GENETICS AND HEREDITY

GENETICS

Genetics is the science which deals with the mechanisms responsible for similarities and differences among closely related species. The term 'genetic' was coined by W.Batesmanin 1905. It is derived from the Greek word 'genesis' meaning grow into or to become.

So, genetic is the study of heredity and hereditary variations it is the study of transmission of body features ; I'e, similarities and difference, from parents to offspring's and the laws related to this **transmission,**

VARIATION

Any difference between individual organisms or groups of organisms of any species, caused either by genetic difference or by the effect of environmental factors, is called variation. Variation can be shown in physical appearance, metabolism, behavior, learning and mental ability, and other obvious characters.

TYPES OF VARIATION

There are two types of variation.

Genotypic variations: - Genotypic variations are caused by differences in the number or structure of chromosomes or by difference in the genes carried by the chromosome. Height, eye colour, body forms are some of the genotypic variations. A variation cannot be identified as genotypic by simply observing the organism unless breeding experiments are performed under controlled environmental conditions.

Somatic variations: - Somatic variations may result from several factors**,** such as climate, food supply, and actions of other organisms. These variations are not due to differences in genes or chromosomes, and in general are not transmitted future generations. Hence they are not significance in the process of evolution.

Heredity: - Is defined as the transmission of characteristics from parents to offspring's. It can also be defined as resemblances among individuals related to descent. It also means the inheritance of like qualities or characters from the one generation to the next and to successive generations.

MENDELS LAWS OF HEREDITY

Gregor Johann Mendel (1822-1844) is known as the father of genetics as he was the first to demonstrate the mechanism of transmission of characters from one generation to the other.

He carried out his work on garden pea, pisum sativum. He selected 7 pairs of contrasting traits of garden peas.

Mendel's gave three laws or principles of inheritance.

1. **Law of dominance**: States that in heterozygous condition among two alleles of a character the alleles which expresses itself is dominant and the one which can't express is recessive.
2. **Law of segregation**: States that although the alleles of a character remain together for long time but they do not mix with each other and separate at the time of gametogenesis so that each gamete receives only one alleles of a character either dominant or recessive.
3. **Law of Independent assortment**: staies that alleles of a character can undergo any sort of combination to give rise to a phenotype differing from both the parents.

MENDEL'S EXPERIMENT

In 1857 Mendel began a series of experiments on the pea plant (Pisum Sativum) to study the pattern of inheritance of various characters. He chose pea plant for three reasons. First, pea plants are self-poillinating .Second they are easy to cultivate. Third, they have a sharply defined characters. Mendels chose to study seven different characters in this plant. Each characters such as height, seed shape, seed colour, etc., had two sharply defined and contrasting traits (e.g, dwarfstem and tall stem, wrinkled seed and smooth seed, yellow seed and green seed). He crossed a variety of pea plants, carrying a particular traits (e.g. tallness) of a character (such as height) with another variety having a contrasting traits (e.g, dwarfness) of the same character. These two types were called parental types (p or p1). The generation

that was produced out of these two was called first filial generation (F1). When these were self –polinated , the second generation that was produced was called second filial generation (F2).

The result of Mendel's experiment followed a pattern, which is as follows:

Whenever two varieties of a character were crossed, the F1 plants showed only one of the traits, the other traits never appeared. It did not matter whether the trait came from the pollen or ova.

The traits that did not appear in F1 reappeared in the F2 but in the ratio ¼ of the total number of the plants.

Mendel called the substance or agent responsible for each trait a 'factor'. According to Mendel, the trait that did not appear in the F1 was not destroyed or altered. He explained the phenomenon by which one trait appeared in the F1 and the other did not. He said that the trait which appeared in the F1 was domi;nant and the one which did not appear was recessive.

