Uses of DNA information on Commercial Cattle Ranches

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Overview

- **What is working well**
  - Identification of recessive/single trait defects
    - Coat color
    - Horned
    - Genetic defects
  - Parentage
- **What is not working so well**
  - DNA tests for selection
- **What does the future hold?**
  - Tests that work across breeds?

Using DNA information to identify carriers of recessive traits

Images from an article by David S. Buchanan, Department of Animal Sciences, North Dakota State University

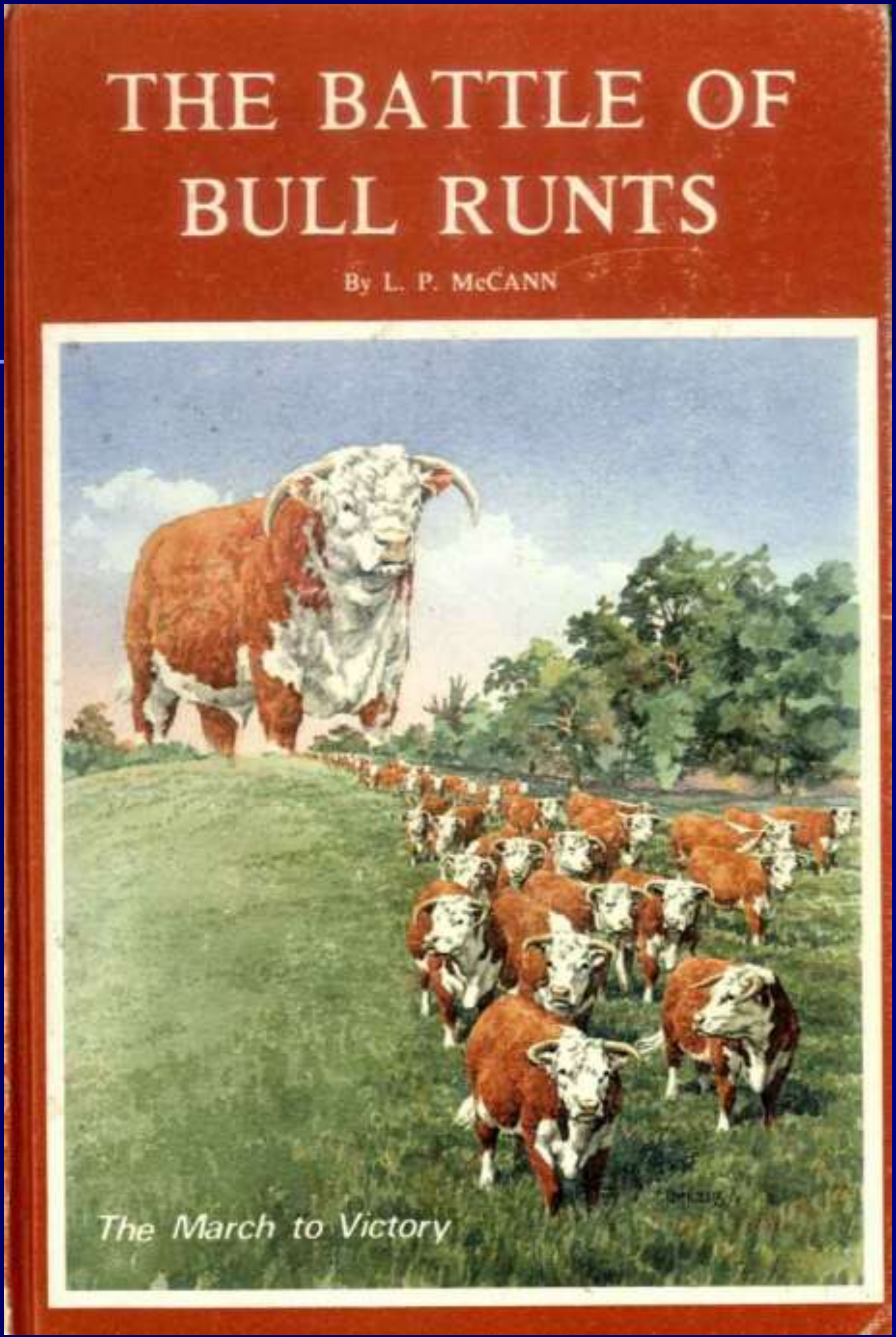
http://www.ag.ndsu.edu/williamscountyextension/livestock/genetic-defects-in-cattle

Compare dwarfism response in the 50s to the response to curly calf (AM)

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

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

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



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.

