DNA Technologies and Production Markers

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Overview

- Background information on genetic improvement and DNA marker technology

- Improvements in genetic gain possible from including DNA information into genetic predictions

- Genetic tests that are on the market for production traits

- DNA testing for recessive genetic defects

Animal Biotechnology and Genomics Education

Traditional animal breeding on the basis of phenotype (appearance) can be very successful

However breeding based on objective performance recording has been spectacularly successful…..

Milk yield in US Holstein cows

Average milk production per lactation of US Holstein cows has nearly doubled during the past 40 years
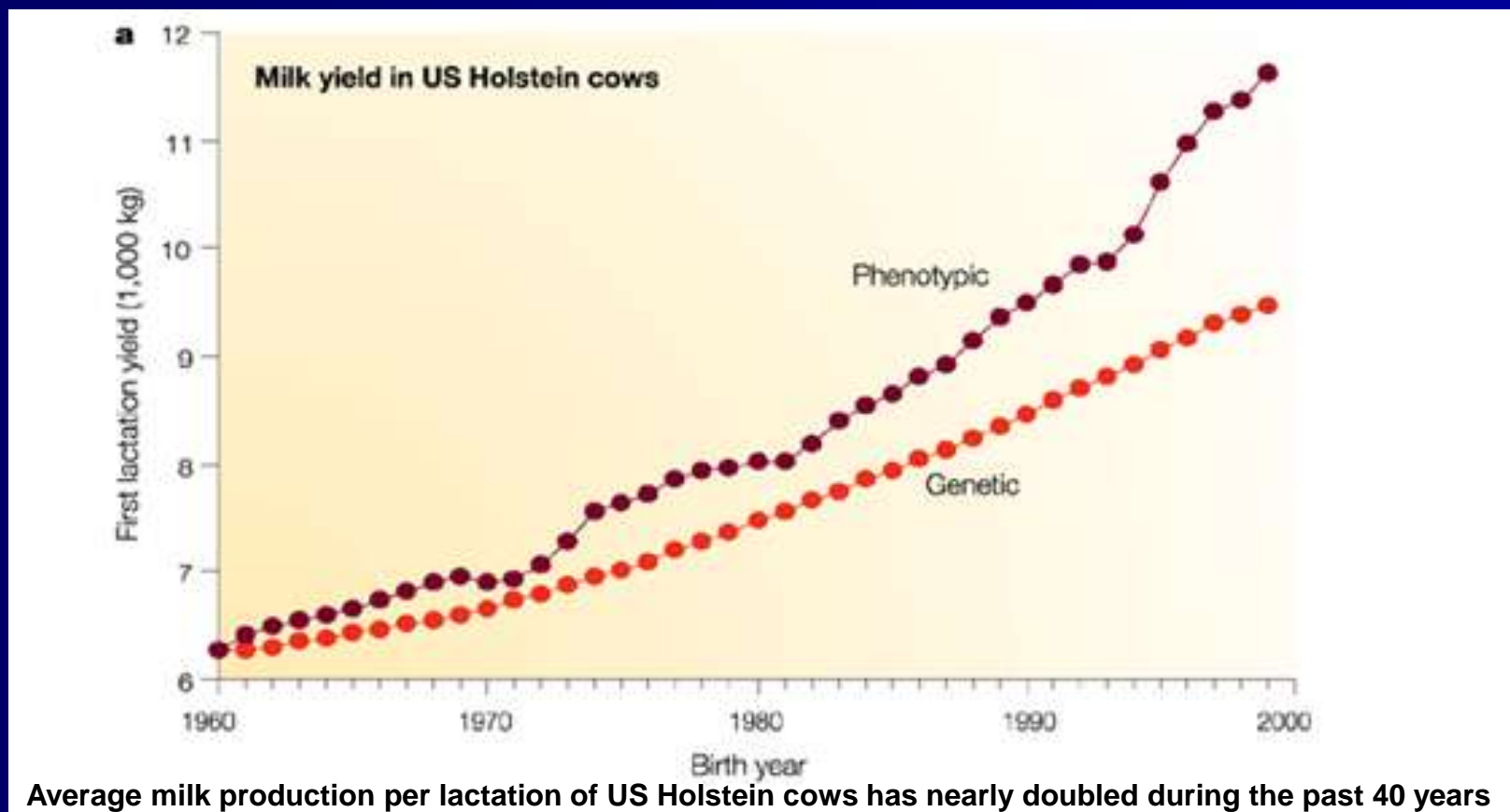
Image from: Dekkers, J.C.M, and F. Hospital, 2002. The use of molecular genetics in the improvement of agricultural populations. *Nature* Reviews Genetics 3: 22-32

What is an EPD?

An animal's **breeding value** is an estimate of its genetic merit, half of which will be passed on to its progeny – this is called the Expected Progeny Difference (EPD). While we will never know the exact breeding value, for performance traits it is possible to make good estimates based on performance records of the animal and its relatives.

Typical EPD Genetic Evaluation

- Calving ease
- Birth Weight
- Weaning Weight
- Yearling Weight
- Milk
- Scrotal
- %IMF
- REA
- %RP
- a mix of others

Reg. No.: 12346200
Calved: 5/16/1995

Semen: $250
Certificates: $35

Angus Semen Service

Production						Maternal					
CED Acc	BW Acc	WW Acc	YW Acc	YH Acc	SC Acc	CEM Acc	Milk Acc	MkH MkD	MW Acc	MH Acc	$EN
+6 .92	+3.1 .97	+42 .96	+92 .95	+.3 .94	+.07 .94	+9 .90	+18 .94	1378 4501	+84 .89	+.8 .89	-.71

Carcass						$Values					
Cwt Acc	Mrb Acc	RE Acc	Fat Acc	C Grp C Prog	U Grp U Prog	Wean Value	Feedlot Value	Grid Value	QG Value	YG Value	Beef Value
+22 .63	+.22 .67	+.48 .67	+.006 .62	16 35	3465 8164	14.59	34.28	21.71	14.59	7.12	50.7

Fall 2008 EPD

G A R Precision 1680
#11520398

Tehama Bando 155

Band 234 of Ideal 3163
Tehama Blackcap G373

9J9 G A R 856

Rito 9J9 of B156 7T26
Blackbird G A R 833

W C C Blackcap C9
+11911768 R

S S Traveler 6T6

Q A S Traveler 23-4
S S Miss Power Play 4A4

Premier Blackcap 6276A

Brusco
Premier Lady Blackcap 2861U

Interpreting an EPD

Sire X has a weaning weight EPD of +20
Sire Y has a weaning weight EPD of +10.

EPDs form a basis for comparison between bulls – on average a +20 WW EPD bull will have calves that weigh 10 more pounds at weaning than a +10 WW EPD bull.