Mendel called that each genetic character was represented or controlled by a pair of unit factors, or elements.(Later on, the unit factors became known as alleles or allelomorphs . when the term 'gene' was coined and defined, the allele became synonymous with the gene.) One of the alleles came from one parent and the other from the other parent. The first generation plants of his experiments were all tall plants. The representing dwarfness could not be expressed in the first generation because it was dominated by the allele representing tallness. in other words the allele for tallness was dominant and the allele for dwarfness was recessive

NOTATIONS USED IN BREEDING EXPERIMENTS

The dominant trait is written with a capital letter .for example tallness is represented as T and darkness is represented with the corresponding small letters t. if tallness is due to both the dominant alleles, it is written as TT. If tallness is due to only one dominant trait then it is written as Tt. If both the alleles are receives, making the organism draft, then it is written as tt. A homozygous condition is one in which both alleles are of the same nature, for example .Tt or tt. Heterozygous condition (here, the two alleles are of different nature) is written as Tt. In a dihybrid cross, two characters are taken into account .Hence the notation for the homozygous domint would be AABB, and for the homozygous receives it would be aabb. When the gamete is formed the traits are separated, as the chromosome number during meiosis is halved.

LAW OF SEGREGATION

When the tall plants in F1 were crossed among themselves , the F2 generation ad 75% tall plants and 25% dwarf plants (ratio 3:1)This led Mendel to conclude that the alleles representing darkness were intact and were neither lost nor contaminated .Medals study with one character (monohybride cross)led to the formulation of the law or principle of segregation . This means that although the alleles of a character remain together, they are separated in subsequent generations.

LAW OF INDEPENDENT ASSORTMENT

After studying the inheritance of one pair of contrasting characters, Mendel went on to take two characters (Dihybrid cross) into account .He crossed a plant having smooth and yellow seeds with a plant having wrinkled and green seeds. All F1 plants had smooth and yellow seeds .when a Certain number of F1 plants were grown and self-crossed they gave rise to four types of seeds:315 smooth yellow, 108 smooth green,101 wrinkled yellow , and 32 wrinkled green. When its ratio is worked out ,it comes to 9:3:3:1.

This shows that the chances for the pea seeds to be smooth or wrinkled has no bearing on their chances to be yellow or green. In other words, each pair of alleles is independently separate of the other pair. This is the principle of independent assortment.

GENETICS AND HEREDITY

MONOHYBRID CROSS

A cross between living organisms in which only one pair of contrasting characters is taken into consideration is called monohybrid. The organism, which are crossed, may vary in more than one pair of contrasting characters.

While performing monohybride cross between two pea plants Mendel took height into consideration. He crossed a pure tall pea plant (TT) with a pure dwarf pea plant (tt). Emasculation of flowers and reciprocal transfer of pollen to stigma s made the cross .Seeds formed were collected and sworn in next season. This generation was given the name first generation of F1 generation . plants of this generation allowed to self-pollinate and seeds obtained were collected and sown in following season. The plants produced from the seeds were found to be tall as well as dwarf in the ratio of 3:1. These plants were given the name second filial or F2 generation and the ratio was called phyenotpic ratio.

When tall plants of this generation were allowed to undergo self pollination and seeds collected were sown in next season , tall as well as dwarf plants were produced which indicated that some tall plants contained dwarf allele. However, when dwarf plants were allowed to breed, they produced only dwarf plants. Thus another ratio 1:2:1. A graphic representation of monohybride cross is as under:

DIHYBRIDE CROSS

Dihybride cross may be defined as a cross between two individuals in which two pairs of contrasting character are taking into consideration. In this cross, mendel took color of seeds coat and texture of seed into consideration.

Mendel crossed a pea plant producing pure yellow and round seeds with another pea plant producing pure green and wrinkled seeds. Emasculating flowers of each variety and placing pollen of one type on the stigmas of the flowers of the other variety made the cross. Seeds collected from cross pollinated plants were all yellow and round indicating that yellow character is dominant over green character and roundness is dominant over wrinkle-less the seeds were sown in next season and the plants produced, representing first filial F1 plants were found to be of four types namely yellow round, yellow wrinkled, green round and green wrinkled. The plants which produced these seeds were roughly found to be in the ratio 9 : 3 : 3 : 1. The plants obtained from these seeds were given the name F2 generation and the ratio came to be called phenotypic ratio of dihybride cross. A graphic account of the cross is as under:

BACK CROSS: - It may be defined as the cross between F1 hybride and of its parents. It is used by animal and plant breeders to rapidly improve a breed or variety by making a useful trait (gene) homozygous, or 'pure'. It is of two kinds namely test cross and out cross.

