Beef Cattle Genomics – where we have been, where we are now, and where we are headed?

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Animal breeders have used the resemblance between relatives to select parents of the next generation and make genetic change.
Rate of change is accelerated when breeders can accurately identify those individuals that have the best genetics at a young age.

\[ \Delta G = \text{intensity of selection} \times \text{accuracy of selection} \times \frac{\sqrt{\text{genetic variance in population}}}{\text{generation interval}} \]
We want to use DNA variations (SNPs) in addition to pedigree and performance information to help select the best animals.
The genomics avalanche
Let’s visit the past

- What is DNA?
- What is a genetic marker (DNA test?)
- Where have we been?
- First tests on the market
- Marker panels
- Reporting of results to producers
- Where we are now
- Where we are headed
The genome age

GENES CONTAIN INSTRUCTIONS FOR MAKING PROTEINS

PROTEINS ARE THE BUILDING BLOCKS OF LIFE AND COLLECTIVELY ACT TO DETERMINE PHENOTYPE
What is a Genetic Marker?

A DNA sequence variation that has been associated with a given trait in one or more populations.

Van Eenennaam Ultrasound 8/28/2012
Animal Genomics and Biotechnology Education
SIMPLE TRAITS
- e.g. Coat Color
- Double muscling
- Polled/horned

100% GENETICS

COMPLEX TRAITS
- e.g. Marbling \((h^2 = 0.37)\)

37% GENETICS
63% ENVIRONMENT
Genotyping

Heterozygous bull

TTGAA

TTTAA

1/2

1/2
Merial, Quantum sign leptin test pact. (Business Report)

Publication: Feedstuffs

Publication Date: 04-AUG-03

Ads by Google

B-Bridge International ELISA Assays for Metabolic Studies Adipocytokines, esRAGE, HGF

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SASKATOON, SASK., and DULUTH, GA. -- Quantum Genetics Inc. and Merial Ltd. announced July 23 that they have entered into a global marketing agreement to provide Merial with exclusive rights to market Quantum's new patent-pending DNA test to determine an animal's leptin genotype.

The leptin protein has been demonstrated...

Introduction to the Leptin Protein in Cattle

- Leptin is a protein that influences appetite and metabolism (energy storage and utilization).
- Leptin is produced by fat tissue stored by the body as energy reserves. The more fat tissue, the higher the leptin concentration circulating in the blood.
- High concentrations of leptin normally signal the brain to suppress appetite and draw on stored energy for maintenance.
- Certain types of leptin are not easily recognized by the brain, so appetite and metabolism are not changed.
- The IGENITY™ L Test can identify the genetic variation that determines what type of leptin an animal will produce.

The function of leptin.

- Leptin is the centerpiece of an important negative feedback system involving key metabolic regulators, including insulin, glucocorticoids and the sympathetic nervous system.
- The word “leptin” comes from the Greek word leptos, meaning “thin.”
- Genotype determines what type of leptin is produced by fat tissues and, to a lesser extent, the type of leptin receptors that operate in the hypothalamus.

Activity of L-cc™ Leptin and Receptors

- As L-cc leptin proteins reach the blood-brain barrier, receptors recognize them.
- If concentration is high, a signal is sent to suppress appetite.

Leptin Genotype. It pays to know now.

- Identifying leptin genotype – and selectively breeding for desired leptin genotype – can have a great impact on a dairy or beef operation.
- The benefits can extend beyond increased milk production or beef marbling to greater management options for ration selection and transition cow nutrition, or beef finishing and marketing strategies.
- The beneficial result is that cattle with the L-tt genotype remain in a “hunger” mode and are predisposed to consume more feed:
  - In dairy cattle, this can result in greater dry matter intake (DMI), greater peak lactation, improved body condition scores and improved energy utilization (less time spent in negative energy balance).
  - In beef cattle, this can result in greater DMI and superior marbling.
- On the other hand, L-cc genotype cattle will tend to have lower DMI at critical phases, such as the first 100 days of lactation in dairy cows, or the final 60 days on feed for beef cattle.
- The science behind the IGENITY L Test provides a simple DNA test to identify leptin genotype with 100% accuracy.
**GeneSTAR™ Marbling** is a DNA genetic marker test offered by Bovigen Solutions, LLC for a major gene (Thyroglobulin) associated with marbling. This marker provides beef producers the opportunity to determine an animal's potential for improved marbling more accurately and at an earlier age.

<table>
<thead>
<tr>
<th>Marbling Results (% Choice)</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yearling Fed</td>
<td>58% 62%</td>
</tr>
<tr>
<td>Calf Fed</td>
<td>34% 41%</td>
</tr>
<tr>
<td>NBCEC Trial¹</td>
<td>47% 54%</td>
</tr>
</tbody>
</table>

In independent trials on over 1500 head, 2-STAR animals produced 16-19% more choice carcasses than 0-STAR animals. Equally important was the effect that the proportion of carcasses qualifying for premium Quality Grades doubled (21% vs. 10%) in 2-STAR carcasses versus 0-STAR.

¹Trial was a study conducted by an independent third party.

"DNA technology, although in its infancy in the beef cattle industry, can help us by identifying genes that affect marbling and tenderness. Tenderness seems to be one that interests many who produce and have concerns for improving end product value for our consumers. The GeneSTAR™ testing at Summitcrest has identified a number of cattle homozygous for marbling and tenderness genes. Having done that, we added market value to our cattle and new customers, even from other breeds of cattle, with tenderness concerns."
- Henry Bergfeld, Summitcrest Farms

**HOW DO I USE THIS IN MY BREEDING PROGRAM?**

Using 2-STAR sires is the quickest way to influence the presence of these genes in a herd. In addition, selecting 2-STAR females will more rapidly increase the frequency of the positive forms of these genes. Overall, selecting 2-STAR animals with appropriate EPDs and good structural and breeding soundness is the recommended way forward.

