Polygenic or quantitative inheritance

Polygenic inheritance

- When one phenotypic character is controlled by more than one gene, it is called **polygenic inheritance**

- **Kolerenter** is known as father of polygenic inheritance

- It is also called **Quantitative inheritance**
- The quantity of inheritance depends on dominant alleles
- Dominant alleles have **cumulative effect** each expressing part of trait

- Gene involved in quantitative inheritance is known as **polygenes**
- Polygenic inheritance don't follow the **mendelian ratio**
- Eg; **skin color of man, wheat kernel colour**

- 1. Each polygenic character is controlled by several independent genes and each gene has cumulative effect.
- 2. Polygenic characters exhibit continuous variation rather than a discontinuous variation. Hence, they cannot be classified into clear-cut groups.
- 3. Effect of individual gene is not easily detectable in case of polygenic characters and, therefore, such traits are also known as minor gene characters.

- 4. The statistical analysis of polygenic variation is based on means, variances and co-variances, whereas the discontinuous variation is analysed with the help of frequencies and ratios. Thus, polygenic characters are studied in quantitative genetics and oligogenic characters in mendelian genetics.
- 5. Polygenic traits are highly sensitive to environmental changes, whereas oligogenic characters are little influenced by environmental variation.
- 6. Classification of polygenic characters into different clear-cut groups is not possible because of continuous variation from one extreme to the other. In case of qualitative characters, such grouping is possible because of discrete or discontinuous variation.

- 7. Generally the expression of polygenic characters is governed by additive gene action, but now cases are known where polygenic characters are governed by dominance and epistatic gene action. In case of oligogenic characters, the gene action is primarily of non-additive type (dominance and epistasis).
- 8. In case of polygenic characters, metric measurements like size, weight, duration, strength, etc. are possible, whereas in case of oligogenic characters only the counting of plants with regard to various kinds like colour and shape is possible. Thus, metric measurement is not possible in case of oligogenic characters.

- 9. Transgressive segregants are only possible from the crosses between two parents with mean values for a polygenic character. Such segregants are not possible in case of qualitative or oligogenic traits.
- 10. The transmission of polygenic characters is generally low because of high amount of environmental variation. On the other hand, oligogenic characters exhibit high transmission because there is little difference between the genotype and phenotype of such character. Thus, polygenic characters differ from oligogenic ones in several aspects

Quantitative Vs Qualitative

- 1. Both quantitative and qualitative characters are governed by genes; the former is controlled by polygenes or minor genes and the latter by oligogenes or major genes.
- 2. Both major as well as minor genes are located on the chromosome in the nucleus.
- 3. The polygenic traits controlling continuous variation exhibit segregation like major genes controlling discontinuous Mendelian variation.

- 4. Polygenic characters show variable expression which is due to non-genetic causes i.e., environmental effects. Qualitative characters also exhibit variation in expression but to a lesser degree than polygenic traits.
- 5. The reciprocal crosses for both types of traits exhibit close agreement in expression of genes.
- 6. The phenomenon of transgression in polygenes can only be explained by Mendelian principles of inheritance.
- 7. Polygenes mutate like oligogenes.

- 8. Dominance and non-allelic interactions are common features of major genes. These features are also observed for polygenes, but are usually complete for major genes and only partial for minor genes.
- 9. Polygenes exhibit linkage like oligogenes. Many cases of linkage between major genes and polygenes controlling continuous variation have been reported.
- Thus, quantitative genetics or biometrical genetics is an extension of Mendelian genetics firmly based on Mendelian principles of heredity.

Difference between Qualitative and Quantitative characters:

S. No.	Qualitative inheritance	Quantitative inheritance
1	Qualitative traits are governed by major genes, whose effects are definite.	These traits are governed by minor genes. Their effect is additive.
2	These traits are not usually affected by environmental factors.	These traits are well affected by environmental factors.
3	Clear-cut difference between the phenotypes (two extremes)	No clear-cut difference between the phenotypes. The phenotype shows a spectrum between the two extremes.
4	Inheritance of These traits results in distinct phenotypic changes (Discontinuous variation).	Inheritance of These traits results in continuous variation. Quantitative characters may not be put up in to clear cut classes. Instead, they show a spectrum of the two extremes.
5	Single gene effect (monogenic inheritance): Effect of two alleles of a single is well detected.	Effect of several genes (polygenic inheritance): Effect of individual genes is too slight to be detected.
6	Concerned with mating of individuals and their progeny	Concerned with population of organisms consisting of all possible kinds of mating
7	Analyzed by making counts and ratios	Statistical analysis gives estimates of population parameters such as mean, standard deviation, variance, etc.

