



Genomics in the beef industry: US situation



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Van Eenennaam Armidale 2/7/2014



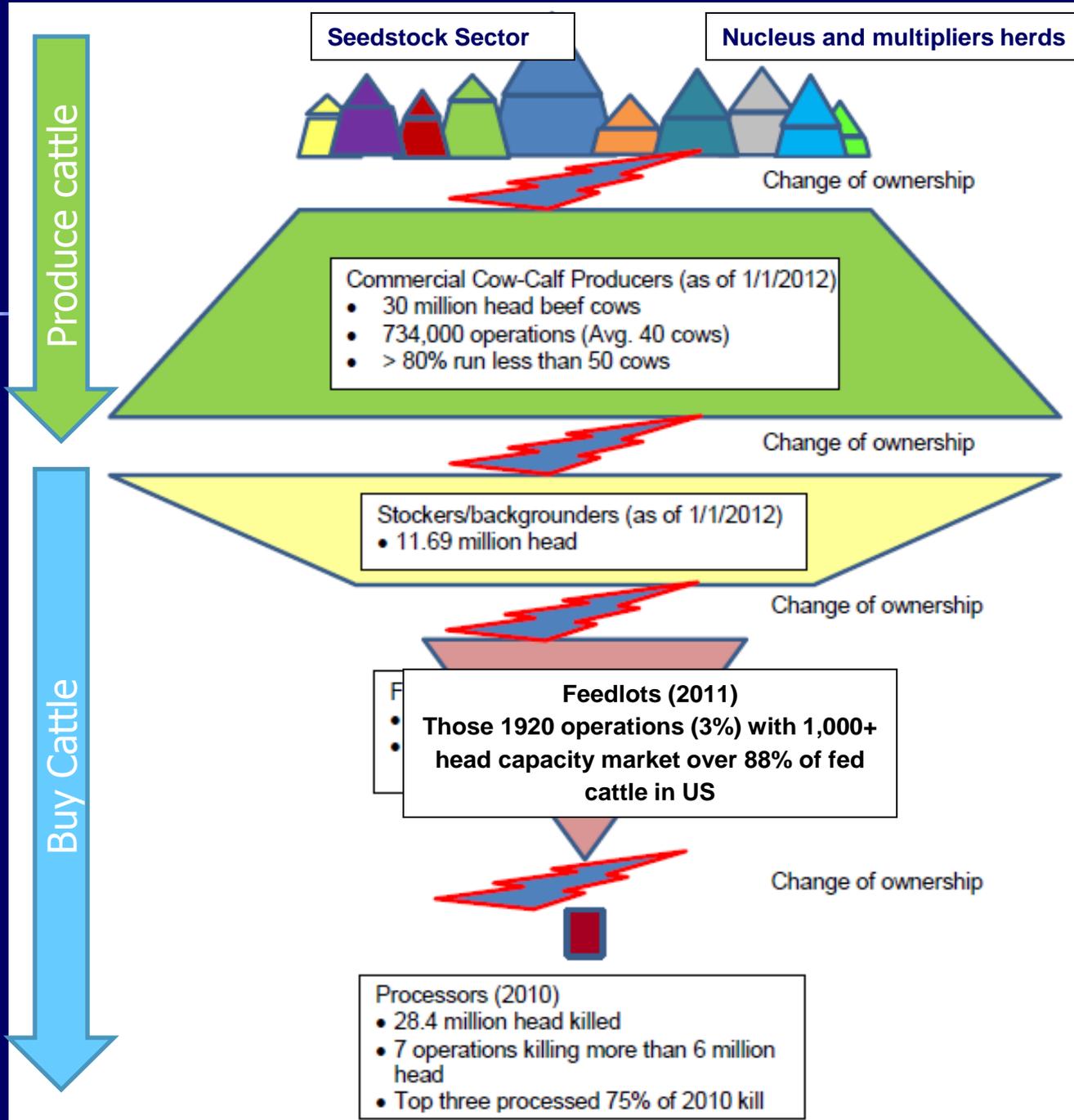
Animal Genomics and Biotechnology Education



Translational Questions for the US Beef Industry



- ? How many phenotypic records and animals are required in the training population?
- ? How does the relationship between the training population and the selection candidate affect accuracy of prediction?
- ? Do predictions work across breeds? Or only within breed
- ? How many markers are needed– 1, 384, 50K, 800K, genome?
- ? How often do prediction have to be recalibrated – especially hard to measure traits as measurement is hard/expensive?
- ? What is the value generated by these tests – do they pay?
- ? Does this technology change optimal breeding program design?



Van Eenennaam
 K. A. Weigel, A.
 E. Young, M.A.
 Cleveland, and
 J.C.M. Dekkers
 2014. Applied
**Animal
 Genomics:
 Results from
 the Field.**
 Annual Review
 of Animal
 Biosciences.
 2:105-139.



