

The process of meiosis is summarised in the diagram below, but it involves the reduction of the genetic material to half. A cell containing the full number of chromosomes (two pairs) is termed **diploid**, but the cells produced during meiosis, the gametes, (eggs and sperm) are termed **haploid** and they contain half the number of chromosomes.

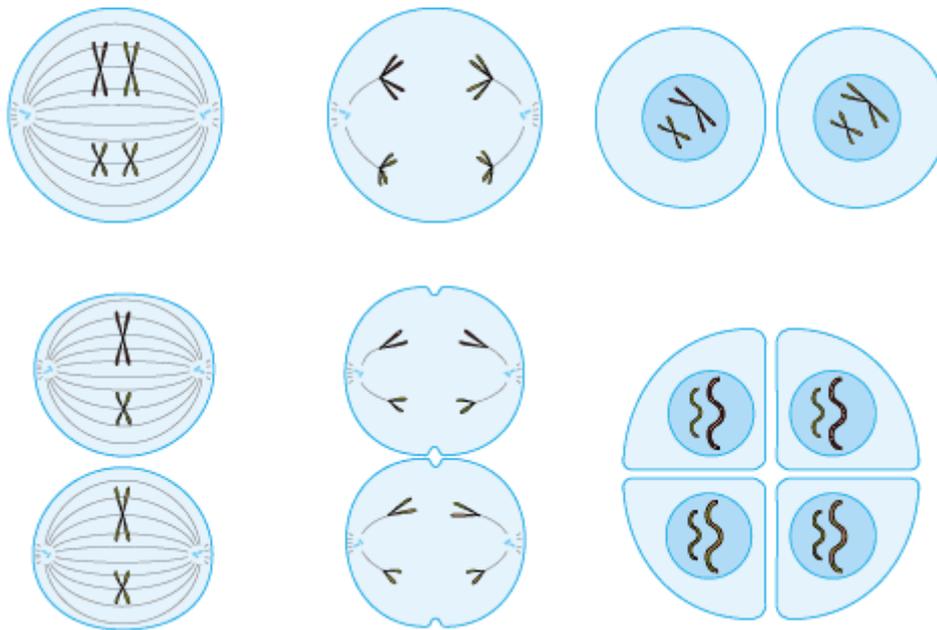


Figure 1 The process of meiosis

The knowledge of heredity is important if we want to calculate the probability of producing offspring with certain traits, for example producing foals of a particular colour. Calculating the mathematical probability of inheriting a specific characteristic can be carried out using a **Punnett** square. These are named after the geneticist Reginald Punnett who worked in the early 20<sup>th</sup> century.

A Punnett square is a grid, where the genotype of one parent is written across the top, and the genotype of the other parent is written down the left hand side. It does not matter which parent is on the side or the top.

For the peas, a Punnett square for green and yellow peas can be written as follows. One parent has a genotype of GG and the other YY

	<b>G (male parent allele)</b>	<b>G (male parent allele)</b>
<b>Y (female parent allele)</b>		
<b>Y (female parent allele)</b>		

The table is completed to show the possible offspring combinations, by taking the allele for the column and the row as shown below

	<b>G (male parent allele)</b>	<b>G (male parent allele)</b>
<b>Y (female parent allele)</b>	<b>GY</b>	<b>GY</b>
<b>Y (female parent allele)</b>	<b>GY</b>	<b>GY</b>

As we can see in this example, all offspring from parents with GG crossed with YY will have alleles that are GY (heterozygous). Because the yellow allele is dominant, all offspring will have a yellow phenotype, so will produce yellow peas.

If both parents have a heterozygous genotype as shown in the Punnett square below, the offspring have a 25% chance of being YY, 25% chance of being GG, and a 50% chance of being YG

	<b>Y (male parent allele)</b>	<b>G (male parent allele)</b>
<b>Y (female parent allele)</b>	<b>YY</b>	<b>YG</b>
<b>G (female parent allele)</b>	<b>YG</b>	<b>GG</b>

The grey colour of horses works in the same way as the colour of the peas. The grey coat colour gene is a simple dominant allele.

Although it may not really be important what colour offspring are, the knowledge of probability of inheritance is very important if an animal carries harmful genes that code for abnormal traits. Some disorders are caused by recessive genes, and a person or animal can carry one copy of the allele without showing any symptoms. However an individual carrying two copies will develop the disorder. If two parents are both carriers for the abnormal gene, then there is a 25% chance of them producing offspring that are normal and do not carry the gene, a 25% chance of them producing offspring that carry two copies of the gene and therefore develop the disease, and a 50% chance that they will produce offspring that carry the gene but do not develop the disease.