Skin colour of man

- It was first studied by **Devenport** (1913) in case of Negro-Europeian intermarriage.

- Skin colour is due to pigment melanin. **More pigment, darker is the colour.**

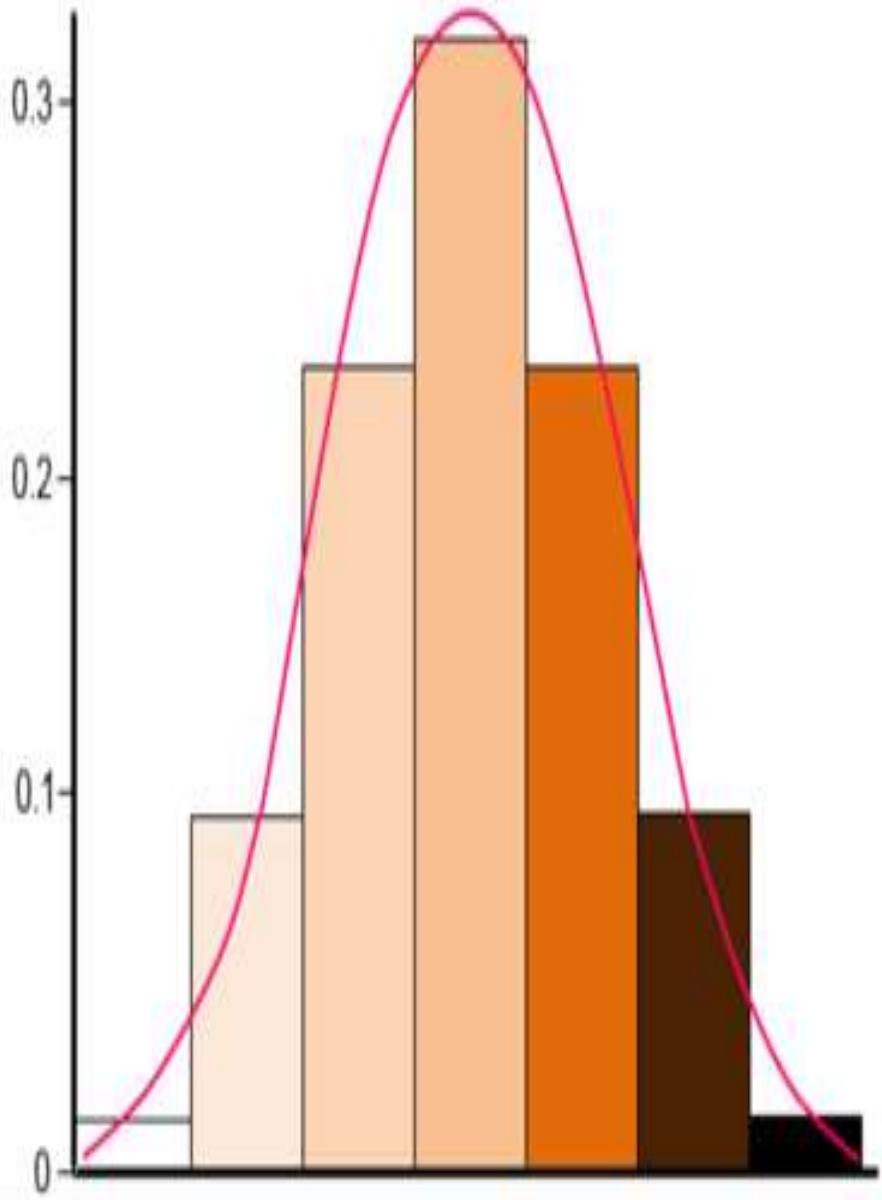
Inheritance of human skin colour

- There are many traits in humans, which show polygenic inheritance, e.g. skin and hair colour, height, eye colour, the risk for diseases and resistance, intelligence, blood pressure, bipolar disorder, autism, longevity, etc.
- Brief description of some of the traits:
- **Skin pigmentation:** inheritance of skin pigmentation is polygenic inheritance. Around 60 loci contribute to the inheritance of a single trait. If we take an example of a pair of alleles of three different and unlinked loci as A and a, B and b, C and c. The capital letters represent the incompletely dominant allele for dark skin colour.