TEST CROSS: - It may be defined as the cross between F1 hybride and it receiving parents. It is used by plant breeders to the validity of cross. It can be explained by following examples.

CHROMOSOMES

Chromosome is a Greek word meaning chrome means color and soma means body. Chromosomes are the thread-like structure present in the nucleons of cell which contain hereditary information of the cell. Chromosomes are made up of DNA and proteins. The characteristics travel from the parents to the offspring in the form of genes situated in the chromosomes present in the nuclei of the gametes. The number of chromosomes is constant for all individuals in a spices and each one of them has a fixed and equal number of chromosomes. The chromosomes of each species occur in pairs.

FUNCTIONS OF CHROMOSOMES

(i) Chromosomes are hereditary vehicles that contain genes. All the hereditary information is located in the genes.

(ii) Chromosomes control the synthesis of structural proteins and thus help in cell division, cell repair and cell growth.

(iii) By directing the xynthesis of enzymatic proteins, chromosomes control cell metabolism.
(iv) Chromosomes guide development and control cell differentiation.
(v) Chromosomes replicate themselves to bring about replication.
(vi) Sex chromosomes (XX and XY or XX and Xo chromosomes) determine the sex of individuals.
(vii) Through the process of crossing over, chromosomes induce variations.
(viii) Chromosomes undergo mutations (changes) and contribute toward evolution of life.
(ix) Chromosomes form a link between the off springs and the parents.

GENES

The term 'gene' was introduced by Johannson. Genes are the units of inheritance forming part of a chromosome. These are passed from parents to the offspring's via chromosomes in the nuclear of the parent's gametes.

FUNCTIONS OF GENES

(i) Genes are associated with the inheritance of characteristics. These are the heredity units.
(ii) They code for different types of RNAs essential for proteins synthesis.
(iii) Genes regulate transcription to generate proteins as and when required in the cells.
(iv) They code for proteins, structural as well as functional, to control the phenotype and metabolism.
(v) Genes contribute to reproduction through their replication.
(vi) They can repair themselves, if damaged, to maintain specificity.
(vii) Genes cause differentiation of cells during development.
(viii) Genes undergo mutation and recombination to help in evolution.

DNA (DEOXYRIBOSE NUCLEIC ACID)

DNA is the genetic material in all organisms. It occurs in the cytoplasm in nucleotides and plasmids. In eukaryotic cells, DNA s largely confixed to the nucleons and is the main component of chromosomes. DNA is a helically – twisted double chain poly-deoxyri bonnucleotide macromolecule. It is a polymer and is made up of several hundred thousands of deoxy-rebo nucleotides or monomers.

FUNCTIONS OF DNA

(i) DNA is a genetic material which carries all the hereditary information coded in the arrangement of its nitrogenous bases.
(ii) It has the property of replication essential for passing genetic information from one generation to the next.
(iii) Crossing-over of DNA produces recombination.
(iv) DNA controls the metabolic reactions of cells through RNA and RNA-directed synthesis of proteins, enzymes and other biochemical.
(v) It gives rise to RNA through transcription.

SEX CHROMOSOMES:

The chromosomes which determine the sex of a person are called sex chromosomes. There are two types of sex chromosomes, one is called X chromosome and the other is called y chromosome.

SEX DETERMINATION IN HUMANS:

A male has one X chromosomes and one Y chromosome. This means that half the male gametes or half the sperms will have X chromosomes and the other half will have Y chromosomes.

A female has two X chromosomes. This means that all the female gametes will have only X chromosomes.

The sex of a child depends on what happens at fertilization.

(a) If a sperm carrying X chromosome fertilizes an own which carries X chromosome, then the child born will be a girl. This is because the child will have XX combination of sex chromosomes.
(b) If a sperm carrying Y chromosome fertilizes an ovum which carries X chromosome, Then the child born will have XY combination of sex chromosomes.

THE TERMS WHICH ARE USED MORE FREQUENTLY IN GENETICS

1. ***Allele*****: -** one of two or more forms that can exist it a single gen locus, distinguished by its different effects on phenotype. Alleles are genes controlling the same characteristic (e.g eye colour) but produce different effects (e.g black or blue), and occupying corresponding positions on homologous chromosomes.

