Genetics and Probability: Understanding Punnett Squares for Simple Mendelian Traits

Punnett squares are a tool used for statistical analysis of predictable patterns in genetics. Patterns and probabilities of heredity can be simplified for traits that follow Mendelian rules of inheritance. Namely, Mendel's two laws are:

1) **The Law of Segregation-** alleles segregate in the formation of gametes.
2) **The Law of Independent Assortment-** genes for different traits assort independently, increasing the genetic variation between the resulting gametes.

These laws dictate specific ratios of probability when performing testable genetic crosses. A **monohybrid (single trait) cross** is represented on the right, and allows for interpretation of breeding patterns when only two alleles are examined for the trait.

Whereas the **dihybrid (two trait) cross** below depicts probability for a pair of traits. Note that each of the alleles still separates from its counterpart (as the sister chromatids split in meiosis), and the genes themselves assort independently (as homologous chromosome pairs separate) so that each possible combination of traits is analyzed.

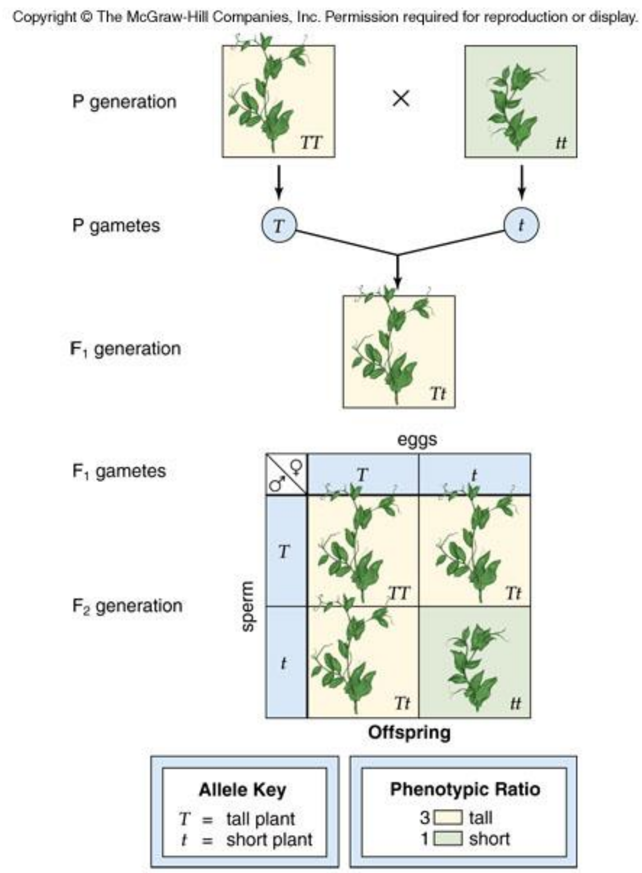

Photo credit: McGraw-Hill Companies, Inc.

For a monohybrid cross, the genotype of the offspring has only three possibilities:

- homozygous dominant (i.e. AA)
- homozygous recessive (i.e. aa)
- heterozygous (i.e. Aa)

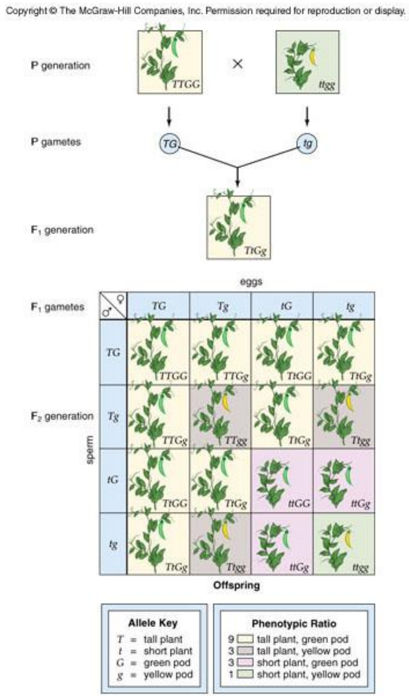

Photo credit: McGraw-Hill Companies, Inc.

These can be translated to only two phenotypes, however: expressing the dominant trait (with either genotype AA or Aa) or expressing the recessive trait (with genotype aa).The nature of dihybrid crosses, however, provides much greater variation in ratios.

Our example cross between the fully homozygous dominant parent (genotype **TTGG**) with the homozygous recessive parent (genotype **ttgg**) results in nine possible genotypes:

TTGG, TTGg, TtGg, TtGG, TTgg, Ttgg, ttGG, ttGg, and ttgg

But there are only four potential phenotypes:

tall/ green, tall/ yellow, short/ green, and short/ yellow