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Struggle of Scientists to Establish the Concept of Heredity

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Introduction

Today we all know the reason of similarity of progeny to their parents (heredity) and the reason of differences among the individuals related to a descent (variation) but in ancient times, there were many controversies on the nature of heredity. Many ideas or theories were given by early philosophers and workers to explain the phenomenon of inheritance which are briefly presented here-

Theory of preformation was proposed by **Johnn Swammerdam** and **Bonnet** (**1720-1793**). This theory states that a miniature human (complete in all aspects called homunculus is already present in eggs or sperm cells. The development of progeny involved only the growth of this homunculus.

Theory of epigenesis was proposed by **Wolf** (**1738-1794**), which states that gametes contain undifferentiated material instead of homunculus. Differentiation in this materials leads to production of tissues and organs of an organism. This theory is universally accepted.

Theory of inheritance of acquired characters was proposed by **Lamarck** (**1744-1829**) in which he tried to prove that the characters gained by an organism after his birth (acquired characters) are heritable in nature. He gave the example of long neck of giraffe to support this theory.

Theory of Pangenesis was proposed by **Charles Darwin** to support the Lamarck's theory. According to this theory each body organ of an individual has very small, exact but invisible copy of its own, called pangene or gemmule. These gemmules transported to the sexual organ through blood stream and take part in sexual reproduction. Therefore, any change in body organ will lead to the change in its gemmule and in this way this will also occurs in the progeny. These two theories (theory of inheritance of acquired characters

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and theory of pangenesis) were disproved by Weismann by proposing germplasm theory.

The germplasm theory was proposed by **Weismann** (**1889**) in which he stated that the changes that occurred in germ cells are heritable. While the changes that occurs in somatic cells are not heritable. He cut the tail of mice for 22 successive generations but there was no any tailless progeny produced from tailless parents. He always got the progeny of mice with tail. This disproves the theory of acquired characters.

Gregor Johnn Mendel in **1965** developed two fundamental principles of heredity *i.e.,* Law of segregation and Law of independent assortment in which he explained the reason of differences among the individuals related to a descent (variation). After **Mendelian era,** many ideas or theories were given by many workers about the nature of heredity. These are briefly presented here-

Mutation Theory was put forth by **Hugo de Varies in 1901** in which he pointed out that spontaneous mutations are potential source of creating new variability in the natural populations. The new variation created by spontaneous mutation is heritable and plays important role in the process of natural evolution. It sometimes leads to formation of new species.

Chromosomal theory of inheritance was proposed by **Sutton** and **Boveri** in **1903** working with grasshopper. This theory states that genes which govern various characters are present in chromosomes. Therefore, chromosomes are physical basis of inheritance and the inheritance of characters from one generation to the next generation is governed by chromosomes.

The concepts such as sex chromosomes, sex linkage, structural chromosomal change, monosomic and nullisomic analysis, bar locus, crossing over etc. support this theory of inheritance and all these concepts provide evidence that genes are located in the chromosome and chromosome act as physical basis of inheritance. This theory is widely accepted.

Hardy-Weinberg Law was proposed by **Hardy** from Holland and **Weinberg** from Germany in **1908**. In this law they states that gene and genotype frequencies in a random mating population remain constant generation after generation if there is no selection, migration, mutation and random genetic drift.

According to this law the gene frequencies in a random mating population for a single locus will be $P + q = 1$ $(A + a = 1)$ and genotype frequencies will be $P^2 + 2Pq + q^2 = 1$ $(AA + 2Aa + aa = 1)$.

Multiple factor hypothesis was originally proposed by **Yule** in **1906** but evidence for this hypothesis was provided by **Nilson Ehle** in **1908** working with kernel

colour in wheat. This hypothesis provides explanation for inheritance of polygenic characters. This theory states that quantitative characters governed by many minor genes that have very small but cumulative effect on the expression of the character, so the effect of single gene on the development of the character is not detectable. Quantitative characters showed continuous variation therefore their classification in distinct groups is not possible. The analysis of polygenic character is based on mean, variances and co-variances. This theory is universally accepted.