AI bull

Production						Maternal					
CED Acc	BW Acc	WW Acc	YW Acc	YH Acc	SC Acc	CEM Acc	Milk Acc	MkH MkD	MW Acc	MH Acc	$EN
+12 .87	-.1 .96	+49 .94	+91 .92	+.4 .91	+.30 .91	+6 .71	+32 .79	166 543	+23 .63	+.7 .64	-3.08

Carcass					
CW Acc	Marb Acc	RE Acc	Fat Acc	Carc Grp/Pg	Usnd Grp/Pg
+22 .65	+.40 .69	+.19 .68	+.054 .64	15 57	1162 2801

Yearling bull with own records and ultrasound

Production						Maternal					
CED Acc	BW Acc	WW Acc	YW Acc	YH Acc	SC Acc	CEM Acc	Milk Acc	MkH MkD	MW Acc	MH Acc	$EN
+6 .30	+2.1 .36	+44 .27	+80 .26		+1.00 .33	+7 .20	+32 .21		I +31 .05	I +.5 .05	-6.50

Carcass					
CW Acc	Marb Acc	RE Acc	Fat Acc	Carc Grp/Pg	Usnd Grp/Pg
+5 .18	+.48 .23	+.04 .26	+.016 .20		

Yearling bull with no records

Production						Maternal					
CED Acc	BW Acc	WW Acc	YW Acc	YH Acc	SC Acc	CEM Acc	Milk Acc	MkH MkD	MW Acc	MH Acc	$EN
I +6 .05	I +2.3 .05	I +42 .05	I +84 .05	I +.2 .05	I +.29 .05	I +7 .05	I +21 .05				+2.09

Carcass					
CW Acc	Marb Acc	RE Acc	Fat Acc	Carc Grp/Pg	Usnd Grp/Pg
I +15 .05	I +.27 .05	I +.31 .05	I +.007 .05		

What is the value of accuracy?

Reg. No.: 12346200
Calved: 5/16/1995
Semen: **$250**
Certificates: **$35**

Production						Maternal					
CED Acc	BW Acc	WW Acc	YW Acc	YH Acc	SC Acc	CEM Acc	Milk Acc	MkH MkD	MW Acc	MH Acc	$EN
+6 .92	+3.1 .97	+42 .96	+92 .95	+.3 .94	+.07 .94	+9 .90	+18 .94	1378 4501	+84 .89	+.8 .89	-.71

Carcass						$Values					
Cwt Acc	Mrb Acc	RE Acc	Fat Acc	C Grp C Prog	U Grp U Prog	Wean Value	Feedlot Value	Grid Value	QG Value	YG Value	Beef Value
+22 .63	+.22 .67	+.48 .67	+.006 .62	16 35	3465 8164	14.59	34.28	21.71	14.59	7.12	50.7

Fall 2008 EPD

G A R Precision 1680 #11520398
  Tehama Bando 155
    Band 234 of Ideal 3163
    Tehama Blackcap G373
  9J9 G A R 856
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    Blackbird G A R 833

W C C Blackcap C9 +11911768 R
  S S Traveler 6T6
    Q A S Traveler 23-4
    S S Miss Power Play 4A4
  Premier Blackcap 6276A
    Brusco
    Premier Lady Blackcap 2861U

Reg. No.: 15399709
Calved: 4/1/2006
Semen: **$25**
Certificates: **$35**

Boyd Heritage was not only Champion sale bull in Denver, he was the high selling bull at $55,000. As Champion of the North American International he displayed flawless structure and confirmation. Heritage stems from the cow family behind bulls like Traveler 004, New Day, On Target, Beef Maker, and Poundmaker. This low 6 frame bull promises excellent growth, thickness, maternal strength and carcass merit. BW 87 lb., WW 744, YW 1,288.

Production						Maternal					
CED Acc	BW Acc	WW Acc	YW Acc	YH Acc	SC Acc	CEM Acc	Milk Acc	MkH MkD	MW Acc	MH Acc	$EN
I +6 .05	I +3.3 .05	I +45 .05	I +83 .05	I +.1 .05	I +.19 .05	I +9 .05	I +32 .05		I +55 .05	I +.7 .05	-7.82

Carcass						$Values					
Cwt Acc	Mrb Acc	RE Acc	Fat Acc	C Grp C Prog	U Grp U Prog	Wean Value	Feedlot Value	Grid Value	QG Value	YG Value	Beef Value
I +15 .05	I +.45 .05	I +.44 .05	I +.015 .05			24.69	24.18	29.86	22.95	6.91	51.99

Fall 2008 EPD

C A Future Direction 5321
  G A R Precision 1680
    Tehama Bando 155
    9J9 G A R 856
  C A Miss Power Fix 308
    S A F Power Fix
    C A Lady Eight 1015

Boyd Forever Lady 7120
  A A R New Trend
    V D A R Shoshone 548
    Donna A A R 74
  S V F Forever Lady 57D
    Leachman Right Time
    S V F Forever Lady 1128

Do EPDs work?
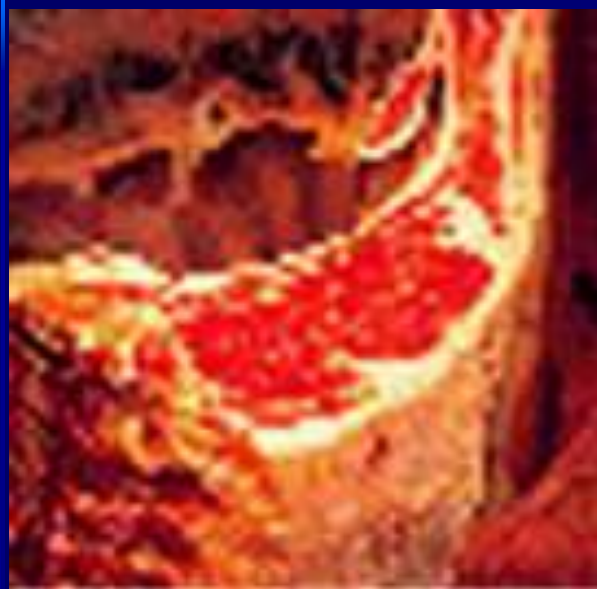
Progeny from Angus bulls with high (>.4) and low (< -0.16) EPDs for marbling were compared. 74% of high offspring graded choice versus 47% of low EPD offspring.

Vieselmeyer, B. A., R. J. Rasby, B. L. Gwartney, C. R. Calkins, R. A. Stock, and J. A. Gosey. 1996. Use of expected progeny differences for marbling in beef: I. Production traits. J Anim Sci. **74**:1009-1013.

