# Quantitative Inheritance

[**Quantitative inheritance:** Concept, mechanism, examples of inheritance of Kernel colour in wheat, Skin colour in human beings. Monogenic vs polygenic Inheritance.]

**Quantitative Genetics** The analysis of traits whose variation is determined by both a number of genes and environmental factors.

**Polygenic inheritance** is the additive effects of two or more genes on a single phenotypic characteristic.

- It is important not to confuse multiple alleles with polygenic inheritance.
- Blood type is an example of multiple alleles, whereby blood type is controlled by three possible alleles) all occurring at one locus. Polygenic inheritance involves many genes at several different loci.

**Continuous vs Non-continuous Variation:** Variation is expressed by the different phenotypes for a characteristic. Variation can be:

**Continuous.** Exhibits a wide range of phenotypes ranging from one extreme to the other.

**Discontinuous.** Usually only has 2 forms.

Polygenic Inheritance can contribute to continuous variation.

**Good examples of quantitative inheritance are afforded by-**

- **Kernel Color in Wheat.**

The first experiment on polygenic inheritance was demonstrated by Swedish Geneticist H. Nilsson - Ehle (1909) in wheat kernels. Kernel colour is controlled by two genes each with two alleles, one with red kernel colour was dominant to white. He crossed the two pure breeding wheat varieties dark red and a white. Dark red genotypes R1R1R2R2 and white genotypes are r1r1r2r2. In the F1 generation medium red were obtained with the genotype R1r1R2r2. F1 wheat plant produces four types of gametes R1R2, R1r2, r1R2, r1r2. The intensity of the red colour is determined by the number of R genes in the F2 generation.

- **Skin Color in Man**

The characters that Mendel studied are sometimes referred to as discrete characters because they can only be classified on an "either-or" basis (e.g., purple or white flowers, green or yellow seeds). Many characters cannot be classified in this manner because they vary in a population across a continuum (gradient). For example, the figure blow illustrates that skin color in humans is a **quantitative character**. Quantitative characters usually indicate that the character is controlled by more than one gene (**polygenic inheritance**). A simplification of the genetics of skin color in humans shows that three genes interact to determine the level of pigment in an individual's skin. The dominant alleles ($A$, $B$, and $C$) each contribute one "unit" of pigment to the individual, and their effects are cumulative such that individuals with more of these alleles will be darker than those with fewer alleles. The recessive alleles ($a$, $b$, and $c$) do not contribute any units of pigment. Therefore, skin color is related to the number of dominant alleles present in each individual's genotype. A cross of two completely heterozygous parents produces seven phenotypes in their offspring, ranging from very light to very dark skin. The distribution of skin color in the offspring would resemble a bell-shaped curve because there would be more

individuals with intermediate skin colors than either extreme. As the number of genes involved increases, the differences between the various genotypes become more subtle and the distribution fits the curve more closely.

Other examples of polygenic inheritance in humans include height, hair color, and eye color. This helps to explain the slight variations in these characters that we see in different individuals

