Punnett Squares Notes

The British mathematician/biologist R. C. Punnett developed a method for visually representing the possible combinations of alleles from the parents. It was then possible to predict the possible outcomes of the offspring.

Before taking a closer look at **Punnett squares** we will describe the parents more carefully. Parents, both male and female, each have two alleles for any trait due to the 23 pairs of chromosomes. Recall that each pair of chromosomes is homologous, that is they have genes responsible for the same characteristic.

If we were tracking the tallness trait, then we know that each parent has two alleles for tallness, one on each chromosome that contains the tallness allele. There is a dominant allele for tallness and a recessive allele for shortness. The easiest way to represent the alleles is to give them a symbol. Usually the symbol for an allele is to give it the first letter of the dominant characteristic - in this case **T** for tallness. The recessive allele is given the lower case letter of the dominant allele - in this case **t** for shortness. Remember that because of meiosis, each parent's sex cell have only one allele of a given trait to contribute to the offspring.

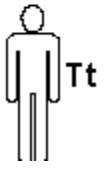
For example, we will assume both parents are tall. The mother is tall with two genes for tallness. The father is tall but has one tall and one short gene. The parents' gene structure for tallnes can be described as shown below.

Mother T T and **Father T t**. Both the mother and father can give only one of their tallness genes to their offspring. In this case, the mother will always give a dominant gene(T) for tallnes, but the father will give either a dominant tallness gene(T) or a recessive shortness gene(t) to the offspring.

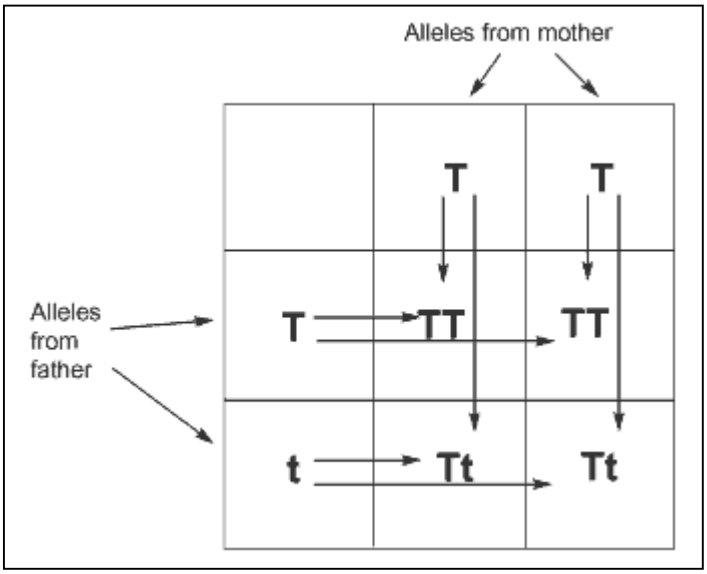
A Punnett Square assigns two alleles for tallness to each parent and predicts the outcome.

We will assume there are parents who are both tall as described above.

The mother is called **homozygous** since she has two alleles that are the same. The **TT** represents the two dominant alleles for tallness.



The father is called **heterozygous** since he has two different alleles. The **Tt** represents the one dominant (**T**) and one recessive (**t**) allele for tallness.



Notice how gametes from the father combine with gametes from the mother to form offspring with two gametes, one from each parent.

