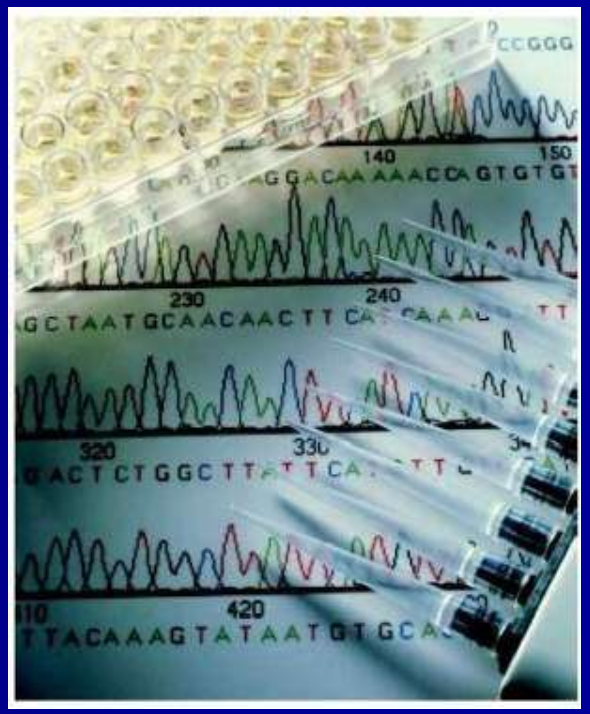
The Value of Accuracy

Alison Van Eenennaam, Ph.D.

Cooperative Extension Specialist
Animal Biotechnology and Genomics
University of California, Davis
alvaneenennaam@ucdavis.edu
(530) 752-7942



animalscience.ucdavis.edu/animalbiotech

What is the value of getting more accuracy than parent average?

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

What is accuracy?

- EPDs are estimates
  - Accuracy tells use how close the estimate is to the true value
- Accuracy increases with additional data
- Accuracy is not a measure of progeny variability
- Accuracy is a measure of how much an EPD could change
  - Way of quantifying risk

Possible Change Table

	Production						Maternal				Carcass				Ultrasound		
Accuracy	CED	BW	WW	YW	YH	SC	CEM	Milk	MW	MH	CW	Marb	RE	Fat	IMF	RE	Fat
.05	7.8	2.49	11.0	16.2	.41	.70	9.3	9.2	38	.62	15.4	.25	.27	.034	.17	.31	.022
.10	7.2	2.36	10.4	15.3	.39	.66	8.8	8.7	36	.58	14.6	.23	.26	.032	.16	.30	.021
.15	6.7	2.23	9.9	14.5	.37	.62	8.3	8.2	34	.55	13.8	.22	.25	.030	.15	.28	.019
.20	6.2	2.10	9.3	13.6	.35	.59	7.8	7.8	32	.52	13.0	.21	.23	.028	.14	.26	.018
.25	5.8	1.97	8.7	12.8	.32	.55	7.3	7.3	30	.49	12.2	.19	.22	.027	.13	.25	.017
.30	5.4	1.84	8.1	11.9	.30	.51	6.8	6.8	28	.45	11.4	.18	.20	.025	.12	.23	.016
.35	5.1	1.71	7.5	11.1	.28	.48	6.3	6.3	26	.42	10.6	.17	.19	.023	.12	.21	.015
.40	4.7	1.58	7.0	10.2	.26	.44	5.8	5.8	24	.39	9.7	.16	.17	.021	.11	.20	.014
.45	4.3	1.44	6.4	9.4	.24	.40	5.4	5.3	22	.36	8.9	.14	.16	.020	.10	.18	.013
.50	3.9	1.31	5.8	8.5	.22	.37	4.9	4.9	20	.32	8.1	.13	.14	.018	.09	.17	.011
.55	3.5	1.18	5.2	7.7	.19	.33	4.4	4.4	18	.29	7.3	.12	.13	.016	.08	.15	.010
.60	3.2	1.05	4.6	6.8	.17	.29	3.9	3.9	16	.26	6.5	.10	.12	.014	.07	.13	.009
.65	2.7	.92	4.1	6.0	.15	.26	3.4	3.4	14	.23	5.7	.09	.10	.012	.06	.12	.008
.70	2.4	.79	3.5	5.1	.13	.22	2.9	2.9	12	.19	4.9	.08	.09	.011	.05	.10	.007
.75	2.0	.66	2.9	4.3	.11	.18	2.4	2.4	10	.16	4.1	.06	.07	.009	.04	.08	.006
.80	1.6	.53	2.3	3.4	.09	.15	2.0	1.9	8	.13	3.3	.05	.06	.007	.04	.07	.005
.85	1.2	.39	1.7	2.6	.06	.11	1.5	1.5	6	.10	2.4	.04	.04	.005	.03	.05	.003
.90	.8	.26	1.2	1.7	.04	.07	1.0	1.0	4	.06	1.6	.03	.03	.004	.02	.03	.002
.95	.4	.13	.6	.9	.02	.04	.5	.5	2	.03	.8	.01	.01	.002	.01	.02	.001

What is BIF accuracy?

"Breeders" or "True" Accuracy (r)

- Defined as the correlation between true and estimated values

BIF Accuracy

- BIF accuracies are more conservative, in that they require more progeny records to achieve high accuracy values

How can you increase accuracy ?

- Get records on parents (Pedigree estimate)
- Get records on the individual
- Get records on other relatives
- Get records on progeny

Collection of records can take a long time – especially for traits collected late in life.