Technology developers had a rocky start in the beef industry



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 SireTRACE[™]
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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



ANGUS
THE BUSINESS BREED

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

Lead Today with 50K



Pfizer Animal Health
Animal Genetics

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

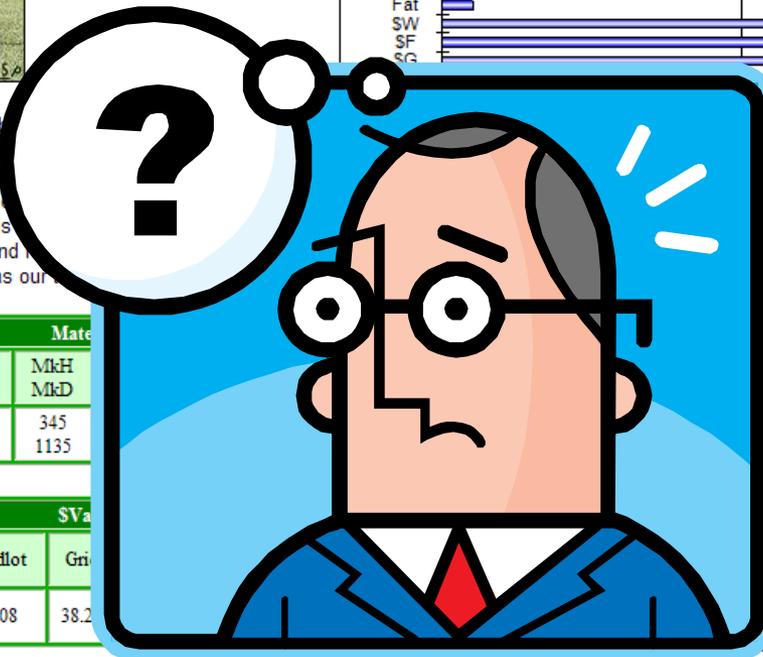
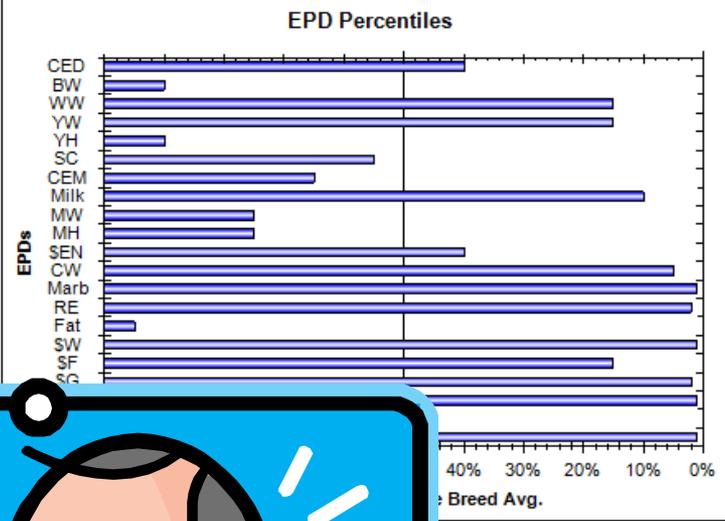


Black Angus Sire

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 world has the real value to cattle as Predestined. Ranking as the #1 bull for \$100,000 that their Predestined-sired cattle return the most dollars to the breeder. Unlike any other 036 son, Predestined tones down size, adds docility, and a pleasant disposition to his offspring. His conception rate is high in timed-AI programs. His progeny look good--his bulls are thick and muscular, and always display additional shape and capacity. He ended 2006 as our top sire. Predestined's many talents for creating value are for real.

Production						Mature		
CED	BW	WW	YW	YH	SC	CEM	Milk	MkH
Acc	Acc	Acc	Acc	Acc	Acc	Acc	Acc	MkD
+7	+4.1	+53	+99	+0	+31	+6	+28	345
.84	.97	.96	.94	.96	.95	.80	.85	1135

Carcass					Usnd		SVa	
CW	Marb	RE	Fat	Grp	UGrp	Wean	Feedlot	Gri
Acc	Acc	Acc	Acc	Prog	UProg			
+26	+1.07	+59	+046	47	4269	37.39	37.08	38.2
.82	.84	.82	.81	261	11990			

As of 03/22/2010

	Ribeye Area	Carcass Weight	Percent Choice	Marbling
	4	2	8	9

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

G A R Predestined															13395344
	CED	BW	WW	YW	ADG	DMI	NFI	CEM	MA	CW	FAT	REA	MS	TND	\$B/\$MVP ^{PL}
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



Need to integrate DNA information into National Cattle Evaluation (NCE)

