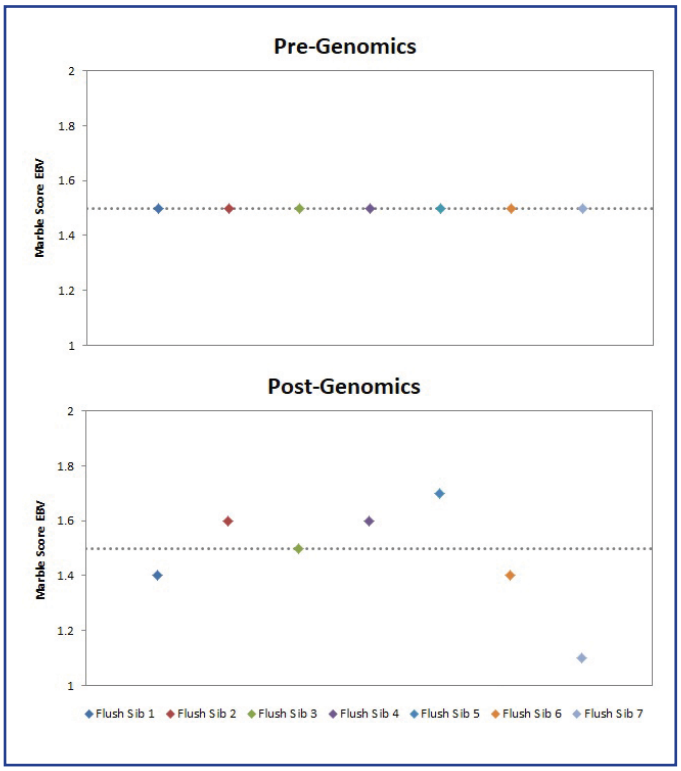
ET Flush Siblings Are Not Identical Twins

The use of artificial breeding technologies, including the production of embryos through flushing and artificial insemination, are common-place in the beef seedstock industry. Breeders are often amazed at the physical diversity that can be seen between full sisters and/or full brothers that are produced from the same embryo transfer (ET) flush. This diversity is a result of genetic differences between embryos; each ET flush sibling is the product of a different egg and a different sperm. This is in contrast to identical twins, which form from a single fertilised egg that split early in embryo development to form two genetically identical individuals.

As each ET flush sibling results from a unique egg and a unique sperm, they are no different to regular full brothers or sisters (except that ET flush siblings are conceived at the same time point). Indeed, ET flush siblings share the same amount of DNA as normal full brothers or sisters (on average 50%). However, the combination of DNA that all full-siblings, including ET flush siblings, inherit from their sire and their dam varies between individuals. This different combination of parental DNA is why there is genetic diversity between related individuals in all species, including humans. For detail of the biological process behind the production of genetic diversity, see the breakout box "The Biology of Cell Division".

Within the BREEDPLAN analysis, full siblings, including those from ET programs, are assumed to have the same EBVs until they have additional data analysed. These EBVs are based on the mid-parent values, with each EBV sitting halfway between the EBVs of the sire and the dam. Once performance records are added to BREEDPLAN, the EBVs for full siblings move to reflect the phenotypic differences observed by breeders.



A story of 7 full-flush Wagyu siblings - the use of genomics clearly shows the effect on EBVs

For breeds that have moved to a Single-Step BREEDPLAN analysis, genomic information (e.g. 50K SNP genotypes) also contributes to the calculation of EBVs. The inclusion of genomic information allows the BREEDPLAN analysis to determine how much DNA an individual has in common with other relatives, including flush siblings. This means that genomics in BREEDPLAN can help differentiate between the genetic merit of full siblings (including ET flush siblings) and, as a consequence, the EBVs for full siblings can vary greatly depending on the relative merit of the genes they received from the parents. With the ability to genotype calves from birth, a further advantage is that Single-Step BREEDPLAN can allow producers to differentiate the genetic merit of full siblings at a much younger age than was previously possible. In this way, the genetic differences between full siblings can be used to inform management and breeding decisions on farm.

THE BIOLOGY OF CELL DIVISION

To understand how genetic diversity occurs between siblings, we need to understand the mechanism through which the diversity is created within the sex cells (sperm and eggs) of an animal.

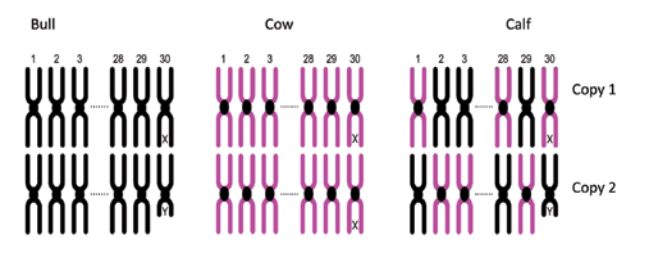
GENETIC MATERIAL:

Chromosomes are the cellular structures that maintain and transmit genetic information. They are made of deoxyribonucleic acid (DNA) combined with proteins. The DNA provides the genetic blueprint for the physical, and some of the behavioural, traits of the animal.

These traits are a unique and random mix of the parents' determined by which particular sperm happens to fertilise which particular egg.

CHROMOSOME PAIRS:

Every cell in cattle (except the gametes) contains 30 chromosome pairs; 60 chromosomes in total. The 60 chromosomes represent one copy of each chromosome from each parent.



