GENETICS

Genetics is the scientific study of heredity and variations between organisms while inheritance describes how the similarities are transferred from the parent to the offspring. The similarities are in form of characteristics such as skin colour, intelligence, height and many others.
Mendel was the first scientist to study genetics and inheritance.

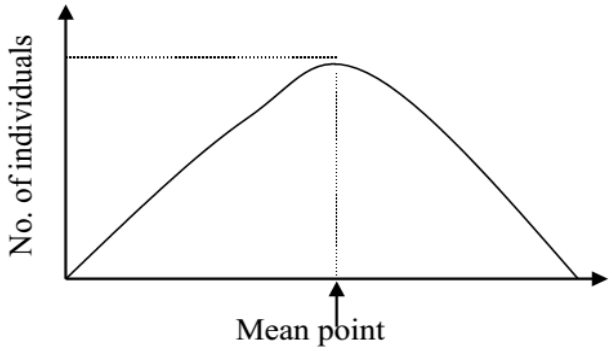
Categories of variation

There are two types of genetic variations.

1. Continuous variations.

These are variations that show a gradual change in individuals without a clear-cut division between the two extremes. It results into formation of intermediates. Such variations include height, intelligence, skin colour, yield in plants, etc. In such variations, organisms are usually very many around the mean/average point.

Graphic illustration of continuous variation



2. Discontinuous variation.

This is a variation, which shows a clear-cut difference between the two extremes without intermediates. This results into expression of only two phenotypes. Examples of discontinuous variations include, tongue rolling, blood groups, sex, etc.

Causes of variation

Some variations are inherited and are called inherited variations while others are occupied as a result of the environment hence called environmental variations.
Examples of inherited variations are blood groups, eye colour, albinism, hair, etc.
Examples of environmental variations are knowledge, etc.

Environmental factors that cause variations

- ✓ Diet
- ✓ Pathogens
- ✓ Altitude
- ✓ Light

Factors that cause inherited variations

- ✓ Mutation
- ✓ Crossing over
- ✓ Fertilization

Terms used in genetics.

1. **Chromosome**. These are thread-like structures bearing genes and located in the nucleus.
2. **Chromatid**. This is half of a chromosome split longitudinally.
3. **Bivalent**. This is a pair of homologous chromosomes.
4. **Gene**. This is a unit of the hereditable material found on the chromosome and responsible for controlling a particular trait/character.
5. **Allele**. This is the alternative form of the same gene. Most genes are made up of two alleles. Alleles of the same gene are represented by the same letter but the dominant allele is represented by a capital letter and the recessive allele by a small letter in the case of dominant-recessive characters
6. **Diploid**. This is a description of a cell, which has a whole set of chromosomes.
7. **Haploid**. This refers to a cell with half the set of chromosomes.
8. **Genotype**. This refers to the genetic composition of an organism.
9. **Phenotype**. This is the physical appearance or the outward expression of an individual.

10. **Dominant gene/dominant allele**. This is a description of a gene /allele whose effect is seen in the phenotype of the heterozygous individual. The effect of the dominant gene/allele is seen in the phenotype even in the presence of another gene/allele.
11. **Recessive**. This is a description of a gene whose effect is not phenotypically expressed in the heterozygous state. The effect of a recessive gene/allele is not seen in the presence of another (dominant) gene/allele.
12. **Homozygous**. This refers to a gene with two identical alleles for example if T represents the gene for height where tallness is dominant to shortness then the allele for tallness is T and that for shortness is t. an individual with TT is said to be homozygous tall and tt is said to be homozygous short.
13. **Homozygous dominant**. This is where both alleles of a gene determine a dominant character.
14. **Homozygous recessive**. This is where both alleles of a gene determine a recessive character.
15. **Heterozygous**. This refers to a gene with two different alleles for example if T represents the allele for tallness and t for shortness then Tt is the heterozygous state of this gene.
16. **Hybrid**. This is an offspring produced by parents of two different pure lines.
17. **Incomplete dominance**. This is a condition where neither of the genes is dominant over the other.
18. **Gametes**. These are reproductive cells.
19. **Fertilization**. This is the fusion of the male and female gametes to form a zygote.
20. **Monohybrid inheritance**. This is a type of inheritance, which involves studying a single pair of contrasting characteristics.
21. **Dihybrid inheritance**. This is a type of inheritance, which involves studying two pairs of contrasting characteristics at ago
22. **Test cross**
    This is a type of back cross which involves crossing an offspring having a dominant character with its recessive parent in order to determine the test of that offspring.
23. **Back cross**
    This is the mating of an offspring with one of its parents.

MENDEL'S EXPERIMENT

For his experiment he collected one of the varieties of garden peas (*pisum sativum*) with contrasting features such as one variety was producing tall plants when stems are about 200cm and another short plant with stems of 25cm. He crossed these plants for his experiments.

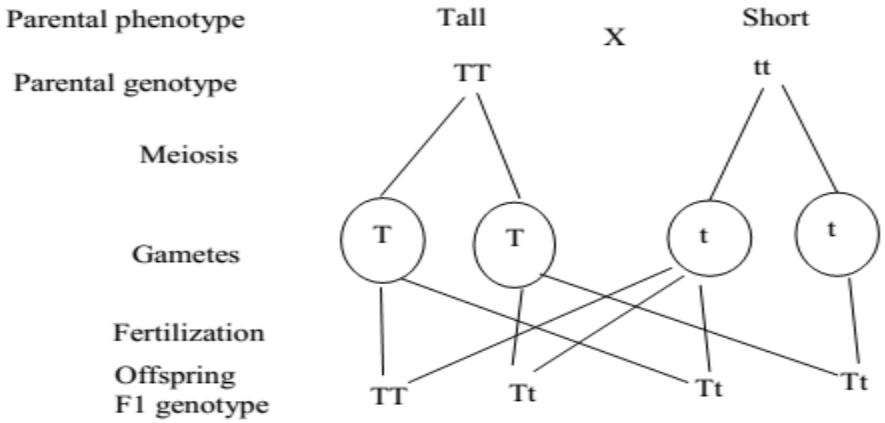
He crossed pure tall pea plants with pure short pea plants and all the off springs were tall (F1 generation)

Tallness was the dominant character and shortness the recessive character.

The dominant character is represented using a capital letter while the recessive character is represented using a small letter.

