RAMA UNIVERSITY

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# FACULTY OF AGRICULTURAL SCIENCES

# AND ALLIED INDUSTRIES

# MULTIPLE FACTOR HYPOTHESIS

**Polygenic inheritance quantitative characters**

It shows more or less continous variation and are governed by a large number of genes called ' multiple gene' or 'multiple factor' or 'polymeric genes' or 'polygenes'.

**Nilson -Ehle's studies on kernel colour in wheat**

The Swedish geneticist Nilson - Ehle (1908) effected crosses between different true breeding strains of wheat with red kernels and those with white kernels. Careful examinations however revealed that, a red colour of the F1 was not so intense as the red colour of the parent and that in the F2. Some red grains wree as dark as those of parent and others only as dark as those of the F1. It was possible to separate the F2 in to the following;

| | | | |
|---|---|---|---|
| Dark red | 1 | - | R1 R2 R2 R2 - 4 contributing genes. |
| Meidum dark red | 4 | - | 3 contributing genes |
| Medium red | 6 | - | " |
| Light red | 4 | - | " |
| White | 1 | - | No " |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Red | | | | | | White | | | |
| Parents | R1 R1 R2 R2 | | | x | | | r1 r1 r2 r2 | | | |
| F1 | R1 r1 R2 r2 Medium red. | | | | | | | | | |
| F2 | 1 | : | 4 | : | 6 | : | 4 | : | 1 | |

It is evident that, red colour is due to two pairs of alleles. Each gene is capable of producing red colour. Each is in completely dominant over white and in cumulative in its effect. The intensity of red colour depends upon the number of colour producing gene present.

From these studies, Nilson-Ehle proposed the multiple factor hypothesis for the inheritance of quantitative characters. This assumes that there is a series of independent genes for a given quantitative trait. Dominance is usually in complete, but these genes are cumulative or additive in their effect. Each gene adds something to the strength of expression of the character, whereas its allele does not posses any effect.

**Transgressive segregation**

The appearance of individuals in the F2 or a subsequent generation which exceed the parental limits withrespect to one or more characters.

e.g. Skin colour in human beings

White x Negro Mariages -

By Daven port (1913) by multiple factor hypothesis.

Hypothetical example,

Plant height (cm)

| | | |
|---|---|---|
| 200 cm tall | | 100 cm tall |
| T1 T1 T2 T2 | x | t1 t1 t2 t2 |

F1 T1 t1 T2 t2 150 cm

T1 T2 - Active contributing genes

T1 t2 neutral or inert alleles F2 1 : 4 : 6 : 4 : 1

Cm 200 175 150 125 100 cm.

**Fine structure of Gene**

**Benzer** in 1955 divided the gene in to recon, muton and cistron. He worked on rII locus of baceriophage. Recon is the recombinational unit, muton is the mutational unit and cistron is the functional unit.

## CYTOPLASMIC INHERITANCE

It is not only the nuclear genes but also a variety of extra nuclear substances that are transmitted from generation to generation. In plant cells, plastids, mitochondria localized in the cytoplasm have been shown to be responsible for the extra nuclear transmission of inherent qualities like the nuclear genes, they are capable of specific self-duplication. They are transmitted from generation to generation.

They totality of heredity transmitted through the cytoplasm is referred to as plasmon, and all cytoplasmic particles which manifest genic properties viz., self duplication, specificity and mutability are called " plasma genes'.

**Inheritance of plastids in Merabilis**:

The inheritance of plastids in Four 'O' clock plant M*eiabilis jalapa* was first described by Correns (1908). In M. Jalapa, some of the branches may have normal green leaves, while in the same plant, some other branches may have only pale green or white leaves and still others may have variegated leaves. Flowers on branches with normal green leaves produce seeds that grow into plants with normal green leaves irrespective of whether they are pollinated by pollen from branches with normal green variegated or pale green leaves.

