Genomics in the beef industry: US situation

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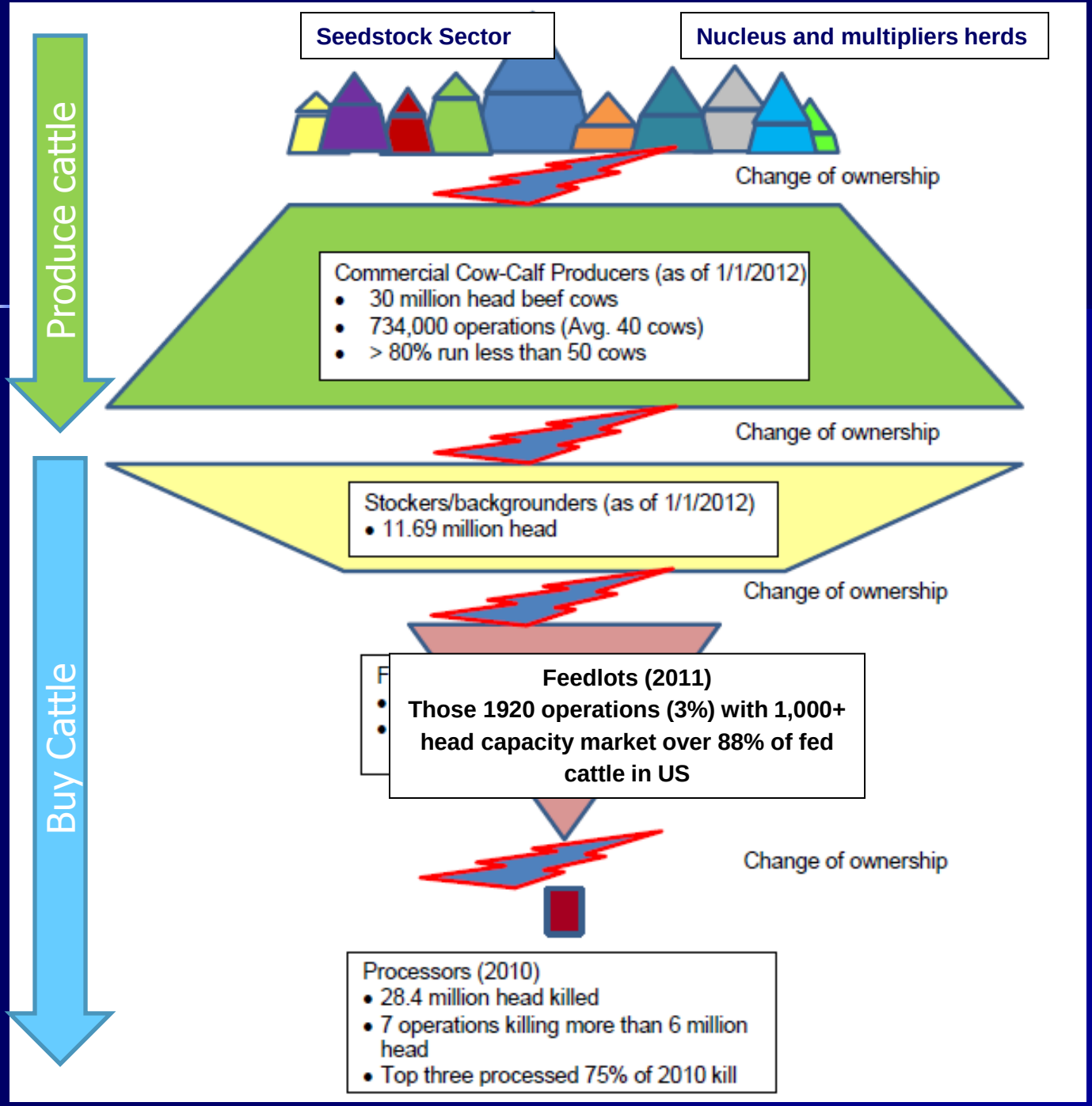
Translational Questions for the US Beef Industry

- ? 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

GeneSTAR SureTRAK SireTRACE GeneSTAR Pfizer Pfizer Animal Genetics

igenity

HD 50K

ImmGen.

GENETICVISIONS

genmark

BIOGENETIC SERVICES, INC.