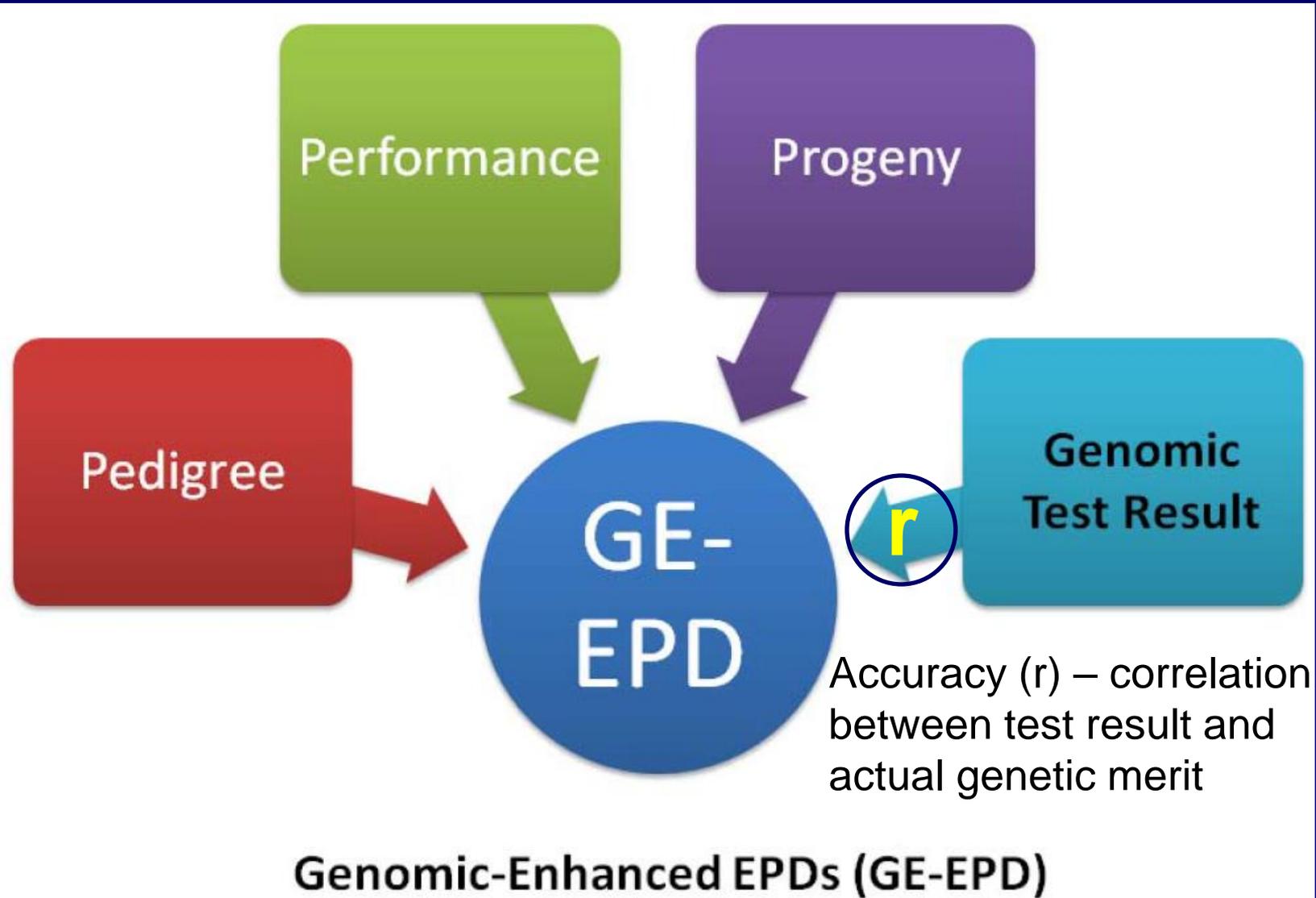


"Information from DNA tests only has value in selection when incorporated with all other available forms of performance information for economically important traits in National Cattle Evaluation (NCE), and when communicated in the form of an EPD with a corresponding BIF accuracy.

For some economically important traits (e.g. feed efficiency), 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).



Information sources for EPDs – DNA just one source of data for GE-EPD





Realized accuracies (r) resulting from genomic selection prediction equations trained in US beef cattle breeds

Trait	Red Angus (6,412) ^b	Angus (3,500)	Hereford (2,980)	Simmental (2,800)	Limousin (2,400)	Gelbvieh (1,181)
Birth weight	0.75	0.64	0.68	0.65	0.58	0.41
Wean weight	0.67	0.67	0.52	0.52	0.58	0.34
Yearling weight	0.69	0.75	0.60	0.45	0.76	—
Milk	0.51	0.51	0.37	0.34	0.46	0.34
Fat thickness	0.90	0.70	0.48	0.29	—	—
Rib eye area	0.75	0.75	0.49	0.59	0.63	0.48
Marbling	0.85	0.80	0.43	0.63	0.65	0.56
Calving ease direct	0.60	0.69	0.68	0.45	0.52	0.48
Calving ease (maternal)	0.32	0.73	0.51	0.32	0.51	—
Scrotal circumference	—	0.71	0.43	—	0.45	0.50

^aData taken from References 29, 30, 131; D. Garrick, unpublished data (personal communication).

^bNumbers indicate training population. The Red Angus training data set includes some Black Angus cattle that have expected progeny difference in the Red Angus Association.



Angus predictions (r) are not very accurate in Red Angus (Data provided by Dorian Garrick)