Curly calf – Arthrogryposis multiplex

- 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
- Dr. David Stefan of the University of Nebraska and Dr. Jon Beever of the University of Illinois worked to develop a genetic test from September – October, 2008

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

- In the 10 months following the release of the test, the AAA posted the results of tests for AM on about 90,000 cattle.
- These AM test costs less than $30.
- Of these, almost 5,000 bulls and more than 13,000 heifers have tested as carriers of AM. **That leaves more than 22,000 bulls and more than 50,000 heifers which tested as free of AM.**

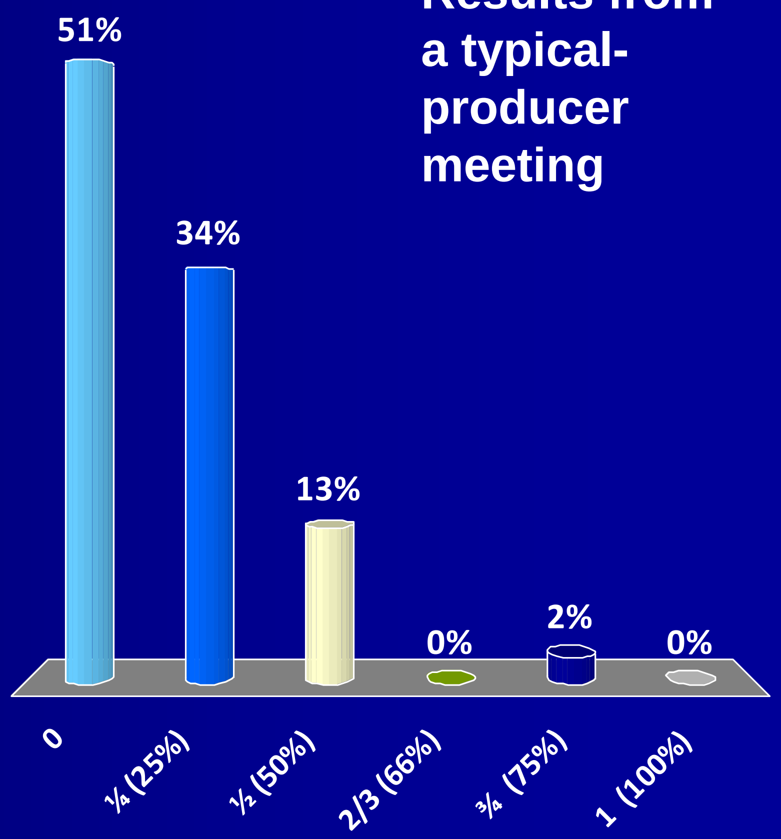
From: Buchanan, D.S. Genetic Defects in Cattle.
http://www.ag.ndsu.edu/williamscountyextension/livestock/genetic-defects-in-cattle

Early extension education about dwarfism explaining carriers and inheritance

Image from Special CollectionsUniversity Libraries, Virginia Tech: http://spec.lib.vt.edu/imagebase/agextension/boxseven/screen/AGR3618.jpg

If you breed a curly calf carrier cow (AMC) to an curly calf free bull (AMF), what is the chance that the offspring will be stillborn as a result of being curly calf?

