

# Understanding Genomics

Genomics is a term used to describe the analysis of the function and structure of a genome, being the complete set of DNA within a single cell or organism.

Within the beef industry, genomics is still an ever expanding technology, with a range of potential applications available within a beef enterprise, plus many more under development.

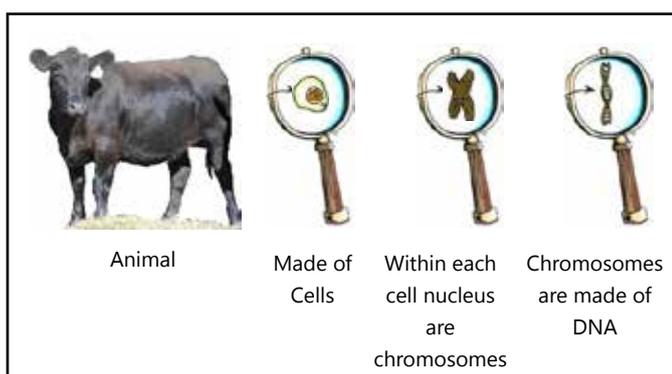
Some of the most common current applications of genomic technology include:

- Parentage Verification
- Management of Genetic Conditions
- Change in Qualitative Traits (e.g. coat colour/polledness)
- Genetic Improvement in Production Traits
- Assessment of Breed Composition

## What is DNA?

Deoxyribonucleic acid (DNA) is an exceptionally important molecule found in the nucleus of all bovine cells. It is often described as the 'blueprint' of an organism because it codes the instructions for how that organism will develop, function and appear.

In plants and animals, DNA is bundled into chromosomes. Beef cattle have 30 chromosome pairs, each pair including one chromosome inherited from the sire and one from the dam. Because the progeny inherit chromosomes from both parents, the DNA 'blueprint' is passed on from one generation to the next.

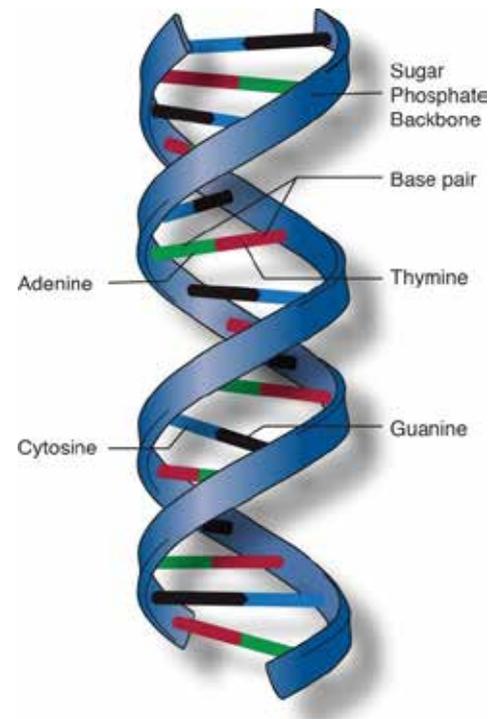


## DNA Structure

DNA looks like a long twisted ladder, or double helix. The sides of the ladder are made up of alternating sugar and phosphate molecules. The rungs connect to the sugar molecules and are known as nitrogenous bases. It is the bases which provide the key functionality of DNA and exhibit variation between individuals.

There are approximately 3 billion base pairs in bovine DNA, with four different bases, Adenine (A), Thymine (T),

Guanine (G) and Cytosine (C). Each rung of DNA is made up of two bases linked together, either G to C or T to A. The sequences of these base pairs make up the 'message' of DNA, and differences in sequences provide the basis for variation between individuals.



## What is a Gene?

A gene is a base pair sequence at a particular location on the chromosome which codes for a specific product. It is estimated there are between 22,000 and 28,000 genes in the beef animals. Genes are separated on chromosomes by areas of 'non-coding DNA' for which no function has been identified, but still make up part of the animal's genotype.

## What is an Allele?

For each gene there may be 2 or more variations, known as alleles, which can result in different phenotypes or observable characteristics. For example one of the genes influencing coat colour has three alleles, the "e" allele for red coat colour, the ED allele for black coat colour and a "Wild type" E+ allele. Which alleles the animal has, and how those alleles interact with each other determines the coat colour of the animal.

