Variations on Mendel's laws (overview)

Extensions, exceptions, and revisions to these laws. Get an overview of variations on Mendel's laws, including multiple alleles, incomplete dominance, co-dominance, pleiotropy , lethal alleles, sex linkage, genetic interactions, polygenic traits, and environmental effects.

Review: Mendel's basic model

The basic principles of Gregor Mendel's model of inheritance have held up for over a century. They can explain how many different characteristics are inherited, in a wide range of organisms including human beings.

Some of the key elements of Mendel's original model were:

1. Heritable traits are determined by heritable factors, now called genes. Genes come in pairs (that is, are present in two copies in an organism).
2. Genes come in different versions, now called alleles. When an organism has two different alleles of a gene, one (the dominant allele) will hide the presence of the other (the recessive allele) and determine appearance.
3. During gamete production, each egg or sperm cell receives just one of the two gene copies present in the organism, and the copy allocated to each gamete is random (law of segregation).
4. Genes for different traits are inherited independently of one another (law of independent assortment).

These rules still form the foundation of our understanding of inheritance—that is, how traits are passed on and how an organism' s genotype (set of alleles) determines its phenotype(observable features). However, we now know of some exceptions, extensions, and variations, which must be added to the model in order to fully explain the inheritance patterns we see around us.

Variations involving single genes.

Some of the variations on Mendel's rules involve single genes. These include:

Multiple alleles. Mendel studied just two alleles of his pea genes, but real populations often have multiple alleles of a given gene.

Incomplete dominance. Two alleles may produce an intermediate phenotype when both are present, rather than one fully determining the phenotype.

Co-dominance.

Two alleles may be simultaneously expressed when both are present, rather than one fully determining the phenotype.

Pleiotropy .Some genes affect many different characteristics, not just a single characteristic.
Lethal alleles. Some genes have alleles that prevent survival when homozygous or Heterozygous.

Sex linkage.

Genes carried on sex chromosomes, such as the X chromosome of humans, show different inheritance patterns than genes on autosomal (non-sex) chromosomes.

Other variations on Mendel's rules involve interactions between pairs (or, potentially, larger numbers) of genes. Many characteristics are controlled by more than one gene, and when two genes affect the same process, they can interact with each other in a variety of different ways. For example:

Complementary genes. Recessive alleles of two different genes may give the same phenotype.
Epistasis. The alleles of one gene may mask or conceal the alleles of another gene.

In addition, some gene pairs lie near one another on a chromosome and are genetically linked, meaning that they don't assort independently.

Polygenic inheritance and environmental effects

Many characteristics important in our everyday lives, such as height, skin colour, eye colour, and risk of diseases like diabetes, are controlled by many factors.

These factors may be genetic, environmental, or both.

Polygenic inheritance.

Some characteristics are polygenic, meaning that they're controlled by a number of different genes. In polygenic inheritance, traits often form a phenotypic spectrum rather than falling into clear-cut categories.

Environmental effects. Most real-world characteristics are determined not just by

genotype, but also by environmental factors that influence how genotype is translated into phenotype.

Genetic background and environment contribute to incomplete penetrance, in which not all individuals with a genotype display a corresponding phenotype, and variable expressivity, in which individuals of a particular genotype may have stronger or weaker versions of a phenotype.