# Challenge for breeders is to accurately identify those individuals that have the best true breeding values

- Performance records – more are better
- Would ideally like records before selection
- **The promise:** Perhaps DNA information can help improve the accuracy of breeding values for all traits based on DNA samples taken upon birth – BEFORE selection

Traditional Genetic Evaluation and EPD-based Selection

Selection on EPDs (derived from the observable performance of the animal and its relatives) has the effect on increasing the frequency of favorable alleles (and sometimes unfavorable alleles) without knowing the corresponding genes and molecular mechanisms

The genome age

genome

cell

chromosomes

DNA
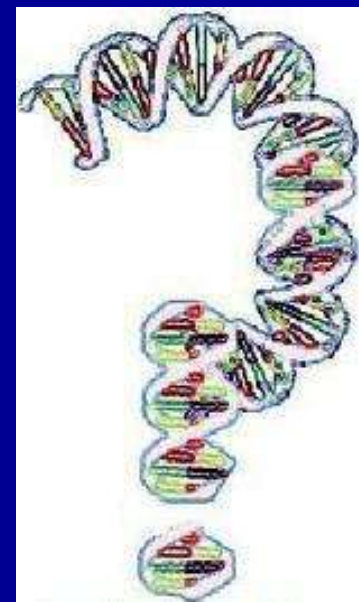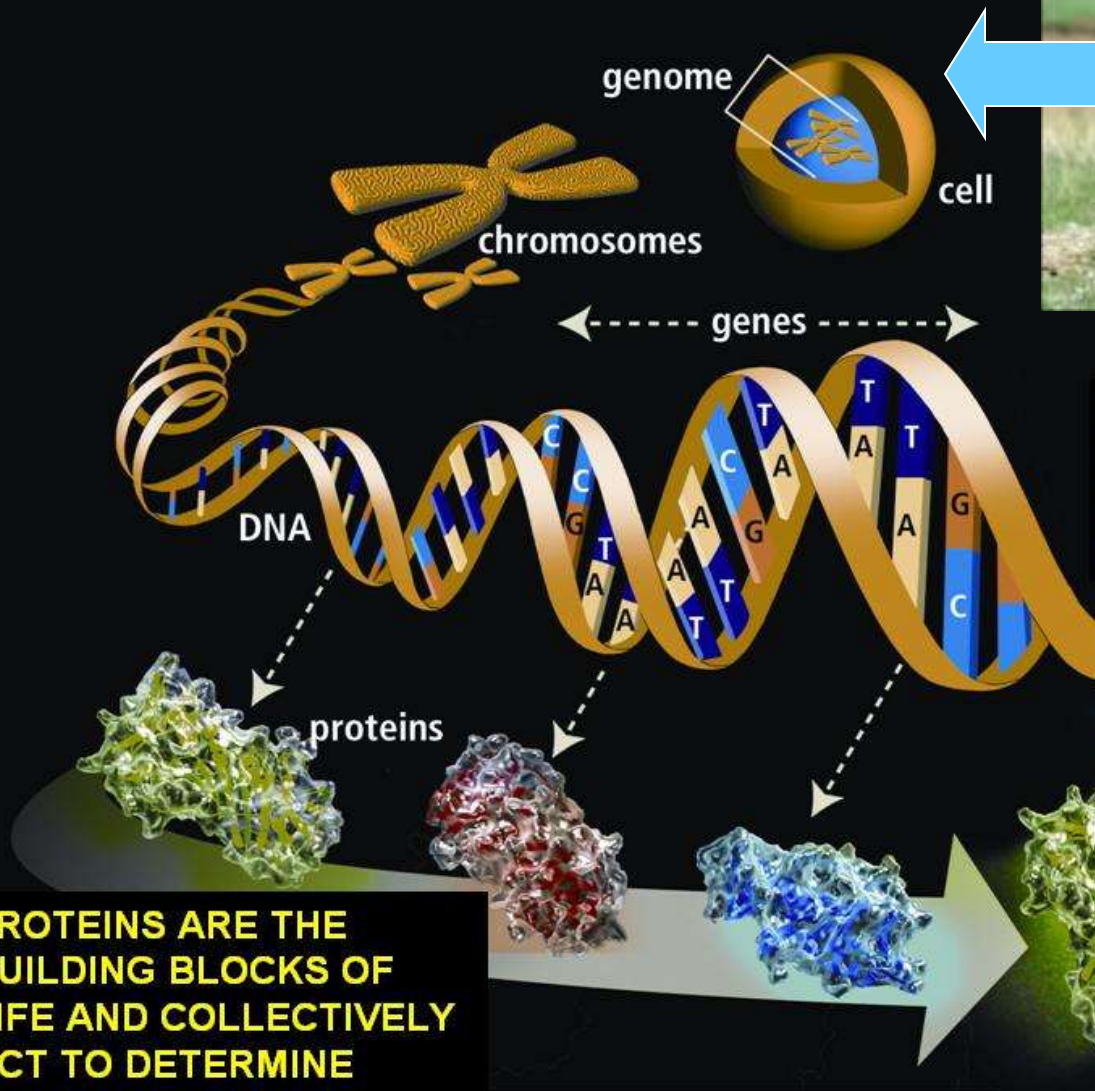
genes

GENES CONTAIN INSTRUCTIONS FOR MAKING PROTEINS

proteins

PROTEINS ARE THE BUILDING BLOCKS OF LIFE AND COLLECTIVELY ACT TO DETERMINE PHENOTYPE

SNP (Single Nucleotide Polymorphism)

A DNA sequence variation that varies sufficiently between individuals that its inheritance can be tracked through families
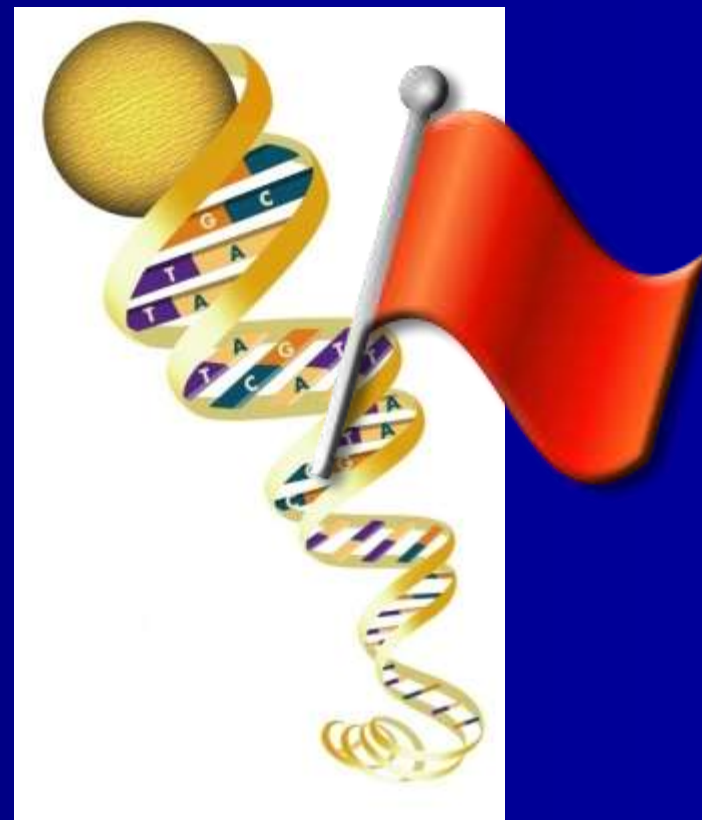
What is a Genetic Marker ?