**Some of the major differences between monogenes and polygenes in inheritance are as follows:**

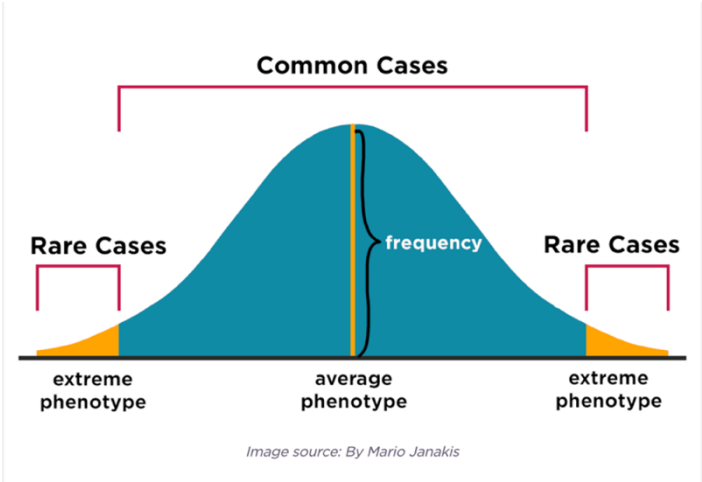


Image source: By Mario Janakis

**Monogenes/Monogenic Inheritance:**

- They produce discontinuous variations in the expression of traits.
- A single dominant allele expresses the complete trait.
- Monogenic inheritance controls qualitative traits.
- A character is represented in an individual by a pair of alleles
- $F_1$ individuals are similar to dominant parent.
- $F_2$ individuals resemble both the parents in the ratio of 3: 1.
- No intermediates are produced in monogenic or qualitative inheritance.
- There is no cumulative action in the presence of two dominant genes
- Individuals with dominant phenotype are more numerous than with recessive phenotype.

**Polygenes/Polygenic Inheritance:**

- Polygenes produce continuous variations in the expression of traits.

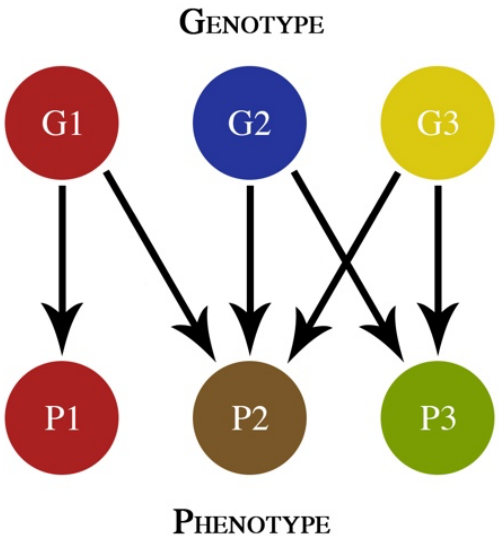
- A single dominant allele expresses only a unit of the trait.
- Polygenic inheritance controls quantitative or metric trait
- A character is represented by one to several pairs of alleles.
- $F_1$, individuals are intermediate between the two parents.
- Depending upon the number of polygenes, 2/4 (one pair), 2/16 (two pairs) or 2/64 (three pairs) $F_2$ individuals resemble the parental types.
- Intermediates are quite common in polygenic or quantitative inheritance.
- The dominant genes have cumulative effect on the expression of the trait.
- Individuals with dominant trait are usually as few as with recessive trait. Intermediate forms are more numerous

**Typical monohybrid cross of Mendel involving a monogenic trait shows the following characteristics-**

1. The parents belong to two distinct phenotypic classes: homozygous dominant and homozygous recessive
2. All F1 offspring resemble one of the parents because one gene is dominant over the other.
3. F2 offspring show segregation into dominant and recessive phenotypes in the ratio of 3:1

**Monohybrid cross involving a polygenic trait shows the following characteristics-**

1. The parents here too belong to two distinct phenotypic classes: homozygous dominant and homozygous recessive.
2. All F1 offspring show a trait intermediate between those between those of parents because the dominant genes fail to fully suppress their recessive alleles.
3. F2 offspring show a wide range of intermediate condition and very limited parental traits.




**Pleiotropy** occurs when one gene influence two or more seemingly unrelated phenotypic traits. Such a gene that exhibits multiple phenotypic expression is called a **pleiotropic** gene.

**Simple genotype-phenotype map that only shows additive pleiotropy effects. G1, G2, and G3 are different genes that contribute to phenotypes P1, P2, and P3**.

The common example of pleiotropy in man is a hereditary disease called sickle-cell anaemia or cooley's anemia found among certain African tribes. A recessive gene causes this disease. In homozygous condition the gene causes production of an abnormal hemoglobin. As a result, the shape of the red blood cell containing it becomes sickle shaped and distorted. However, in heterozygous condition, the individuals possess both normal and abnormal hemoglobin and have mild anemia. In Drosophila gene responsible for the size of wing also affects the eye colour, shape of spermatheca, and position of dorsal bristles.

**References**

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[The information, including the figures, are collected from the above references and will be used solely for academic purpose.]