<table>
<thead>
<tr>
<th>Sire is</th>
<th>Dam is</th>
<th>% of Progeny</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-STAR</td>
<td>0-STAR</td>
<td>100%</td>
</tr>
<tr>
<td>0-STAR</td>
<td>0-STAR</td>
<td>50% 50%</td>
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<tr>
<td>0-STAR</td>
<td>0-STAR</td>
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</tr>
<tr>
<td>1-STAR</td>
<td>0-STAR</td>
<td>50% 25%</td>
</tr>
<tr>
<td>2-STAR</td>
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<td>50% 25%</td>
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<tr>
<td>0-STAR</td>
<td>0-STAR</td>
<td>50% 50%</td>
</tr>
<tr>
<td>0-STAR</td>
<td>0-STAR</td>
<td>100%</td>
</tr>
</tbody>
</table>

**LEGEND**

The results of the GeneSTAR™ tests are reported as:

- **2-STAR** = two copies of the desired gene
- **1-STAR** = one copy of each form of the gene
- **0-STAR** = no copies of the desired gene
Now, know more about the genetic potential of your cattle.

igenity. L
Know. Now.

BOVIGEN SOLUTIONS, L.L.C.
1-877-BEEF-DNA • www.bovigensolutions.com
Igenity L was a single T/C SNP test for Leptin

Advanced technology. Advanced knowledge.

What if there was a test that could tell you – in advance – an animal’s genetic potential for energy utilization or carcass quality? You’d have the advantage of knowing an animal’s potential now, instead of discovering it later through success or failure in the milk string or when the animal goes to market.

Researchers have discovered the specific gene that carries the code for the production of a protein called leptin. Leptin is associated with an animal’s potential for appetite and energy utilization, among other things.

- For dairy cattle this translates directly into maximum dry matter intake (DMI) and peak milk production.
- For beef cattle it relates to days on feed and carcass quality.

The IGENITY™ L Test identifies leptin genotype (L-tt™, L-ct™ or L-cc™). Now you have another important resource to help you breed, feed, sort, manage and market cattle at an optimum level.

- Leptin is involved in the regulation of feed intake, energy balance, milk production, milk components, marbling scores, puberty, fertility and immune functions.

- Knowing an animal’s leptin genotype empowers you to make more informed, strategic management decisions regarding breeding and nutrition.

- The IGENITY L Test identifies an animal’s leptin genotype at the DNA level, with 100% accuracy.

Market your cattle with the IGENITY L logo system:

- L-tt™
- L-ct™
- L-cc™
Which would you rather have???

- A bull that is ‘homozygous’ for a positive genetic variant with a low-accuracy EPD of +3, or

- Or an unrelated bull carrying no copies of that genetic variant with a low-accuracy EPD of +3
Both are important!!

- The ‘homozygous’ bull is a source of favorable alleles (genetic variant) of the gene. Can eventually be used to create homozygous calves.
- The other bull contributes favorable unmarked alleles of other genes, which will improve the frequency of other desirable alleles for the trait.
- Breeding the marker-associated form of the gene into the bull that has no copies should improve the trait by combining all of the good forms of the genes together in one animal.
DNA TEST FOR MARBLING EXPLAINS SOME $\% (r_g^2)$ OF GENETIC VARIATION

- DNA TEST
- OTHER GENES
- GENETICS
- EPD estimates all genes

63% ENVIRONMENT

37% GENETICS
Prior to moving genetic markers from discovery populations to commercialization, it is important to validate their purported effects on the trait(s) of interest in the target population and different breeds and environments, and assess them for correlated responses in associated traits.
Independent validation of DNA tests
http://www.nbcecc.org/nbcecc/


The purpose of the NBCEC commercial DNA test validation is to independently verify associations between genetic tests and traits as claimed by the commercial genotyping company using phenotypes and DNA from reference cattle populations.

The validation process is a partnership of the owners of DNA and phenotypes (e.g., breed associations) and genomics companies, facilitated by the NBCEC.
Leptin Genotype Effects on Marbling Score (NBCEC Data)

Data provided by R. L Quaas, Cornell
Recap of early product offerings

- Single gene tests reported as actual results of genotyping (** or AT)
- Great deal of explanation of what the gene was and how it had its effect
- DNA-test billed as 100% accurate
- The need for third-party validation of commercial tests becomes evident
- A lot of emphasis was put on a single SNP
First multi-gene test arrives

**GeneSTAR® Tenderness** was the first multi-gene single trait DNA test commercially available to the beef industry. It combines test results for several markers and genes for the same trait. The test is based, in part, on two genes involved in the post-mortem tenderness process: Calpastatin and Calpain. Calpain is an enzyme which weakens muscle fibers thereby making the fibers more tender. Calpastatin is an enzyme which inhibits the post-mortem tenderization process by inhibiting the effects of Calpain.

**GeneSTAR® Tenderness Genetic Progeny Difference**

As an added tool to GPDs, the Mating Design table shows the predictable results which can be obtained through planned breeding decisions utilizing DNA test results from Bovigen.

<table>
<thead>
<tr>
<th>SIRE IS</th>
<th>DAM IS</th>
<th>% of Progeny</th>
</tr>
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<tbody>
<tr>
<td>🌟🌟🌟🌟</td>
<td>🌟🌟🌟🌟</td>
<td>100%</td>
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<tr>
<td>🌟🌟🌟</td>
<td>🌟🌟🌟</td>
<td>50%</td>
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<td>🌟🌟</td>
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<td>100%</td>
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<tr>
<td>🌟🌟🌟🌟</td>
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<td>🌟🌟🌟🌟</td>
<td>🌟🌟</td>
<td>50%</td>
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<td>100%</td>
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<tr>
<td>🌟🌟🌟🌟</td>
<td>🌟🌟🌟🌟</td>
<td>100%</td>
</tr>
</tbody>
</table>

DNA tests should be considered additional information to be used in conjunction with available performance data for each animal. When comparing two bulls with similar EPDs, GeneSTAR® GPD® results can be used to further evaluate an animal’s true genetic potential.

**BOVIGEN COMPANY PROFILE**

Bovigen is an innovative-driven genomics company developing a portfolio of world class DNA technological products. Our mission is to promote excellence in the beef industry through
Together they have a significant effect on tenderness as measured by Warner-Bratzler Shear Force (WBSF). In fact, in independently validated research, the calpain and calpastatin markers included in IGENITY TenderGENE are associated with improving tenderness as much as 2.3 lb.

The benefits of IGENITY TenderGENE are proven.

- IGENITY TenderGENE includes markers discovered by researchers at the U.S. Meat Animal Research Center (MARC) and the University of Guelph.
- IGENITY TenderGENE is a powerful tenderness test that is fully validated by the NBCEC.
- Validation work involved cattle from the NCBA National Carcass Merit Project.
- Research included more than 1,200 animals, representing all breed types.
- Because of the favorable effect on WBSF of up to 2.3 lb, selecting for tenderness using IGENITY TenderGENE can help ensure a quality eating experience for consumers.