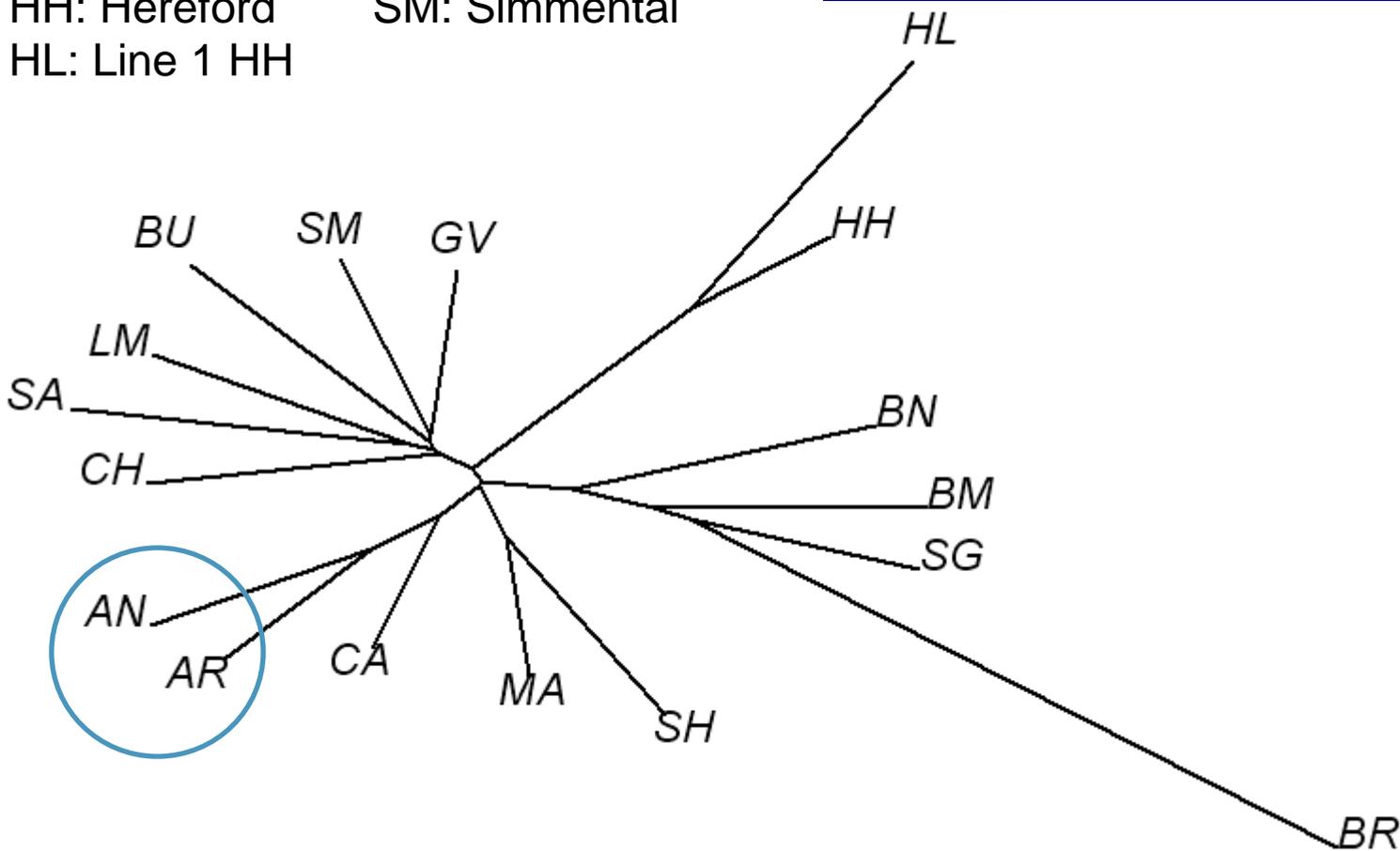
Trait	Trained in Black Angus/Validated in Black Angus	Trained in Black Angus/Validated in Red Angus
BirthWt	0.64	0.27
WeanWt	0.67	0.28
YearlingWt	0.75	0.23
Fat	0.70	0.21
Rib Eye Area	0.75	0.29
Marbling	0.80	0.21
CalvEase (D)	0.69	0.14
CalvEase (M)	0.73	0.18

Angus = ASREML 5-fold validation Red Angus = correlation Training on de-regressed EPDs Saatchi et al (GSE)



AN: Angus	GV: Gelbvieh
BM: Beefmaster	LM: Limousin
BN: Brangus	MA: Maine Anjou
BR: Brahman	RA: Red Angus
BU: Braunvieh	SA: Salers
CA: Chiangus	SG: Santa Gertrudis
CH: Charolais	SH: Shorthorn
HH: Hereford	SM: Simmental
HL: Line 1 HH	

Approximate genetic distance between breeds using data from the 2,000 Bull Project.
Larry Keuhn, USDA MARC
<http://www.nbcec.org/topics/BeefBreeds.pdf>





American Angus Association performs weekly evaluations with genomic data – recently updated to include heifer pregnancy

- Association's genetic evaluations, the DNA test results are incorporated into the EPDs using a correlated trait approach.
- The correlations (r) between the HD 50K prediction and the phenotypic data at the Association are updated with each recalibration effort and effectively range from .60 to .70, except for milk (.38) and heifer pregnancy (.49).
- The December 6, 2013, EPD update includes HD 50K predictions from over 51,000 registered Angus animals with genotypes retained at the Association. Results are incorporated into at least 15 EPDs which are then components of the Angus \$Value selection index suite.

<http://www.angus.org/AGI/GenomicCalibrationRelease.pdf> December 2013



Other breeds?

The following U.S. breed associations have/are working with Dorian Garrick (IA State) to develop their own 50K-based prediction equations



Breed	Breed code
Hereford	HER
Red Angus	RAN
Simmental	SIM
Brangus	BRG
Limousin	LIM
Gelbvieh	GVH
Maine Anjou	RDP

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Hereford introduces genomic-enhanced EPDs

American Hereford Association | Updated: August 20, 2012

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The American Hereford introduces and marks the development of genomic-enhanced EPDs (GE-EPDs).

The AHA approach is a scientific community Consortium (NBCEC) population. This approach allows access to all of the genomic information which will allow the Hereford to train and build the Hereford's genetic future.

Today more than 1,200 and eight sires which have been used to train the Hereford at Dorian Garrick, Iowa breeding and genetic research and development.

According to Garrick and validating the Hereford genomic program members. During this research and work Department of Agriculture Center and other global.

In late June AHA train located in Lincoln, NE the option to utilize a genomic-enhanced EPD (GE-EPD). The genomic-enhanced EPD (GE-EPD) is a new product that can help.

Submit a DNA Sample Increase EPD accuracy*

If you are interested in knowing more about your young animals, ASA's new product can help.

*For more information, see accompanying article

\$90/sample

Genotyping performed at **GENESEEK**

Call or email Leoma Wells 406-587-4531 lwells@simmgene.com

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THE FUTURE IS HERE!

By Wade Shafer Ph.D.

