RAMA UNIVERSITY

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QUALITATIVE AND QUANTITATIVE CHARACTERS

The phenotype of any individual can be classified into two types:

1) Qualitative characters and 2) Quantitative characters

Qualitative characters: The characters that show discontinuous variation and which cannot be measured easily are known as qualitative characters. These are also known as classical mendelian traits.

Eg: Corolla colour – Red white or pink no continuous variation

Seed shape – Round wrinkled variation is not continuous

Quantitative characters are those showing continuous variation and which can be measured easily? These characters are also known as metric traits. The data obtained from such characters is known as quantitative data. This data can be subjected to statistical analysis and the branch of science which deals with such analysis is known as quantitative genetics or biometrical genetics.

Eg: Yield, Plant height

Characters	**Quantitative characters**	**Qualitative characters**
Deals with	Traits of degree Eg: Plant height, seed weight, yield etc.	Traits of kind Eg: Corolla colour, seed shape, appearance etc
Variation	Continuous	Discontinuous
Effect of individual gene	Small and undetectable	Large and detectable
No. of genes involved	Several (polygenic)	one or few (mono /oligogenic)
Grouping into distinct Classes	Not possible	Possible
Effect of environment	High	Low
Metric measurement	Possible	Not Possible
Statistical analysis	Based on mean, variance, standard	Based on ratios and
Stability	Low	High
Transgressive segregation of	Yes	No
Dominance effect	No	Yes
Cumulative effect of each	Yes	No

QUANTITATIVE TRAITS - QUALITATIVE TRAITS AND DIFFERENCES BETWEEN THEM

Quantitative genetics (Inheritance of Multiple Genes)

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) and so on. We have already discussed in previous chapters that each 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 and forms a spectrum of phenotypes which blend imperceptively from one type to another to cause continuous variations. In contrast to qualitative traits, the quantitative traits may be modified variously by the environmental conditions and are usually governed by many factors or genes (perhaps 10 or 100 or more), each contributing such a small amount of phenotype that their individual effects cannot be detected by Mendelian methods but by only statistical methods.

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.

Certain Characteristics of Quantitative Inheritance

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 F_1 was uniformly red, but of a shade intermediate between the red and white of the parental generation. This might suggest incomplete dominance, but when F_1 offsprings were crossed among themselves, the F2 zygotes showed five different phenotypic classes in a. ratio of 1 : 4 : 6 : 4:1

While operating in this cross. Each gene was supposed to contain two alleles. One allele produces a given quantity of the red pigment, while its counterpart did not produced any pigment. All alleles were equally potent in the production or lack of production of pigment. If we symbolize the genes for red with the capital letters A and B and their, alleles resulting in lack of pigment production by a and b: We can illustrate the results of this cross as follows:or 1/16 Red: 4/16 Dark: 6/16 Medium: 4/16 Light: 1/16 White.

P:	Red		White
	AABB	x	aabb
Gametes:	(AB)(AB)		(ab)(ab)
F_1:	Medium		Medium
	AaBb	x	AaBb

2. Noting that 1/16 of the F2 was an extreme in colour as either of the parental plants (red or white), they theorized that two pairs of genes controlling production of red pigment while operating in this cross. Each gene was supposed to contain two alleles. One allele produces a given quantity of the red pigment, while its counterpart did not produced any pigment. All alleles were equally potent in the production or lack of production of pigment. If we symbolize the genes for red with the capital letters A and B and their, alleles resulting in lack of pigment production by a and b: We can illustrate the results of this cross as follows:or 1/16 Red: 4/16 Dark: 6/16 Medium: 4/16 Light: 1/16 White.