GENESEEK a Neogen Company

ANGUSURE

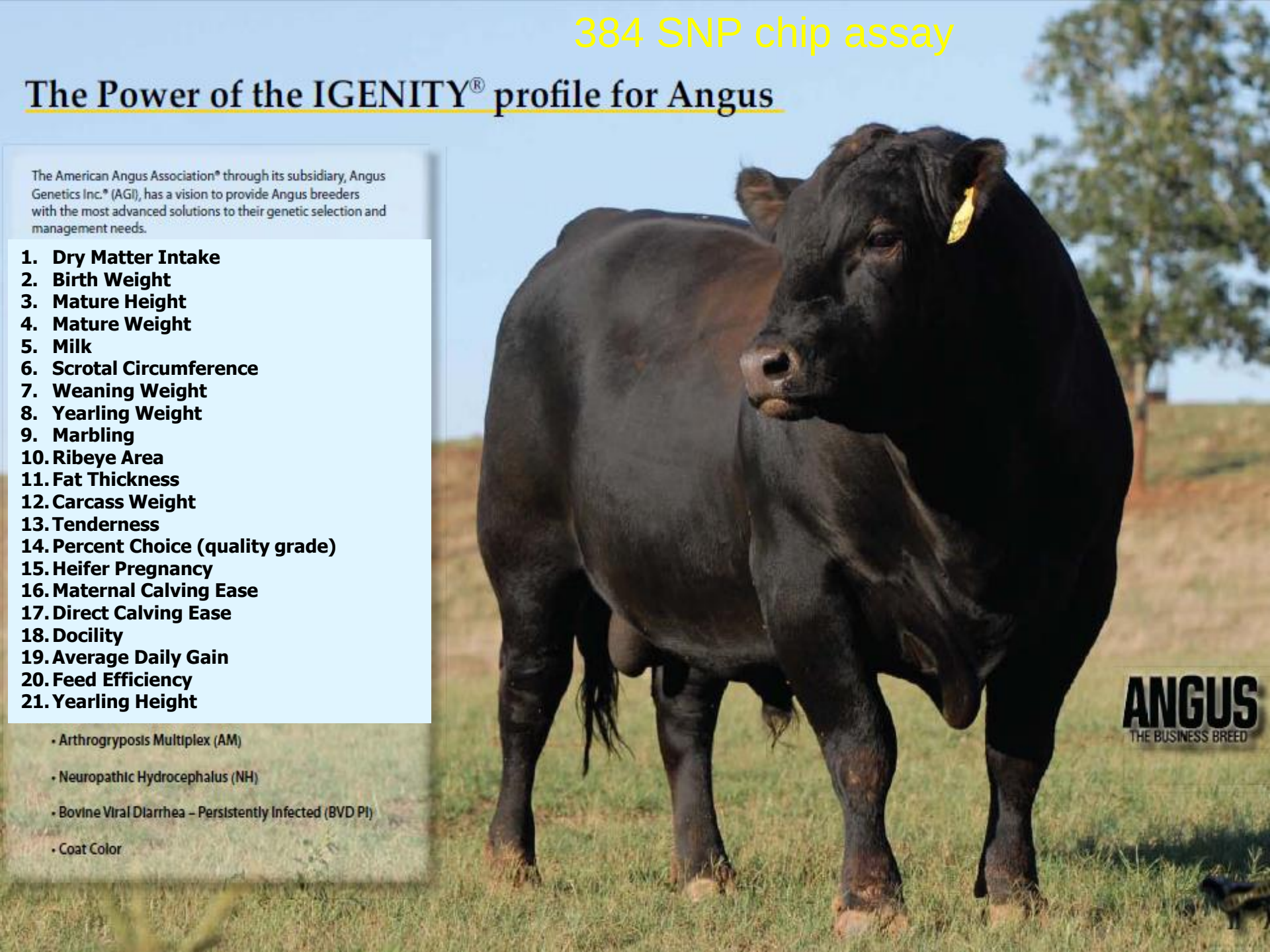
GENAISSANCE PHARMACEUTICALS

MMI GENOMICS, INC. BREED-TRU DNA VERIFIED

METAMORPHIX, INC.

