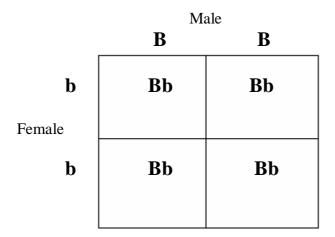# Punnett Squares

Often times, people will refer to a trait or characteristic such as eye color or hair color as being genetic, but what does the word genetic really mean?

Genetics is termed as the study of heredity and how traits in offspring are based upon those of the parents.

Heredity is the process in which traits (characteristics that can be passed only from a living thing to its young) are passed from parents to offspring.

A **Punnett square** is a grid system that can be set up and used to predict the possible outcomes that may result from the mating process between two individuals, when their genotypes are known. Each cell within the square is representative of one possible genotypic outcome for any offspring; in this example, all offspring will be Bb genotype.

Male

	B	**B**
b	**Bb**	**Bb**
b	**Bb**	**Bb**

Female

The term **genotype** refers to the genetic make-up of an organism. In the diagram above, the genotype of the male is BB and that of the female is bb.

Genotype is represented by using letters of the alphabet to stand for each allele that has been passed from the parents. A capital letter represents the dominant allele and a lower case letter represents the recessive allele.

Alleles are all the forms of a gene for any given trait. There are usually two allele possibilities for every trait. For example: B and b are both alleles for the trait of hair color.

Since genotype is the genetic make-up, **phenotype** is the physical result of a gene combination.

If, in the above situation, B represents the gene for brown hair, brown hair is said to be a dominant trait. **Dominance** is when one allele can mask the presence of another. For example: all the offspring of the couple in the diagram will have genotypes of Bb, and they will all have

brown hair. This is because the presence of one B, or dominant, allele results in the expression of that trait.

So how does a child with blond hair like the mother result? Since B is dominant, b is a recessive gene. **Recessive** refers to a characteristic that is masked by the presence of a dominant allele. The only way to have a recessive trait expressed is to have both alleles be recessive, bb, resulting in the blond hair color (in this instance).

Both parents in the square are said to be **homozygous**. This is because homozygous is defined by the occurrence where the paired alleles for a specific trait, in this case hair color, are identical; the male is BB and the female is bb.

Because both parents are homozygous, they can each only pass on one allele type to their offspring. The male can only pass on a B allele and the female, only a b allele. This means that all the offspring will have one B and one b allele and will be Bb genotype.

This Bb genotype is termed as **heterozygous**. A heterozygous genotype is when the genes that an offspring receives are different, Bb. In this instance, dominance will also be expressed because the offspring will have the dominant trait of brown hair.
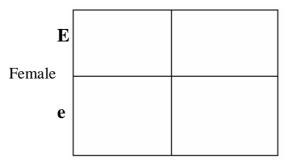
How do you set up a Punnett square?
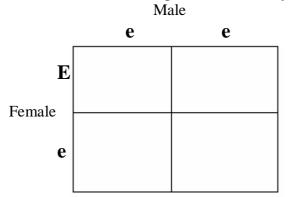Let's run through an example, one step at a time.

If you are told that a man and a woman are having a baby and you want to figure out what their child's traits might be there are some things you must know about the parents first.

You are told that having ear lobes that are attached to the head is dominant over having ear lobes that are unattached to the head. The mother has attached ear lobes and is heterozygous. The father has unattached ear lobes. E represents the dominant allele for attached ear lobes, and e represents the recessive allele.
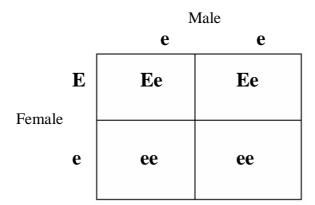
Since you are told that the mother is heterozygous, you can immediately assume that her genotype is Ee, because heterozygous means what? That the genes (alleles) present are different from one another. So you can add her genes to the Punnett square, along the vertical side. Only one allele is to be put for each segment of the side and the dominant allele is labeled first.

E		
e		

Female

The next step is to determine the father's genotype. All you were told was that he has unattached ear lobes. But since you know that having unattached ear lobes is a recessive trait, meaning there is only one gene combination that will express such a trait, you can figure out that he is ee.

Male

	e	e
E		
e		

Female

Now that the Punnett square is laid out, you can determine the possible genotypes of the offspring. To do this, follow each gene at the top and side of the square to the cell where they meet. Write the combination in, remembering to put the dominant gene first.

Male

	e	e
E	**Ee**	**Ee**
e	**ee**	**ee**

Female

What does this all mean?

This Punnett square shows that there are two possible genotypes for the offspring. They will either be Ee and have attached ear lobes since E is dominant and masks the recessive gene, or they will be ee and have unattached ear lobes.

For an offspring to have a recessive trait expressed, both parents must have at least one recessive allele in their genotype.