## What is a Gene Marker (or DNA Marker)?

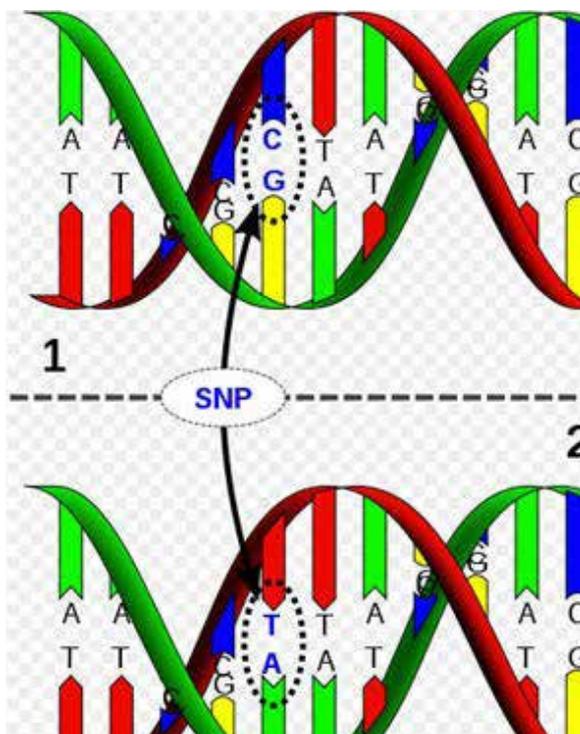
A gene or DNA marker is a known, heritable base pair sequence which is associated with a particular gene. The DNA marker sequence does not necessarily have to be part of the gene that codes for the trait but only associated with it, therefore the value of the genetic marker will vary.

There are several types of DNA markers, but those most commonly being used in the beef industry are SNPs (pronounced "snips"), microsatellites and Indels.

### What is a SNP?

Single Nucleotide Polymorphisms (SNPs) are markers where there is a difference in a single base pair. For example, in the figure below, the top animal has a "C & G" base pair at the particular location in the DNA, whereas the bottom animal has a "T & A" base pair.

While early DNA technology only evaluated an animal's DNA for a relatively small number of SNPs, SNP chips now routinely evaluate animals at many thousands of individual SNPs. For example, DNA chips with 7,000 (i.e. 7K), 50,000 (i.e. 50K) or 800,000 (i.e. 800K) SNPs on them are now available.



### What is a Microsatellite?

A microsatellite is a repeat of a particular base pair sequence at a specific location in an animal's DNA, for example CACACACA. The number of base pair repeats differs between animals. Microsatellites form the basis for traditional DNA parent verification, which use multiple microsatellites to determine a calves' parentage through the exclusion of possible candidates which do not have the same microsatellites.

■ CACACACACACACACA ■  
 ■ GTGTGTGTGTGTGTGT ■

## Key Terms

**Trait** – Attribute or characteristic of animals that can be measured and improved genetically (for example, growth rate, fertility, carcass or meat quality)

**Genotype** – the full genetic makeup of an animal including dominant and recessive alleles that may not be expressed

**Phenotype** – the observable characteristics or traits of an animal that result from the interaction between the animal's genotype and the environment

**Locus** – the specific location of a gene or DNA sequence on a chromosome

**Allele** – one form of a gene or a genetic locus

**Homozygous** – animal carries identical alleles for a gene

**Heterozygous** – animal carries different alleles for a gene

**Dominant** – an allele is dominant over another so that the phenotype of the dominant allele is always expressed over the recessive allele

**Recessive** – an allele is recessive, so that the phenotype is only expressed when two copies of the allele are present (i.e. it is homozygous).

**Carrier** – animal which is heterozygous and 'carries' a recessive allele which is not being expressed phenotypically

### What is an Indel?

An Indel is an insertion or deletion of a particular base pair sequence at a specific location in an animal's DNA. Indels are often associated with recessive genetic conditions.

### What is a Genomic Prediction Equation?

As each production trait is influenced by many genes, inferring genetic merit for a particular trait requires the accumulated effects of many markers. Genomic Prediction Equations take the genotype of an animal as collected using dense SNP chips (e.g. 50,000 SNPs), to estimate the animal's breeding value based on the known effect of each SNP on the trait of interest.

For further information, please contact staff at:

Angus Australia  
 Phone: 02 6773 4600  
 Email: [office@angusaustralia.com.au](mailto:office@angusaustralia.com.au)  
 Website: [www.angusaustralia.com.au](http://www.angusaustralia.com.au)