384 SNP chip assay

The Power of the IGENITY® profile for Angus



Lead Today with 50K

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

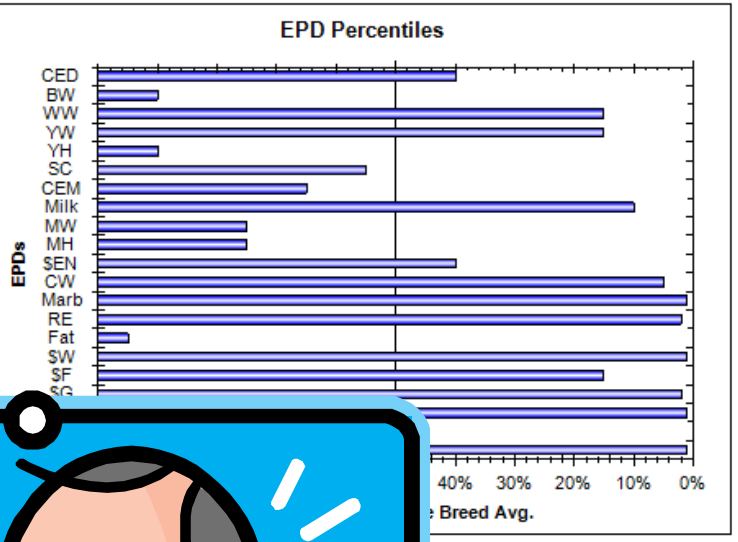
Pfizer Animal Health
Animal Genetics

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

Black Angus Sire

G A R Predestined

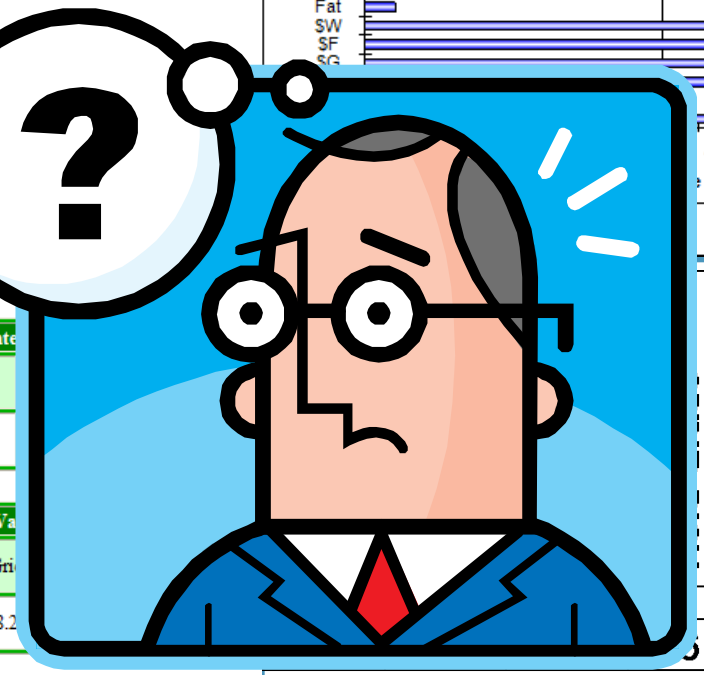
Reg. No.: 13395344
Calved: 8/16/1999
Tattoo: 5899
Semen: $25
Certificates: $20
Spring 2010 EPD



G A R Predestined:
From start to finish--conception to carcass--no other bull in the
real value to cattle as Predestined. Ranking as the #1 bull for $
that their Predestined-sired cattle return the most dollars to the
Unlike any other 036 son, Predestined tones down size, adds d
and a pleasant disposition to his offspring. His conception rate is
timed-AI programs. His progeny look good--his bulls are thick and
always display additional shape and capacity. He ended 2006 as our
Predestined's many talents for creating value are for real.

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

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



As of 03/22/2010

Ribeye Area	Carcass Weight	Percent Choice	Marbling
4	2	8	9

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	

G A R Predestined 13395344

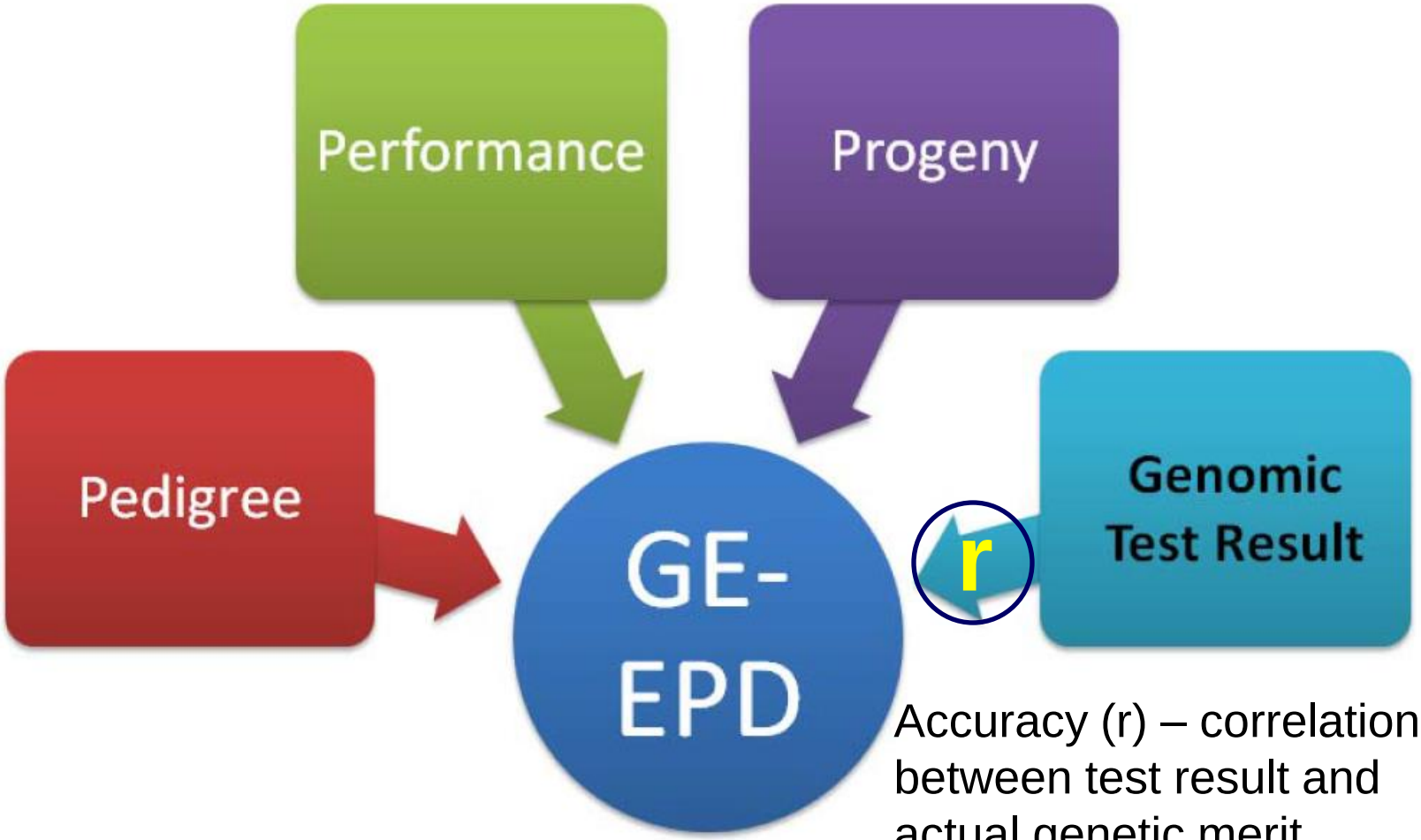
	CED	BW	WW	YW	ADG	DMI	NFI	CEM	MA	CW	FAT	REA	MS	TND	$B/$MVP[FL]
EPD	7	4.1	53	99	-	-	-	6	28	26	0.046	0.59	1.07	-	69.78
ACC	0.84	0.97	0.96	0.94	-	-	-	0.8	0.85	0.82	0.81	0.82	0.84	-	-
EPD % Rank	**30**	**85**	**15**	**15**	-	-	-	**55**	**10**	**4**	**90**	**2**	**1**	-	**1**
MVP	13	1.0	37	-	0.45	0.97	0.04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