1. 0
2. ¼ (25%)
3. ½ (50%)
4. 2/3 (66%)
5. ¾ (75%)
6. 1 (100%)



Results from a typical-producer meeting

Arthrogryposis Multiplex (**AM**; "Curly Calf Syndrome"); Neuropathic Hydrocephalus (**NH**); Contractural Arachnodactyly (**CA**; "Fawn Calf Syndrome")

DATE	AM	NH	CA
Recognized as genetic defect	November 15, 2008	June 12, 2009	July 14, 2010
Commercial test becomes available	January 1, 2009	June 15, 2009	October 4, 2010
Number of carriers recorded (current as of March 2011)	34,653	32,193	5,088
HEIFERS: Must test & all can register if born before or on	December 31, 2011	June 14, 2012	October 4 , 2013
HEIFERS: Only non-carriers can be registered if born on or after	January 1, 2012	June 15, 2012	October 5, 2013
BULLS: Must test & all can register if born before or on	December 31, 2009	June 14, 2010	October 4, 2011
BULLS: Only non-carriers can be registered if born on or after	January 1, 2010	June 15, 2010	October 5, 2011

"How do you make cost-effective use of DNA information in commercial animal production?"

GOAL: Determine how DNA-based information is best incorporated into commercial cattle production systems

1. **Which of several incorporation methods is best?**
2. **Which is feasible for commercial ranches to use?**
3. **Which provides the most/any economic benefit?**

- **Research objectives**: Determine association between breed-association genetic predictions (EPDs), and DNA-based genetic predictions (stars, scores, MBVs, MVPs, GEPDs) and evaluate their ability to predict the genetic potential of 125 commercial sires based on the performance and carcass records of their offspring

USDA-funded project entitled: "Integrating DNA information into beef cattle production systems"

Four ranches on this project (UC Davis and 3 commercial cooperators in Siskiyou Co.)

- Cowley 900 (550 Spring; 350 Fall) 45
- Kuck 500 (200 Spring; 300 Fall) 16
- Mole-Richardson 700 (Fall) 40
- UC Davis 300 (Fall) 26

Approximately 125 Angus bulls, and 2,400 cows per year on project

Happy Cows come from Siskiyou County

Cowley Ranch

Kuck Ranch

Mole-Richardson Farms

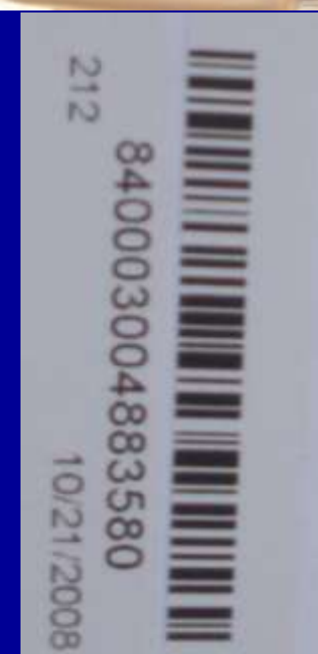
UC Davis – Sierra foothills

Work flow and collaborators

- DNA on all bulls goes for 50K whole genome scan – collaboration with Jerry Taylor (MO) and John Pollak (Meat Animal Research Center (NE)
- Molecular breeding value (MBV) prediction of genetic merit based on MARC training data set – collaboration with Dorian Garrick (IA) and Mark Thallman, U.S. Meat Animal Research Center (NE)
- Ranch data including sire groupings, birth dates and weaning weights on all calves, all EIDed, and "DNAed" for parentage determination – collaboration with Dan Drake and producers (CA)
- Steer feedlot in weights, treatments, and carcass traits (Hot weight, grading information and meat sample collected in the processing plant – collaboration with Harris Ranch (CA)
- Compile data and compare three sources of genetic estimates: breed EPDs (bEPDs), commercial ranch EPDs (rEPDs), and MBVs, Kristina Weber, UC Davis, PhD student