Learn how this inside information can give you a competitive edge. Call 1-877-IGENITY.
First multi-trait test arrives

Practical ways to profit from the IGENITY® profile.

A DNA test is just a test — but IGENITY is a comprehensive profile.

Here are a few of the traits that are analyzed to create the genetic potential expressed in an IGENITY profile.*

- Maternal and reproductive traits
  - Heifer pregnancy rate
  - Calving ease
  - Stayability

- Carcass composition traits
  - Tenderness
  - Ribeye area
  - Fat thickness
  - Marbling
  - Yield grade
  - Hot carcass weight
  - Quality grade

- Docility
- Coat color
- Parentage in multiple-sire settings
- Breed-specific horned/polled
- Commercial Ranch Genetic Evaluation option for calculating in-herd EPDs
- BVD-PI status

*For the most current list of economically important traits included in the IGENITY profile, please visit www.igenity.com.

The IGENITY profile is the most comprehensive and researched tool of its kind. Each of the DNA analyses are validated in a minimum of four separate commercial populations with different environments and breeds. The effects of the IGENITY profile also are confirmed in a landmark project involving 50,000 head of DNA-profiled cattle.
In this example, the results describe an animal for Feed Efficiency. The genes identified for Feed Efficiency thus far, identify cattle with lower Net Feed Intake (NFI). Cattle with lower NFI will eat less without sacrificing ADG or any other performance trait. The animal in this example will consume 3.2 lbs less feed per day and still have the same ADG and Marbling potential as the rest of his contemporary group. Simply put, the more STARS for Feed Efficiency, the less feed consumed without sacrificing any performance!!

In this example, the results describe an animal for its Tenderness potential. Nationwide, tenderness is measured by Warner-Bratzler Shear Force, or the pounds needed to cut a core sample from a ribeye. The animal in this example will produce a ribeye that is 2.0 pounds more tender than an animal without the STARS for tenderness.

The GeneSTAR Tenderness panel continues to lead the industry in identification of markers for one of the most valuable traits for producing a quality eating experience. GeneSTAR animals that are homozygous for all the Tenderness markers (T1, T2, T3) show a difference in Tenderness that virtually eliminates the “unsatisfactory eating experience” that plagues nearly 25% of all carcasses compared to an animal devoid of these genes.

In this example, the results describe an animal for Quality Grade. The genes identified thus far for Quality Grade work across all breeds and identify animals with a greater chance of grading Choice or higher. The animal in this example has a 27.42% greater chance of grading Choice or higher than an animal with out the STARS for Quality Grade.
**FEATURES**
- Contains 128 DNA markers where each marker is highly associated with expression of marbling score
- Measures the cumulative effects of all 128 markers associated with marbling
- Results are expressed as the Molecular Genetic Value (MGV) which can be utilized to rank animals by their genetic potential
- Animals can be tested at any age
- Validated in Angus (validation in other breeds is underway)

**BENEFITS**
- The most powerful and comprehensive DNA selection tool currently available for marbling
- Accounts for a significant proportion of total observed genetic variation for marbling
- Results are easy to utilize and incorporate into any existing breeding program
- Can be used to make early selection and breeding decisions
- Provides accurate and reliable results for ranking and/or selection of animals

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**PROVEN RESULTS**

One in a series of break-through products that will advance breeding practices in the cattle industry, **TRU-MARBLING™** is a powerful and comprehensive DNA selection tool that can determine the genetic potential of animals to express marbling. In a collaborative research program between Cargill and MMI Genomics, an innovative scientific approach was used on over 4000 feedlot animals to identify the majority of regions throughout the bovine genome that have an effect on this economically important trait.

**TRU-MARBLING™** is a DNA-based genetic test that contains a panel of 128 unique DNA markers, each one highly associated with the expression for marbling score and quality grade. By measuring the cumulative effects for each of these 128 markers, **TRU-MARBLING™** accounts for a significant proportion of the total genetic variation for this complex metabolic trait—the first DNA-based product to do so.

**TRU-MARBLING™** is an advanced and revolutionary tool that will allow cattle producers to make early breeding decisions that increase the accuracy of selection and decrease the age at which animals can be selected.

The results? Rapid improvement of marbling within herds and the ability to determine the "Tru" genetic potential of animals.

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**PROVEN RESULTS**

One in a series of break-through products that will advance breeding practices in the cattle industry, **TRU-TENDERNESS™** is a powerful and comprehensive DNA selection tool that can determine the genetic potential of animals to produce tender meat. In a collaborative research program between Cargill and MMI Genomics, an innovative scientific approach was used on over 4000 feedlot animals to identify the majority of regions throughout the bovine genome that have an effect on this valuable consumer trait.

**TRU-TENDERNESS™** is a DNA-based genetic test that contains a panel of 11 unique DNA markers, each one highly associated with expression for tender meat. By measuring the cumulative effects for each of these 11 markers, **TRU-TENDERNESS™** accounts for a substantial proportion of the total genetic variation for this complex metabolic trait.

Since tenderness can only be measured in harvested cattle it is difficult, time consuming and expensive to make genetic progress for this trait using traditional genetic improvement tools. **TRU-TENDERNESS™** changes this paradigm by allowing producers to accurately assess the genetic potential of their breeding stock to produce tender meat. In addition, **TRU-TENDERNESS™** also shortens the interval for making genetic progress because it can be used to test animals of any age. **TRU-TENDERNESS™** is an advanced and revolutionary tool that will allow cattle producers to make early breeding decisions that increase the accuracy of selection and decrease the age at which animals can be selected.

The results? Rapid improvement of tenderness within herds and the ability to determine the "Tru" genetic potential of animals.
Results reported on 1-10 scale


It's easy to understand an IGENTITY profile.

One of the greatest values of the IGENTITY profile is that all results are integrated and provided in one single profile, similar to the report shown here.