A DNA sequence variation that has been associated with a given trait in one or more populations
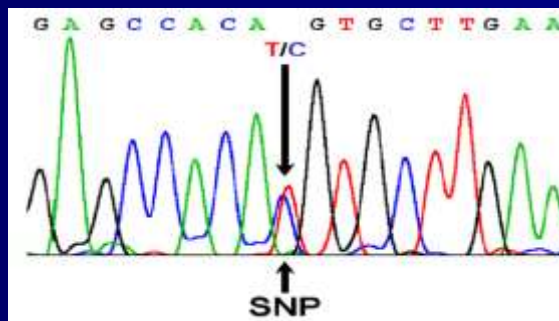
What is needed for develop a DNA test?

TRAINING

- Population
- Phenotypes
- Genotypes

Training = Need a population where genetic markers have been associated with production traits in BREED of interest

Prediction = the results of training can then be used to predict the genetic merit of new animals based on their DNA genotype alone

There are DNA-markers for simple traits

- DNA test result is highly predicitive

  - Coat color
  - Polled/horned staus
  - Certain genetic diseases (e.g. "curly calf")

Animal Biotechnology and Genomics Education

SIMPLE TRAITS
e.g. Coat Color
Double muscling
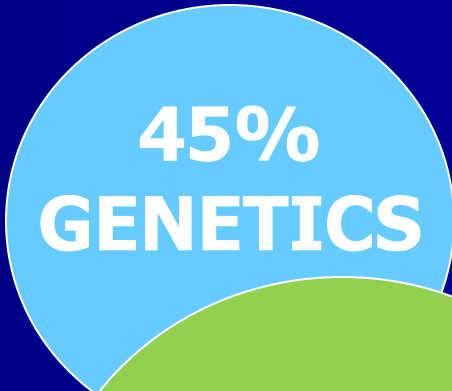
COMPLEX TRAITS
e.g. Marbling ($h^2 = 0.45$)

100 % GENETICS

45% GENETICS

55% ENVIRONMENT

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

Publication: Feedstuffs

Publication Date: 04-AUG-03

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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...

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Igenity L was a single T/C SNP test for Leptin

igenity

Know. Now.

Igenity™ L. Know. Now.

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.

MERIAL

BOVIGEN....

GeneSTAR®

MARBLING

GeneSTAR™ Marbling is a DNA genetic marker test offered by **Bovigen Solutions,℠ L.L.C.** 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.

Marbling Results (% Choice)	O	★	★★	★★&O Difference
Yearling Fed	58%	62%	74%	16%
Calf Fed	34%	41%	53%	19%
NBCEC Trial[1]	47%	54%	64%	17%

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.

[1] Trial was a study conducted by an independent third party.
- National Beef Cattle Evaluation Consortium.

LEGEND

The results of the GeneSTAR™ tests are reported as:

★★ 2-STARS = two copies of the desired gene

★ 1-STAR = one copy of each form of the gene

O 0-STARS = no copies of the desired gene

"DNA technology, although in its infancy in the beef cattle industry, can help us by identifying genes that effect 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.

Mating Design		% of Progeny		
Sire is	Dam is	O	★	★★
O	O	100%		
O	★	50%	50%	
O	★★		100%	
★	O	50%	50%	
★	★	25%	50%	25%
★	★★		50%	50%
★★	O		100%	
★★	★		50%	50%
★★	★★			100%

Which would you rather have???

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

- Or an unrelated bull carrying no copies of that genetic variant with a low-accuracy marbling 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^2) OF GENETIC VARIATION

DNA TEST

OTHER GENES

45% GENETICS

55% ENVIRONMENT
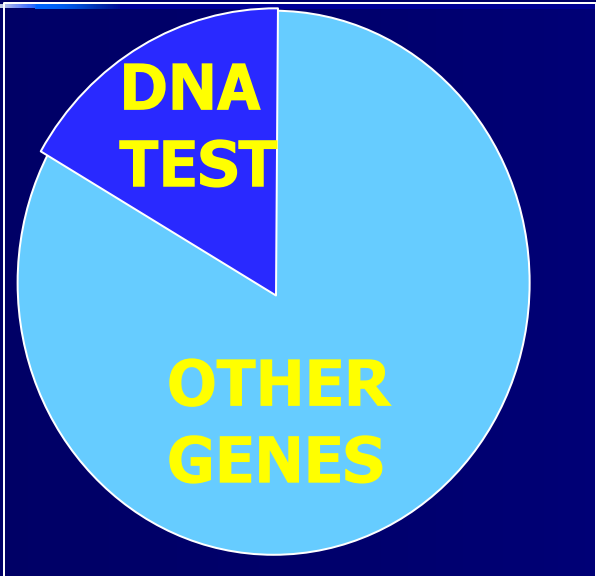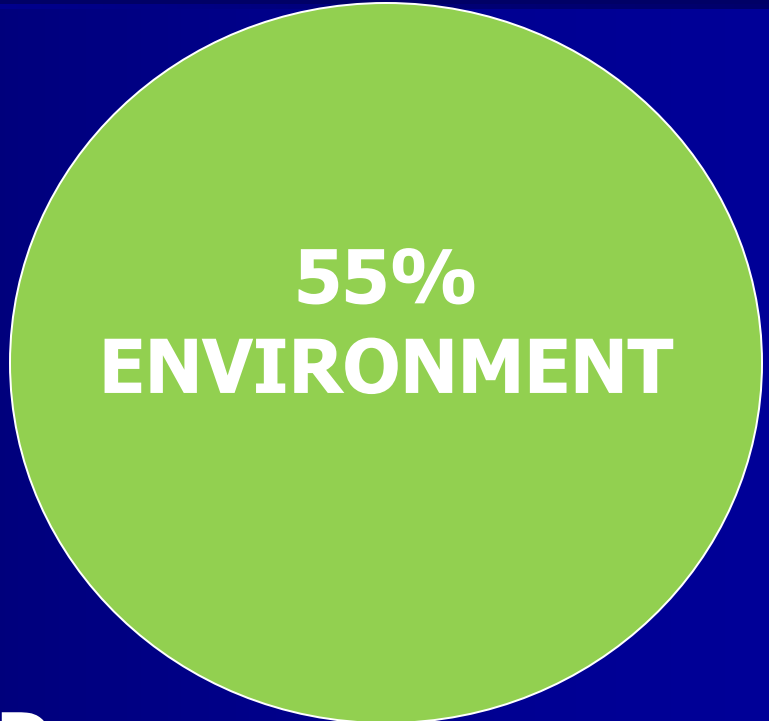
EPD estimates all genes

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

IGENITY® TenderGENE™
A practical, powerful tenderness selection tool.