**Progeny of a Variegated four 'O' clock plant**

| Type of branch from which flowers are chosen for pollination | Type of branch from which pollen was obtained | Type of leaf in the progeny grown from seed |
|---|---|---|
| Green | Green, | Only green |
| | variegated, | " |
| | pale green | " |
| Variegated | Green | Green, variegated, or pale |
| | Variegated | " |
| | Pale green | " |

| | | |
|---|---|---|
| Pale green | Green | Green, pale green |
| | Variegated | “ |
| | Pale green | “ |

It is clear that variegation is determined by agencies transmitted through the female and that it is not influenced by the type of pollen used. These agencies are the chloroplast. They are capable of self-duplication and are transmitted from generation to generation through the cytoplasm of the egg. Seeds borne on a green branch have three gene only green plastids, seeds borne on a pale green branch have three gene only pale green plastids and seeds borne on a variegated branch have green or pale green or a mixture of the two types of plastids.

Variegation is thus a heredity character determined by stable, self-duplicating, extra nuclear particles called plastids. Neither the nucleus of the female gamete nor the male gamete is involved in the control of this type of heredity character.

**Maternal inheritance by ‘iojap’ gene in maize**

The egg regularly contributes much more cytoplasm to the next generation than does the sperm. It should therefore be expected that in cases of cytoplasmic inheritance, differences between reciprocal crosses would result.

*Rhoades (1946) identified the ‘iojap’ gene (ijij) in maize located in chromosome VII controlling plastid inheritance in the plant. The gene ‘Ij’ is responsible for the normal green colour of the plant.*

When normal green plants with IjIj are used as female and pollinated by pollen from stripped with ijij, F1 plants are wholly green.

1. Green x stripped

↓

Ε Γ

Ij Ij ij ij

F1 Ijij Green

F2 3 green : 1 Iojap.

When striped with ijij are pollinated by pollen from the normal green plants with IjIj the F1 plants, all of which have the same genotype. Ijij are of 3 different phenotypes.

**Stripped ijij X Green Ij Ij**

Ε (Iojap) Γ

F1 Ijij Green, stripped or white (Iojap)

When plants with same genotype Ijij have different phenotype viz., normal green, stripped or white, the differences can be attributed only the differences in plastids.

***Cytoplasmic male sterility in Maize***

In case of male sterility in maize, pollen grains of such male sterile are aborted. This male sterility is transmitted only through the female and never by the pollen. When all of the chromosomes of the male sterile line were replaced with chromosomes of normal plants, the line still remained male sterile, showing thereby that male sterility in controlled by some agency in the cytoplasm. It was later recognized that cytoplasmic male sterility in maize results from alterations in the heredity units in the mitochondria (mitochondrial DNA).

**Inheritance of Kappa particles in Paramecium**

In *Paramecium aurelia,* two strains of individuals have been reported. One is called as ‘ Killer’ which secretes a toxic substance ‘ paramecin’ and the other strain in known as ‘ sensitive’ and is killed if comes in contact with the ‘paramecin’. In the cytoplasm of the killer strain the kappa particles (cytoplasmic – DNA) are present kappa particles are absent in sensitive strains. The transmission of kappa particles is through cytoplasm but maintenance of kappa particles and production of paramecin is controlled by ‘k’ we assume that the killer strains carry dominant allele ‘kk; and that sensitive ‘kk’.

On conjugation, conjugents exchange their nuclear material so that ex-conjugants ‘kk’ resulted from conjugants ‘kk’ and ‘kk’ when conjugation is for normal time, then only nuclear material is exchanged and therefore killer will produce killer daughters and sensitive will produce sensitive daughters. But if the conjugation is in longer period, there will be exchange of cytoplasm resulting in the inheritance of kappa particles by both the ex-conjugants so that all the daughter paramecia produced are killers because all inherit the kappa particles through the mixing of cytoplasm. Therefore this trait is transmitted through cytoplasmic heredity. The trait is only stable is killer strains.

**Inheritance through mitochondria**

Mitochondria can self-replicate and represent another genetic system in the cell. Of course, the amount of mitochondrial DNA is so small, representing less than 1% of the nuclear DNA is mammalian cells and it can code for a part of the protein in the mitochondria. The synthesis of the cytochrome found in mitochondria for example, is known to be present in minute amount in cytoplasm under the control of nuclear genes. Therefore, it is suggested that both mitochondria and chloroplast seem to have a semi-autonomous existence and their DNA forms the basis for genetic systems separate from that in the nucleus.

## EPISOME IN BACTERIA

Some hereditary particles have been found to exist in two states, either in an autonomous state in the cytoplasm, where they replicate in dependently, of the chromosomes, or in an integrated state incorporated into the chromosome. Particles with such properties are known as episomes and include such things as the sex factor. The episomes are apparently not essential to the life of the bacteria, because they may or may not be present. If they are absent, they can be acquired only from an external source.