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

[a]Data taken from References 29, 30, 131; D. Garrick, unpublished data (personal communication).
[b]Numbers indicate training population. The Red Angus training data set includes some Black Angus cattle that have expected progeny difference in the Red Angus Association.

Van Eenennaam *et al*. 2104. Annual Review Animal Biosciences 2:105-139.

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

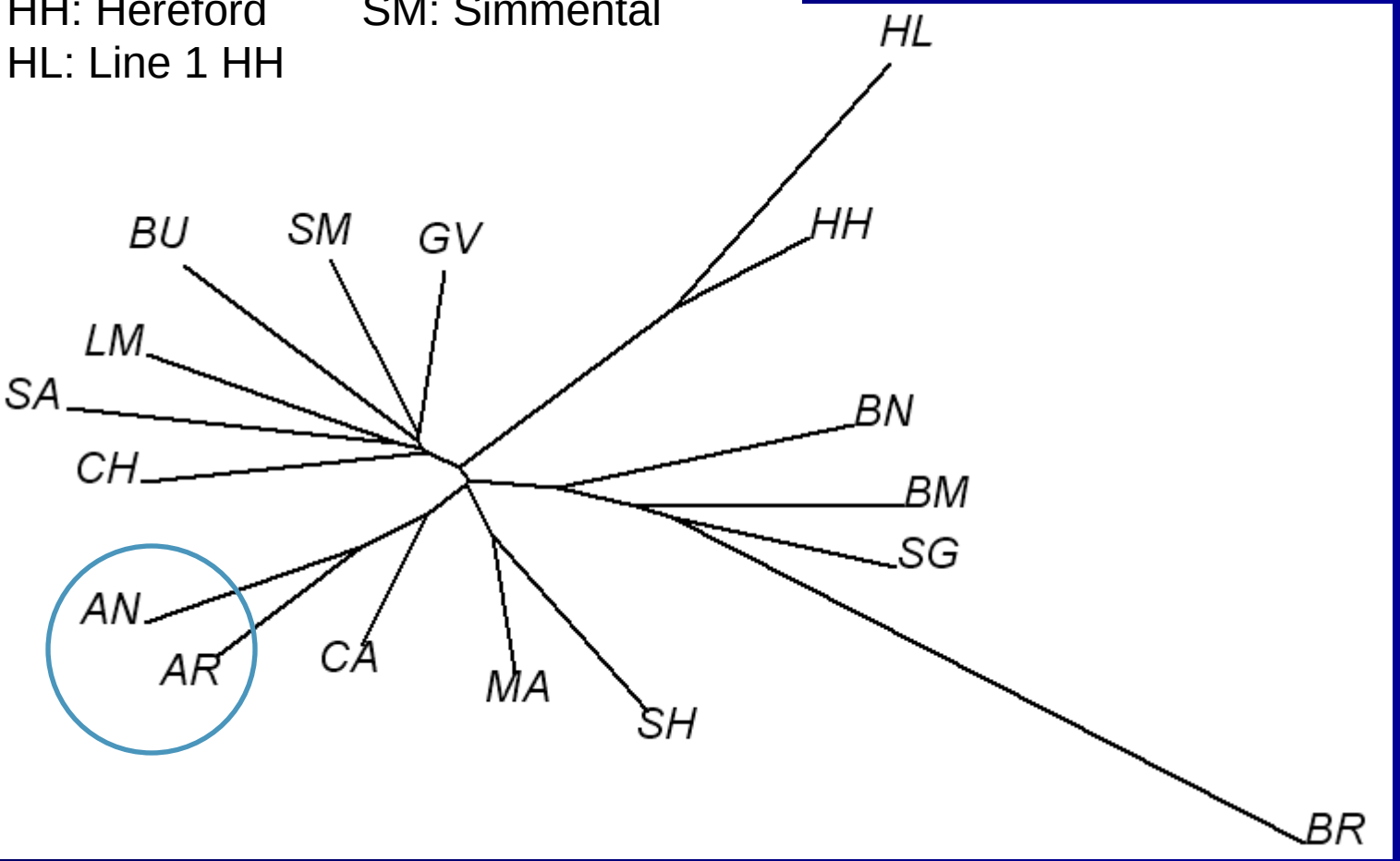
Trait	Trained in Black Angus/Validated in Black Angus	Trained in Black Angus/Validated in Red Angus
BirthWt	0.64	0.27
WeanWt	0.67	0.28
YearlingWt	0.75	0.23
Fat	0.70	0.21
Rib Eye Area	0.75	0.29
Marbling	0.80	0.21
CalvEase (D)	0.69	0.14
CalvEase (M)	0.73	0.18