What do you bring to the table?

IGENITY® TenderGENE™
The inside track to tender beef.

IGENITY® TenderGENE™ profiles the tenderness potential of an animal and is:

- A powerful and comprehensive tenderness selection tool
- Fully validated by the National Beef Cattle Evaluation Consortium (NBCEC)
- Informative in all breed types, including *Bos indicus*

IGENITY TenderGENE analyzes multiple markers associated with the calpain and calpastatin genes. Both of these genes are important for profiling an animal's potential for tenderness:

- Calpain enzymes weaken muscle fibers during the post-mortem aging process.
- Calpastatin interacts with the calpain enzymes to impact overall tenderness.

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.

GeneST★R®
★★ Tenderness
★★ Marbling

GeneST★R® FEED EFFICIENCY
www.bovigen.com • 1.877.BEEF.DNA

USDA PROCESS VERIFIED
INDEPENDENT 3RD PARTY VALIDATION

GeneST★R DNA Test Results

Feed Efficiency	FE1	FE2	FE3	FE4	Total	GPD
Feed Efficiency	★★	★	★	★★	6	-3.2

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!!!

GeneST★R DNA Test Results

	T1	T2	T3	Total	GPD
Tenderness	★★	★	★★	5	2

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.

GeneST★R DNA Test Results

	QG1	QG2	QG3	QG4	Total	GPD
Quality Grade	★★	★	★★	★	6	27.42

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.

1.877.BEEF.DNA   www.bovigen.com
250 Plauche St.   Harahan, LA 70123

USDA PROCESS VERIFIED

Work in Your Best Genes

TRU-MARBLING™

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.

PROVEN RESULTS

Tru-Marbling™ has been validated in both commercial cross-bred feeder cattle populations and in Angus cattle.

The validation in Angus was conducted using samples from the National Carcass Merit Project, representing Angus sires bred to Angus-based commercial cows. While this is a small population of animals, the data indicate that Tru-Marbling™ **accounts for 70% of the genetic variation** observed in this population.

No. of samples:	414
Heritability*:	0.36
No. of markers:	128
Phenotypic variation explained (R²)**:	0.25
As a percent of Heritability	70%

* Angus National Cattle Evaluation, Spring 2007
** estimated from a model that included contemporary group and MGV

Explains 70% of the genetic variation in marbling with 128 markers

Tru-Marbling™ has also been validated against commercial cross-bred feeder cattle populations. This study utilized 89 marbling markers that are a subset of the 128 markers used in the purebred Angus population. The data clearly demonstrates the relationship between quality grade and average Molecular Genetic Value (MGV).

	STEERS			HEIFERS		
Quality Grade	Number	% of total	Avg. MGV	Number	% of total	Avg. MGV
Prime	9	0.1%	14	5	0.1%	14
High Choice	93	1.1%	20	78	1.3%	12
Medium Choice	475	5.8%	14	423	7.0%	9
Low Choice	2006	24.3%	7	1526	25.2%	0
High Select	3989	48.3%	-6	2835	46.9%	-9
Low Select	1344	16.3%	-14	915	15.1%	-20
No Roll	337	4.1%	-20	268	4.4%	-23
Totals	8255	100.0%		6050	100.0%	

14,305 head tested from 8 commercial feedlots

Unlike other products, Tru-Marbling™ MGVs account for a highly significant amount of variation for marbling score.

Work in Your Best Genes

TRU-TENDERNESS™

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.

PROVEN RESULTS

Tru-Tenderness™ has been validated in Angus using samples from the National Carcass Merit Project, representing Angus sires bred to Angus-based commercial cows. While this is a small population of animals, the data indicate that Tru-Tenderness™ accounts for 100% of the genetic variation observed in this population as measured by Warner-Bratzler shear force.

No. of samples:	407
Heritability*:	0.35
No. of markers:	11
Phenotypic variation explained (R²)**:	0.38
As a percent of Heritability	100%

* as estimated in Minick et al, 2004, Can. J. Anim. Sci. 84:599
** estimated from a model that included contemporary group and MGV

Explains 100% of the genetic variation in tenderness

Results reported on 1-10 scale

The IGENITY profile.
Comprehensive. Practical. Powerful.

It's easy to understand an IGENITY profile.

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

IGENITY Profile

Animal ID	M/F	Breed	Sample Barcode #	Tenderness	Red/Black Coat Color	Heifer Pregnancy Rate	Yield Grade	Ribeye Area	Hot Carcass Weight	Quality Grade	Stayability	BVD-PI	Polled
701	M	-	nv011507_01	10	ED/ED	9	8	8	8	8	8	POS	Homozygous
702	F	-	nv011507_02	6	ED/ED	3	4	6	5	7	6	NEG	
704	F	-	nv011507_04	10	ED/E	7	3	8	6	6	6	POS	
705	F	-	nv011507_05	6	ED/D	3	4	6	5	5	3	NEG	

Results reported as a MGV

MOLECULAR GENETIC VALUE (MGV) REPORT

NAME	Legends of the West - Angus Farm	REPORT DATE	08/23/2006
ADDRESS	13457 Trujillo Creek Road	ORIGINAL REPORT	08/23/2006
	Aguilar, CO	CASE ID	MT-0059302S
	81020	CUSTOMER	LWAF - Legends of the West Angus Farm
CONTACT	Wes Johnson, Foreman		

TRU-MARBLING and TRU-TENDERNESS REPORT

BREED	NAME	REG #	TAG/TATTOO	SEX	BORN	SAMPLE ID	MARBLING MGV	TENDERNESS MGV
Angus	AF Paul Bunyan	19352178	AZ-105	M	06/14/2004	0539812G	-28.61	0.92
Angus	AF Casey Jones	19352211	AZ-112	M	05/29/2004	0539813G	-19.41	-3.98
Angus	AF Alamo Rising	19352385	AZ-146	M	06/19/2005	0539814G	42.79	-0.75
Angus	AF Geronimo	19352448	AZ-175	M	12/20/2004	0539815G	70.15	-4.40

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 aquired Bovigen – results reported as GPD

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 still being presented separately from EPDs

Lead Today with 50K

1. Birth weight
2. Weaning weight
3. Weaning maternal (milk)
4. Calving ease direct
5. Calving ease maternal
6. Marbling
7. Backfat thickness
8. Ribeye area
9. Carcass weight
10. Tenderness
11. Postweaning average daily gain
12. Daily feed intake
13. Feed efficiency (net feed intake)

Pfizer **Pfizer Animal Health**
Animal Genetics

50K SNP chip assays
50,000 SNPs spread
throughout genome

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.