The rate of genetic gain can be accelerated by altering components of the "breeders" equation:

$$\Delta G = (i_m r_m + i_f r_f)/ (L_m + L_f)$$

i_m Intensity of male section

r_m Accuracy of male section

i_f Intensity of female section

r_f Accuracy of female section

L_m Male generation interval

L_f Female generation interval

How can DNA tests improve accuracy?

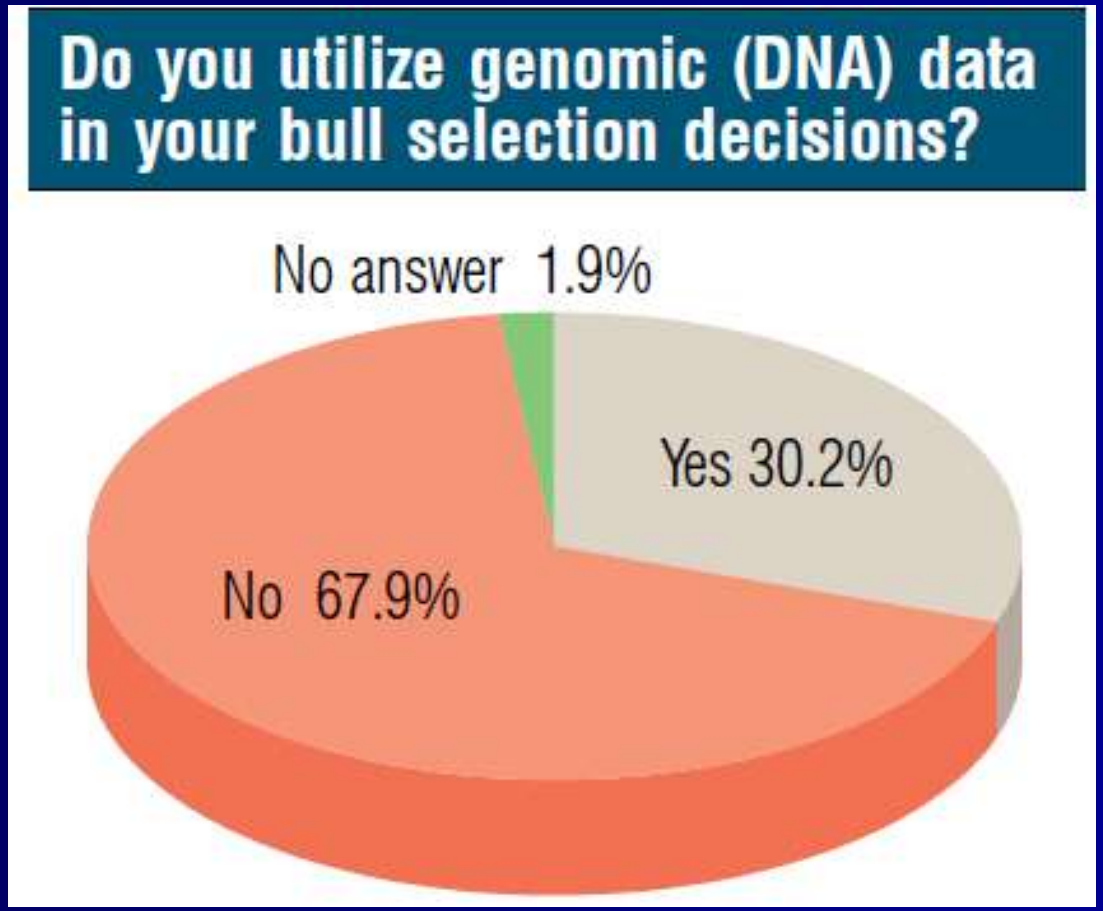
Proposition behind DNA testing is that they will increase the accuracy of genetic estimates in young animals because you can tell which offspring got a better than average sampling of their parents' genes

DNA tests are particularly useful for traits that are:

- Lowly heritable
- Hard or expensive to measure
- Measured late in life
- Sex specific

March 1, 2010 Beef Magazine Survey

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



Base = 635 (All Cow-Calf Operations)

Why is there a value associated with increased accuracy?

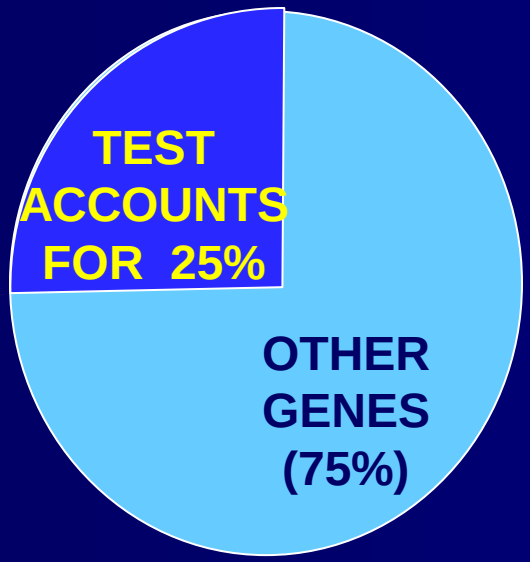
The rate of genetic change (ΔG) increases depending upon how accurately (r) you can select superior individuals – who is the best?