2. ***Homozygous Organism*****:-**An organism containing both alleles of same type for a particular trait or character e.g, A Pea plant having TT alleles for tallness is homozygous tall pea plant.

3. ***Heterozygous Organism*****:** - An organism having different alleles for a particular trait or character e.g, A pea plant having tt alleles for tallness is heterozygous tall.

ORGANIC EVOLUTION

The term 'evolution' means "unrolling or unfolding" change from one condition to another. It means members of species change generation after generation accordance with environmental requirements to turn into better organized and more complex new species.

Evolution can be defined as the sequence of gradual changes which take place in the primitive organisms over mlleons of years in which new species are produced. Since the evolution is of the living organisms, so it is called 'organic evolution'.

EVIDENCE OF ORGANIC EVOLUTION

Some of the important sources which provide evidences for organic evolution are:

(i) Fossils,
(ii) Homologous organs,
(iii) Analogous organs,
(iv) Vestigial organs, and
(v) Embryology

Fossils provide evidence for evolution: - The remains (or impressions) of dead animals or plants that lived in the remote past are known as fossils. The fossils provide evidence for evolution. For example, a fossil bird called Archaeopteryx looks like a bird it has many other features which are found in the reptiles. This is because Archaeopteryx has feathered wings like those of birds but teeth and tail like those of reptiles. Archaeopteryx is, therefore, a connecting link between the evolved from the reptiles. Thus, fossils provide the evidence that the present animals (and plants) have originated from the previously existing ones through the process of continuous evolution.

Homologous organs provide evidence for evolution: - If we look at the way in which living organism are made, we can often see quite striking similarities in their construction. One of these is the presence of homologous different functions.

The presence of homologous forelimbs in a frog, a bird and a man indicate that all these forelimbs have evolved from a common ancestral animal which had a 'basic design' limb. In other words, it tells us that a frog, a bird and a man, all have evolved from a common ancestor. Thus, the presence of homologous organs in different animals provides evidence for evolution by telling us that they are derived from the same ancestor who had the 'basic design' of the organ on which all the homologous organs are based.

Analogous organs provide evidence for evolution: - those organs which have different basic structure (or different basic design)but have similar appearance and perform similar functions are called analogous organs. For example, the wings of an insect and bird have different structures (the insects have a fold of membranes as wings which are associated with a few muscles whereas a skeleton, flesh and feathers support bird's wings) The presence of analogous organs indicates that even the organisms having organs with different structures

can adapt perform similar functions for their survival under hostile environmental conditions. Thus, the presence of analogous organs in different animals provide evidence for evolution by telling us that though they are not derived from common ancestors, they can still evolve to perform similar functions to survive, flourish and keep on evolving in the prevailing environment. the analogous organs actually provide a mechanism for evolution.

Vestigial organs provide evidence for evolution: - Vestigial means 'small and useless'. Those organs in an organism which are functionless and useless now (but used to function in its ancestors) are called vestigial. Vestigial organs (or vestigial structures) are actually the functionless remnants of the once functioning organs provide evidence for evolution. The vermiform appendix of the large intestine and the nictitating membrane of the eye are vestigial organs in human beings. Though the appendix is a vestigial organ in humans but the appendix is still functioning among the herbivorous ruminating mammals (like cow and buffalo). This indicates that human beings may have evolved from such mammals which had a functional appendix in them. Similarly, the nictitating membrane in human humans (which is present as a small fold of skin in the corner of the eye) is a vestigial organ but the nictitating membrane is still functioning in birds and provides protection to their eyes. This indicates that human beings may have evolved from those ancestors who had a working nictitating membrane in the eyes. Thus, the presence of vestigial organs is a good evidence for the evolution of human beings.

Embryology provides evidence for evolution: - A study of the development of the embryo of an animal is called embryology. A study of the development of the embryos of the different vertebrate animal's shows striking similarities in their structure. In fact, the embryos of the different vertebrate animals are so similar in their early stages of development that it is difficult to distinguish one from the other. The fact that the early embryos of all vertebrate animals like fish, salamander, tortoise, chick, calf and human look alike indicates that all these animals have evolved from a common ancestor.