Genomic-enhanced Expected Progeny Differences (EPDs) can now be calculated for your animals using the highly predictable American Angus Association database along with IGENITY® profile results to provide a more thorough characterization of economically important traits and improved accuracy on young animals.

Using the IGENITY profile for Angus, breeders receive comprehensive genomic results for multiple, economically important traits.

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
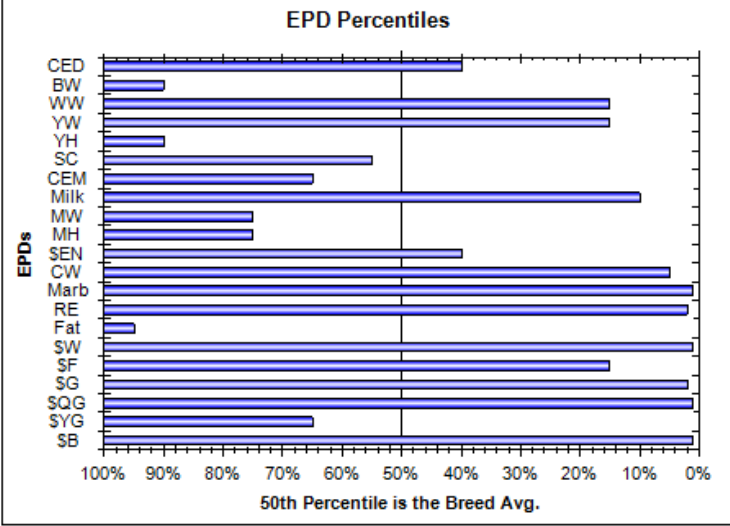20. Feed Efficiency
21. Yearling Height
22. Scrotal Circumfrence

ANGUS
THE BUSINESS BREED

G A R Predestined

Reg. No.: 13395344
Calved: 8/16/1999
Tattoo: 5899
Semen: **$25**
Certificates: **$20**
Spring 2010 EPD

G A R 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						Maternal					
CED Acc	BW Acc	WW Acc	YW Acc	YH Acc	SC Acc	CEM Acc	Milk Acc	MkH MkD	MW Acc	MH Acc	EN$
+7 .84	+4.1 .97	+53 .96	+99 .94	+0 .96	+.31 .95	+6 .80	+28 .85	345 1135	+13 .81	+.2 .81	+5.24

Carcass					Usnd	$Values					
CW Acc	Marb Acc	RE Acc	Fat Acc	Grp Prog	UGrp UProg	Wean	Feedlot	Grid	$QG	$YG	Beef
+26 .82	+1.07 .84	+.59 .82	+.046 .81	47 261	4269 11990	37.39	37.08	38.21	35.04	3.17	69.78

GeneStar	QG1	na	QG2	na	QG3	na	QG4	na	QG GPD	
	T1		T2	0	T3	0	-	-	T GPD	-0.35
	FE1	na	FE2	na	FE3	na	FE4	na	FE GPD	

EPD Percentiles

50th Percentile is the Breed Avg.

Current Sires Percent Breakdown

As of 03/22/2010

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

G A R Predestined — 13395344

	CED	BW	WW	YW	ADG	DMI	NFI	CEM	MA	CW	FAT	REA	MS	TND	$B/$MVP FL
EPD	7	4.1	53	99	-	-	-	6	28	26	0.046	0.59	1.07	-	69.78
ACC	0.84	0.97	0.96	0.94	-	-	-	0.8	0.85	0.82	0.81	0.82	0.84	-	-
EPD % Rank	30	85	15	15	-	-	-	55	10	4	90	2	1	-	1
MVP	13	1.0	37	-	0.45	0.97	0.04	8	33	55	0.07	0.92	1.52	-0.43	243
MVP % Rank	3	70	10	-	30	90	90	4	1	1	90	1	1	80	1

American Angus Association performs weekly evaluations with genomic data

	Igenity	Pfizer
Calving ease (CED)	✓	✓
Growth (BW WW YW Milk)	✓	✓
Residual Average Daily Gain (RADG)	✓	✓
Docility (DOC)	✓	
Carcass (CWT MARB RIB FAT)	✓	✓

http://www.angus.org/AGI/GenomicChoice070811.pdf

Animal Biotechnology and Genomics Education

DNA TEST FOR MARBLING EXPLAINS SOME % (r^2) OF GENETIC VARIATION

??