- The more capital letters show skin colour towards the darker range and small letters towards the lighter colour of the skin. Parents having genotype AABBCC and aabbcc will produce offspring of intermediate colour in the F_1 generation, i.e. AaBbCc genotype. In the F_2 generation of two triple heterozygotes (AaBbCc x AaBbCc) mate, they will give rise to varying phenotypes ranging from very dark to very light in the ratio 1:6:15:20:15:6:1.

- The pigment melanin is responsible for dark coloration in the skin and there are at least three genes, which control for human skin colour. Using a hypothetical example where the production of melanin is controlled by *contributing alleles* (denoted here as A, B and C), resulting in dark skin colour, and therefore light skin colour is produced by *non contributing alleles* (denoted here as a, b and c), it is possible to see how the spectrum of different skin colours can result in the offspring.

	ABC	*ABc*	*AbC*	*aBC*	*Abc*	*aBc*	*abC*	*abc*
ABC	6	5	5	5	4	4	4	3
ABc	5	4	4	4	3	3	3	2
AbC	5	4	4	4	3	3	3	2
aBC	5	4	4	4	3	3	3	2
Abc	4	3	3	3	2	2	2	1
aBc	4	3	3	3	2	2	2	1
abC	4	3	3	3	2	2	2	1
abc	3	2	2	2	1	1	1	0