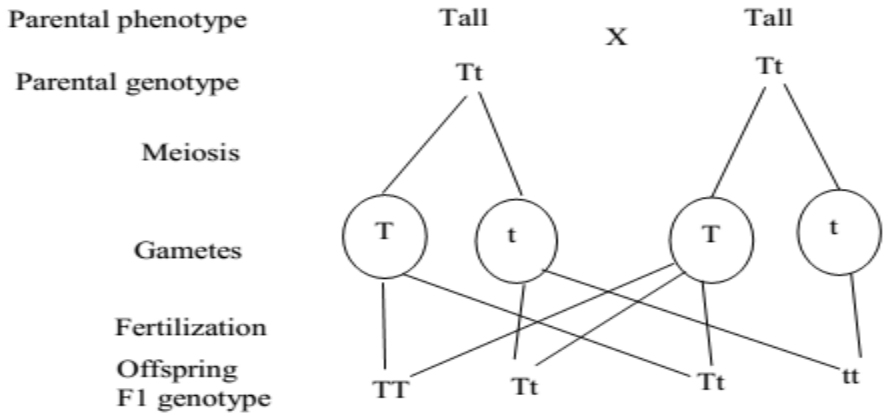
Let T represent the gene for tallness

Let t represent the gene for shortness



Offspring phenotype: All tall

Mendel then selfed the plants of the F1 generation and obtained an F2 generation with tall and short plants in a ratio of 3:1



Genotypic ratio; TT: Tt: tt = 1:2:1
Phenotypic ratio; 3 tall: 1 short

Mendel's conclusions

Mendel suggested the following to explain his results.

1. Gametes like pollen grains and ovules of the garden peas carry characters determining factors through which resemblance is passed on from one generation to the next.
2. A character like height of the garden pea is controlled by a pair of genes. These separate during formation of gametes and only one goes into each gamete. This means that only half of the usual number of genes is present in the gametes. However the normal number is restored at fertilization by the fusion of the two gametes
3. He named a gene determining a dominant character as a dominant gene and one determining a recessive character as a recessive gene. In his representation dominant genes were given capital letters and recessive genes were given small letters.

Mendel's laws of inheritance

From his observations, Mendel put up two laws of inheritance.

First law: The law of segregation.

This law states that the character of an organism is determined by a pair of alleles. Only one allele of such a pair is carried in a gamete.

Second law: The law of independent assortment.

This states that each of the alleles in a pair may combine with another allele from another pair randomly.

Conclusions from Mendel's' crosses.

1. A character can be transmitted from parent to offspring independent of other characters.
2. Genes occur as a pair of alleles.
3. Only one allele of the same gene is carried in a single gamete.

MONOHYBRID INHERITANCE

Inheritance is the passing over of characteristics of the parents to their off springs. Monohybrid inheritance involves the study of how one character is inherited from the parents to the off springs. Mendel carried out several experiments on peas to study monohybrid inheritance.

Mendel chose garden peas for his experiments because of the following reasons:

1. They grow very fast and produce results in a very short period of time.
2. They are relatively small and can be grown on a small plot for study purposes.
3. Some of their characters are controlled by single genes, which make it easy to study them.
4. They have characteristics, which show clear-cut differences without intermediates like tall and short, green and yellow cotyledons, etc.

He therefore concluded that their reproduction can be manipulated by pollination.

Questions:

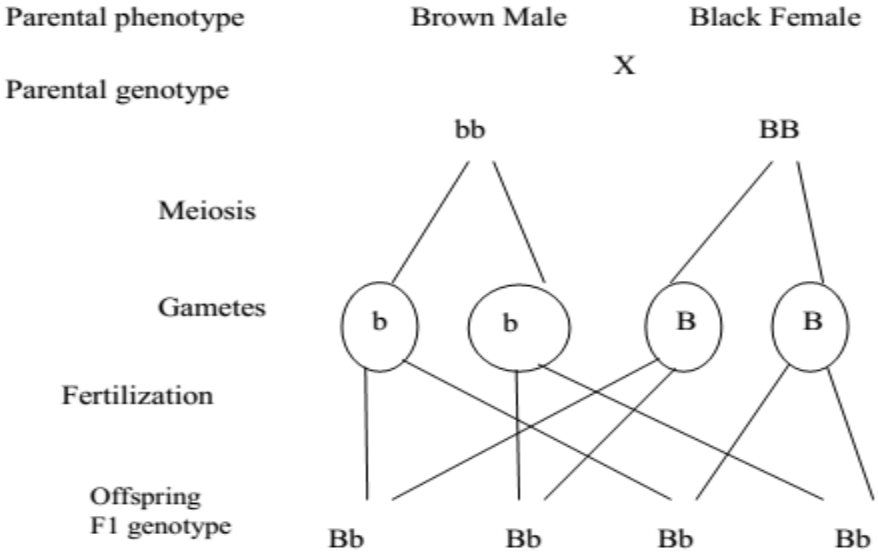
What would be the offsprings for a cross between homozygous black and homozygous brown. Take B for black and b for brown.

Let the gene for black fur be represented by B and that for brown b.

Note.

1. It is one gene controlling a character, which is fur colour. For this reason we use the same letter
2. Black colour is dominant that is why we use (B) and brown is recessive (b)
3. The term pure-breeding is used to mean homozygous for that particular gene.

Crosses.

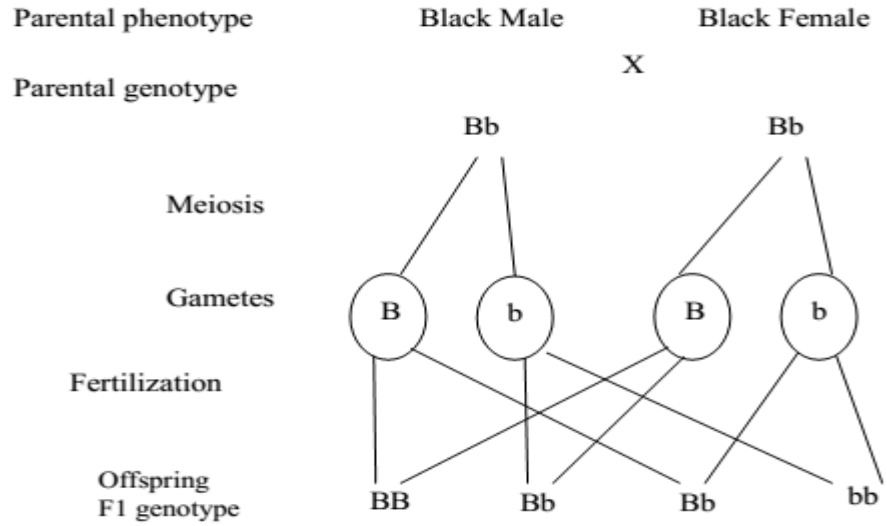


Offspring genotype: all Bb (heterozygous)

Offspring phenotype: all black.