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

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

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

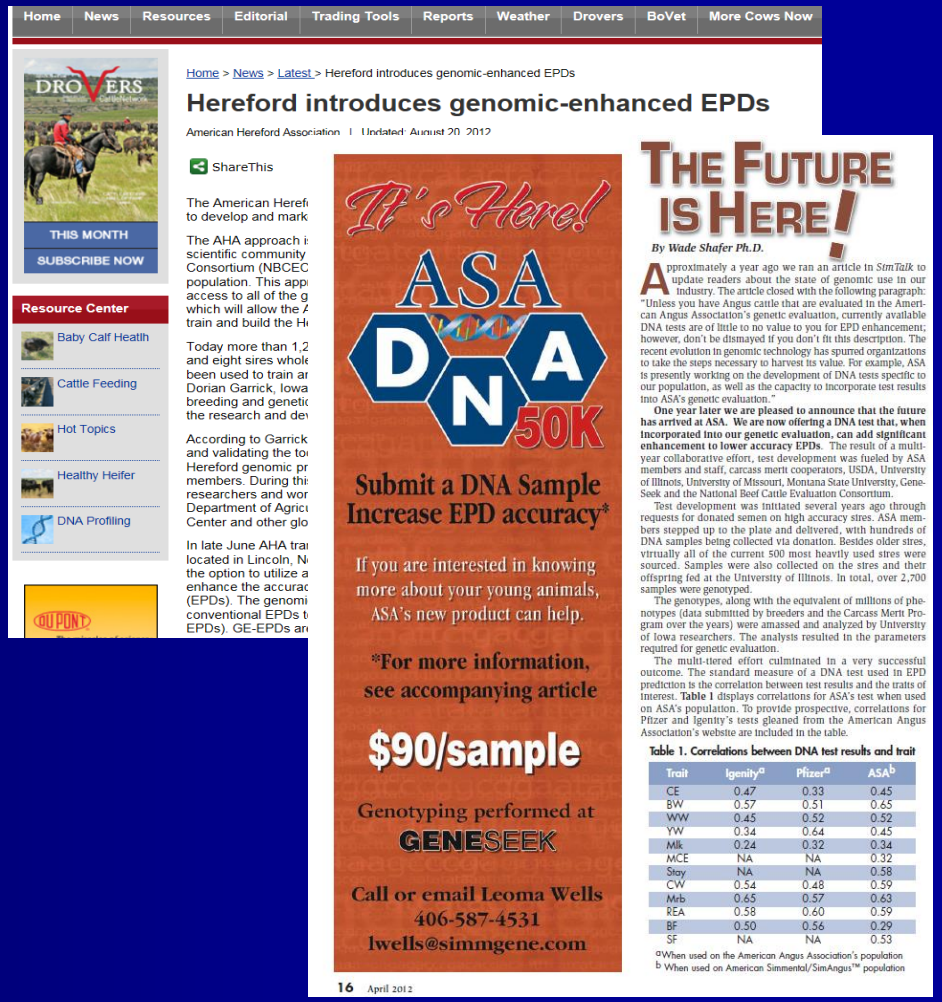
- Association's genetic evaluations, the DNA test results are incorporated into the EPDs using a correlated trait approach.
- The correlations (r) between the HD 50K prediction and the phenotypic data at the Association are updated with each recalibration effort and effectively range from .60 to .70, 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



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

AGI DNA Tests	Price
Parentage	$18.00
Coat Color Test	$18.00
Arthrogryposis Multiplex (AM) Test	$22.00
Neuropathic Hydrocephalus (NH) Test	$22.00
Contractural Arachnodactyly (CA) Test	$22.00
Developmental Duplication (DD) Test	$22.00
Myostatin (M1) Test	$22.00
Dwarfism (D2) Test	$22.00

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.

