BCRC
BEEF CATTLE RESEARCH COUNCIL

Fact Sheet

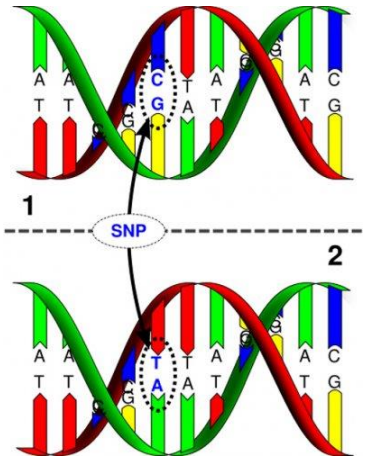
RESEARCH & TECHNOLOGY DEVELOPMENT FOR THE CANADIAN BEEF INDUSTRY

Special thank you to Dr. John Crowley, Director of Scientific and Industry Advancement for the Canadian Beef Breeds Council, for contributing his time and expertise in the development of this fact sheet.

Genomics and Beef Production – What is available and what should I do?

Every living thing has a genetic code, known as a **genome**, made of DNA. The genome is the complete set of genes in a living organism. **Genomics** is the branch of molecular biology that is concerned with the structure, function, mapping and evolution of genomes. A genome dictates how living things, including beef cattle, look, perform and adapt. A **genotype** is defined as the genetic constitution of an individual organism but simply put, in a breeding context, a **genotype** is a snapshot of an animal's genome. The size, or **density**, of the snapshot varies. The bigger, denser or higher resolution the snapshot, the more expensive it may be to develop a genotype for a specific animal. As genotypes become a common piece of data in animal breeding and management, the number of different products and options to use these genotypes in selection and mating programs grows. Genomics can be used by itself or to complement other selection and management protocols.

Before moving on, the term "density" needs further understanding in the context of genomics. A single strand of DNA can be compared to a set of instructions written in an alphabet that only has four letters (C, G, T and A). The genome of cattle is 3 billion pairs of letters long organized into around 22,000 genes. When DNA is copied, small copying mistakes occur sometimes. A "T" may be accidentally replaced with an A, G, or C. These are called single nucleotide polymorphisms (SNPs), and regularly referred to as "markers" or "SNP markers." So far, beef geneticists have discovered around 30 million different SNPs.



These SNPs largely dictate the physical differences we see among animals, including liveweight, stature, coat color, butterfat, horns, marbling, or average daily gain, among others.

To measure all 35 million of these SNPs would be very expensive, therefore labs take smaller snapshots or "panels" of these SNPs, which makes genotyping affordable for animal breeding and genetics purposes. One could categorize panels into 5 different categories based on density;

i) *Small panel* test ranges from analyzing just a few SNPs to around 2000 SNPs. Used for parentage, condition testing and population specific genomics.

ii) *Low Density (**LD**) panel* measure between 5,000 to 30,000 SNPs. This type of panel is used for genomic prediction/selection purposes when there are a lot of higher density genotypes available to refer to.

iii) *Medium Density (**50K**) panel* measures between 50,000 and 150,000 SNPs. This density is able to tell you a lot about your population without having to go any denser. Usually a breed will begin gathering

a reference set of 50,000 SNP genotypes on influential animals in the breed, which are used to predict what less dense genotypes mean for performance traits.

iv) *High Density (**HD**) panels* analyze 500,000 to 1 million SNPs. This panel is less popular in beef as the cost-to-benefit ratio (benefit being an increase in EPD accuracy) is low.

v) *Whole Genome Sequence (**WGS**)* occurs when an animal's entire genome is sequenced (i.e. all 3 billion pairs of letters are read). This type of test is presently used for research and is too expensive to be commercially employed.

What does an animal's genotype data look like? Figure 1 below shows what a genotype file from the lab might look like. 50,000 individual SNP results can be overwhelming and meaningless unless analytics have been performed to produce informative parentage assignments, breeding values or genetic condition scores.

Animal	SNP1	SNP2	SNP3	SNP4	SNP5	SNP6	. . .	SNP50000
001	CT	CT	CC	CC	CT	CT	. . .	CC
002	AT	AA	AA	AA	AA	AA	. . .	AA
003	GA	AG	GA	AG	GG	GG	. . .	AG
004	TA	TT	AA	TT	TT	TT	. . .	TT
005	GT	GT	GT	GT	GG	GG	. . .	GT
006	CC	CC	CG	CC	CC	CC	. . .	CC
007	TG	TT	TT	GG	TG	TG	. . .	GG

Figure 1. Example of raw genotyping output

Genotyping in Cattle Production

The cost of a specific density of genotype may vary based on the number of animals being genotyped (volume discount), the panel or product used to genotype, the service provider and exchange rates. Genotypes, of all different densities, are utilized in many different ways.

Parentage

Either for parentage discovery (e.g. multi-sire pasture) or verification (e.g. registry requirements), 120 (min) SNP can be analyzed on all calves and potential parents in order to identify the sire and/or dam of each calf. For this to work flawlessly, all animals need to be genotyped. The present cost of parentage using a 120 SNP parentage panel is $12-$20.