They are all black because black is dominant to brown and it shows up in the heterozygous state.

Consider Selfing of F1 (crossing two offsprings of F1 above).



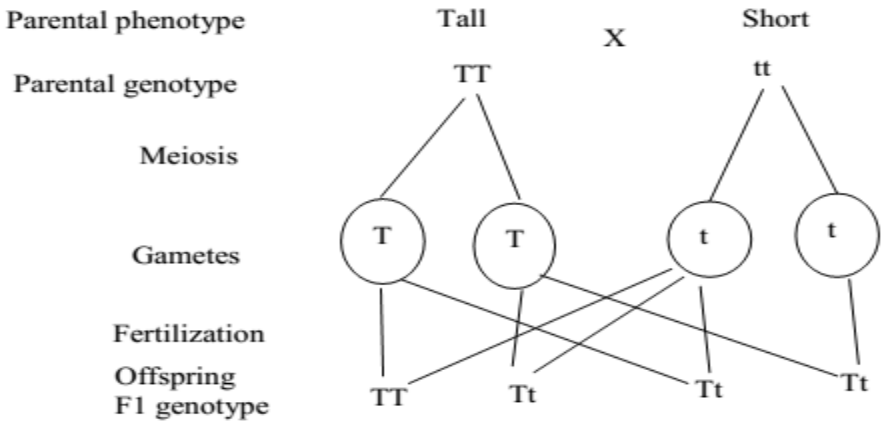
F2 phenotypic ratio. 3 black: 1 brown

3:1

Example ii

Consider a gene for height in garden peas. Tallness is dominant over shortness.

Let the gene for tallness be represented by T and that for shortness t. show the cross between pure-breeding tall pea and a pure-breeding short pea.



F1 phenotype. All offsprings are tall.
Selfing of F1 produces F2 with a phenotypic ratio of 3 tall to 1 brown. (3:1)

Monohybrid inheritance in human beings

1. Albinism

This is a condition in human beings where the individual fail to produce skin pigments called melanin.
Albinos have;

- ✓ Light skin
- ✓ White hair
- ✓ Pink eyes
- ✓ They are sensitive to bright light

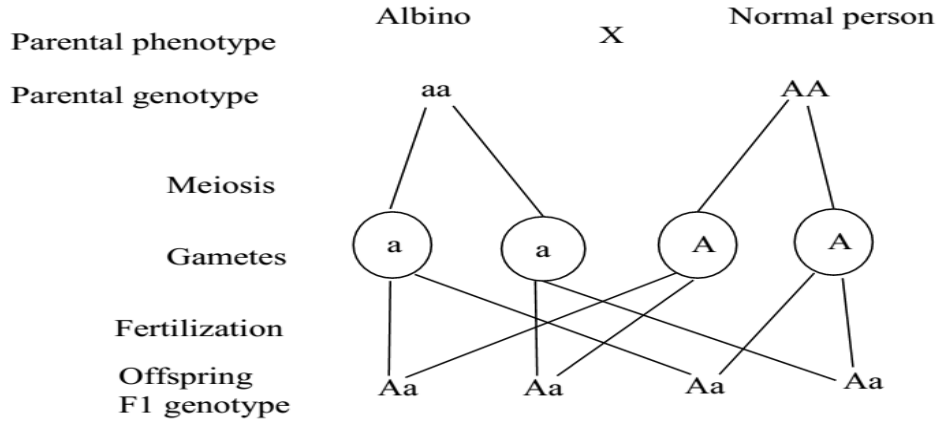
Albinism is caused by a recessive gene.

Examples

1. What would be the off springs if an albino marries a normal person?

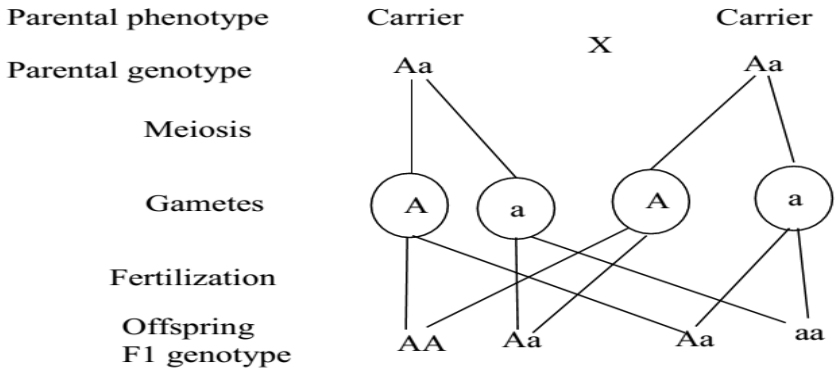
Let A represent the allele for normal skin colour
Let a represent the allele for no skin colour

Genotype	Phenotype
AA	Normal skin colour
Aa	Carrier for albinism
aa	albino



All the off springs will be carriers of albinism

2. What would be the off springs when 2 individuals who are carriers of albinism get married?

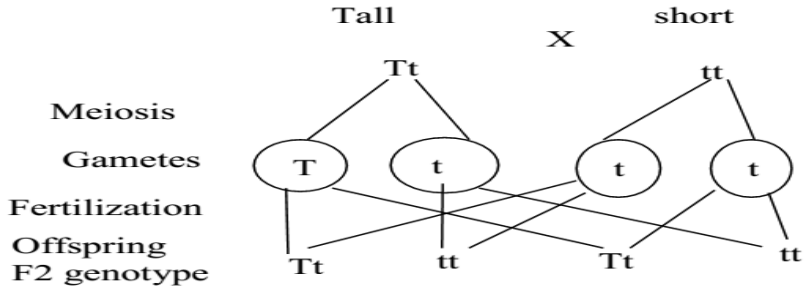


Genotypic ratio; 1 normal: 2 carrier: 1 albino
1:2:1
Phenotypic ratio; 3:1

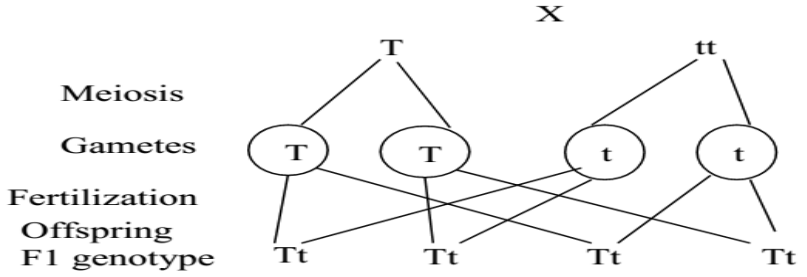
Assignment:
In peas, yellow seed colour is dominant over green seed color. What would be the phenotype of the offspring if a true breeding yellow-seeded plant is crossed with a green-seeded plant?