Approximately a year ago we ran an article in *SimTalk* to update readers about the state of genomic use in our industry. The article closed with the following paragraph: "Unless you have Angus cattle that are evaluated in the American Angus Association's genetic evaluation, currently available DNA tests are of little to no value to you for EPD enhancement; however, don't be dismayed if you don't fit this description. The recent evolution in genomic technology has spurred organizations to take the steps necessary to harvest its value. For example, ASA is presently working on the development of DNA tests specific to our population, as well as the capacity to incorporate test results into ASA's genetic evaluation."

One year later we are pleased to announce that the future has arrived at ASA. We are now offering a DNA test that, when incorporated into our genetic evaluation, can add significant enhancement to lower accuracy EPDs. The result of a multi-year collaborative effort, test development was fueled by ASA members and staff, carcass merit cooperators, USDA, University of Illinois, University of Missouri, Montana State University, Geneseek and the National Beef Cattle Evaluation Consortium.

Test development was initiated several years ago through requests for donated semen on high accuracy sires. ASA members stepped up to the plate and delivered, with hundreds of DNA samples being collected via donation. Besides older sires, virtually all of the current 500 most heavily used sires were sourced. Samples were also collected on the sires and their offspring fed at the University of Illinois. In total, over 2,700 samples were genotyped.

The genotypes, along with the equivalent of millions of phenotypes (data submitted by breeders and the Carcass Merit Program over the years) were amassed and analyzed by University of Iowa researchers. The analysis resulted in the parameters required for genetic evaluation.

The multi-tiered effort culminated in a very successful outcome. The standard measure of a DNA test used in EPD prediction is the correlation between test results and the traits of interest. Table 1 displays correlations for ASA's test when used on ASA's population. To provide perspective, correlations for Pfizer and Igenty's tests gleaned from the American Angus Association's website are included in the table.

Table 1. Correlations between DNA test results and trait

Trait	Igenty ^a	Pfizer ^a	ASA ^b
CE	0.47	0.33	0.45
BW	0.57	0.51	0.65
WW	0.45	0.52	0.52
YW	0.34	0.64	0.45
Mk	0.24	0.32	0.34
MCE	NA	NA	0.32
Sty	NA	NA	0.52
CV	0.54	0.48	0.59
Mrb	0.65	0.57	0.63
REA	0.58	0.60	0.59
BF	0.50	0.56	0.29
SF	NA	NA	0.53

^aWhen used on the American Angus Association's population

^bWhen used on American Simmental/SimAngus™ population



Can I use genomics/DNA-information to make money?



AGI DNA Tests	Price	Genomic Tests	Price
Parentage	\$18.00	Zoetis® HD50K (includes Parentage)	\$75.00
Coat Color Test	\$18.00	Add Coat Color	\$5.00
Arthrogryposis Multiplex (AM) Test	\$22.00	Add AM Test	\$8.00
Neuropathic Hydrocephalus (NH) Test	\$22.00	Add NH Test	\$8.00
Contractural Arachnodactyly (CA) Test	\$22.00	Add CA Test	\$8.00
Developmental Duplication (DD) Test	\$22.00	Add DD Test	\$10.00
Myostatin (M1) Test	\$22.00	GeneSeek® GGP-HD (includes Parentage)	\$75.00
Dwarfism (D2) Test	\$22.00	Add Coat Color	\$5.00
		Add AM Test	\$8.00
		Add NH Test	\$8.00
		Add CA Test	\$8.00
		Add DD Test	\$10.00
		Add M1 Test	\$18.00
		Add Dwarfism (D2) Test	\$20.00

Additional Sample handling fee of 2.00 will be charged per sample for samples submitted in blood tubes or hair not on proper hair cards.



Value of improved selection response for commercial bulls due to DNA-test increase in index accuracy