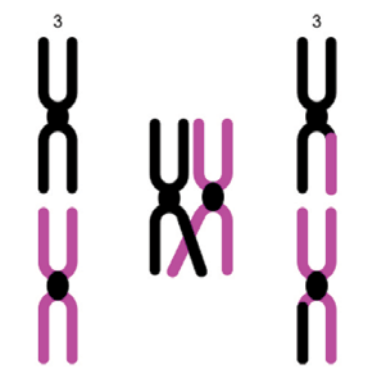
Each calf receives one copy of each of 30 chromosomes from each parent (60 copies in total - 2 of each chromosome.

SEX CELLS - THE GAMETES:

Gametes are special cells that have undergone reduction and contain only 30 chromosomes (one copy of each chromosome). These gametes are the female egg and the male sperm that fuse together during fertilisation, restoring the 60 chromosomes in the fertilised cell and initiating the events that result in embryo development.

CREATION OF SEX CELLS (MEIOSIS):

Meiosis is the process that creates the gametes within the sperm and the egg of each of the parents. Meiosis occurs in two stages. In meiosis stage 1, the two copies of 30 chromosomes are sorted into two groups. The cell nucleus then dissolves and the 30 pairs of chromosomes line up along the centre of the cell.



An example of the crossing over between the pairs of chromosomes for chromosome three. The above is only to illustrate the principle as crossing over normally occurs between a number of the chromosome pairs during meiosis.

Some pair members from each parent exchange portions of their DNA in a process called crossover that helps increase genetic diversity by creating non-identical pairs.

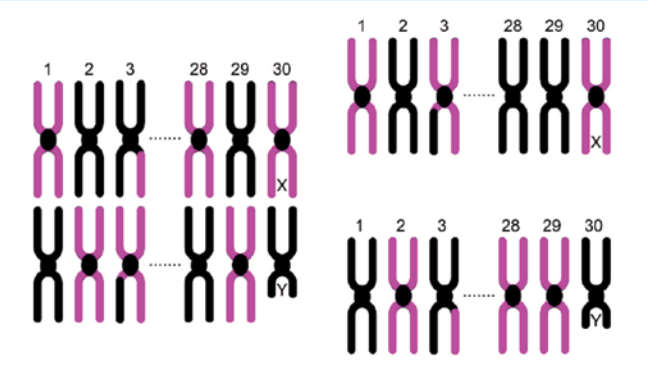
Following crossover, one copy of each chromosome pair (1-30) is pulled to one side of the cell while the other copy is pulled to the opposite side (see illustration below).

This process (also called independent assortment) occurs randomly to separate the chromosome pairs to opposite ends of the cell. A gamete will therefore end up with the full 30 chromosomes, but each gamete will have one of many different combinations of chromosomes and crossovers from the original set of 60.

This reshuffling of genes into unique combinations increases the genetic variation in a population and explains the variation we see between siblings with the same parents.

The halving of the number of chromosomes in gametes ensures that, after fertilisation, the embryo will have the same number of chromosomes as the parents (30 come from each parent gamete to make the 60 in total). This is critical for stable sexual reproduction through successive generations.

THE BIOLOGY OF CELL DIVISION



One chromosome of each pair is dragged to each side, halving the number of chromosomes in each cell. Independent assortment caused black chromosome 28 and (mainly pink) chromosome 3 to be dragged to the top cell, while pink chromosome 28 and (mainly black) chromosome 3 are dragged to the bottom cell.

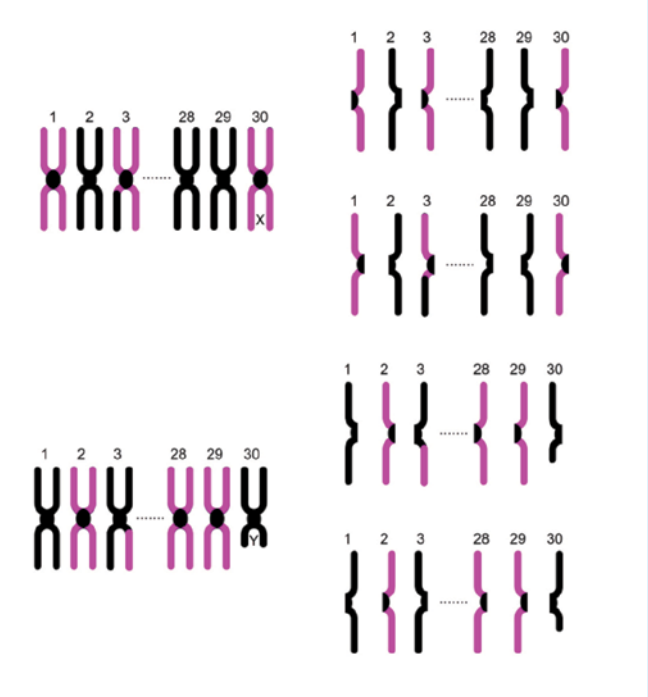
Meiosis stage 1 ends when the cell divides into two daughter cells, each having only the 30 chromosomes which were gathered at each opposite end of the cell.

To further genetic diversity, another round of meiosis occurs - meiosis stage 2.

The chromosomes once again align at the centre of the cell. This time, the single-copy of chromosomes are distributed to two daughter cells known as gametocytes. In this way, one cell results in four non-identical gametocytes that undergo further development to become sperm or eggs.

To the right is a much-simplified illustration of the process which assures genetic diversity and variation in the population.

In addition to meiosis a population is also under the influence of mutations which could also modify the genetic makeup of the population and could benefit or be to the detriment of the population.



At the completion of meiosis one cell has divided into four non-identical sperm or egg cells.

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