<table>
<thead>
<tr>
<th>Animal ID</th>
<th>M/F</th>
<th>Breed</th>
<th>Sample Barcode</th>
<th>Tenderness</th>
</tr>
</thead>
<tbody>
<tr>
<td>701</td>
<td>M</td>
<td>-</td>
<td>nv011507_01</td>
<td>10</td>
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<tr>
<td>702</td>
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<td>705</td>
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<td>-</td>
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<td>6</td>
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<table>
<thead>
<tr>
<th>IGENTITY Profile</th>
<th>Red/Black Coat Color</th>
<th>Heifer Pregnancy Rate</th>
<th>Yield Grade</th>
<th>Ribeye Area</th>
<th>Hot Carcass Weight</th>
<th>Quality Grade</th>
<th>Stayability</th>
<th>BVD-PI</th>
<th>Polled</th>
</tr>
</thead>
<tbody>
<tr>
<td>ED/ED</td>
<td>9</td>
<td>8</td>
<td>8</td>
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<td>8</td>
<td>8</td>
<td>POS</td>
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<tr>
<td>ED/ED</td>
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<td>4</td>
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<td>5</td>
<td>5</td>
<td>3</td>
<td>NEG</td>
<td></td>
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</tr>
</tbody>
</table>
All four animals represented in the above test result have *Tru-Marbling™* and *Tru-Tenderness™* MGVs. All MGVs within a trait have the same accuracy because every animal has the same number of markers in the prediction of genetic potential.

Paul Bunyan and Casey Jones are predicted to grade in the low Select and No Roll USDA grades because of their large negative marbling MGVs. Alamo Rising and Geronimo are predicted to grade in the USDA grades of high Choice and Prime because of their high MGVs for marbling. MGVs near 0 are expected to grade in the high Select USDA grading category.

Paul Bunyan is predicted to produce tough meat with the larger MGV for *Tru-Tenderness™*. Casey Jones and Geronimo are predicted to produce very tender meat. Alamo Rising is predicted to produce acceptable tenderness, bordering on slightly tough.

These results can be used to rank bulls for their genetic potential for marbling and tenderness.
Pfizer Animal Genetics acquired Bovigen – results reported as GPD

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**GeneSTAR Feed Efficiency**

GeneSTAR Feed Efficiency is based on Net Feed Intake (NFI). NFI is the difference between an animal's actual feed intake and the amount of feed an animal is expected to eat based on its size, composition and growth rate.

- Calves that eat less than expected will have a negative NFI
- Negative NFI = Superior Feed Efficiency
- Calves that eat more than expected will have a positive NFI
- Positive NFI = Superior Feed Efficiency

**GeneSTAR GPD**

GeneSTAR GPD was the first multi-gene single trait DNA test commercially available to the beef industry. It contains test results for several markers and genes for the same trait. The test is based, in part, on two genes involved in the post-mortem tenderization process: Calpastatin and Calpain. Calpain is an enzyme which weakens muscle fibers thereby making the fibers more tender. Calpastatin is an enzyme which inhibits the post-mortem tenderization process by inhibiting the effects of Calpain.

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**Quality Grade**

GeneSTAR Quality Grade is a DNA genetic marker panel test offered by Pfizer Animal Genetics which identifies the presence of multiple major genes associated with quality grade. These markers provide beef producers with a quicker and more accurate test to determine an animal's potential for improved quality grade. GeneSTAR Quality Grade includes TG5, which was the first gene marker for a production trait in beef cattle. This panel of markers is the only marbling or quality grade test to have passed an independent validation by the National Cattle Evaluation Consortium.

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Preserve Sample Identification
Repeateable Genetic Analysis:
- Genetic Markers for Animal Quality & Management
- Genetic Markers for Beef Quality & Management
- Parentage
- DNA Traceability

Advancing Beef Science Solutions Through DNA Technology™
Recap of next generation of products

- Multigenic marker panels start to become the norm
- Number of traits and markers grow exponentially
- No longer any emphasis on which genes the markers are associated with, or how those genes function
- No independent validation of many tests
- Multiple different reporting systems that do not allow interchange (1-10, MGV, GPD, Number of Stars) or interpretation relative to EPDs
- DNA information was still being presented separately from EPDs
The Power of the IGENITY® profile for Angus

The American Angus Association® through its subsidiary, Angus Genetics Inc.* (AGI), has a vision to provide Angus breeders with the most advanced solutions to their genetic selection and management needs.

1. Dry Matter Intake
2. Birth Weight
3. Mature Height
4. Mature Weight
5. Milk
6. Scrotal Circumference
7. Weaning Weight
8. Yearling Weight
9. Marbling
10. Ribeye Area
11. Fat Thickness
12. Carcass Weight
13. Tenderness
14. Percent Choice (quality grade)
15. Heifer Pregnancy
16. Maternal Calving Ease
17. Direct Calving Ease
18. Docility
19. Average Daily Gain
20. Feed Efficiency
21. Yearling Height

- Arthrogryposis Multiplex (AM)
- Neuropathic Hydrocephalus (NH)
- Bovine Viral Diarrhea – Persistently Infected (BVD PI)
- Coat Color
1. Calving ease direct
2. Birth weight
3. Weaning weight
4. Yearling weight
5. Yearling height
6. Mature weight
7. Mature height
8. Dry matter intake
9. Residual feed intake
10. Scrotal circumference
11. Docility
12. Calving ease maternal
13. Milking ability
14. Carcass weight
15. Fat thickness
16. Ribeye area
17. Marbling score
18. Tenderness

50K SNP chip assays
50,000 SNPs spread throughout genome
**GAR Predestined**

From start to finish—conception to carcass—no other bull in the beef business today adds as much real value to cattle as Predestined. Ranking as the #1 bull for $B in the breed—our customers tell us that their Predestined-sired cattle return the most dollars to their pockets—they know that $B works. Unlike any other 036 son, Predestined tones down size, adds depth of flank, superior feet and legs and a pleasant disposition to his offspring. His conception rate is high and he’s been a standout in timed-AI programs. His progeny look good—his bulls are thick and his heifers are fancy—and they always display additional shape and capacity. He ended 2006 as our top-seller and rightfully so—Predestined’s many talents for creating value are for real.