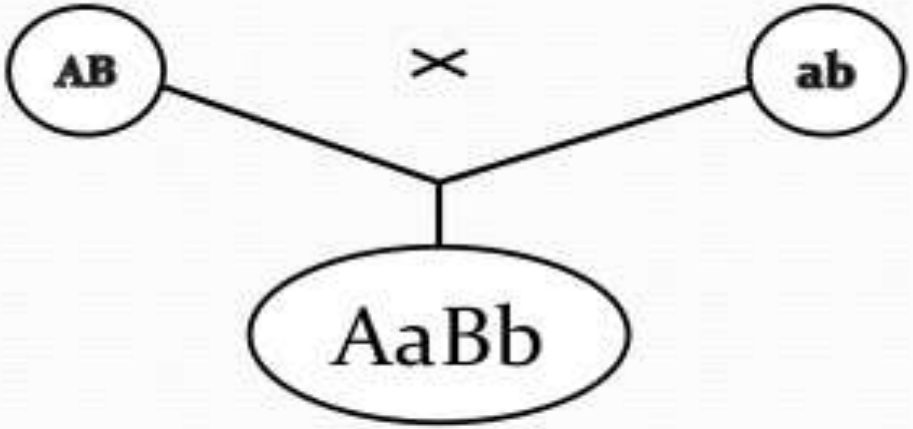


- **Parents-**

Negro
(high melanin)
AABB

Albino
(no melanin)
aabb

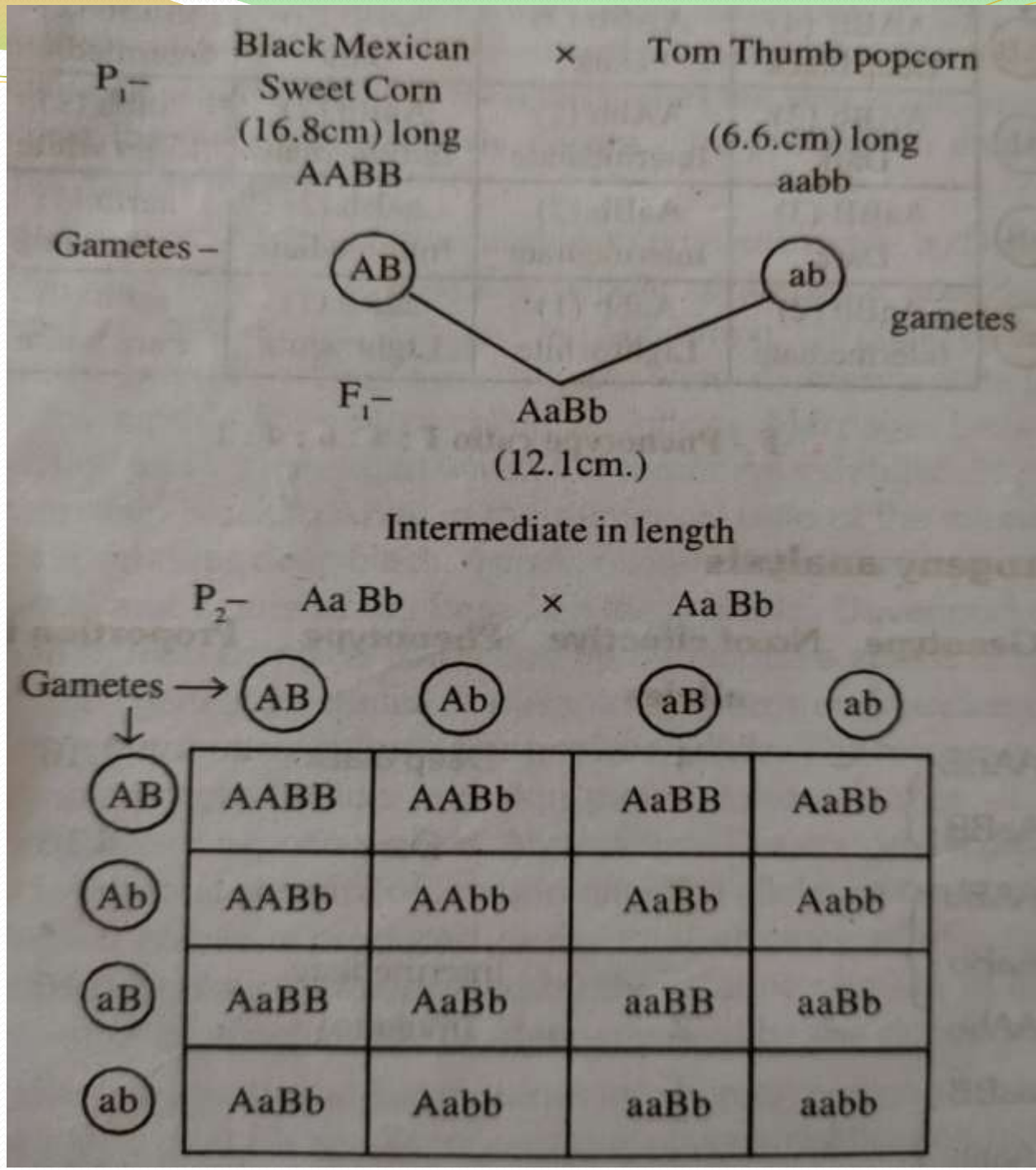
- **Gametes-**



- **F1--**

Mulleto

Inheritance of ear size in maize



F_2	Genotypes	Genotypic frequency	Phenotypes (earlength)	Phenotypic ratio	No. of alleles for ear
	AABB	1	16.8cm	1	4
	AaBB	2	14.2	4	3
	AABb	2	14.2		
	AaBb	4	11.7		
	aaBB	1	11.7		
	AAbb	1	11.7	6	2
	aaBb	2	9.1	4	1
	Aabb	2	9.1		
	aabb	1	6.6	1	0

Monogenic v/s Polygenic Inheritance

Monogenic Inheritance	Polygenic Inheritance
Discontinuous variation	Continuous variation
Single allelic gene	Many non-allelic genes
Qualitative inheritance	Quantitative inheritance
F1 individual resembles dominant parent	F1 individual are intermediate between the parents
Phenotype not influenced by environment	Phenotype influenced by environment
No intermediates	Numerous intermediates
Eg: All seven characters studied by Mendel	Eg: Skin color in human, Wheat kernel color, etc.

Thank You