Test cross

A test cross is used to distinguish between homozygous and heterozygous dominant forms. This is when an F1 individual with the phenotype of the dominant parent is crossed with the recessive parent to determine the phenotype of the parent.
If the F1 is homozygous dominant, all the off springs will show the dominant character.
If the F1 individuals are heterozygous, a 1:1 ratio of dominant or recessive characters is obtained. E.g.
Let T represent the allele for tallness
Let t represent the allele for shortness



Two off springs will be heterozygous tall and 2 will be homozygous short.



All are heterozygous tall

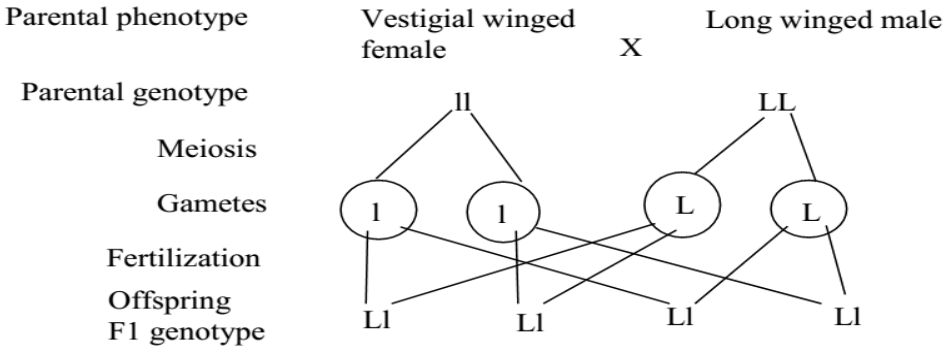
Question:
The fruit fly (drosophila melangaster) usually has wings twice as long as its abdomen but some drosophila have very short or vestigial wings. A long winged drosophila (male) was crossed with a vestigial winged female drosophila and all the F1 off springs were long winged. The long winged F1 generation were then mated.

i) How can the cross be represented diagrammatically
ii) State the phenotypes of the off springs in the F2 generation and state their genotypic ratio.

iii) What is the percentage of the vestigial winged drosophila flies in the F2 generation?
iv) A drosophila is normally used in experiments on heredity, why do you think it is suitable for such experiments.

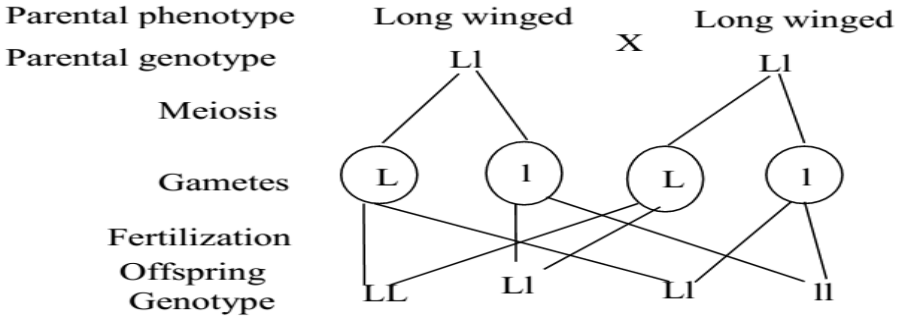
Solution:

Let L represent the allele for long wing and l represent the allele for vestigial wing l
The long winged female can be LL or Ll because long winged is dominant to short winged.
i)



F1 phenotype. All long winged.

ii)



One of the off springs will be homozygous long winged
Two of them will be heterozygous long winged
One of them will be homozygous short winged or vestigial winged
Genotypic ratio; 1:2:1
iii) ¼ x100=25%
iv) It's because they:

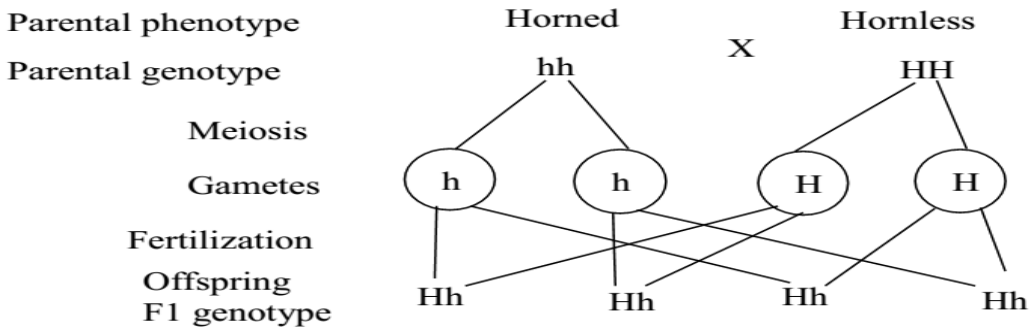
- ❖ Have contrasting characters
- ❖ Have short life span
- ❖ Show clear cut differences.

Question:

In cattle, the gene for hornless condition is dominant over one for horns. A pure hornless cow was mated with a horned bull. Using genetic symbols, show the possible phenotype and genotype of the F1 offspring.

Solution:

Let h represent the allele for horned condition.
Let H represent the allele for hornless condition



All were horned cows.