### Production and Maternal Performance

<table>
<thead>
<tr>
<th>Production</th>
<th>Maternal</th>
</tr>
</thead>
<tbody>
<tr>
<td>CED Acc</td>
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</tr>
<tr>
<td>CEM Acc</td>
<td>CEM Acc</td>
</tr>
<tr>
<td>Milk Acc</td>
<td>Milk Acc</td>
</tr>
<tr>
<td>MHW Mlk</td>
<td>MHW Mlk</td>
</tr>
<tr>
<td>MW Mlk</td>
<td>MW Mlk</td>
</tr>
<tr>
<td>MH Mlk</td>
<td>MH Mlk</td>
</tr>
<tr>
<td>ENS</td>
<td>ENS</td>
</tr>
</tbody>
</table>

### Carcass and Sire Values

<table>
<thead>
<tr>
<th>Carcass</th>
<th>Sire</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>CW Acc</td>
<td>Marb Acc</td>
<td>Wc</td>
</tr>
<tr>
<td>+26.82</td>
<td>-1.07</td>
<td>4269</td>
</tr>
</tbody>
</table>

### EPD Percentiles

- CED: 88.2%
- BW: 96.9%
- WW: 99.2%
- YW: 99.2%
- YH: 97.0%
- SC: 97.0%
- CEM: 87.1%
- Milk: 85.9%
- MHW: 86.4%
- MW: 86.4%
- MH: 82.9%
- ENS: 81.4%

### Current Sires Percent Breakdown

- Registration #: 13395344
- Tenderness: 3
- Fat Thickness: 6
- Yield Grade: 6
- Ribeye Area: 4
- Carcass Weight: 2
- Percent Choice: 8
- Marbling: 9

### Genetic Traits

<table>
<thead>
<tr>
<th>Trait</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>EPD</td>
<td>7.41</td>
</tr>
<tr>
<td>ACC</td>
<td>0.97</td>
</tr>
<tr>
<td>EPD Rank</td>
<td>10</td>
</tr>
<tr>
<td>MVP</td>
<td>1.07</td>
</tr>
<tr>
<td>MVP Rank</td>
<td>1</td>
</tr>
</tbody>
</table>

### Summary

Predestined is a standout in the beef industry with impressive EPD and carcass traits, making him an excellent choice for your cattle herd.
March 1, 2010 Beef Magazine Survey

http://beefmagazine.com/genetics/beef-asked-answered-20100301

Do you feel like you have a good understanding of the genomic (DNA) information being offered by some seedstock suppliers?

- No 52.3%
- Yes 46.6%

Base = 635 (All Cow-Calf Operations)
Why do you use DNA tests? (Audience Response BIF 2009)

1. Strictly marketing 33%
2. Better than EPDs 9%
3. Marker-Assisted Selection 23%
4. Improve accuracy of EPDs 35%
Need to integrate DNA information into National Cattle Evaluation (NCE)

“Information from DNA tests only has value in selection when incorporated with all other available forms of performance information for economically important traits in NCE, and when communicated in the form of an EPD with a corresponding BIF accuracy. For some economically important traits, information other than DNA tests may not be available. Selection tools based on these tests should still be expressed as EPD within the normal parameters of NCE” (Tess, 2008).
High-throughput genotyping technology enabled a new approach

- The sequencing of the bovine genome allowed for the development of a 50,000 marker chip!
- Can simultaneously test 50,000 markers
With high density (50K) SNP chips it is possible to:

- Divide genome into 50,000 chromosome segments based on marker intervals.
- Marker density must be sufficiently high to ensure that all of the genes affecting a traits are “linked” (close to) a marker.
- Idea is to capture all genetic variance with evenly spread markers and assign an “EPD” value to each segment.
What is needed for “genomic” selection?

**THEORY**

- Population
- Phenotypes
- Genotypes

**Training** = estimate the value of every chromosome fragment contributing variation in a population with phenotypic observations

**Prediction** = the results of training can then be used to predict the merit of new animals, not contained in the training data set.
Implementation of Genomic Selection

**Training 1:** Old Progeny Tested Bulls

**Retraining each generation:** Old Bulls & New Progeny of Tested Bulls

Degree of genetic relationship between populations (ideally similar)

Calibration (Validation) (Estimation of $r_g$):
New Progeny of Tested Bulls

Application:
New Sire Candidates

Slide modified from Marc Thallman, US MARC

Van Eenenaan Ultrasound 8/28/2012

Animal Biotechnology and Genomics Education
Breeding value prediction in Dairy Sires

Young sire Parent Average

Young sire Progeny Test

Young sire Genomic Selection

Birth

5 years; $50,000 cost

Birth; << $50,000 cost

Mendelian Sampling

Reliability 0.20

Reliability 0.80

Reliability 0.65
Dairy industry suited to WGS

- High use of AI
- Only one breed
- Clear selection goal (total net merit)
- Large number of high accuracy A.I. sires for training
- **Extensive, uniform collection of data on traits**
- Central evaluation (AIPL) receiving genotypes
- Obvious way to increase rate of genetic gain
- AI companies funding the genotyping because they get a clear cost savings in terms of young sire program
Information sources for EPDs – DNA tests are another source of information to improve the accuracy of EPDs

- Pedigree Information
- Individual Performance Data
- +/- Progeny Performance Data
- DNA test Information

EPDs

Time, Money and increased generation interval

Modified from slide from Kent Anderson, Pfizer Animal Genetics, presented at BIF 2011

Van Eenennaam Ultrasound 8/28/2012

Animal Genomics and Biotechnology Education
So the question changed from “do they work (validation)” to “how well do they work (calibration or estimation of $r_g$)”?

Which Genomic Test is Best?

Now, thanks to High-Density (HD) 50K genomic technology for Angus, you can more dependably predict the genetic merit of young animals, before progeny information is available. But, what makes this genomic test superior?

**High density vs. low density**

The HD 50K platform includes more than 54,000 DNA markers, significantly more than iGENITY®, which utilizes only 384 markers. With greater coverage of the genetic makeup of Angus animals, no other DNA test provides more dependable predictions of genetic potential than HD 50K.
<table>
<thead>
<tr>
<th>Genetic Correlation ( (r)/(r^{2%}) )</th>
<th>Igenity/Neogen</th>
<th>Pfizer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calving Ease Direct</td>
<td>.47 (22%)</td>
<td>.33 (11%)</td>
</tr>
<tr>
<td>Birth Weight</td>
<td>.57 (32%)</td>
<td>.51 (26%)</td>
</tr>
<tr>
<td>Weaning Weight</td>
<td>.45 (20%)</td>
<td>.52 (27%)</td>
</tr>
<tr>
<td>Yearling Weight</td>
<td>.34 (12%)</td>
<td>.64 (41%)</td>
</tr>
<tr>
<td>Dry Matter Intake (component of RADG)</td>
<td>.45 (20%)</td>
<td>.65 (42%)</td>
</tr>
<tr>
<td>Yearling Height</td>
<td>.38 (14%)</td>
<td>.63 (40%)</td>
</tr>
<tr>
<td>Yearling Scrotal</td>
<td>.35 (12%)</td>
<td>.65 (42%)</td>
</tr>
<tr>
<td>Docility</td>
<td>.29 (.08%)</td>
<td>.60 (36%)</td>
</tr>
<tr>
<td>Milk</td>
<td>.24 (06%)</td>
<td>.32 (10%)</td>
</tr>
<tr>
<td>Mature Weight</td>
<td>.53 (28%)</td>
<td>.58 (34%)</td>
</tr>
<tr>
<td>Mature Height</td>
<td>.56 (31%)</td>
<td>.56 (31%)</td>
</tr>
<tr>
<td>Carcass Weight</td>
<td>.54 (29%)</td>
<td>.48 (23%)</td>
</tr>
<tr>
<td>Carcass Marbling</td>
<td>.65 (42%)</td>
<td>.57 (32%)</td>
</tr>
<tr>
<td>Carcass Rib</td>
<td>.58 (34%)</td>
<td>.60 (36%)</td>
</tr>
</tbody>
</table>

