Chapter 5.4 Polygenic genetic variation

Many traits are determined by more than a single gene. Figure 2 shows an example of three genes that together determine skin colour. You can see that with three genes you can already form 64 different genotypes! But these 64 genotypes do not result in 64, but only 6 different phenotypes due to epistasis: The expression of the genes depend on the combination of alleles and these 64 genotypes result in only 6 different grades of expression. If you would plot the frequency at which these genotypes occur per phenotype then you get this bell-shape curve. The intermediate phenotype occurs most frequent and both extremes the least frequent. The more genes are involved in expression of a trait, the more the frequency plot will resemble a smooth bell-shape. This bell-shape is a very common shape when you look at frequency distributions of traits with discrete values.

Figure 2. Example of the variation that can be obtained for a trait with only three genes involved: 64 genotypes are possible, resulting in 7 different phenotypes.
In animal breeding a general assumption is that traits are determined by an infinite number of genes, each with a very small effect, so that the bell-shape is very smooth. It is also assumed that this infinite number of gene effects are all additive. The model underlying this assumption is called the *infinitesimal model*.

**Definition**

The *infinitesimal model* assumes that all traits are determined by an infinite number of genes, each with an infinitely small effect. This assumption results in a smooth bell-shaped distribution that can be described by the *Normal Distribution*. This distribution comes with a number of rules that animal breeding theory is built on.

Recent research has shown that, even though of course the number of genes involved in expression of a trait is not infinite, the general assumption that many genes with small effect are involved very often is true. This is very convenient because this bell-shape fits the *Normal Distribution*. The normal distribution comes with a set of statistical rules that make it easier to make predictions. And that is what we want to do in animal breeding: predict genetic potential of animals and predict how the next generation will improve if we decide to use a certain proportion of the animals as parents. More on that in the chapter about ranking the animals.