$$\Delta G = (i_m r_m + i_f r_f) / (L_m + L_f)$$

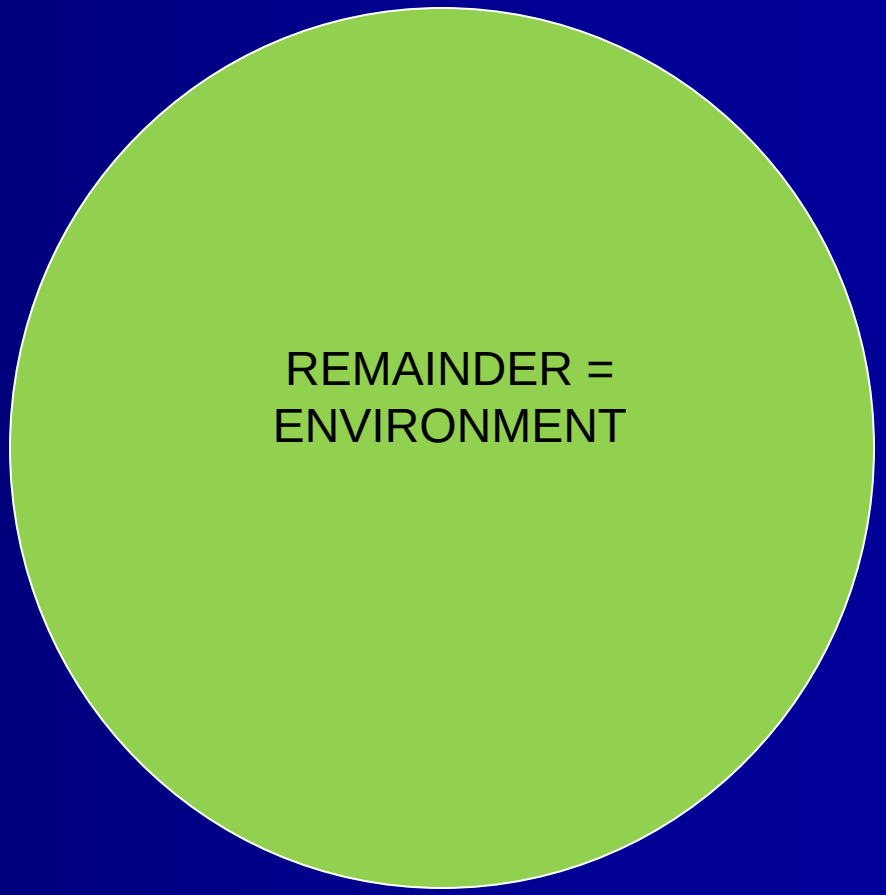
There is value derived from accelerated genetic progress

Effect of markers on r (accuracy) will depend on how much and when DNA testing improves the accuracy of EPDs over the use of traditional phenotypes of individual and relatives

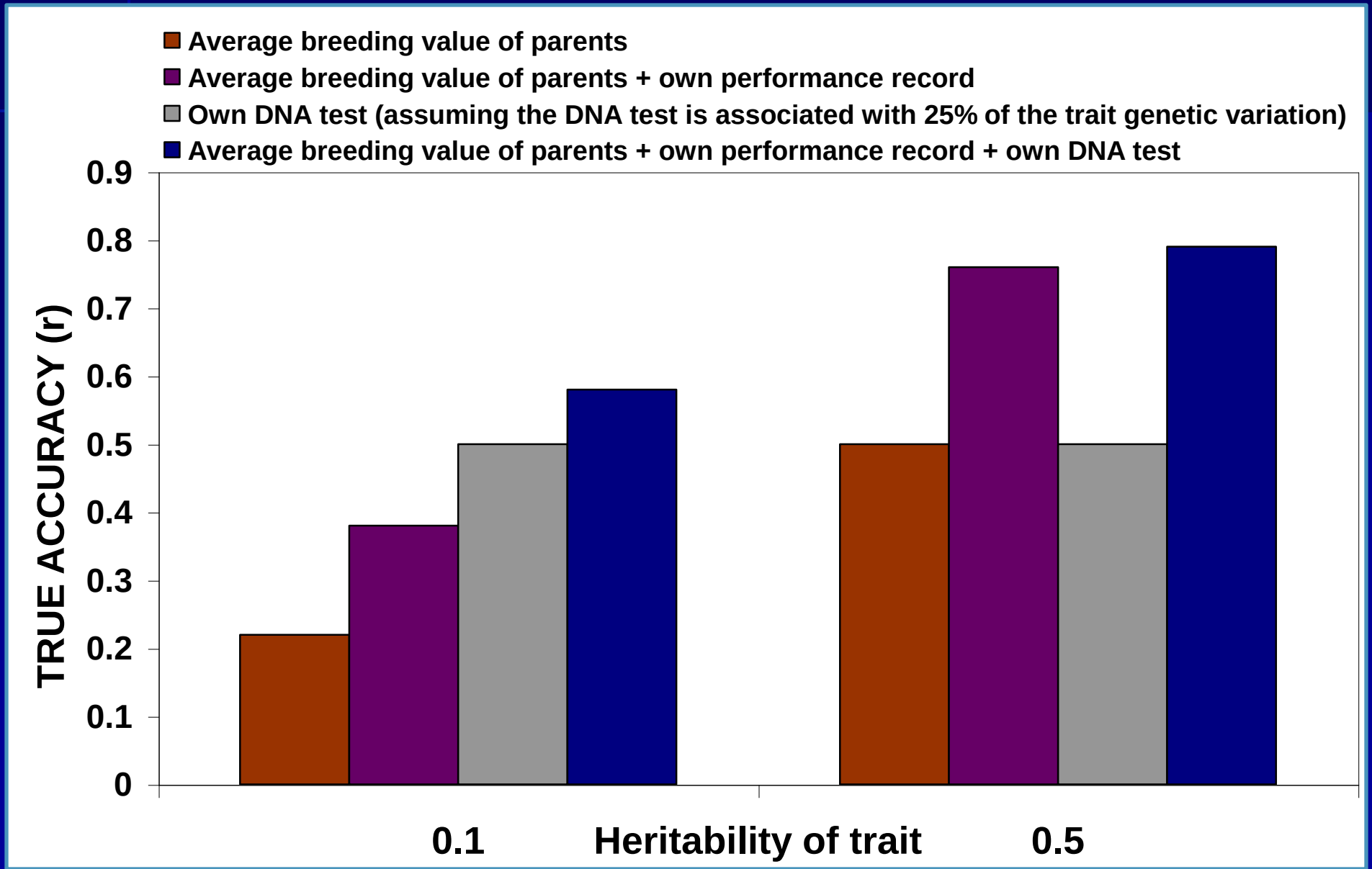
Consider that there is a DNA test associated with 25% of trait genetic variation