DARWIN'S THEORY OF EVOLUTION BY NATURAL SELECTION

Charles Robert Darwin, an English scientist sailed on the survey ship, H.M.S. Beagle in 1831 as a young naturalist, when he was only 22 years old. Over a period of next five years, he studied variety of animals and collected a great deal of data on variations.

Based on this data, in 1839, Darwin formulated his theory and published his book **"The Origin of Species".**

The theory proposed by Darwin is popularly known as the **"Theory of natural selection"** or **Darwinism.**

SUMMARY OF DARWIN'S THEORY OF EVOLUTION

Darwin's theory of evolution by natural selection can be summarized as given below:

All organized produce **much more offspring's than can actually survive.** For example, a house fly lays thousands of legs; a fern plant produces millions of spores etc.

1. ***Struggle for existence***. Due to over population, there is struggle between the members of same species as well as from other species for food, water, air and space. Only a few are able get it and survive and the rest perish and get eliminated.
2. ***Variations exist within population***. The offspring's of the same parents also differ from one another and show variations. Also apart from visible variations, certain hidden variations also exit.

The variations are very important for evolution for some of these help the individual to survive in a certain type of environment while others may not.

3. ***Survival of the fittest or Natural selection*.** The individuals will favorable variations survival in the struggle. The organism with unfavorable variations die out and so only the fittest individuals survive, reproduce and transmit their favorable characters to the next generation.

This process of the survival of the fittest over many generations slowly increases the population of fit individuals due to the heritable favorable variations. In other words, nature

selects the individuals that are well adapted to the environment and allows them to survive. At the same time, nature rejects those that are poorly developed .hence nature selection is a weeding put process by which only the fittest individuals are selected.

4. ***Origin of new species***. As the favourable variations of the fittest animals are inherited to the offspring's these variations when accumulated over for a long time, lead to the origin of new species.

ACQUIRED AND INHERITED TRAITS

Changes in the environment (food, temperature, light etc.) influence the functioning and behavior of livening organisms and intr4oduce changes in their structure. New characters are acquired or accumulated in an organism during its life time by use and disuse of organs or by the influence of the environment. These characters are called acquired characters. The environment and use and disuse of organs affect somatic cells only. This means acquired characters are restricted to somatic cells alone and do not influence germ cells. So, these traits cannot be inherited.

Examples:-

1. The weight of the beetle is reduced because of starvation that will not change the DNA of the germ cells. So, this change in weight is not an example of evolution. It is also not passed (inherited) over generations.
2. If any of the parent becomes blind or deaf or lame before producing the offspring, they do not produce blind, deaf or lame offspring.
3. The strong muscles of a wrestler are not inherited by his children.

SPECIATION

The process by which new species develop from the existing species is known as speciation. In simple words, the formation of new species is called speciation.

FORMATION OF NEW SPECIES

In most of the cases, new species are formed when the population of same species splits into two separate groups which then get isolated from each other geographically by the barriers such as mountain ranges, rivers or the sea. The geographically isolation of the two groups of population leads their reproductive isolation due to which no genes are exchanged between them. However, breeding continuous within the isolated populations producing more and more generations. Over the generation, the processes of genetic drift (random change in gene frequency), and selection operate in different ways in the two isolated groups of population and make them more different from each other .After thousands of years, the individuals of these isolated groups of population become so different that they will be incapable of reproducing with each other even if they happen to meet again. We say that two new species have been formed.

The important factors which could lead to rise (or formation) of a new species are the following:-

1. Geographical isolation of a population caused by various types of barriers (such as mountain, ranges, rivers and sea). The geographical isolation leads to reproductive isolation due to which there is no flow of genes between separated groups of population.
2. Genetic drift caused by drastic changes in the frequencies of particular genes by chance alone.
3. Variations caused in individuals due to natural selection.

CHARACTERISTICS

Characteristics are details of behavior or appearance. It can also be defined as a particular form or a particular function. The plants can photosynthesise, fungus can decompose, we have four limbs, we have external ear pinna, and all these are characteristics. There is a great diversity among different kinds of organisms, yet they have certain common characteristics and life processes. The more characteristics two species will have in common, the more closely they are related. They will also have a common ancestor.