- iv)** List out the factors which are involved in theory of natural selection.
- v)** Relate artificial selection with natural selection.

C. EXTENSIVE RESPONSE QUESTIONS:

- i)** Describe the Waston and Crick model of DNA.
- ii)** How gene express describe in detail.
- iii)** State and explain the law of segregation of Mendel's.
- iv)** Explain the inheritance of dihybrid cross by law.
- v)** Explain the Darwin of theory of natural selection.