h^2 = GENETIC COMPONENT



Consider a DNA test associated with 25% of the additive genetic variation



Interconverting between true accuracy (r) and BIF accuracy

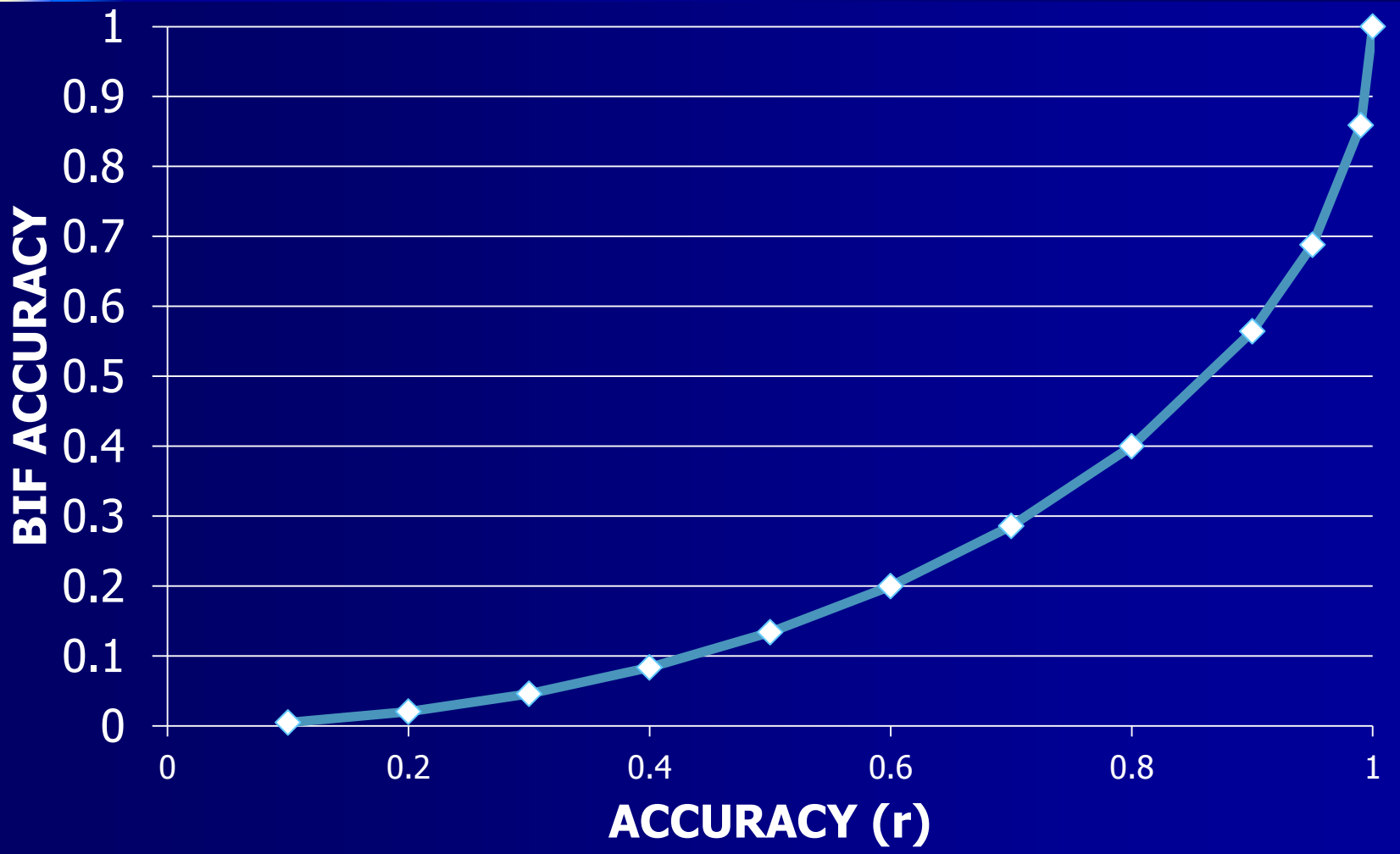
$$Accuracy(r) = \sqrt{1-(1-ACC_{BIF})^2}$$

$$ACC_{BIF} = 1-\sqrt{1-r^2}$$

So for my example that explains 25% of the genetic variation (i.e. r = 0.5)

$$ACC_{BIF} = 1-\sqrt{1-(0.5x0.5)} = 0.13$$

BIF Accuracy versus Accuracy (r)



Proportion of genetic variation (r^2) associated with DNA tests on the market as reported by the company or in company studies.