OTHER GENES

45% GENETICS
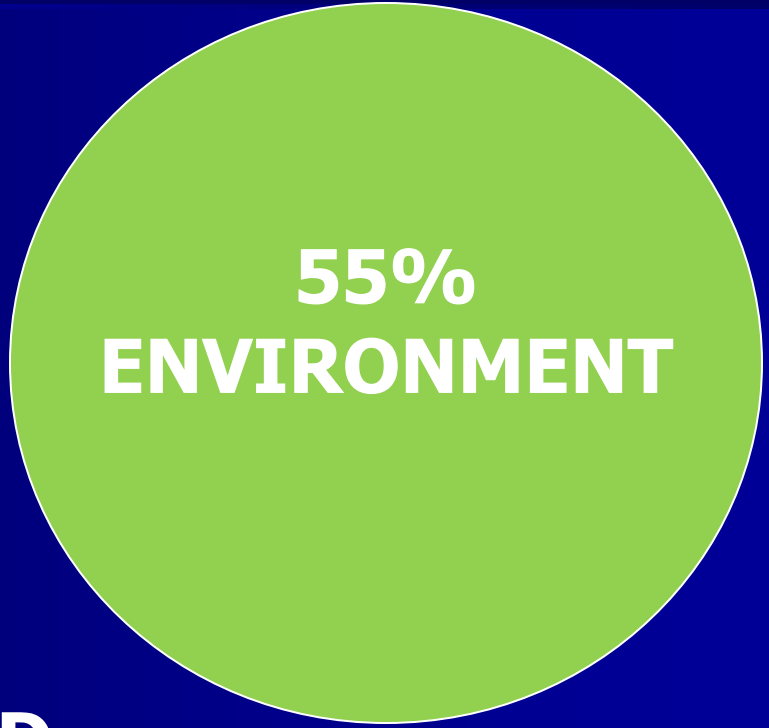
55% ENVIRONMENT

EPD estimates all genes

Trait	AGI h^2	IGENITY® Angus Profile		Pfizer HD 50K for Angus	
		Included	% Genetic variation (r^2)	Included	% Genetic variation (r^2)
Average Daily Gain		X		X	30[2]
Net/residual Feed Intake				X	12[2]
Dry matter intake	0.31	X	20[1]	X	42[1]
Feed Efficiency		X		X	
Tenderness		X		X	26[2]
Calving Ease (Direct)	0.20	X	22[1]	X	11[1]
Birth weight	0.42	X	32[1]	X	26[1]
Weaning Weight	0.20	X	20[1]	X	27[1]
Yearling Weight	0.20	X	12[1]	X	41[1]
Yearling Height		X			
Calving ease (maternal)		X		X	40[2]
Milking Ability	0.14	X	6[1]	X	10[1]
Heifer Pregnancy		X			
Docility	0.37	X	22[1]		
Mature Height		X			
Mature Weight		X			
Scrotal Circumference		X			
Carcass weight	0.40	X	29[1]	X	23[1]
Backfat thickness	0.34	X	25[1]	X	31[1]
Ribeye area	0.33	X	34[1]	X	36[1]
Marbling score	0.45	X	42[1]	X	32[1]
Percent choice		X			

[1] Northcutt, S.L. (2011) Genomic Choices. American Angus Association®/Angus Angus Genetics Inc. release. http://www.angus.org/AGI/GenomicChoice070811.pdf (updated July 7, 2011)
[2] Pfizer Animal Genetics. 2010. Technical Summary. (posted April, 2010) https://animalhealth.pfizer.com/sites/pahweb/US/EN/PublishingImages/Genetics%20Assets/HD50K/50K%20Tech%20Summary%204-13-10.pdf.

Summary

- Selection requires accurate identification of genetically superior animals to become parents of next generation
- Accuracy of EPDs can be improved by
  - Having performance records on individual and its relatives
  - Maintaining contemporary groups – especially in feedlot
  - DNA tests that have been shown to work in Wagyu breed
- Need training populations of each breed of cattle with records and genotypes to develop accurate DNA tests for each breed

DNA tests are most valuable for traits that are

- **low heritability** (influence that genetics rather than environment has on a trait)

- **are difficult or expensive to measure** (feed efficiency)

- **cannot be measured until after selection has occurred** (carcass data)

- **are currently not selected for due to lack of available phenotypic data** (tenderness)

There are a large number of genetic abnormalities in cattle occurring in a variety of breeds.
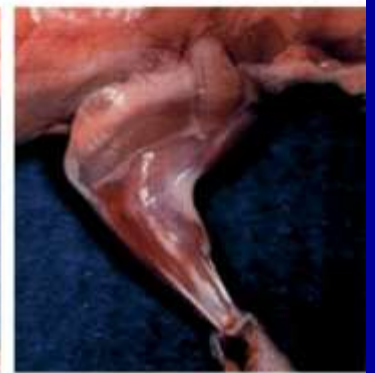
Images from an article by David S. Buchanan, NDSU
http://www.ag.ndsu.edu/williamscountyextension/livestock/genetic-defects-in-cattle

Myostatin:
mutations in cattle, mice and humans

Phenotypic comparisons of: "double muscled" bull homozygous for loss-of-function allele at the myostatin (MSTN) locus, mouse, and human.

Womack J E Genome Res. 2005;15:1699-1705

Economic implications of recessive genetic factors

A Triple Compounded
EILEENMERE

Look at the Blood Line Wealth concentrated in one animal. "SHORT SNORTER"

An early '50's advertisement that superimposed a measuring stick in the picture of this bull who was nick-named "<u>Short Snorter</u>."

Based upon his height and age, he was less than a frame score 1.

Image from <u>https://www.msu.edu/~ritchieh/historical/shortsnorter.jpg</u>

Animal Biotechnology and Genomics Education

THE BATTLE OF
BULL RUNTS

By L. P. McCANN

The March to Victory

A 1956 survey of Hereford breeders in the USA identified 50,000 dwarf-producing animals in 47 states.

Through detailed pedigree analysis and test crosses, the American Hereford Association, in concert with breeders and scientists, virtually eliminated the problem from the breed. Because carrier status was difficult to prove and required expensive progeny testing, some entire breeding lines were eliminated.

Arthrogryposis multiplex; aka Curly Calf

- From a scientific standpoint, AM is the complete deletion of a segment of DNA that encompasses two different genes

- One of these genes is expressed at a crucial time in the development of nerve and muscle tissue. The mutation results in no protein being produced from this gene and therefore it is unable to carry out its normal function so homozygotes show phenotype

From September 8 – November 3, 2008 identified genetic problem, developed test, and released carrier status of 736 bulls!

- In the 11 months following the release of the test, the AAA posted the results of tests for AM on about 96,247 cattle.

- **This amounts to $2.4 million in testing costs**

- Of these, 20% (19,529) were carriers of AM. **That leaves 23,638 bulls and more than 53,000 heifers which tested as free of AM.**

- **At $4K/bull and $2K/heifer ~ $200 million of suspect animals shown to be free of RGF allele**