Condition testing

Genotyping can test for conditions such as horned/polled and coat color. Genotyping can also identify animals that may look normal, but carry recessive alleles for harmful or deadly genetic abnormalities. If two carriers are mated, there is a one in four chance that their calf could be born dead, deformed or very sick.

Service labs provide a comprehensive list of genetic abnormalities and conditions for which they test, including:

Alpha-mannosidosis (MA)	Developmental Duplication (DD)	Myostatin (MYO)
Arthrogryposis Multiplex (AM)	Digital Subluxation (DS)	Neuropathic Hydrocephalus (NH)
Chondrodysplasia (CHO)	Dun Coat Colour (DS)	Osteopetrosis (OS)
Coat Colour Dilutor (DL)	Hypotrychosis (HY)	Pulmonary Hypoplasia w/Anasarca (PHA)
Contractural Arachnodactyly (CA)	Idiopathic Epilepsy (IE)	Tibial Hemimelia (TH)

Genomic selection (GE-EPDs, MBVs, Profiles)

One of the uses of genomic data is to more accurately assess an animal's genetic merit for economically relevant traits (ERTs). Where a genetic merit score, such as an EPD, already exists on an animal through its pedigree, a genotype can be used to increase the accuracy of the EPD. This is referred to as a gEPD or GE-EPD (genomic EPD, or genomically enhanced EPD). These are especially effective in young animals who have no progeny of their own on which to judge their genetic merit. Increased EPD accuracy at a younger age can greatly affect the rate of genetic gain. Where an EPD is not available on an animal for whatever reason, a breeding value based solely on its genotype can be created. This works best when the whole group of selection candidates are genotyped together and is referred to as a molecular breeding value (MBV). After calculating GE-EPDs and MBVs, a trait profile can be generated for a genotyped animal. This ranks an animal for a number of traits on a scale (usually 1 – 10).

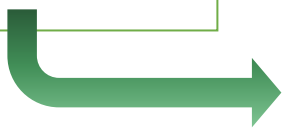
In some cases, the accuracy of GE-EPDs or MBVs depends on how closely related the animals tested are to the population that was used to generate the GE-EPDs or MBVs. In general, genomics is presently more accurate within breed (some tests being breed specific), although there is a lot of research going into across breed and crossbred genomics.

In all selection processes, multi-trait selection is of the utmost importance. Single trait selection results in unintended and potentially negative impacts on other traits not currently being selected for. While genetic progress will be slower with multi-trait selection, it is critical to ensure one performance trait isn't being sacrificed for another.

Management (Breed composition, inbreeding, matings, nutrition)

Determining breed composition and the level of inbreeding of an animal is presently available. A specific animal or a group of animals can be managed based on their genetics. While this field is relatively unexplored, there is ongoing research to determine whether genomics information can be used to fine-tune the management of animals sharing similar genomic profiles.

Where to Look? There are many service providers for your genotyping needs. Contacts, available testing, and other relevant information may be found on these sites:



http://bridgingintelligence.com/
http://www.deltagenomics.com
http://genetics.zoetis.com/canada/
http://genetix.quantumgenetix.com/
http://www.livestockgentec.com
http://www.neogen.com/Genomics/

Table 1. Potential uses of genomic information for beef sectors

Use	Seedstock	Commercial	Feedlot	Processor
DNA-Assisted Selection	X	X		
Parentage	X	X		
Recessive Allele testing	X	X		
Control of inbreeding	X	X		
Mate selection	X	X		
DNA-assisted management	X	X	X	
DNA-based purchasing			X	X
Product differentiation				X
Traceability				X

Source: Van Eenennaam, A. L., and D. J. Drake. 2012. Where in the beef cattle supply chain might DNA tests generate value? Anim Prod Sci 52(3) 185-196.

The Step by Step of Genetic Testing

1. *Sample collection:* Tail hair (with follicles), tissue, semen and blood are the preferred biological DNA samples to be sent to a lab. Sampling kits are available from service providers and laboratories. Individual labs will provide guidelines for collecting samples.
2. *Accompanying details:* A complete set of details provided on the appropriate form must accompany an animal's sample, including any and all methods that the particular animal is identified.
3. *Understanding results:* Depending on why you are genotyping, the presentation of results and reports may look different. When results are received, the interpretation of those should be clear and performed without error. The laboratories' recommendations on usage should be followed and not extrapolated.

Producers may want to collect and store tail hair samples on animals the next time they run them through the chute. Even if producers are not ready to perform DNA tests on their cattle, having a DNA catalog of their herd will be valuable for genetic testing in the future.

Genotyping Packages: based on the needs of a producer, genetic service providers may package multiple genetic processes together, depending on popularity, for an overall reduced cost. For example, a combined test that examines coat colour, parentage, and horns may be available at a particular lab.

The Beef Cattle Research Council, a division of the Canadian Cattlemen's Association, sponsors research and technology development and adoption, in support of the Canadian beef industry's vision to be recognized as the preferred supplier of healthy, high quality beef, cattle and genetics.

For More Information Contact:

Beef Cattle Research Council
#180, 6815 – 8th St NE
Calgary, AB T2E 7H7
Tel: (403) 275-8558 Fax: (403) 274-5686
info@beefresearch.ca

For More Information, Visit:

www.beefresearch.ca