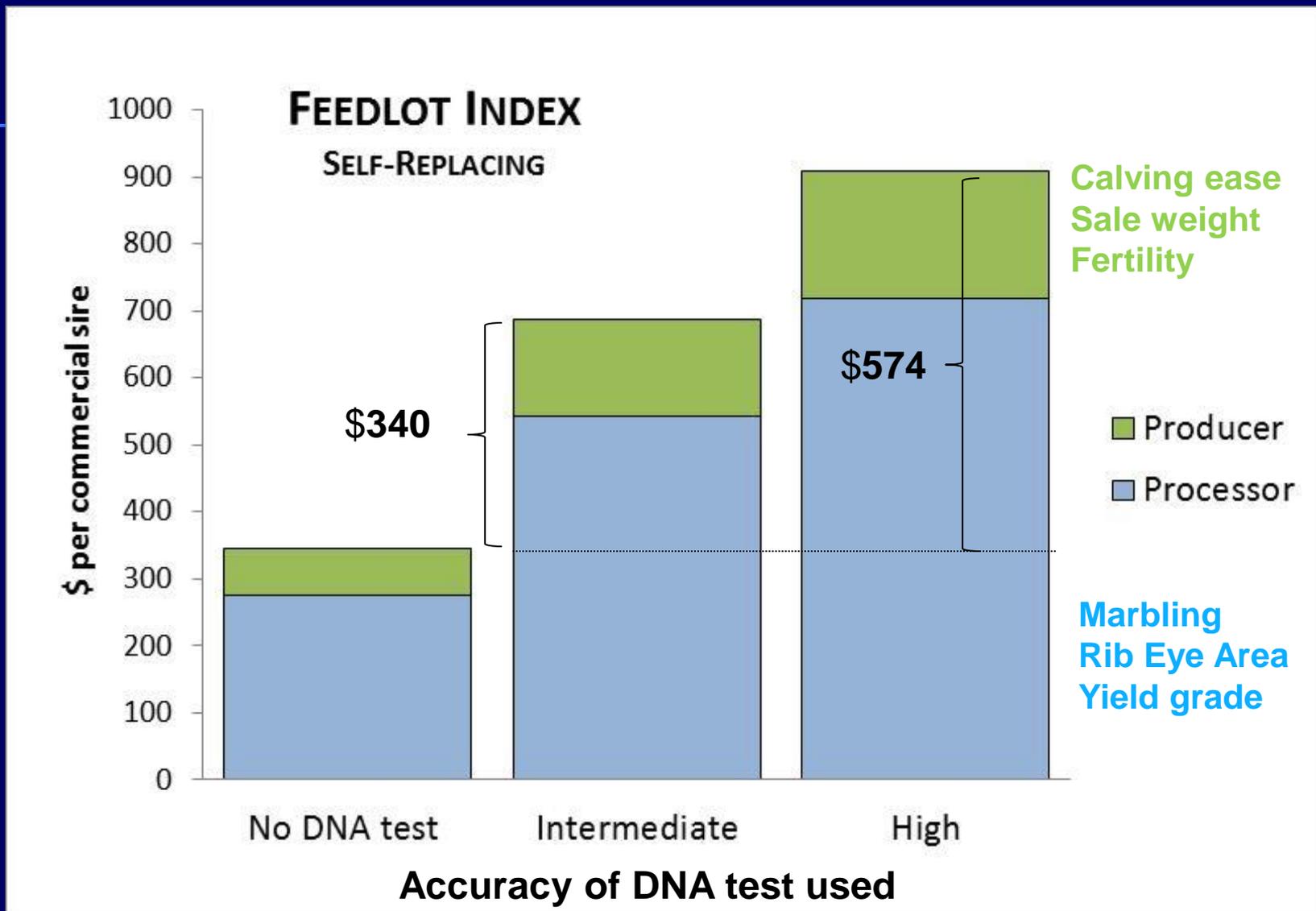


Variable	Unit	Accuracy of DNA test used	\$ Feedlot Index Value
Increased value derived from ΔG in commercial sires	\$/bull	Intermediate	340
		High	574

Van Eenennaam, A. L., J.H. van der Werf, and M.E. Goddard. 2011. **The value of using DNA markers for beef bull selection in the seedstock sector.** Journal of Animal Science. 89:307-320.



Where are returns from genetic gain (ΔG) realized?



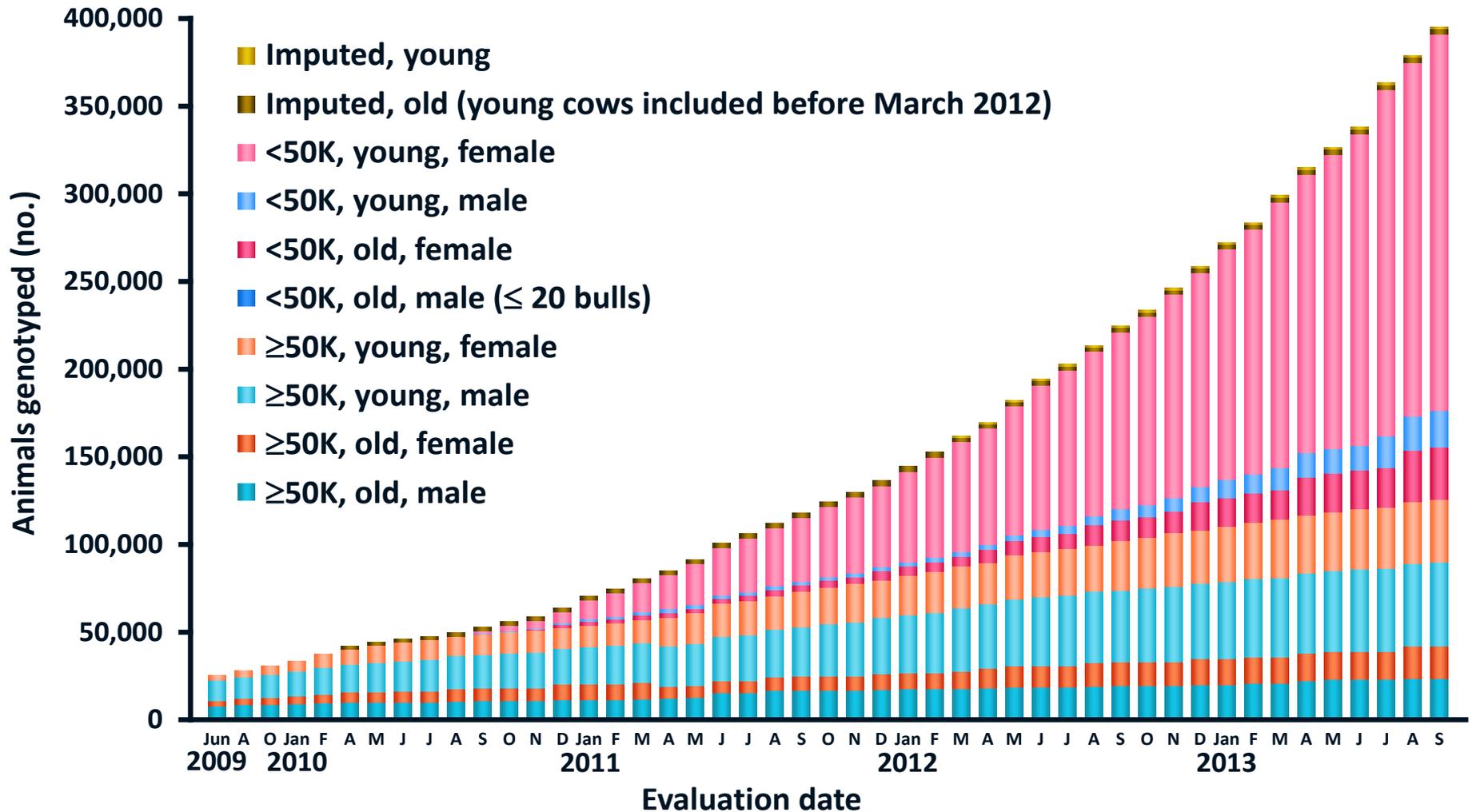


What is the value of genetic improvement in commercial females?