TRAIT	Igenity "first" Angus Profile	Igenity 384 Angus Profile	Pfizer 50K HD	MMI*
Average Daily Gain			30%	
Net Feed Intake			12%	
Dry matter intake			11%	
Residual feed intake				
Tenderness		24%	26%	100%
Calving Ease (Direct)			22%	
Birth weight			28%	
Weaning Weight			32%	
Yearling Weight				
Calving ease (maternal)			40%	
Milking Ability			27%	
Heifer pregnancy rate				
Docility				
Stayability				
Carcass weight			29%	
Backfat thickness			40%	
Ribeye area			29%	
Marbling score	~15%	~40%	34%	70%
Yield Grade				
Percent Choice				

* http://www.metamorphixinc.com/16858-trubreed_marketingmaterials.pdf

MMI Genomics, Inc.

BREED TRU

DNA VERIFIED

Work in Your Best Genes

TRU-MARBLING™

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

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 (R^2):**	**0.25**
As a percent of Heritability	**70%**

* *Angus National Cattle Evaluation, Spring 2007*

** *estimated from a model that included contemporary group and MGV*

BIF Guiding Philosophy on DNA traits

"BIF believes that information from DNA tests only has value in selection when incorporated with all other available forms of performance information for economically important traits in national cattle evaluations (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."

Integration of DNA information into carcass EPDs began with the first Igenity Angus Profile

- 114 SNP marker panel (Igenity) explained 13.7% the genetic variation in marbling*
- For animals with no ultrasound record or progeny data, the marker information improved the BIF accuracy of the Angus marbling EPD from 0.07 to 0.13.
- Assuming a heritability of 0.3 for marbling, a BIF accuracy of 0.13 is equivalent to having approximately 5 progeny carcass records on a young animal, or an ultrasound record on the individual itself.

* MacNeil, M. D., J. D. Nkrumah, B. W. Woodward, and S. L. Northcutt. 2010. Genetic evaluation of Angus cattle for carcass marbling using ultrasound and genomic indicators. J. Anim Sci. 88: 517-522

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.

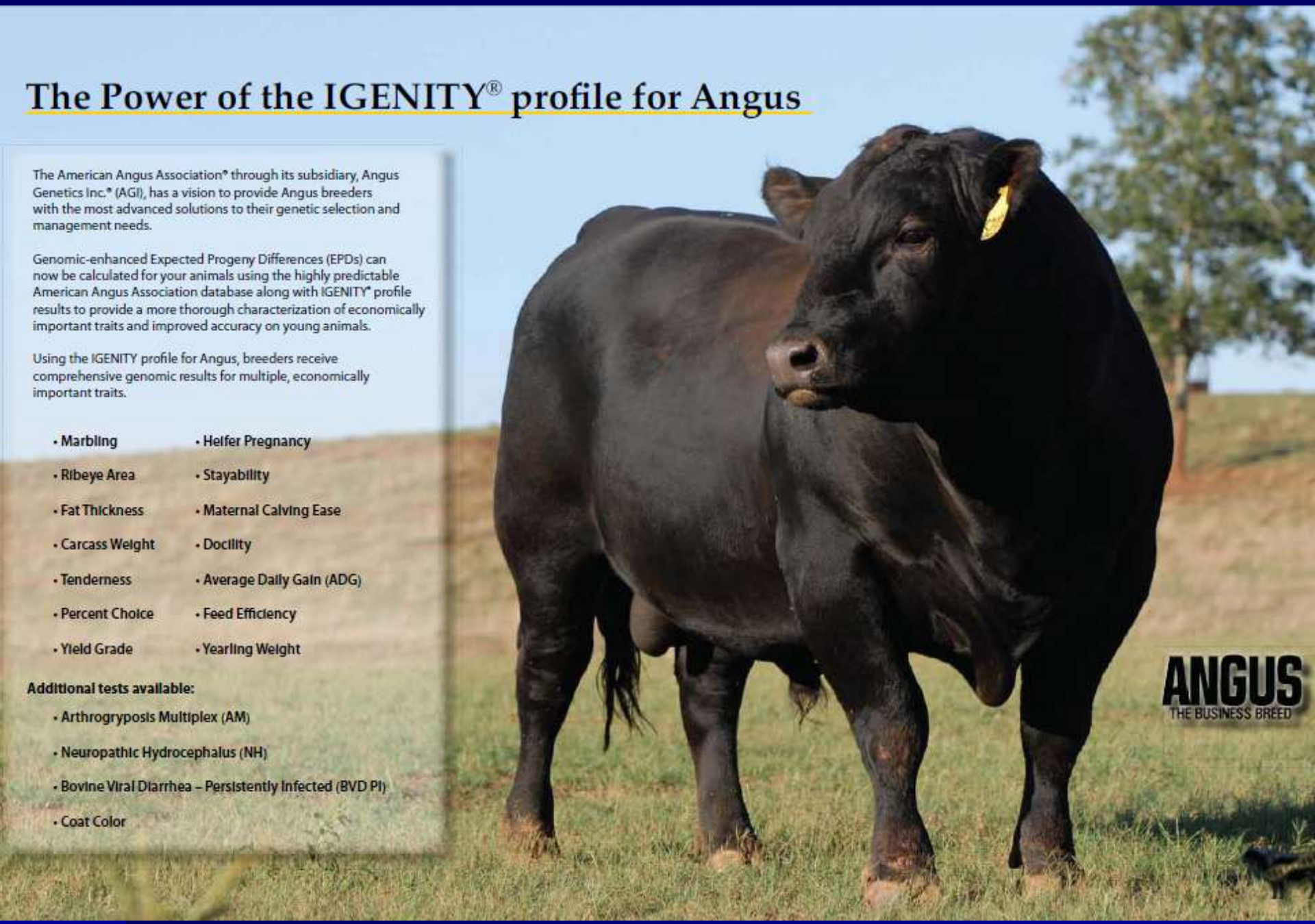
Genomic-enhanced Expected Progeny Differences (EPDs) can now be calculated for your animals using the highly predictable American Angus Association database along with IGENITY® profile results to provide a more thorough characterization of economically important traits and improved accuracy on young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