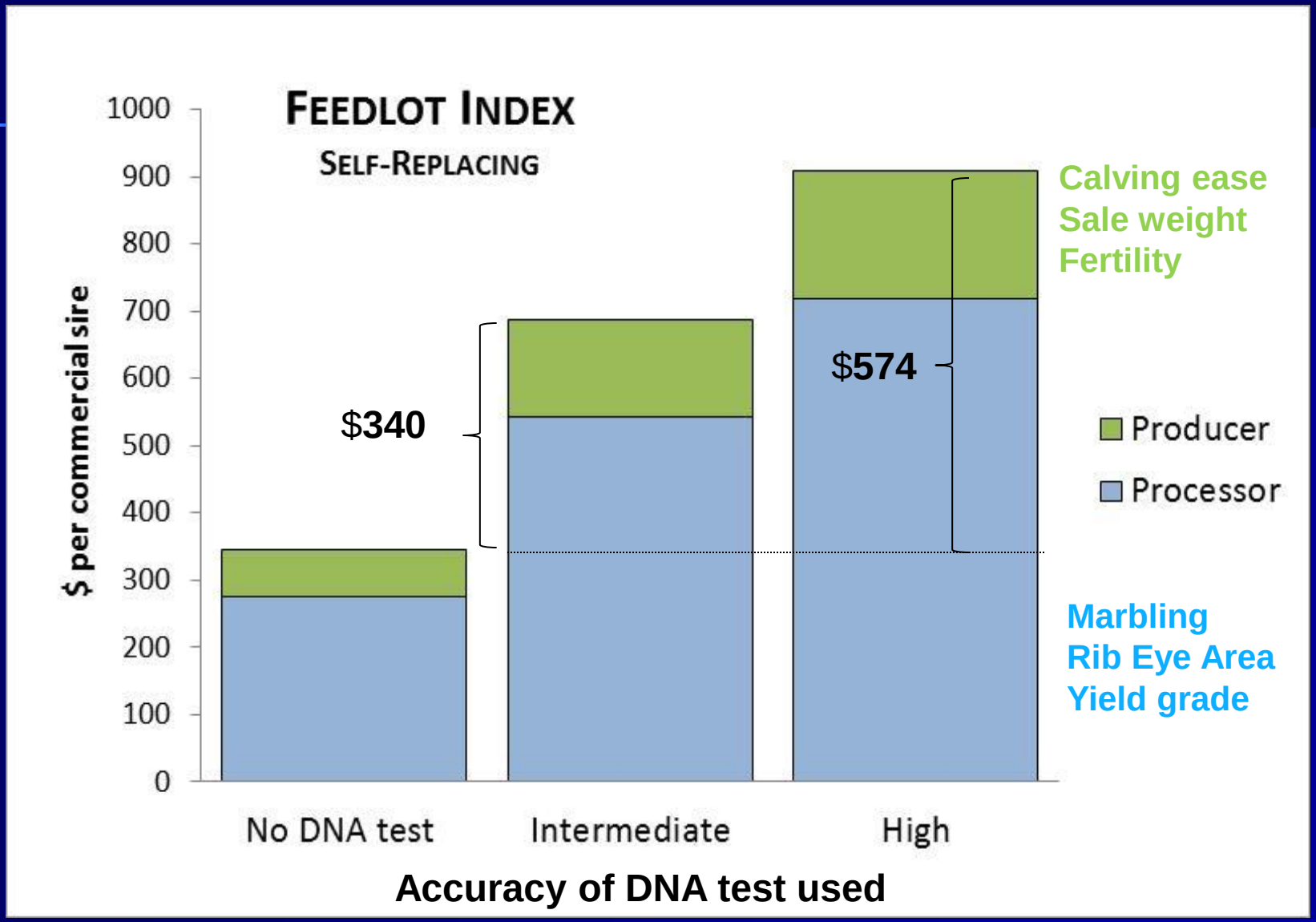
Genomic Tests	Price
Zoetis® HD50K (includes Parentage)	$75.00
Add Coat Color	$5.00
Add AM Test	$8.00
Add NH Test	$8.00
Add CA Test	$8.00
Add DD Test	$10.00
GeneSeek® GGP-HD (includes Parentage)	$75.00
Add Coat Color	$5.00
Add AM Test	$8.00
Add NH Test	$8.00
Add CA Test	$8.00
Add DD Test	$10.00
Add M1 Test	$18.00
Add Dwarfism (D2) Test	$20.00

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.