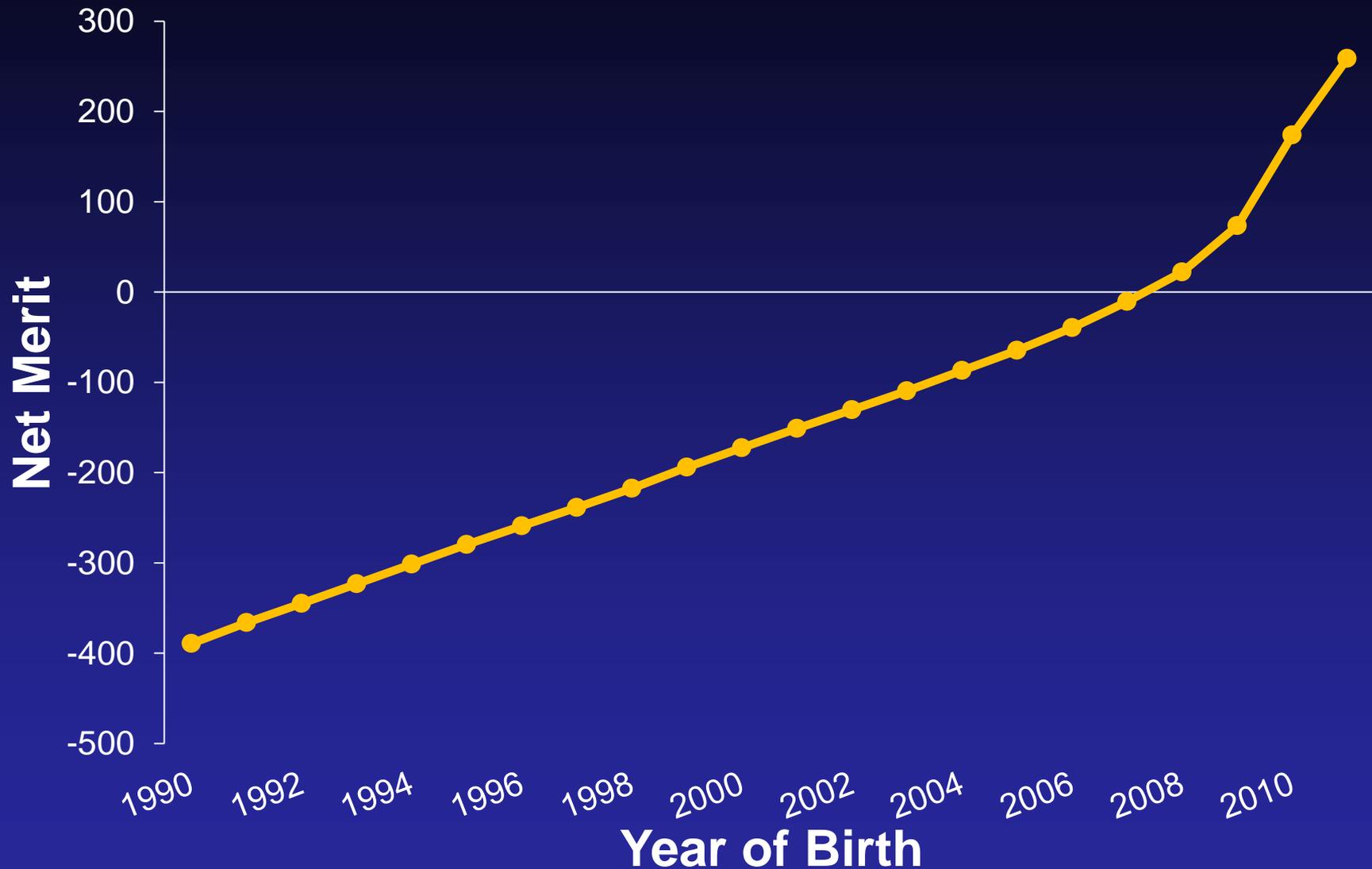
- The breakeven cost of testing replacement heifers was **\$3.63** and **\$6.53** per test for the intermediate and high accuracy DNA tests, respectively.
- The value of increasing the accuracy of commercial replacement heifer genetic evaluations is less (ten-fold in this case) than that for commercial bulls because bulls produce more descendants from which to derive returns for accelerated genetic improvement.
- This assumes the test includes accurate predictions for traits of importance for commercial heifer replacement decisions