P:	**Red**		**White**
	AABB	x	aabb
Gametes:	(AB)(AB)		(ab)(ab)
F_1:	Medium		Medium
	AaBb	x	AaBb

Female/Male	**AB**	**Ab**	**aB**	**ab**
AB	ABB Red	AABb Dark	AaBB Dark	AaBb Medium
Ab	AABb Dark	AAbb Medium	AaBb Medium	Aabb Light
aB	AaBB Dark	AaBb Medium	aaBB Medium	aaBb Light
Ab	AaBb	Aabb	aaBb	Aabb

3. Skin Colour in Man

Another classical example of polygenic inheritance was given by Davenport (1913) in Jamaica. He found that two pairs of genes, A-a and B-b cause the difference in skin pigmentation between Negro and Caucasian people. These genes were found to affect the character in additive fashion. Thus, a true Negro has four dominant genes, AABB, and a white has four recessive genes aabb. The F_1 offspring of mating of aabb with AABB, are all AaBb and have an intermediate skin colour termed mulatto. A mating of two such mulattoes produces a wide variety of skin colour in the offspring, ranging from skins as dark as the original Negro parent to as white as the original white parent. The results of this cross are as follows :

Parents:	Negro		White
	AABB	x	aabb
Gametes:		↓	
F_i:	Mulatto		Mulatto
	AaBb	x	AaBb
		↓	

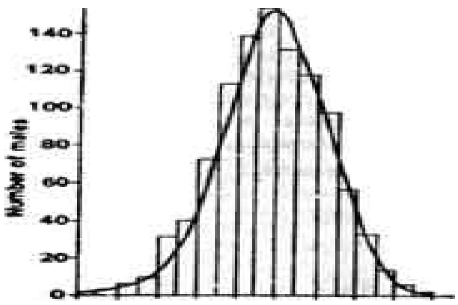
F_2 results:

Phenotypes	Genotypes	Genotypic Frequency	Phenotypic Ratio
Black (Negro)	AABB	1	1
Dark	AaBB, AA Bb	2 2	4
Intermediate	AaBb aaBB AA bb	4 1 1	6
Light	Aabb Aa Bb	2 2	4
White	as bb	1	1

These results are clearly showing that A and B genes produce about the same amount of darkening of the skin ; and therefore, the increase or decrease of A and B genes cause variable phenotypes in F2 in the ratio of 1 Negro: 4 dark : 6 intermediate: 4 light : 1 white.

4. Height in Man

Skin colour in man is a rather simple example of polygenic inheritance because only two pairs of genes are involved. The inheritance of height in man is a more complex phenomenon involving perhaps ten or more pairs of genes. The character of tallness is recessive to shortness, thus, an individual having the genotype of more dominant genes will have the phenotype of shortness. Because, this quantitative trait is controlled by multiple pairs of genes and is variously influenced by a variety of environmental conditions. The heights of adults range from 140 cm to 203 cm.



If one measured the height of a thousand adult men and the height of each is plotted against height in centimeters and the points connected, a bell-shaped curve is produced which is called curve of normal distribution and is characteristic of quantitative inheritance. 6. Other Examples

Likewise, if one measures the length of thousand sea shells the same species, or counts the number of kernels per ear in a thousand ears of corn, or the number of pigs per litter in a thousand litters, or weighs one thousand hen's egg, one will find a normal curve of distribution in each case.

Qualitative characters

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 indeterminant 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.

The major differences between the two are following:

Qualitative genetics	Quantitative genetics
It deals with the inheritance of traits of kind, viz., form, structure, colour, etc.	It deals with the inheritance of traits of degree, viz., heights of length, weight, number, etc.
Discrete phenotypic classes occur which display discontinuous variations	A spectrum of phenotypic classes occur which contain continuous variations.
Each qualitative trait is governed by two or many alleles of a single gene.	Each quantitative trait is governed by many non-allelic genes or polygenes.
The phenotypic expression of a gene is not influenced by environment.	Environmental conditions effect the phenotypic expression of polygenes variously.
It concerns with individual matings and their progeny.	It concerns with a population of organisms consisting of all possible kinds of matings.
In it analysis is made by counts and ratios.	In it analysis is made by statistical method