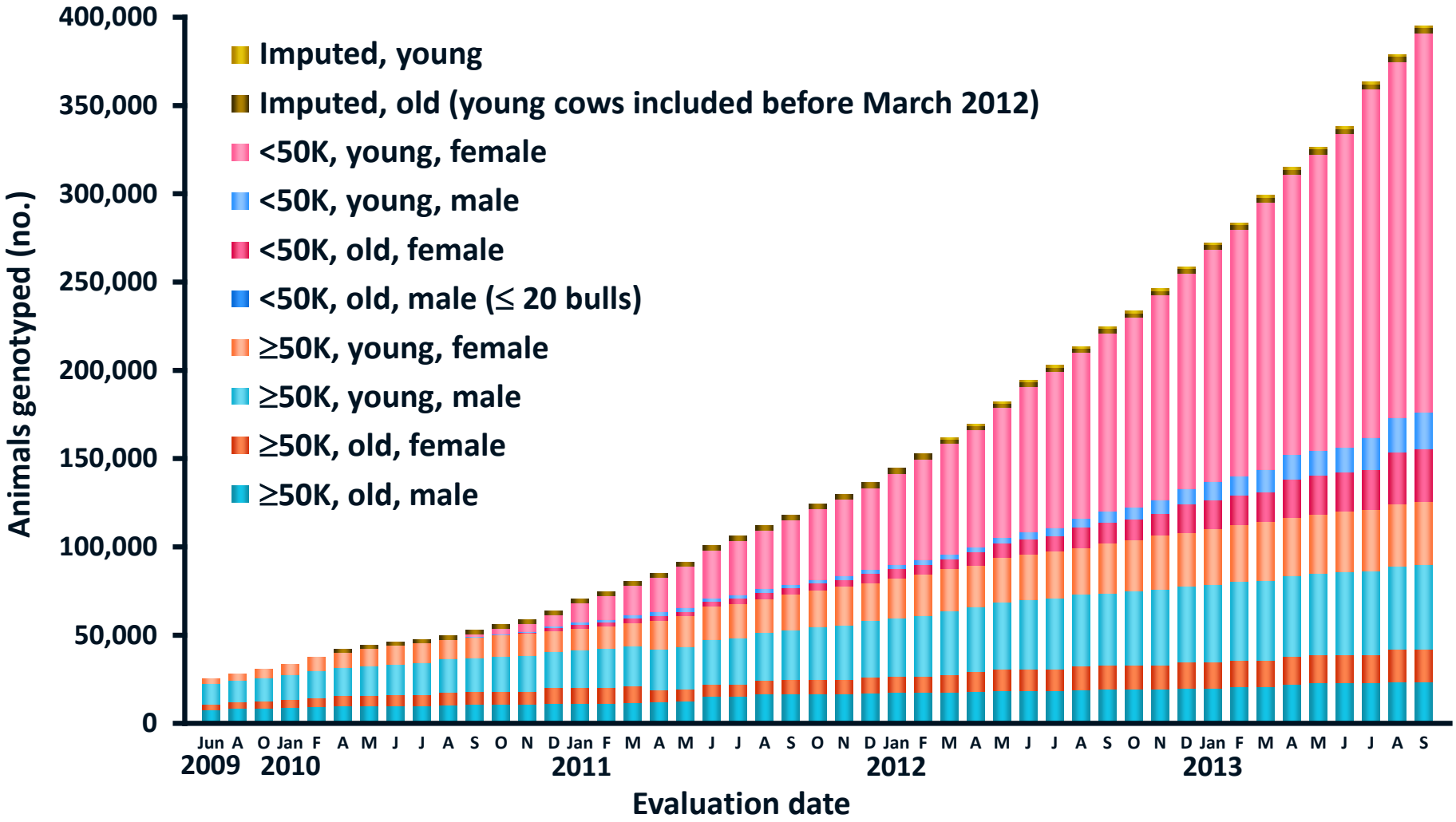
Where are returns from genetic gain (ΔG) realized?



What is the value of genetic improvement in commercial females?

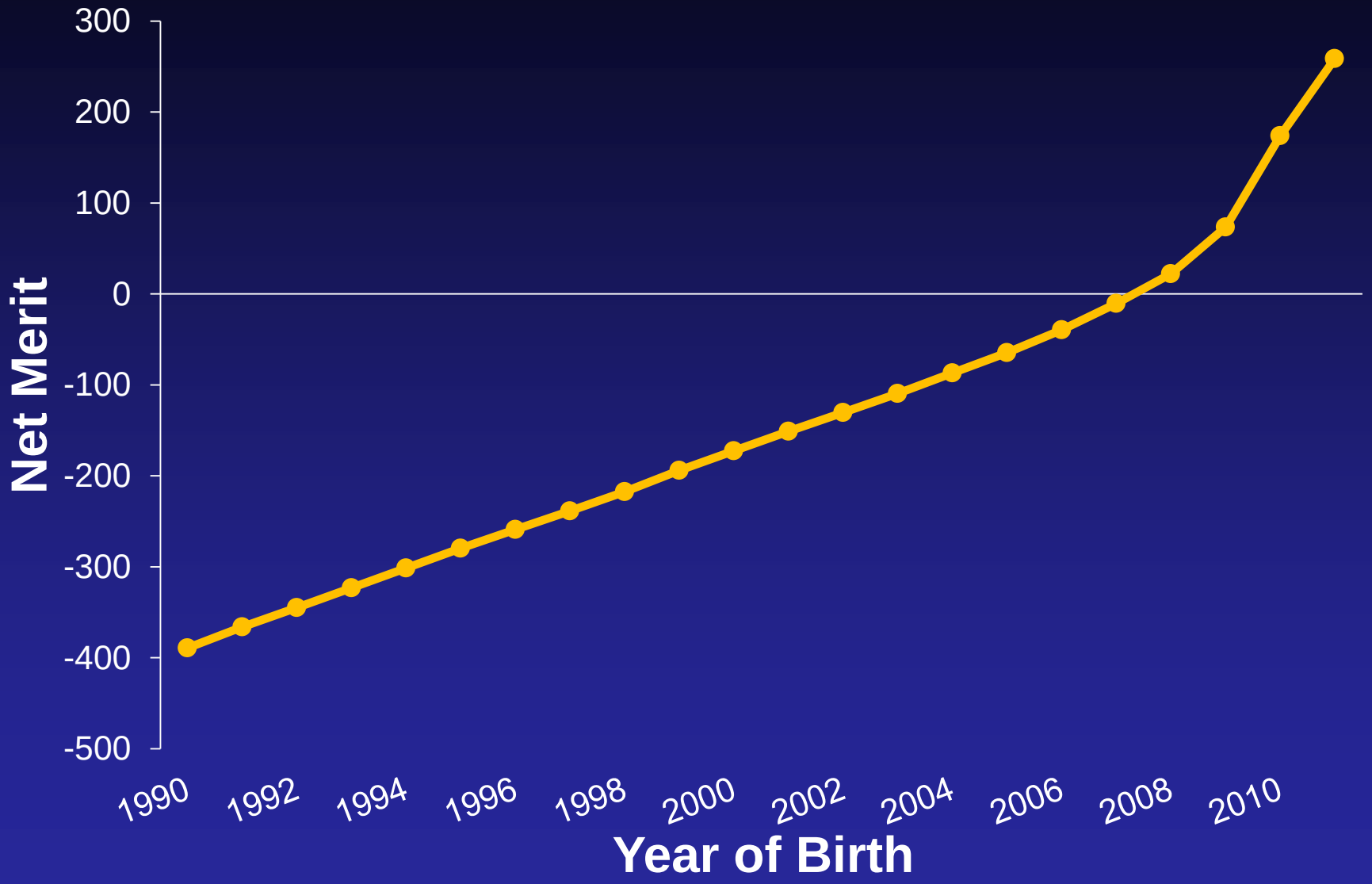
- The breakeven cost of testing replacement heifers was **$3.63** and **$6.53** per test for the intermediate and high accuracy DNA tests, respectively.
- The value of increasing the accuracy of commercial replacement heifer genetic evaluations is less (ten-fold in this case) than that for commercial 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