The specific inherited disorders of the horse are covered in more detail later on.

### **3.2 Genetic mutations**

It has already been stated that acquired characteristics are not passed on, and indeed it is true that genes do not get altered by lifestyle. For example a person who works out a lot in a gym and develops big muscles will not necessarily produce offspring with large muscles, in the same way that someone with naturally brown hair that bleaches it blonde will not pass genes to their offspring for the blonde hair that they have acquired. There can however be some alterations of genetic material, which can occur spontaneously and are called **mutations**.

During the process of cell division, the two strands of DNA in the double helix unwind and are copied. During the replication, the four bases, adenine, guanine, thymine and cytosine pair up to make the new strands of DNA. Adenine always pairs with thymine and cytosine always pairs with guanine. Occasionally the process of pairing goes wrong, and mutations can occur, although they are rare.

The types of mutation that can occur during the replication of DNA are as follows:

- **Deletion**  
If one of the bases is missing, then the rest of the DNA sequence that follows will be out of place, and this could prevent a particular protein from being created.
- **Insertion**  
Similar to the effects of deletion, an extra base being inserted into a genetic sequence will alter the rest of the chain following it.
- **Inversion**  
Where a section of a sequence is reversed so that the bases are laid down in the wrong order
- **Substitution**  
In this case a certain base is replaced with a different one, and this

may affect the type of amino acid that should be created from the particular sequence of DNA. If it is an essential amino acid, then the results could be serious

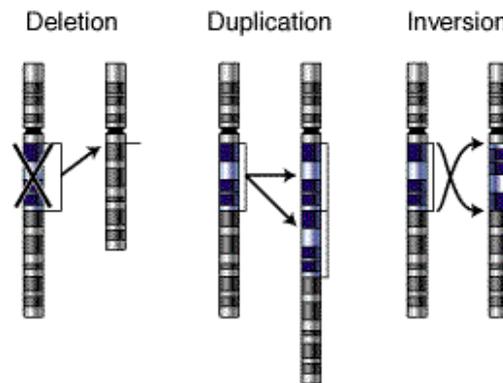


Figure 2 Types of mutation

Individuals inheriting the mutated genes may have abnormal or harmful characteristics, and some mutations may be so serious that the offspring die even before birth. Some mutations may not prove to be either harmful or beneficial, and this is believed to be the case for most of the mutations that do occur. It is only the sections of DNA that code for the building blocks of the body that will affect the health of the individual. Occasionally some mutations may prove to be beneficial to the individual inheriting them, and this is the foundation of evolution, which is discussed later.

It should be remembered that the process of DNA replication is very efficient, and it is believed that only a tiny minority of mutations occur when compared to the number of cell divisions that are carried out, and even when they do occur, many are repaired by the body.

Sometimes mutations can be caused by exposure to harmful substances, such as chemicals, radiation or exposure to viruses. Some drugs that are prescribed for various conditions are known to increase the risk of mutations. These are termed **teratogens**.

### 3.3 The inheritance of sex

Horses have 32 pairs of chromosomes, whereas humans have only 23 pairs. The corresponding pairs are termed **homologous** pairs, and although the chromosomes from each parent are similar and

are identical in terms of the positions of the genes on them, they do not necessarily carry identical information, due to the possibility of different alleles. The matching pairs of chromosomes are termed **autosomes**, and this word is used to refer to all chromosomes that are not the sex chromosomes. The sex chromosomes are the X and Y chromosomes, and one is inherited from each parent. However a female has two X chromosomes, and so can only ever pass on an X chromosome to her offspring. A male has an X and a Y, and so if he passes on the X, the offspring will be female, and if he passes on a Y, the offspring will be male. The sex of the offspring is always determined by the male parent.

The total number of the chromosomes of a species is termed the karyotype. The karyotype of the male horse is shown below, and the 31 homologous pairs of autosomes are shown, together with the sex chromosomes, X and Y, making 32 pairs in total.



Alleles that are located on one of the X or Y chromosomes, but not on both give rise to sex linked traits. The condition of haemophilia, which is where the blood does not clot properly is a sex-linked trait. It is recessive, and is carried on the X chromosome, but never on the Y. Haemophilia is rare in horses because animals with the condition would either not live long enough, or would not usually be allowed to reproduce. If a carrier female is mated to a normal male, the probability of the offspring would be 25% normal male, 25% normal female, 25% carrier female and 25% haemophiliac male. The only way for a female to actually have the condition is if she had a haemophiliac sire, and a dam who carries the recessive

**allele for it. It is unlikely that a stallion with this condition would be used for breeding, and hence the condition is rare.**