In bacteria, E coli, sex is determined by the presence or absence of the sex factor (F). Male bacterial cells (donor) have the sex factor and this factor is responsible for the transfer of DNA from male to female bacterial cells (Recipient). This sex factor is the cytoplasmic particle.

## QUANTITATIVE AND QUALITATIVE INHERITANCE

The phenotypic traits of the different organisms may be of two kinds, viz., qualitative and quantitative. The qualitative traits are the classical Mendelian traits of kinds such as form (e.g., round or wrinkle seeds of pea); structure (e.g., horned or hornless condition in cattles); pigments (e.g., black or white coat of guinea pigs); and antigens and antibodies (e.g., blood group types of man).

Qualitative trait may be under genetic control of two or many alleles of a single gene with little or no environmental modifications to obscure the gene effects. The organisms possessing qualitative traits have distinct (separate) phenotypic classes and are said to exhibit discontinuous variations.

The quantitative traits, however, are economically important measurable phenotypic traits of degree such as height, weight, skin pigmentation, susceptibility to pathological diseases or intelligence in man; amount of flowers, fruits, seeds, milk, meat or egg produced by plants or animals, etc. The quantitative traits are also called metric traits. They do not show clear cut differences between individuals. Such genes which are non-allelic and effect the phenotype of a single quantitative trait, are called polygenes or cumulative genes. The inheritance of poly genes or quantitative traits is called quantitative inheritance, multiple factor inheritance, multiple gene inheritance or polygenic inheritance. The genetical studies of qualitative traits are called qualitative genetics.

The quantitative inheritance has following characteristics:

1. The segregation phenomenon occurs at an indefinitely large number of gene loci.

2. If a substitution of a allele occurs in a gene locus then such allelic substitutions have trivial effects.

3. The genes for a multiple trait have different biochemical functions but similar phenotypic effects, therefore, the phenotypic effects of gene substitutions are interchangeable.

4. Blocks of genes are bound together by inversions and transmitted as units from inversion heterozygotes to their progeny, but such blocks are broken up by crossing over in insersion homozygotes.

5. The polygenes have pleiotropic effects; that is, one gene may modify or suppress more than one phenotypic trait. A single allele may do only one thing chemically but may ultimately affect many characters.

6. The environmental conditions nave considerable effect the phenotypic expression of poly genes for the quantitative traits. For example, height in many plants (e.g., corn, tomato, pea, marigold) is genetically controlled quantitative trait, but some environmental factors as soil, fertility, texture, and water, the temperature, the duration and wavelength of incident light, the occurrence of parasites, etc., also affect the height. Similarly, identical twins with identical genotypes, if grow up in different kinds of environments, show different intelligence quotients.

Examples of Quantitative Inheritance 1. Kernel Colour in Wheat Nilsson-Eble (1909) and East (1910, 1916) gave first significant clue of quantitative inheritance by their individual works on wheat. They crossed a strain of red kernel wheat plant with another strain of white kernel. Grain from the F1 was uniformly red, but of a shade intermediate between the red and white of the parental generation. This might suggest incomplete dominance, but when F1 off-springs were crossed among themselves, the F2 zygotes showed five different phenotypic classes in a. ratio of 1 : 4 : 6 : 4:1

Qualitative characters are the easiest characters, or traits, to deal with are those involving discontinuous, or qualitative, differences that are governed by one or a few major genes. Many such inherited differences exist, and they frequently have profound effects on plant value and utilization. Examples are starchy versus sugary kernels (characteristic of field and sweet corn, respectively) and determinant versus indeterminate habit of growth in green beans (determinant varieties are adapted to mechanical harvesting). Such differences can be seen easily and evaluated quickly, and the expression of the traits remains the same regardless of the environment in which the plant grows. Traits of this type are termed highly heritable.

A qualitative trait is expressed qualitatively, which means that the phenotype falls into different categories. These categories do not necessarily have a certain order. The pattern of inheritance for a qualitative trait is typically monogenetic, which means that the trait is only influenced by a single gene. Inherited diseases caused by single mutations are good examples of qualitative traits. Another is blood type. The environment has very little influence on the phenotype of these traits.