Based on calculations in Buchanan, D.S. 2009. Genetic Defects in Cattle.
http://www.ag.ndsu.edu/williamscountyextension/livestock/genetic-defects-in-cattle
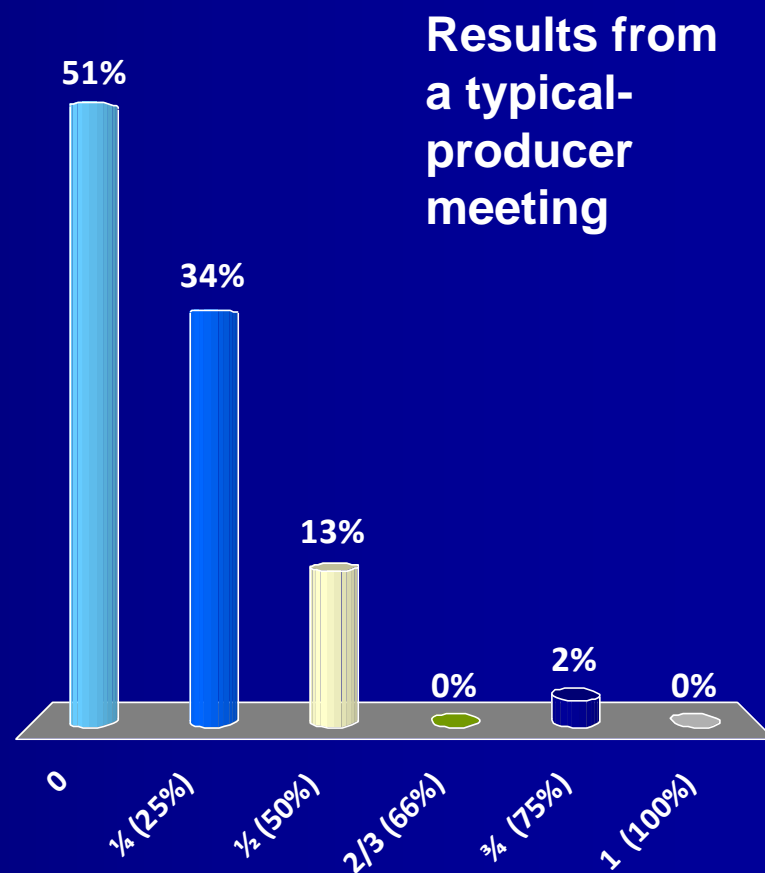
Estimates of US genetic testing costs (Angus)

	US
AMF	113,526
NHF	77,067
CAF	28,837
TOTAL NUMBER	294,054
COST (@ $25/test)	7,351,350

Numbers kindly shared by Bryce Schumann, American Angus Association

Genetic implications of recessive genetic factors

"*Carrier animals....their overall breeding value worth may outweigh the economic value of carrier status*"

Chalier C. et al. (2008) Highly effective SNP-based association mapping and management of recessive defects in livestock. Nature Genetics 40:449-454

Should the market decide or should this choice be directed by industry (e.g. disallowing registration of known carriers)?

Some questions that remain about recessive genetic defects

- If all animals carry recessive genetic factors/defects – how should "defects" be managed

- Can 50K or 800K data be also used to identify carrier status to spread the costs of DNA extraction. If so does it infringe on diagnostic test patents/IP

- Can we use genomics to better manage recessive genetic factors/defects

- Are appropriate decision support tools available for producers

Ideally cattle would be genotyped once early in life and genotypes shared among production sectors to derive the maximum value from the fixed DNA collection and extraction costs

Potential Value of Genomics to Sector

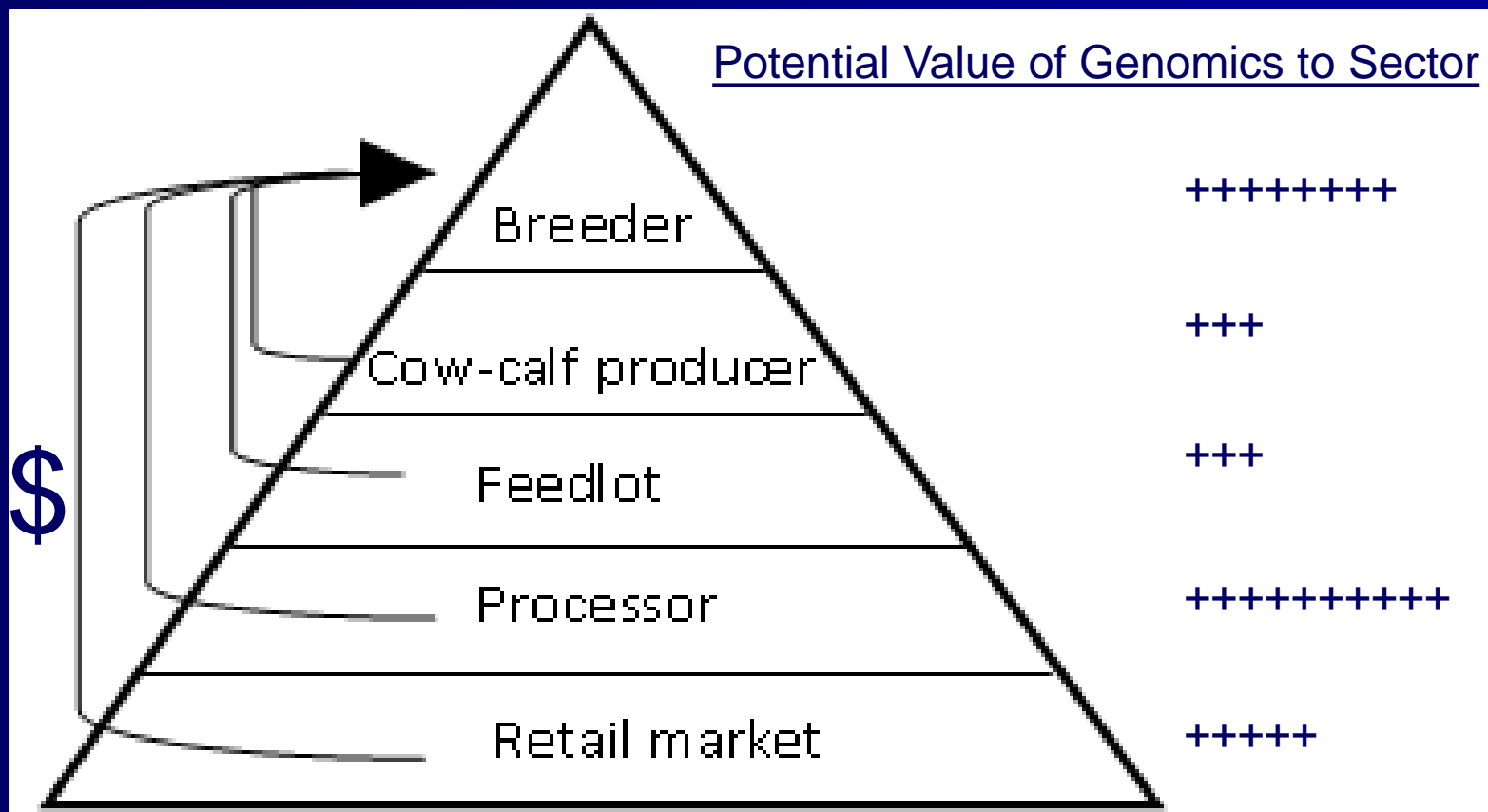| Sector	Value
Breeder	++++++++
Cow-calf producer	+++
Feedlot	+++
Processor	++++++++++
Retail market	+++++

Figure from McEwan, J. C. 2007 Current status and future of genomic selection. Proceedings of the New Zealand Society of Animal Production 67: 147-152.

Animal Biotechnology and Genomics Education

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