American Angus Association performs weekly evaluations with genomic data – recently updated to include new traits

<table>
<thead>
<tr>
<th>Trait</th>
<th>Igenity</th>
<th>Pfizer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calving ease (CED)</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Growth (BW WW YW Milk)</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Residual Average Daily Gain (RADG)</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Docility (DOC)</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Yearling Scrotal/Height (SC,YH)</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Mature Weight (MW)</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Carcass (CWT MARB RIB FAT)</td>
<td>✔️</td>
<td>✔️</td>
</tr>
</tbody>
</table>

How much do DNA tests help increase accuracy of EPDs?

<table>
<thead>
<tr>
<th>Trait</th>
<th>AGI Heritability</th>
<th>AGI HD 50K Correlation</th>
<th>Avg. 50k Change in ACC - from .05</th>
<th>Approximate Progeny Equivalents</th>
</tr>
</thead>
<tbody>
<tr>
<td>BW</td>
<td>0.42</td>
<td>0.51</td>
<td>0.25</td>
<td>8</td>
</tr>
<tr>
<td>WW</td>
<td>0.20</td>
<td>0.52</td>
<td>0.23</td>
<td>16</td>
</tr>
<tr>
<td>YW²</td>
<td>0.20</td>
<td>0.64</td>
<td>0.27</td>
<td>20</td>
</tr>
<tr>
<td>RADG³</td>
<td>0.31</td>
<td>0.65</td>
<td>0.27</td>
<td>13</td>
</tr>
<tr>
<td>Milk</td>
<td>0.14</td>
<td>0.32</td>
<td>0.15</td>
<td>12</td>
</tr>
<tr>
<td>CW</td>
<td>0.31</td>
<td>0.48</td>
<td>0.17</td>
<td>7</td>
</tr>
<tr>
<td>Marb⁴</td>
<td>0.26</td>
<td>0.57</td>
<td>0.24</td>
<td>12</td>
</tr>
<tr>
<td>RE⁴</td>
<td>0.32</td>
<td>0.60</td>
<td>0.23</td>
<td>9</td>
</tr>
<tr>
<td>FAT⁴</td>
<td>0.26</td>
<td>0.56</td>
<td>0.23</td>
<td>11</td>
</tr>
</tbody>
</table>

¹These changes are less for higher initial accuracy values
²Post-weaning ADG
³Dry matter intake
⁴Carcass progeny, not scanned progeny

Data from Kent Anderson, Pfizer Animal Genetics, presented at BIF 2011
DNA Enhanced Accuracy Calculator

As stated by the Beef Improvement Federation (BIF), DNA tests only have utility when incorporated into national cattle evaluation, i.e., into traditional EPDs. As with any data added to an animal's record (e.g., birth weight, IMF score), the value of DNA data can be gauged by the increase in accuracy achieved when incorporating it into an EPD. Because this tool calculates the resultant accuracy for an animal's EPD when information from a DNA test is added to its record, it provides the user with an objective measure of the value of the DNA test.

The calculator requires an estimate of what genomic companies refer to as the "reliability" of the test for the trait of interest. In statistical terms, reliability is the correlation between DNA test estimates and animals' true genetic value for the trait, which, put another way, is the square root of the proportion of total additive genetic variation accounted for by the DNA test. The calculator also requires the animal's current accuracy level for the trait of interest. The difference between DNA enhanced accuracy and initial accuracy is the increase in accuracy due to the DNA test.

You will notice that the accuracy value required for input and calculated for output is called BIF accuracy. BIF accuracy is the accuracy ASA and all beef breeds in the US publish along with EPDs. Genomic companies may provide an estimate of accuracy (e.g., "reliability") with their DNA tests, however, the estimates are not comparable with BIF accuracy unless a conversion is performed. This calculator performs the conversion.

Reliability of Panel
Initial BIF Acc
= Genomically Enhanced BIF Acc

https://herdbook.simmental.org/simmapp/template/employee,wade,GenomicCalc.vm
**EPD Percentiles**

<table>
<thead>
<tr>
<th></th>
<th>Production</th>
<th>Maternal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CED Acc</td>
<td>BW Acc</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>+10</td>
<td>.9</td>
<td>+47</td>
</tr>
<tr>
<td>.32</td>
<td>.36</td>
<td>.28</td>
</tr>
</tbody>
</table>

**Carcass**

<table>
<thead>
<tr>
<th></th>
<th>Marb Acc</th>
<th>RE Acc</th>
<th>Fat Acc</th>
<th>Carc Grp</th>
<th>Usnd Grp</th>
</tr>
</thead>
<tbody>
<tr>
<td>CW Acc</td>
<td>.94</td>
<td>.13</td>
<td>.023</td>
<td></td>
<td></td>
</tr>
<tr>
<td>.23</td>
<td>.26</td>
<td>.29</td>
<td>.24</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**$Values**

<table>
<thead>
<tr>
<th></th>
<th>$W</th>
<th>$F</th>
<th>$G</th>
<th>$QG</th>
<th>$YG</th>
<th>$B</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>+28.01</td>
<td>+33.86</td>
<td>+35.39</td>
<td>+36.38</td>
<td>-.99</td>
<td>+70.98</td>
</tr>
</tbody>
</table>

EPDs are enhanced by genomic results generated by: [Igenity](https://www.igenity.com) [Pfizer](https://www.pfizer.com)
Angus predictions are not very accurate in Red Angus (Data provided by Dorian Garrick)