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

- Marbling
- Ribeye Area
- Fat Thickness
- Carcass Weight
- Tenderness
- Percent Choice
- Yield Grade
- Heifer Pregnancy
- Stayability
- Maternal Calving Ease
- Docility
- Average Daily Gain (ADG)
- Feed Efficiency
- Yearling Weight

Additional tests available:

- Arthrogryposis Multiplex (AM)
- Neuropathic Hydrocephalus (NH)
- Bovine Viral Diarrhea – Persistently Infected (BVD PI)
- Coat Color



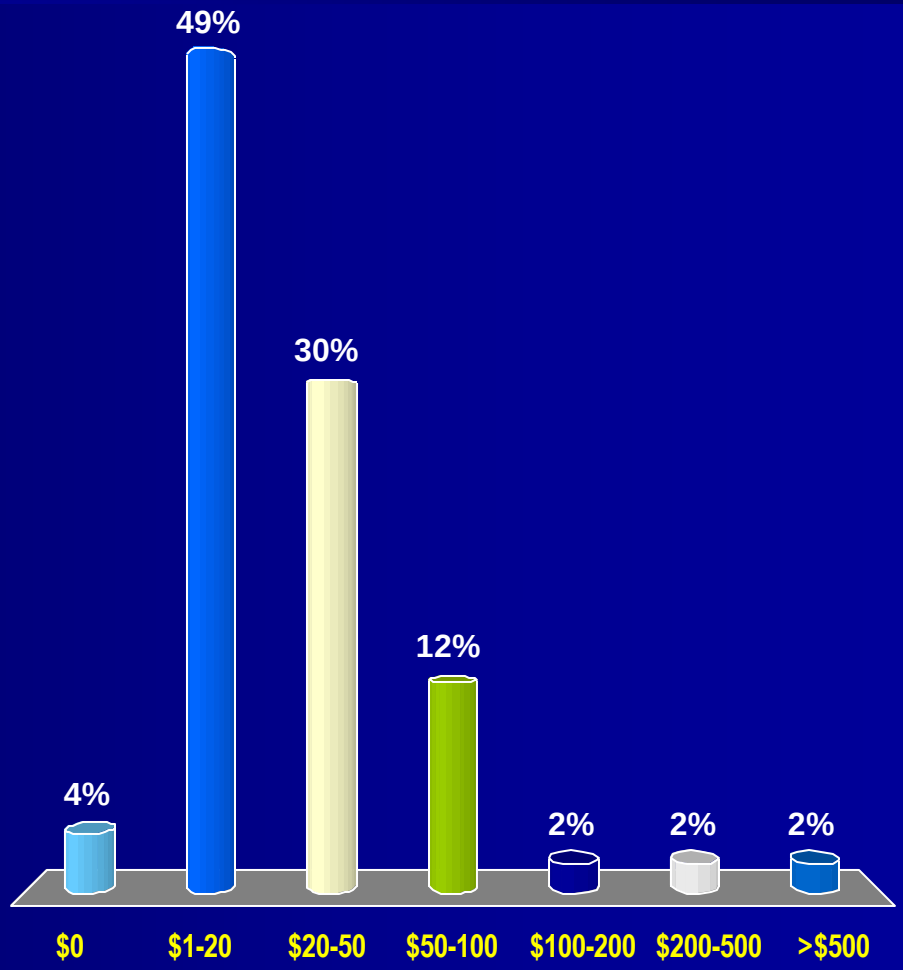
How much would a test that explains 40%* of the additive genetic variation in marbling score improve the BIF accuracy of marbling score EPDs?

Information available	Marbling Score BIF Accuracy
Base phenotypic records available for use as selection criteria assumed to be those recorded by breeders including ultrasound on dam, sire, individual and 20 half-sib progeny	.15
DNA test results on individual only	.23
DNA test information + base phenotypic records	.28

* MacNeil, M. D., S. L. Northcutt, R. D. Schnabel, D. J. Garrick, B.W. Woodward and J. F. Taylor. 2010. Genetic correlations between carcass traits and molecular breeding values in Angus cattle. Proc. 9th World Congr. Genet. Appl. Livest. Prod. Leipzig, Germany.

? How much would you pay for a DNA test that increases marbling score BIF accuracy from 0.15 to 0.28?