Wiggans, 2013

Dams of Cows – Net Merit

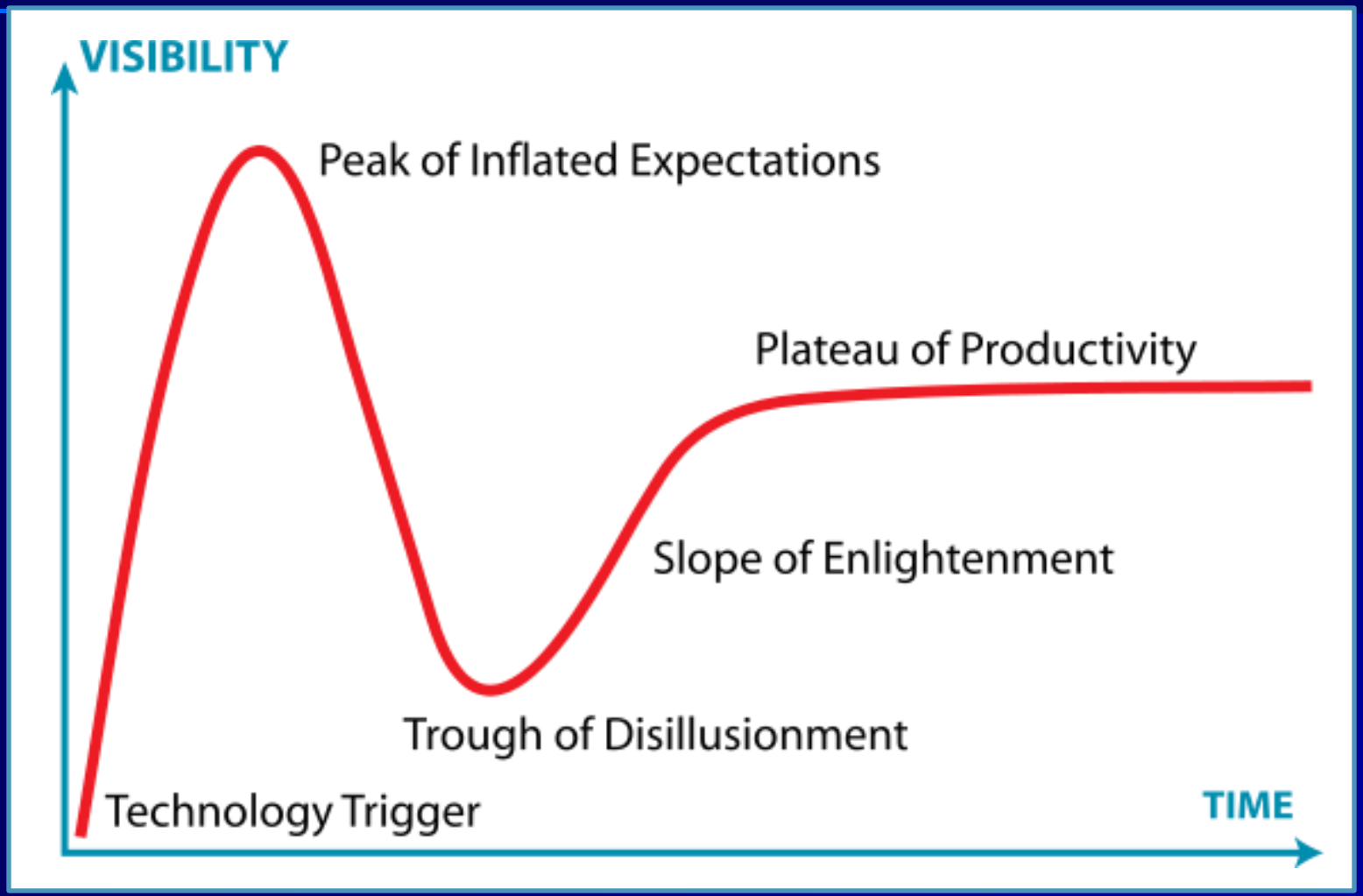


Slide provided by Van Tassell

Unpublished data


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?