<table>
<thead>
<tr>
<th>Trait</th>
<th>Validating in American Angus</th>
<th>Validating in Red Angus</th>
</tr>
</thead>
<tbody>
<tr>
<td>BirthWt</td>
<td>0.64</td>
<td>0.27</td>
</tr>
<tr>
<td>WeanWt</td>
<td>0.67</td>
<td>0.28</td>
</tr>
<tr>
<td>YearlingWt</td>
<td>0.75</td>
<td>0.23</td>
</tr>
<tr>
<td>Fat</td>
<td>0.70</td>
<td>0.21</td>
</tr>
<tr>
<td>REA</td>
<td>0.75</td>
<td>0.29</td>
</tr>
<tr>
<td>Marbling</td>
<td>0.80</td>
<td>0.21</td>
</tr>
<tr>
<td>CalvEase (D)</td>
<td>0.69</td>
<td>0.14</td>
</tr>
<tr>
<td>CalvEase (M)</td>
<td>0.73</td>
<td>0.18</td>
</tr>
</tbody>
</table>

Angus = ASREML 5-fold validation Red Angus = correlation
Training on de-regressed EPDs Saatchi et al (GSE)
Red Angus is more closely related to Angus than is Hereford
Approximate genetic distance between breeds using data from the 2,000 Bull Project. Larry Keuhn, USDA MARC
http://www.nbcec.org/topics/BeefBreeds.pdf


So what about other breeds?
The following breed associations are working with Dorian Garrick (IA State) to develop their own 50K-based prediction equations.

<table>
<thead>
<tr>
<th>Breed</th>
<th>Breed code</th>
<th># Training Records</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hereford</td>
<td>HER</td>
<td>1,725</td>
</tr>
<tr>
<td>Red Angus</td>
<td>RAN</td>
<td>296</td>
</tr>
<tr>
<td>Simmental</td>
<td>SIM</td>
<td>2,853</td>
</tr>
<tr>
<td>Brangus</td>
<td>BRG</td>
<td>896</td>
</tr>
<tr>
<td>Limousin</td>
<td>LIM</td>
<td>2,319</td>
</tr>
<tr>
<td>Gelbvieh</td>
<td>GVH</td>
<td>847</td>
</tr>
<tr>
<td>Maine Anjou</td>
<td>RDP</td>
<td>115</td>
</tr>
</tbody>
</table>
Predictions in Some Beef Breeds
(Data provided by Dorian Garrick)

<table>
<thead>
<tr>
<th># Records in training</th>
<th>Angus (3,500)</th>
<th>Hereford (800)</th>
<th>Simmental (2,800)</th>
<th>Gelbvieh (847)</th>
<th>Gelbvieh including Angus (1,181)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BirthWt</td>
<td>0.64</td>
<td>0.43</td>
<td>0.65</td>
<td>0.38</td>
<td>0.41</td>
</tr>
<tr>
<td>WeanWt</td>
<td>0.67</td>
<td>0.32</td>
<td>0.52</td>
<td>0.31</td>
<td>0.34</td>
</tr>
<tr>
<td>YearlingWt</td>
<td>0.75</td>
<td>0.30</td>
<td>0.45</td>
<td>0.21</td>
<td>NC</td>
</tr>
<tr>
<td>Milk</td>
<td>0.51</td>
<td>0.22</td>
<td>0.34</td>
<td>0.36</td>
<td>0.34</td>
</tr>
<tr>
<td>Fat</td>
<td>0.70</td>
<td>0.40</td>
<td>0.29</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>REA</td>
<td>0.75</td>
<td>0.36</td>
<td>0.59</td>
<td>0.38</td>
<td>0.48</td>
</tr>
<tr>
<td>Marbling</td>
<td>0.80</td>
<td>0.27</td>
<td>0.63</td>
<td>0.54</td>
<td>0.56</td>
</tr>
<tr>
<td>CED</td>
<td>0.69</td>
<td>0.43</td>
<td>0.45</td>
<td>NC</td>
<td>0.48</td>
</tr>
<tr>
<td>CEM</td>
<td>0.73</td>
<td>0.18</td>
<td>0.32</td>
<td>NC</td>
<td>NC</td>
</tr>
<tr>
<td>SC</td>
<td>0.71</td>
<td>0.28</td>
<td>NA</td>
<td>0.50</td>
<td>0.50</td>
</tr>
</tbody>
</table>
Hereford announces genomic-enhanced EPDs (8/20/12)

Hereford introduces genomic-enhanced EPDs

The American Hereford Association (AHA) is the first beef breed to develop and market its own genomic predictions.

The AHA approach is the first of its kind to work with the scientific community and the National Beef Cattle Evaluation Consortium (NBCEC) to build its own training and validation population. This approach is important because AHA now has access to all of the genotypes, phenotypes and pedigrees, which will allow the Association and its members to continue to train and build the Hereford-specific panel.

Today more than 1,200 Herefords have been 50k genotyped and eight sires whole-genome sequenced. This population has been used to train and validate the Hereford-specific panel. Dorian Garrick, Iowa State University Lush Chair in animal breeding and genetics and NBCEC executive director, has led the research and development.

According to Garrick AHA took a pro-active approach testing and validating the tools available to make sure when releasing a Hereford genomic product it was reliable and useful to AHA members. During this process the Association aligned itself with researchers and worked collaboratively with the NBCEC, U.S. Department of Agriculture (USDA) Meat Animal Research Center and other global Hereford associations.

In late June AHA transitioned its DNA testing to GeneSeek Inc. located in Lincoln, Neb. With this move, Hereford breeders have the option to utilize a 50k panel to obtain genomic information to enhance the accuracy of Hereford expected progeny differences (EPDs). The genomic information obtained is blended with conventional EPDs to produce genomic-enhanced EPDs (GE-EPDs). GE-EPDs are available on all traits reported by the AHA.

Limousin plans to start using DNA in EPDs in December 2012

Genomic information is the next step in technology for the beef industry. The North American Limousin Foundation has done extensive work over the last few years in cooperation with Igenity Inc. (now part of GeneSeek Inc.) to develop a Limousin specific 50,000 SNP (pronounced ‘snip’; single-nucleotide polymorphism) panel. This test goes beyond the DNA marker tests that were introduced years ago, which included only a small number of markers and were unable to generate values that could be incorporated in National Cattle Evaluations (NCE).