Linkage theory was given by **Thomas Hunt Morgan** in **1910** working with fruit fly (***Drosophila melanogaster***). This theory states that genes located in the same chromosome in linear fashion inherited together during inheritance. The maximum number of linkage group in an organism will be equal to gametic chromosome number of the concerned species. For this outstanding theory T.H. Morgan got awarded with **Nobel Prize** in **1933**. This theory is universally accepted.

One gene one enzyme hypothesis was given by **Beadle** and **Tatum** in **1941** working with **pink bread mould** (***Neurospora crassa***) to explain the gene action. This hypothesis states that a specific enzyme specified by a specific gene and this enzyme catalyzes a specific metabolic pathway. Thus genes control the chemical reaction by production of specific enzyme. One of the **first clear cut proof** of this hypothesis came from arginine biosynthesis pathway of ***E.coli***. This pathway consist of 8 biochemical reactions each of which is controlled by a specific enzyme and such enzymes controlled by a specific genes. For this outstanding work in the area of biochemical genetics **Beadle** and **Tatum** along with **Lederberg** got **Nobel Prize** in **1958** in Medicine.

One gene one polypeptide hypothesis was proposed by **Ingram** in **1957**. According to this hypothesis many enzymes are composed of single polypeptide while many other enzymes are composed of two or more polypeptides and each polypeptide is controlled by a single specific gene. For example, tryptophan synthesis in E.coli consists of four polypeptide chains (two alpha and two beta chains) which are encoded by two different genes located adjacent to each other.

Thus one gene one enzyme is valid for only those enzymes that are composed of a single polypeptide.

This is notable that many genes specify nonenzyme protein molecule *e.g.*, haemoglobin, myoglobin, structural protein etc.

Therefore, the one gene one polypeptide hypothesis is more appropriate and accounts for monomeric, dimeric etc.

enzymes and for nonenzyme proteins. It is also notable that many genes do not produce polypeptide; they only encode RNA molecules that perform various functions *e.g.*, tRNA genes, rRNA genes and genes for small nuclear RNA (snRNA).

Therefore, one gene one enzyme or polypeptide hypothesis would be applicable to only those genes that encode polypeptide sequences.

Operon hypothesis was proposed by **Jacob** and **Monod** in **1961** working with E.coli to explain the mechanism of gene regulation in prokayotes. This hypotheis states that, in prokaryotes many genes clustered together and they have only single regulatory sequence. Such types of genes clustered with single regulatory sequence called operon which is found in only prokaryotes. **Jacob** and **Monod** got **Nobel Prize** for this universally accepted hypothesis in **1965**.

Wobble hypothesis was proposed by **Crick** in **1966** to explain degeneracy of genetic code (two or more different codon may code a single amino acid) and to explain unusual base pairing between codons and anticodons.

According to this hypothesis only the first two bases of a codon must pair in the usual manner with bases of tRNA anticodon, the third base of the codon can pair in a different way. This hypothesis is universally accepted.

Lyons hypothesis was proposed by **Lyon** in **1969**. This hypothesis states that an individual may have any number of X chromosomes but only one will be active and others will be inactive. The number of inactive X chromosomes is represented by the number of **sex chromatin bodies** or **barr bodies**.

In organism that has heterogametic male, the male has only one dose of X chromosome while female has double dose of X chromosome but they do not differ in their gene products. This indicated that either one X chromosome of female is inactivated or both the X chromosomes of females are hypoactivated or X chromosome of male is hyperactivated to compensate the gene product in male and female. This phenomenon is known as **Dosages Compensation** which was proposed by **Muller** in **1932.**

The inactive or heterochromatinized X chromosomes are termed as Barr body by **Murray Barr** working with nerve cells of cat. Total number of barr bodies in an organism will be n-1 where n = number of X chromosomes.