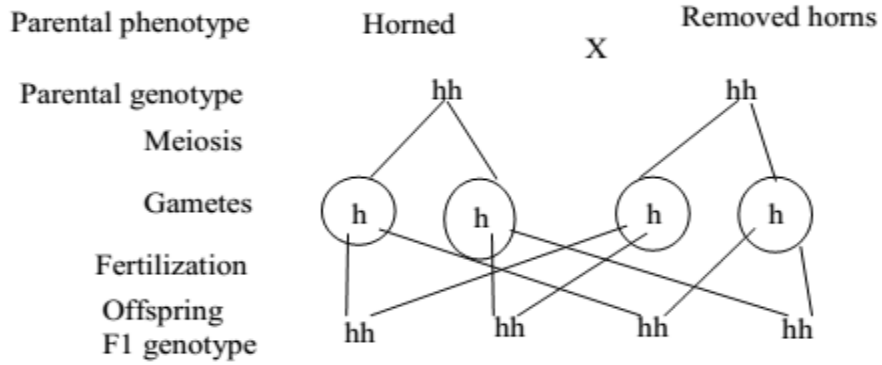
Question:

A bull whose horns were removed was mated to a horned cow. Show the possible genotypes and phenotypes of the F1 off springs. Give a reason for your answer.

Solution:

Let h represent the allele for horned condition.

Let H represent the allele for hornless condition



All are horned

Note: Because the bull with cut off horns still has the genes for horned and cutting off the horns doesn't change the genes.

Sex determination in human beings

There are 23 pairs of chromosomes in each cell of the human body. One pair determines the sex of the individual and they are called sex chromosomes.

There are two sexes, i.e. male and female. The gene controlling sex is carried in the reproductive cells on the sex chromosomes. There are two sex chromosomes the X chromosome and the Y chromosome. These chromosomes occur in a pair to determine the sex of an individual. Each gamete carries one of the sex chromosomes.

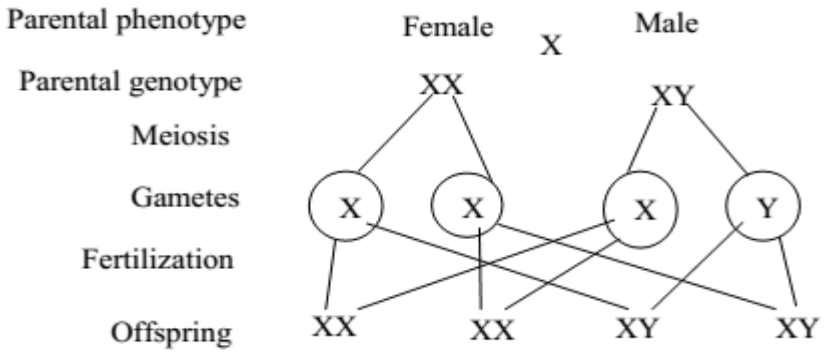
In males some of the sperms contain the X chromosome while some contain the Y chromosome. Y only occurs in males.

In females all the eggs contain the X chromosome.

At fertilization, a sperm fuses with the egg. If the X sperm fuses with an egg (X), the resulting offspring is XX and is a female. If a Y sperm fuses with an egg (X), the resulting individual is XY and is a male. Therefore the male determines the sex of the offspring. This is because the male produces two different sperms (X and Y) while the female produces only eggs with X chromosomes.

Note: The Y sperms are more active and persistent than the X sperms. This increases the chances of an ovum to be fertilized by a Y sperm. So to every 100 girls, 120 boys are born but more boys than girls die at the time of birth.

Illustration:



Phenotypic ratio; 2 boys: 2 girls

SEX LINKED TRAITS/CHARACTERS

These are traits or genes associated with the sex of the individual. These characters are carried on the sex chromosomes and are controlled or determined by the genes on those chromosomes. Such characters appear in a recessive form hence are very common in males than in females. Such characters include;

- ✓ Colour blindness
- ✓ Haemophilia (bleeder disease)
- ✓ Etc.

Inheritance of colour blindness

Colour blindness is a defect of the eyes caused by a recessive gene on the X chromosome.

Example

Let B represent the allele for normal colour vision

Let b represent the allele for colour blindness

Genotype	Phenotype
X^BX^B	Normal female
X^BX^b	Carrier female
X^bX^b	Colour blind female
X^BY	Normal male
X^bY	Colour blind male

***Question*:**

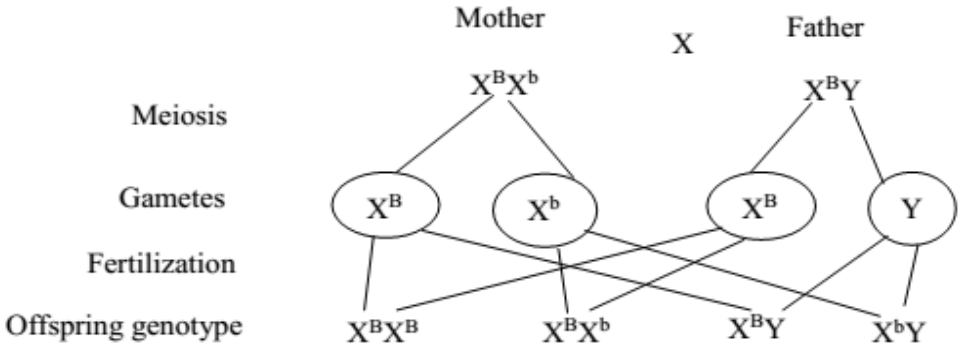
i) What would be the off springs when a carrier female for colour blindness marries a male with normal colour vision?

ii) Write the genotypic ratio of the off springs and make a comment of their condition.

Solution:

Let B represent the allele for normal colour vision

Let b represent the allele for colour blindness.



Genotypic ratio 2:1:1

2 will be normal girls (females)

1 will be normal boy (male)

1 will be carrier girl (female)
1 will be colour blind boy (male)

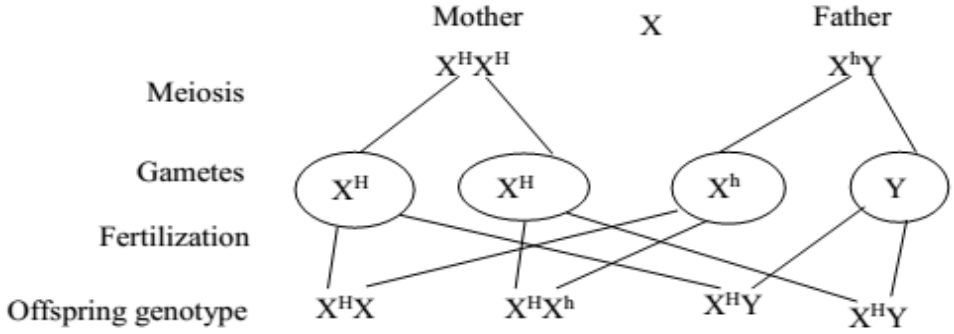
Assignment:
What would be the offspring if a colour blind woman marries a normal man?