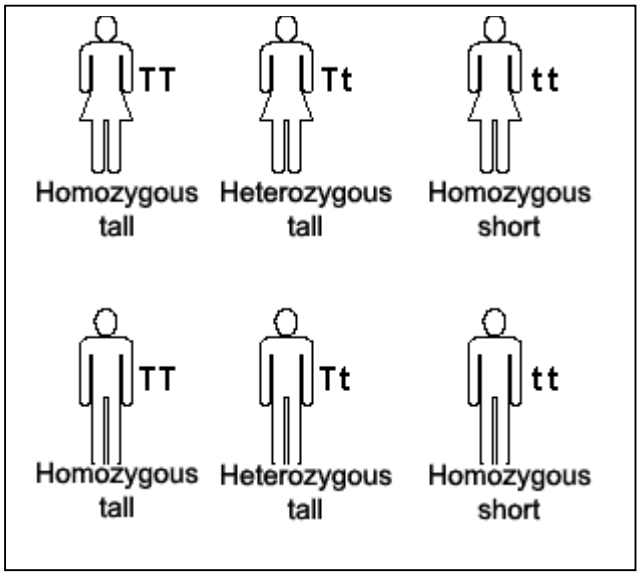
The possible offspring with the tallness trait are shown below.

1. Two homozygous tall **TT** - **Homozygous** means both genes are the same.

2. Two heterozygous tall **Tt - Heterozygous** means the two genes are different. It also tells us that the trait, tallness in this case, is based on the dominant gene.

The Punnett square tells us that every offspring will be tall

The diagrams below illustrate the various combinations of genotypes and phenotypes that are possible from the two sets of genes for tallness. In order to have any possibility of a short offspring, one of the parents must be short.



Using Punnett Squares To Predict Offspring Traits

Suppose we were given the task of predicting the tallness of offspring from a heterozygous tall father and a homozygous short mother. The steps to solving this problem follow.

Before solving the problem we must review two terms:

- Phenotype

  Phenotype refers to the organisms appearance and behaviour resulting from its genetic makeup. If we use the parents in this problem, the mother's phenotype is shortness and the father's phenotype is tallness.

- Genotype

  Genotype refers to the genetic code that determines the trait. The mother's genotype is **tt** and the father's genotype is **Tt**.

When solving problems:

State the genotypes for each parent

When writing symbols for genotypes follow the rules below:

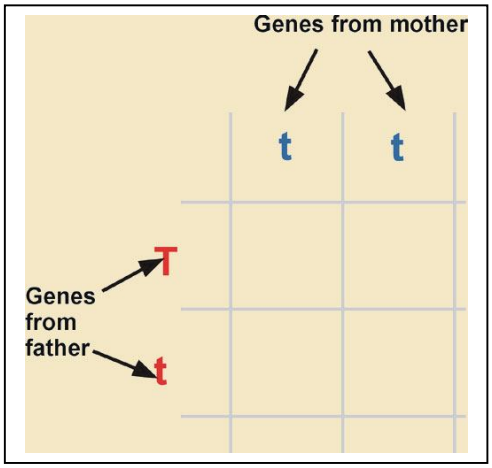
The letter representing the gene is the first letter of the name of the trait. In the problem the letter would be t for tallness.

The letter for the dominant gene is capitalized and the letter for the recessive gene is lower case. In the problem the dominant tallness gene is "T" and the recessive shortness gene is "t".

- mother = tt (homozygous short)
- father = Tt (heterozygous tall)

Draw the Punnett square and place the parents at the top and the left side of the square.

Complete the Punnett square by combining the possible genes from each parent in each square.



Place one gene from each parent in the appropriate squares. For example, in the upper left square the mother contributes a recessive short gene and the father a dominant tall gene.

Considering **genotypes**, the Punnett square suggests the probability that for every four offspring, two will be heterozygous tall(Tt) and two will be homozygous(tt) short.

The Punnett square tells us that the probability of **phenotyopes** is 50% of the offspring will be tall and 50% will be short.

Punnett squares are probability predictors. In the practice Punnett Square problem above,we predicted that 50% of the offspring are going to be tall. *This does not mean that parents with these gametes having four children will produce two tall and two short offspring. It is possible for them to produce one tall and two short, for example.* However, with a large sample of families with the same genes, we would find that very close to 50% of the offspring would be tall. Punnett Squares give us three types of information.

- They show us the gametes each parent can produce
- They show us the genotype combinations that are possible

They tell us the probability that a given genotype and phenotype will occur