# Understanding DNA Technology

There are now a range of DNA based technologies available that can be applied within a beef seedstock enterprise, with many more under development. Before making the decision to invest in DNA technologies it makes sense to be informed about the theory of DNA and the current applications available.

## THE THEORY OF DNA

### 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.



Animal made of cells    Within each cell nucleus are chromosomes    Chromosomes are made of DNA
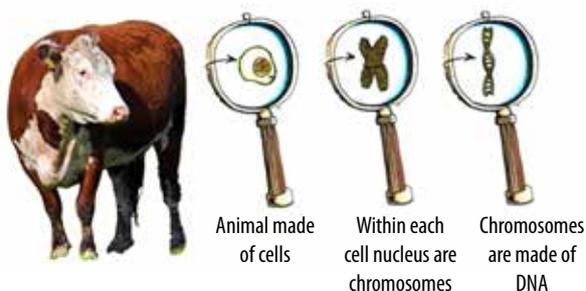
### DNA Structure

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. There are four different bases, Adenine (A), Thyamine (T), Gaunine (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 makeup part of the animal's genotype.

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 microsatellites, SNPs (pronounced "snips") and INDELS.

## 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
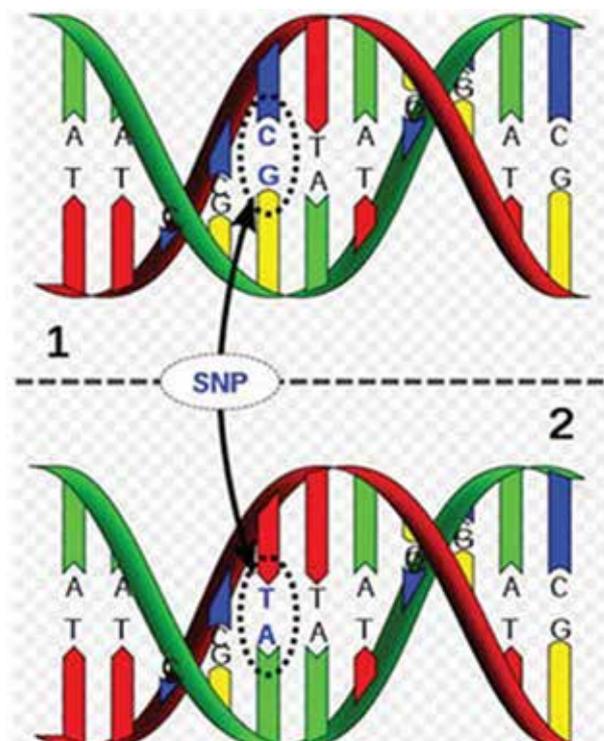


## What is a SNP?

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 (ie. 50K) or 800,000 (ie. 800K) SNPs on them are now available.

## 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.

## CURRENT APPLICATIONS OF DNA TECHNOLOGY

There are many potential applications of DNA technology within a beef seedstock enterprise. Some of the most common current applications include:

i.   Parentage Verification

ii.  Management of Genetic Conditions

iii. Change in Qualitative Traits (e.g. coat colour/polledness)

iv.  Genetic Improvement in Production Traits

v.   Assessment of Breed Composition