Inheritance of haemophilia (bleeder disease)

It is a disease in which blood takes a long time to clot at a wound. It is also known as the bleeder's disease. This disease is caused by a recessive gene which is carried on the X chromosome.
Let H represent the allele for normal blood clotting
Let b represent the allele for haemophilia

Genotype	Phenotype
X^HX^H	Normal female
X^HX^h	Carrier female
X^hX^h	Haemophiliac female
X^HY	Normal male
X^hY	Haemophiliac male

Question:
What would be the off springs if a normal woman marries a haemophiliac man?
Solution:
Let H represent the allele for normal blood clotting
Let h represent the allele for haemophilia



2 carrier females: 2 normal males

Sex limited traits

These are characteristics that only show in one sex e.g. secondary sexual characteristics, hairy pinna, etc.

Sickle cell anaemia

It is due to a mutation of a gene. A person suffering from sickle cell anaemia has a defective type of haemoglobin. ***It is caused by a recessive gene.***
When the concentration of oxygen is low in blood, the red blood cells assume the shape of a sickle. Because of this, the red blood cells cannot absorb oxygen properly.
This is a hereditary disease and can be passed on to the children by the parents in their gametes. Sickle cell anaemia has a fatal effect on people who are homozygous for this mutated gene.
People who are heterozygous i.e. they have mutated and non-mutated genes have normal red blood cells.

Example:
Let B represent the allele for normal RBC
Let b represent the allele for sickle shaped RBC

Genotype	Phenotype
BB	Normal RBC
Bb	Normal but carrier
bb	Sickle shaped RBC

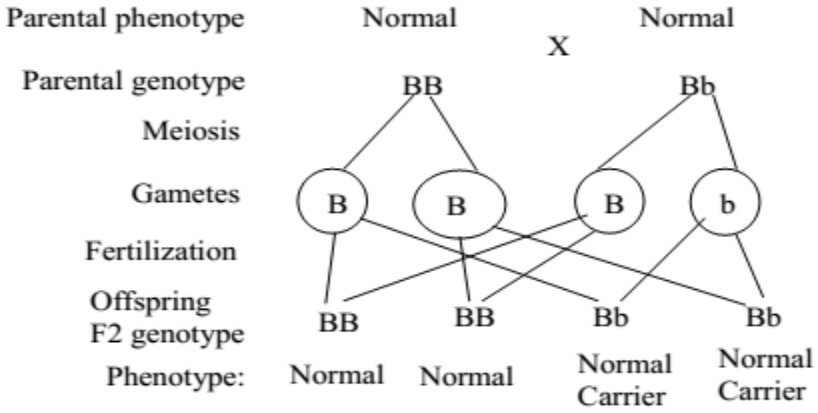
Question:

A normal male married a carrier female for sickle cell anaemia. Determine the phenotype and genotype of the children.

Solution:

Let B represent the allele for normal RBC

Let b represent the allele for sickle cell



Assignment:

A normal male whose mother had sickle cell anaemia married a carrier female. What percentage of their children had sickle cell anaemia?

EXCEPTIONS TO MENDELIAN INHERITANCE

The following do not conform to the process of inheritance as illustrated by Mendel.

1. Linkage
2. Incomplete dominance.
3. Co-dominance
4. Multiple alleles.

CO-DOMINANCE

This is a condition where genes determining a particular character all show up such that the phenotype of the offspring is a mixture of that of the parents. All the characters of either parents appear in the offspring, e.g. black and white gives white and black spots in the offspring***. It mainly occurs in animals.***

Co-dominance is where in the heterozygous state neither allele is completely dominant over the other i.e. the 2 alleles are co-dominant. This results in the phenotype intermediate between the parent's appearances. The alleles for each trait are represented with different capital letters.

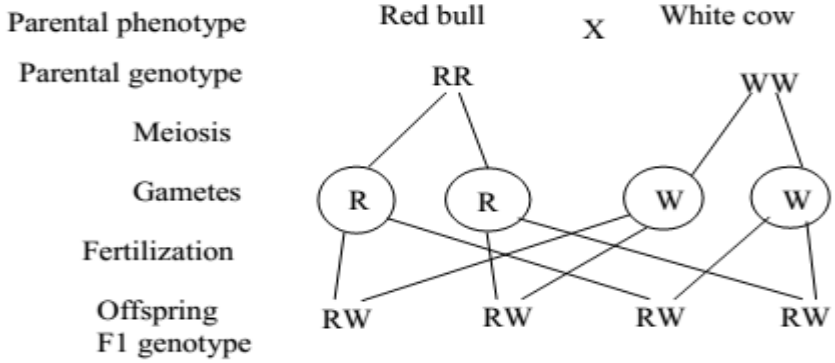
Questions:

1) In animals, the genes for fur colour are co-dominant. What will be the offsprings when a red bull is crossed with a white cow?

Solution:

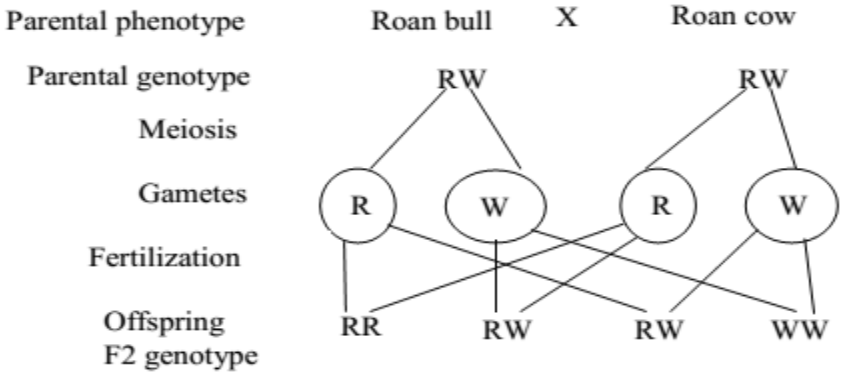
Let R represent the allele for red bull

Let W represent the allele for white cow



F1 phenotype: all the off springs will be roan.

2) What would be the off springs in the 2nd generation?



F2 phenotype: 1 red, 2 roan and 1 white.