Each SNP alone does not reveal much information. It is only through study of the quantitative effects of a number of critically selected SNPs that generates molecular breeding values (MBVs) for each trait. These MBVs will be factored into the interim EPDs of the animal as well as the NCE based upon the correlation of the MBV to the trait. MBVs will be available for every EPD trait and will be beneficial through increased EPD accuracy of traits that are either difficult or expensive to measure such as Stayability and the carcass traits.

It is important to note that even though a genomic panel yields increased accuracy to EPDs, it is still only one tool in the genetic evaluation toolbox. Weights, measurements, ultrasounds and docility scores will still be vital to build a complete picture of an animal’s genetic merit. Those measures will also be crucial to the updating and expanding on the accuracy of the panel and its genetic correlations.

Once animal has had a sample submitted to NALF for the Limousin Genomic Profiler-Igenity® Enabled, the sample will be sent to GeneSeek, Inc. where a panel will be run. NALF will receive the MBVs which will then be factored into the animal’s EPDs starting in December 2012 and the NCE soon after. The animal’s owner will receive a report with the Igenity 1-10 scores on that animal similar to their earlier Beef Profile report. NALF would recommend that selection decisions be made based on the Genomic-Enhanced EPDs as they are a more accurate tool for determining genetic merit.
**NBCEC projects** [http://www.nbcec.org](http://www.nbcec.org)

- Genomic selection in beef cattle (Garrick - IA)
- Single-step approach to incorporating genomic information into EPDs (Misztal - GA)
- Reducing data loss and improving accuracy in National Cattle Evaluation (Bertrand - GA)
- Industry effort to enhance beef cattle selection (aka Weight Trait Project) (Pollak/Spangler - NE)
- Developing selection tools for longevity and reproduction (Pollak – US MARC)
- Genetics of feedlot cattle health (Enns, CO – funded by Pfizer)
- Healthfulness of beef project (Reecy, IA – funded by Pfizer)
USDA funded projects – competitive call for proposals

- **BIGS – Bioinformatics to implement genomic selection** – finishes 4/14 (Garrick/Snelling/Golden) See website [http://bigs.anisci.iastate.edu/](http://bigs.anisci.iastate.edu/)
- Identification of molecular markers to improve fertility of beef cattle (Thomas, CO) – finished 12/2011
  - >10,000 DNA samples and phenotypes on heifers
- **Integrating DNA information into beef cattle production systems** (Van Eenennaam, CA) – finishes 12/2013
  - 7,000 DNA samples & weaning weight records, 4500 carcass records
- **National program for genetic improvement of feed efficiency in beef cattle** (Taylor, MO) – finishes 4/2016
  - Genotype ~ 2,400 head on HD chips
  - $5 million, 5 year project; April 2011 – April 2016
- **Integrated program for reducing bovine respiratory disease (BRD) in beef and dairy cattle** (Womack, TX) – finishes 4/2016
  - Collection and HD genotypes on 6,000 BRD case-control animals
  - $10 million, 5 year project; April 2011 – April 2016
- Reproductive grants that have not yet been officially announced
<table>
<thead>
<tr>
<th>Year</th>
<th>Description</th>
</tr>
</thead>
</table>
| 2003 | - single marker/single trait  
- reported genotypes  
- single marker accounted for small amount of genetic variation  
- limited adoption  
- technology oversold |
| 2008 | - multimarker tests for a few traits reported in a variety of formats  
- no tie between DNA test results and national genetic evaluation or breed associations  
- tests accounted for < 10% additive genetic variation  
- limited validation  
- technology not in a form producers could use |
| 2013 | - panels with hundreds of markers for many traits  
- results reported in units of the trait  
- incorporation of DNA information into national genetic evaluation  
- DNA-based evaluations improve accuracy of EPDs  
- large numbers of genotyped populations are available for calibration/validation |
| 2020 | - universal marker panel used by worldwide beef cattle community  
- seamless submission of genotype data to national genetic evaluation/breed associations  
- cost is low  
- DNA information used for traceability, parentage, genetic defects, selection, marker-assisted management, product differentiation |
“It is perhaps the cumulative value derived from using DNA test information for multiple purposes (traceability, parentage, genetic defects, selection for difficult to measure traits, marker-assisted management, product differentiation), in combination with the rapidly-declining cost of genotyping, that will ultimately push the economics of DNA-based technologies over the tipping point towards more widespread industry adoption”

Summary

- DNA test results are now being combined with pedigree and performance records in Angus, Simmental, and Hereford NCE – others to follow.
- DNA information is most useful to improve otherwise low accuracy EPDs (i.e. parent-average EPDs from animals with no records).
- Need to continually retrain equations - phenotype is king – we will still need ultrasound information.
- It is envisioned in the future there will also be tests for hard to measure traits e.g. feed efficiency and disease resistance – will need LOTS of phenotypes!
The National Beef Cattle Evaluation Consortium (NBCEC) is an organization of researchers, educators, producers and industry leaders focused on genetic evaluation of beef cattle. Its mission is to advance U.S. beef genetics, increase the sustainability and competitiveness of the beef industry, and provide consumers with affordable and healthy beef products. NBCEC shows this commitment through research, animal evaluation, genetic test validation, industry collaboration and outreach, and professional development.

**White Paper - Delivering Genomics Technology to the Beef Industry**

**HOT TOPIC!**

The Weight Trait Project Meeting was held in June at the Meat Animal Research Center, Clay Center, NE. The meeting focused on DNA Technology: Where we’ve been, where we are, and where we’re headed. For more information please go to [www.beefefficiency.org/marcmtgjune12.html](http://www.beefefficiency.org/marcmtgjune12.html)

**Commercial Heifer Selection Using Genomics** - Factsheet by Alison Van Eenennaam, UC Davis

Application of Genomic Information: The California Commercial Ranch Project - Factsheet by Alison Van Eenennaam, UC Davis

**Results from the USMARC 2000 Bull Project** - Factsheet by Mark Thallman, USMARC

**Relationships of Beef Breeds Using the 50K Chip** - Factsheet by Larry Kuehn, USMARC

"The NBCEC has improved the genetics of beef cattle in the U.S. through research, evaluation, test validation and education. Genetic improvements in the herd lead to increased value and productivity for the producer while providing consumers the highest quality beef in the world. While all segments of the beef industry benefit from the genetic improvements enabled by technologies such as marker assisted selection, catt..."
Questions?