1. $0
2. $1-20
3. $20-50
4. $50-100
5. $ 100-200
6. $200-500
7. >$500



Black Angus Sire

G A R Predestined

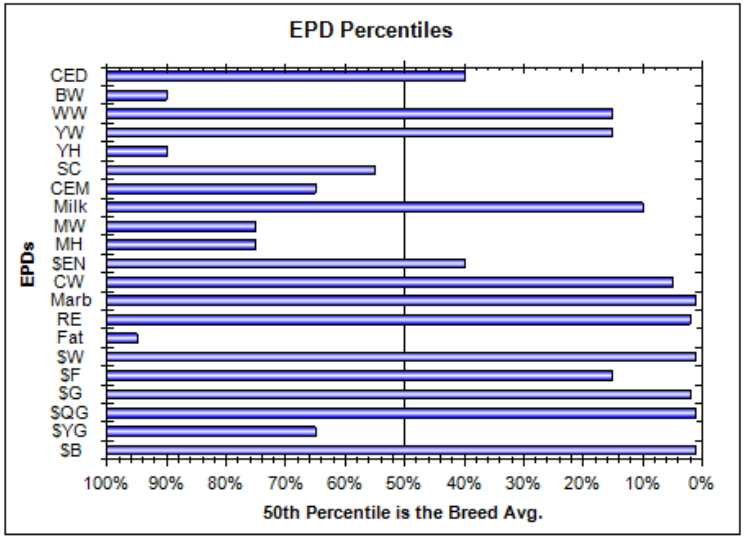
Reg. No.: 13395344
Calved: 8/16/1999
Tattoo: 5899
Semen: $25
Certificates: $20
Spring 2010 EPD

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

GeneSeek										
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	



Current Sires Percent Breakdown

As of 03/22/2010

Multibreed version 2008

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

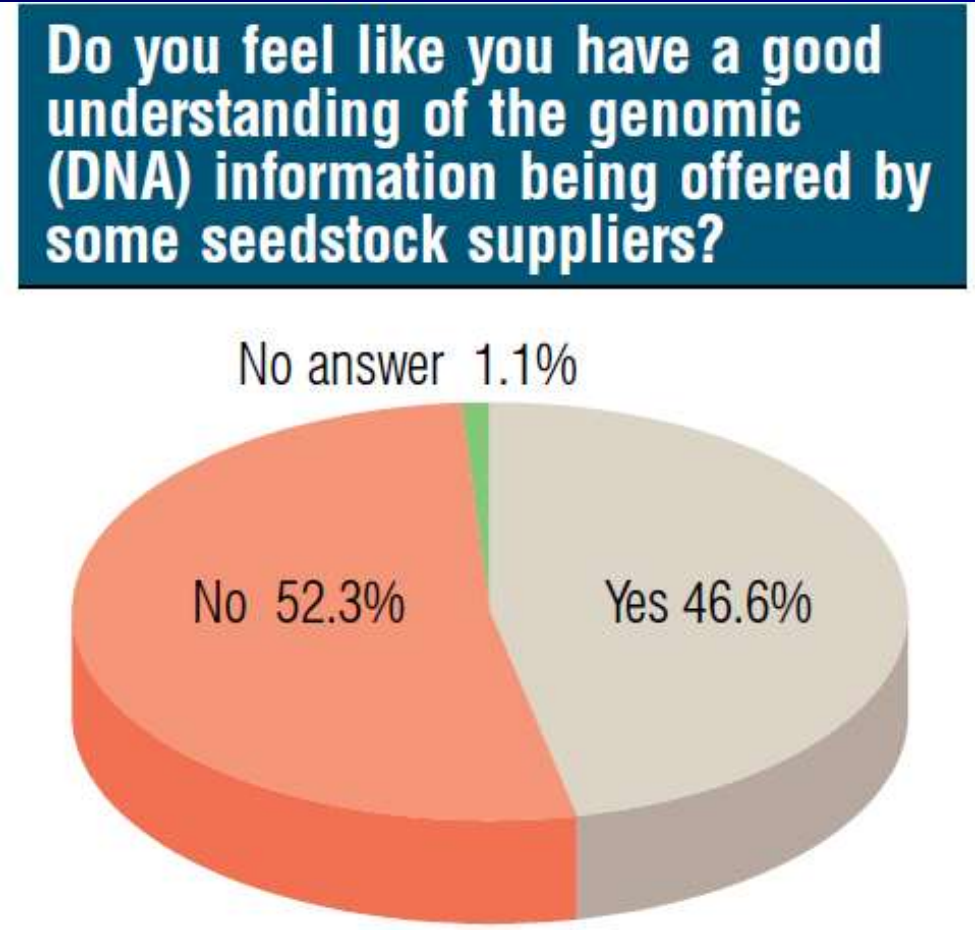
EPDs (CW, Marb, RE, Fat) are enhanced by genomic profiles generated by igenity.

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**

March 1, 2010 Beef Magazine Survey

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



Base = 635 (All Cow-Calf Operations)

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 Animal Health
Animal Genetics

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

Australian PAG 50K HD Calibration Results

Pfizer Animal Genetics Trait	h^2	% Genetic variation explained		BIF accuracy if EPD derived from DNA information alone
		Pfizer 50K (2010)*	Australian Calibration (11/2010)	
Average Daily Gain	0.28	30%	1-10%	.01-0.05
Net Feed Intake	0.39	12%	0%	0
Dry matter intake	0.39	11%	4-5%	.02-.03
Tenderness	0.37	26%	Not evaluated	
Calving Ease (Direct)	0.1	22%	6%	.03
Birth weight	0.31	28%	12-16%	.06-.08
Weaning Weight	0.25	32%	12-19%	.06-.10
Calving ease (maternal)	0.1	40%	4%	.02
Milking Ability	0.25	27%	10-14%	.05-.07
Carcass weight	0.39	29%	6-13%	.03-.07
Backfat thickness	0.36	40%	14-19%	.07-.10
Ribeye area	0.4	29%	10-20%	.05-.11
Marbling score	0.37	34%	4-11%	.02-.06