INCOMPLETE DOMINANCE

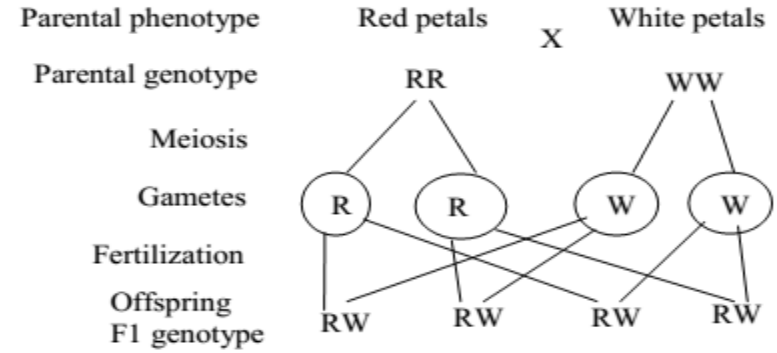
This is a condition in the heterozygous where neither of the alleles is dominant over the other and the phenotype of the offspring is an intermediate between that of the parents. An intermediate of the parents' phenotype results, e.g. black and white gives grey. ***It mainly occurs in plants.***

For example, consider petal colour in flowers: when a red flowered plant is crossed with a white flowered plant, the offsprings produced are all pink coloured petal flowers.

Example:

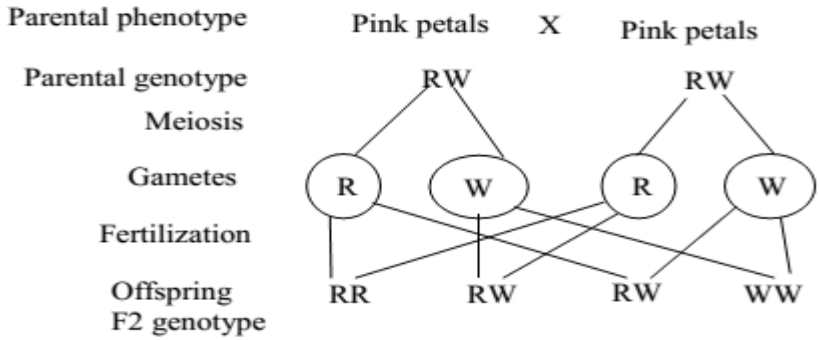
Let R represent the allele for red petal colour.

Let W represent the allele for white flowers



F1 phenotype: all pink petals.

Then Selfing F1. (Cross between offspring in F1)



F2 phenotype: 1 red, 2 pink and 1 white.

F2 Phenotypic ratio: 1 red: 2 pink: 1 white. (1:2:1)

MULTIPLE ALLELES

This is where one character is determined by more than two alleles. This implies that a single gene contains more than two alleles. An example is blood group inheritance.

Inheritance of blood groups

The gene controlling blood groups is made up of three different alleles (multiple alleles). These alleles are A, B and O. The inheritance of blood groups is also an example of co-dominance. There are 4 blood groups that is group A, B, AB and O. An individual inherits two of these alleles one from each parent. The table below shows the possible blood groups that can arise from the different genotypes.

Genotype (alleles)	Blood group (phenotype)
AA	A
OA	A
BB	B
OB	B
AB	AB
OO	O

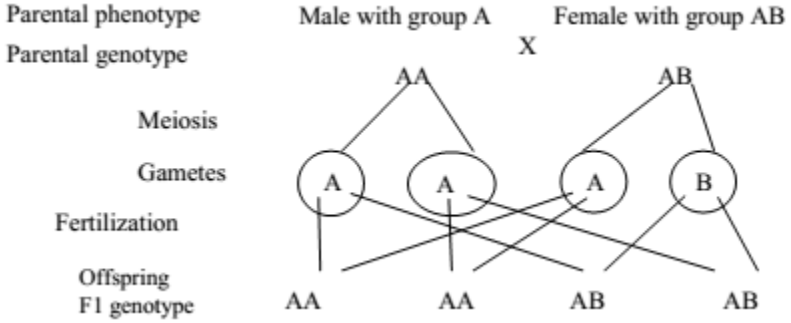
Example:

Work out the possible blood groups of the off springs produced if a man of blood group A marries a woman of blood group AB

***Solution**:*

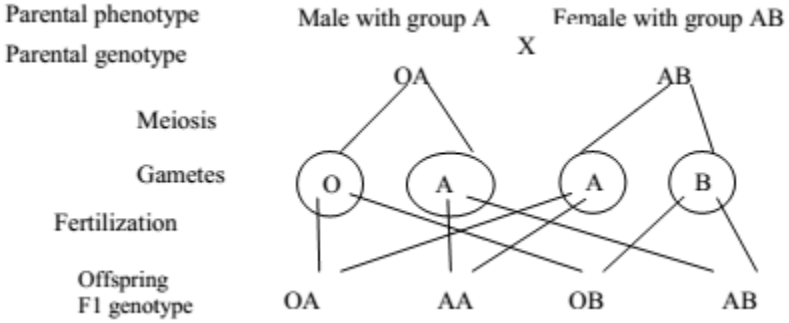
The man can have two possible genotypes, i.e. OA and AA. This is because allele A is dominant to allele O.

Considering the case where the man is AA



Offspring phenotype: 2 blood group A and 2 blood group AB

Considering the case where the man is OA



Offspring phenotype. 2 have blood group A, 1 has blood group AB and 1 has blood group B

Assignment one:

a) What is meant by genotype? (01 mark)

b) A man of blood group A, married a woman homozygous for blood group B and they produced a son of blood group B.

   i) Work out the genotypes of the father and of the son. (04 marks)

ii) The son married a wife of blood group O. Show your working and give the percentages of the possible phenotypes of their offspring. (03 marks)

c) Blood groups in humans show discontinuous variation. Explain what you understand by this statement. (02 marks)

Assignment two:

a) i) Give any four differences between mitosis and meiosis. (4 marks)
ii) Give the parts where meiosis occurs in plants and animals respectively. (2 marks)

b) What is the relevance of meiosis? (2 marks)

c) When a white haired male fox was mated with a black haired female fox, both pure breeding, all off springs were grey.
i) Explain why the offsprings were grey in colour? (1 mark)
ii) Using genetic diagrams, show how the F1 offsprings were produced; and F2 offsprings if two of the F1 foxes were allowed to interbreed. (6 marks)

Application of genetics

i) The study of genetics encourages breeding of animals with good characteristics to improve livestock.
ii) It helps to eliminate or reduce harmful characteristics through the study of genetics.
iii) Through genetic counseling and advice individuals may be advised on the possibility of their off springs.
iv) It helps in prediction of offspring from two mating individuals and solves problems like fraternal uncertainty.