> 400,000 Genotypes run in US dairy cattle



Dams of Cows – Net Merit



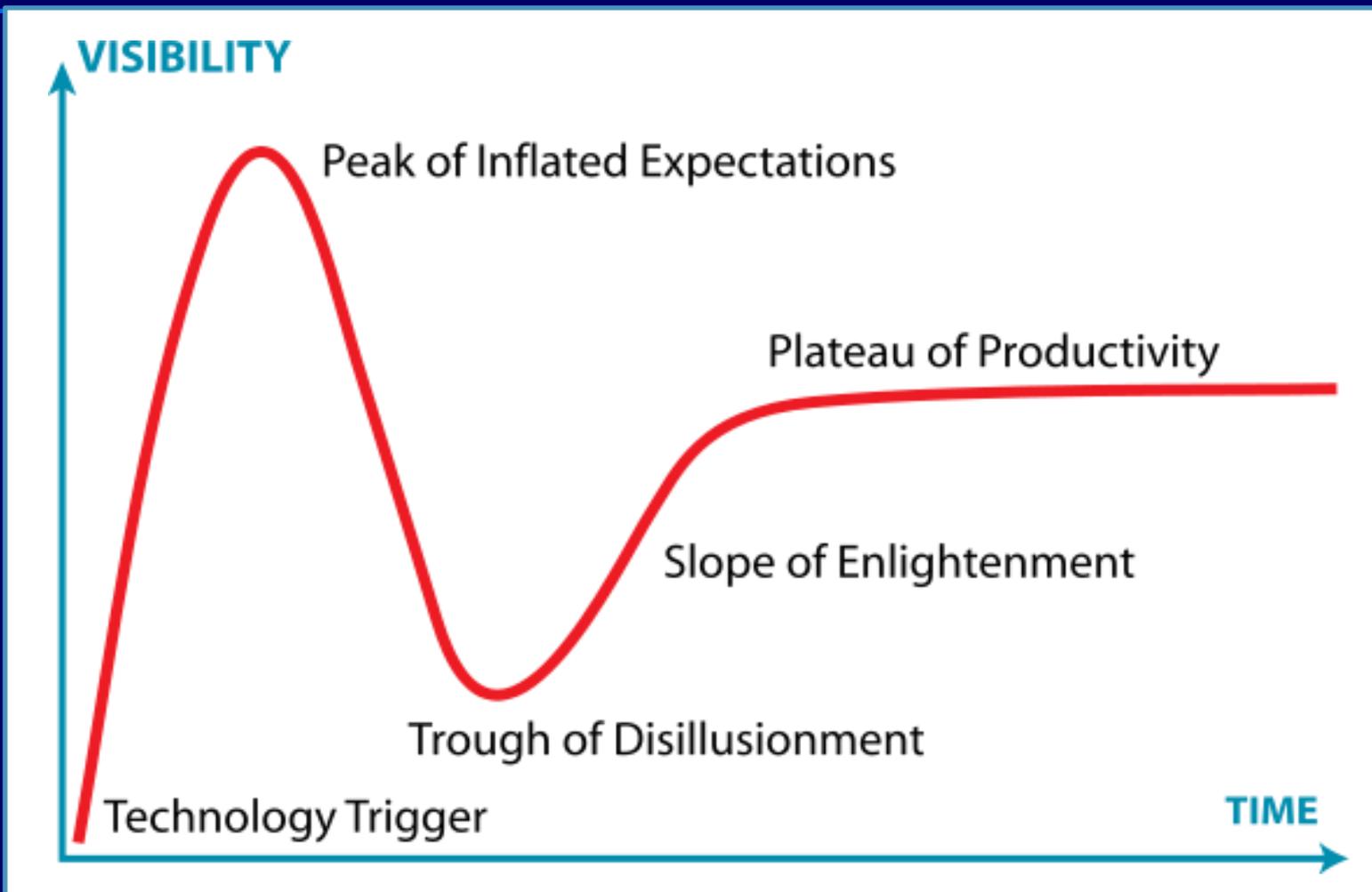
The Future

NEXT EXIT





Hype cycle: the over-enthusiasm or "hype" and subsequent disappointment that typically happens with the introduction of new technologies





USDA funded projects – competitive call for proposals: NIFA AFRI-funded projects

- **National program for genetic improvement of feed efficiency in beef cattle**
(Taylor, MO) – finishes 4/2016 (<http://www.beefefficiency.org>)
 - Genotype ~ 2,400 head on HD chips; 7000 records FE records
 - \$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 (<http://www.brdcomplex.org>)
 - Collection and HD genotypes on 6,000 BRD case-control animals
 - \$10 million, 5 year project; April 2011 – April 2016
- **Identification and management of alleles impairing heifer fertility while optimizing genetic gain in Angus cattle**
(Patterson, Taylor, et al. MO; Van Eenennaam, CA) – finishes 12/17
 - Sequence up to 250 cattle from up to 10 different beef breeds
 - \$3 million, 5 year project; Jan 2013 – December 2017





CONCLUSION: Ramifications of DNA-enabled selection

- The benefits of genomic selection are best captured in well-structured industries (e.g. dairy/poultry/swine) that are already making significant genetic progress
- May encourage more vertical integration to collect phenotypes to enable predictions for EPDs for all sectors
- May see genetic evaluations developed for novel traits – e.g. feed efficiency, disease resistance if large enough populations can be amassed and data shared
- May see breeds/countries start to share data – especially with whole genome sequencing and causative SNP
- This technology might accelerate vertically-integrated breeding companies owning all sectors of industry





Concluding thought....

Breeds/groups that can organize themselves and **technologically** and **structurally** to seamlessly obtain and marry entire supply chain phenotypes and genotypes and take advantage of the rapidly-declining cost of genotyping to capture the cumulative value derived from using genomic information for multiple purposes (selection, parentage, genetic defects, marker-assisted management, product differentiation, traceability) will be ideally positioned to fully realize the nascent potential of genomic information.

Van Eenennaam, A. L., and D. J. Drake. 2011. Where in the beef cattle supply chain might DNA tests generate value? *Animal Production Science*. 52(3) 185-196.



Questions?