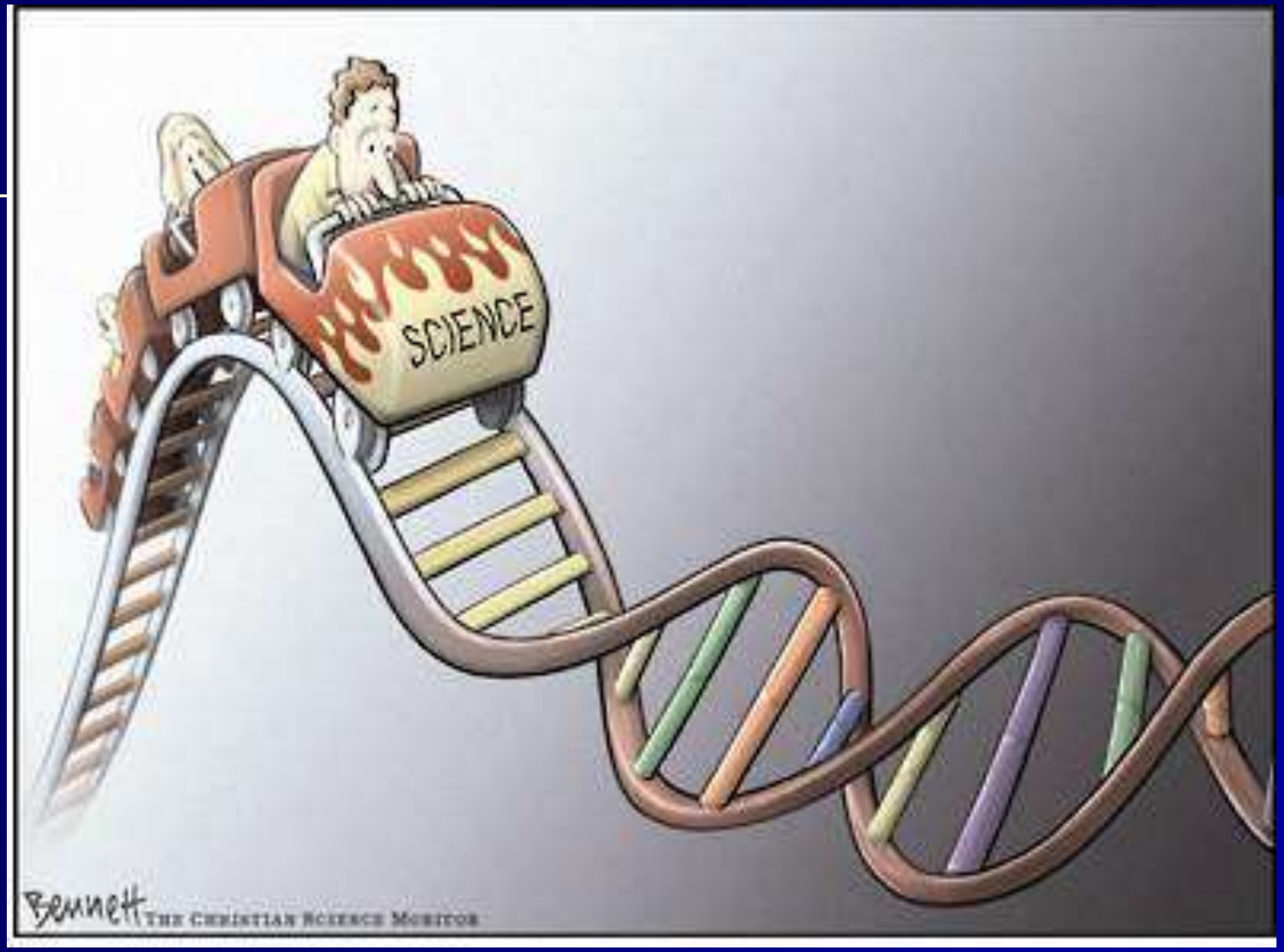
* http://www.pfizeranimalgenetics.com/sites/PAG/Documents/50K%20Tech%20Summary.pdf

The selection response and resultant value from using markers depends on

- Which trait the test is for, and its accuracy in the absence of DNA information
- % of genetic variation explained by the DNA test
- The value of a unit of genetic improvement
- Do YOU get paid for that trait?
- Results will be herd-specific and cannot be generalized
- Ideally DNA results will be integrated into EPDs so there is only one source of information

Or more simply: Does it work? Is it useful? Does it pay?

- Need independent estimates of proportion of genetic variation explained by test (r^2) to determine **if it works**
- **Usefulness** will depend on how much the DNA information improves the accuracy of genetic evaluations at the time of selection, and the value of a unit of genetic improvement.
- **Value proposition** will depend on individual operation and level of industry integration
- **Exact value** will require an economic weighting of traits with DNA and/or records (i.e. an index) of relevance for U.S. beef production systems


SCIENCE
Bennett
THE CHRISTIAN SCIENCE MONITOR

Need to know a lot of information to determine the value of tests

What is the value of a multi-trait test?

1. Accuracy of genetic estimates already available to inform selection decisions
2. Genetic correlation between MVP and the trait (r_g)
3. Heritability of the analyzed trait (h^2)
4. Cost of test, and which animals are being tested
5. Value derived from accelerated genetic progress
6. Sector where value is derived and how value is shared up the production chain
7. Biological attributes and structure of stud and commercial herds
8. Selection objective being targeted
9. Genetic variances and covariances for selection index calculations
10. Regression coefficient of phenotype on MBV (b)
11. Selection intensity of replacement stud sires and bulls for sale (and females)
12. Number of calves per exposure
13. Type of herd (terminal, maternal)
14. Financial planning horizon etc., etc., etc.