MUTATION

This is a sudden/spontaneous change in the structure and composition of a gene or chromosome.

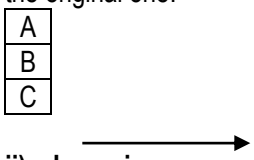
Types of mutation

i) Chromosome mutation: this is a sudden change in the number or structure of a chromosome.
ii) Gene mutation: This is a sudden change in the chemical nature of a gene.

Types of chromosome mutation

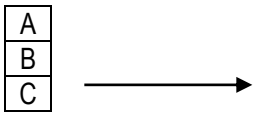
i) Deletion:

This is when a piece of chromosome is broken off and lost therefore the chromosome becomes shorter than the original one.



ii) Inversion:

A piece of the chromosome breaks and joins on a different side of the same chromosome.

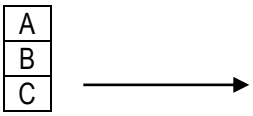


iii) Duplication:

A chromosome gains a piece from another chromosome of the same type and becomes longer.

iv) Translocation:

A piece of chromosome breaks and joins to another chromosome of different type.



Examples of chromosome mutation in man

i) **Turner's syndrome:** the individual has one X chromosome. This gives rise to a sterile abnormal short female and it is due to loss of one sex chromosome.
ii) **Down's syndrome (mongolism):** this is due to the increase in the number of chromosomes. The individual is mentally retarded with weak muscles, a big or large head, a broad chest, stunted growth and dropped eyes.
iii) **Clinefelter's syndrome:** this is due to an additional X chromosome in an individual. This results in a sterile male who may be mentally retarded.

Examples of gene mutation are: Albinism and Sickle cell anemia

Causes of mutations.

Mutations are caused by substances generally referred to as **mutagens**. These include;

i) High temperatures.
ii) Chemicals such as mustard gas, colchine and caffeine.
iii) High-energy particles such as alpha and beta particles.
iv) High-energy radiations such as x-rays, gamma rays and ultra violet radiations.

Note; most mutations are disadvantageous and recessive. They are rare but persistent in the population.

EVOLUTION

Evolution is the process by which more complex forms of organisms arise from simpler forms over a long period of time. Or

This is a gradual process by which organisms change from simple to complex forms over a period of time.

But how then did the first primitive organisms arise and from where? To answer the question, many biologists have tried to put up theories to explain the origin of life.

Theories of origin of life

The origin of life is not exactly known. However some theories have been put forward to explain the origin of life. These are:

1. **Special creation theory:**

All living things were created by God.

2. **Steady state theory:**

It suggests that life has no origin and it has been in existence.

3. **Spontaneous generation theory:**

It suggests that life arose from non-living matter.

4. **Cosmozoan theory:**

It suggests that life arose from another planet of the universe and arrived on earth by some means.

5. **Biochemical evolution theory:**

It suggests that inorganic molecules i.e. DNA and chromosomes and other protein molecules were organized into a basic unit of life called a cell.

It is the most accepted theory of the origin of life. The simple life (cell) gradually underwent numerous changes along different lines to form the present diversity of complex organisms.

This confirms that all the present organisms despite of their differences arose from the same ancestors, a process called ***evolution.***

Natural selection

This is the process by which organisms that are better adapted to the environment survive to reproduce while those less adapted fail to do so and become extinct. Or

This is a process by which nature selects for the best adapted organisms and selects against the less adapted ones.

When the environment changes, it affects organisms and those, which possess characters that enable them to survive in the changing environment survive while those less adapted, die over a long period of time. This occurs because organisms possess variations (differences between them).

The survival of the best adapted and removal of the less adapted is known as ***survival for the fittest.***

This theory was stated by Charles Darwin.

Darwin suggested that there must be a struggle for existence where by the fit individuals (better adapted) survive and the unfit ones die (survival for the fittest). Over a very long period of time these organisms can change into a different species.

EVIDENCE OF EVOLUTION

There are several evidences put forward to support the theory of evolution. These include;

- ✓ Comparative anatomy
- ✓ Comparative embryology
- ✓ Paleontology
- ✓ Taxonomy

- ✓ Comparative biochemistry
- ✓ Geographical distribution of organisms

1. Paleontology

This is the study of fossils. Fossils are remains of organisms that lived in the past and were preserved in rocks. Fossil studies show that organisms that lived in the past had some resemblance to the present day organisms. This shows that they had a common ancestry. The differences between them shows that evolution has occurred in the present day organisms.

2. Comparative embryology.

The study of the development of the zygote shows that organisms had a common ancestor. In all vertebrates for example the zygote develops a tail in the early stages and it is surrounded by membranes (amnion and allantois).

3. Cell biology.

The study of cells shows similarities between organisms. For example all cells of multicellular organisms have a nucleus, mitochondria and other organelles. This shows that the organisms had a common ancestry. The differences e.g. chloroplasts in plant cells shows that evolution took place

4. Comparative anatomy.

When anatomical structures of organisms are studied, they show similarities and differences. Similarities indicate that the organisms had a common ancestor while the differences show that they have evolved. For example all vertebrates have a pentadactyl limb but the limb has been modified in the different vertebrates and it performs different functions.

Homologous structures: These are structures from the common ancestral origin that serve different functions e.g. the pentadactyl limb composed of five digits like in the horse for running, monkeys for grasping, human beings for handling and bats for flying.

This type of evolution is called ***divergent evolution*** which is the type of evolution where by organisms with common ancestors have developed structures that perform different functions because of change in the environment they live in.

When structures are further compared, it is observed that some of them differ but serve the same functions. Such structures are known as ***analogous structures.***

Thus ***analogous structures are structures from different ancestral origin but serve the same functions***. Such evolution is called convergent evolution which is a type of evolution where by different organs with different ancestral origins perform the same function. This is because of the similar environments they live in e.g. wings of birds and wings of insects.

5. Comparative biochemistry.

The study of chemical composition and functioning between living organisms shows that they have a common ancestor for example all organisms have DNA, they have enzymes made out of protein, etc.

6. Geographical distribution:

Distribution of plants and animals in different parts of the world indicates evolution. I.e. different environment look different. However some organisms in different geographical location are similar meaning that they had a common ancestor.

"What men have done, man can do"