DELL
DYMO
LabelWriter 400 Turbo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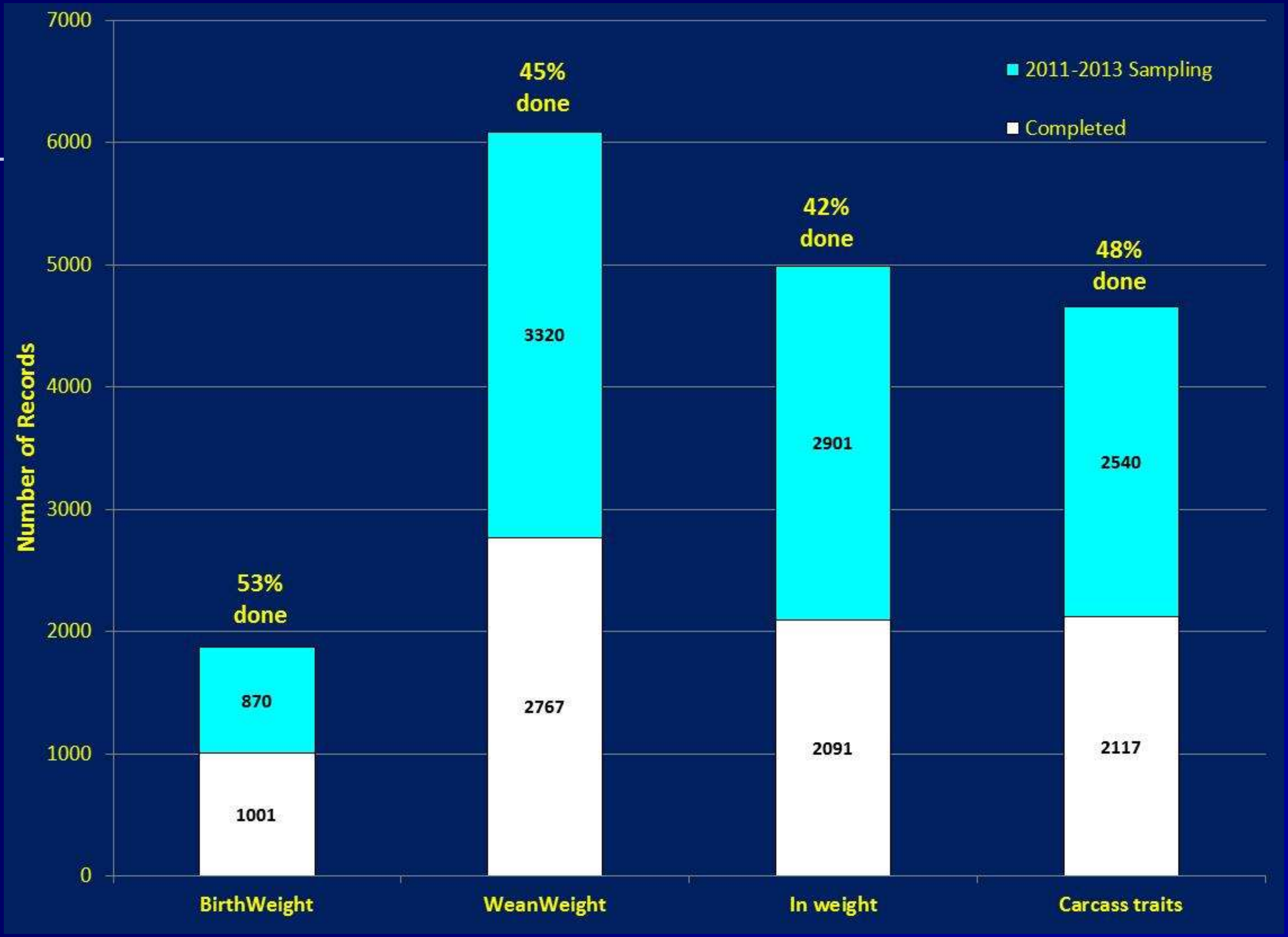
840003004883580
10/21/2008

Commercial ranch applications

A key issue in commercial situations is ease of DNA sampling, tracking and quality of resultant DNA

Sampling Summary : Total



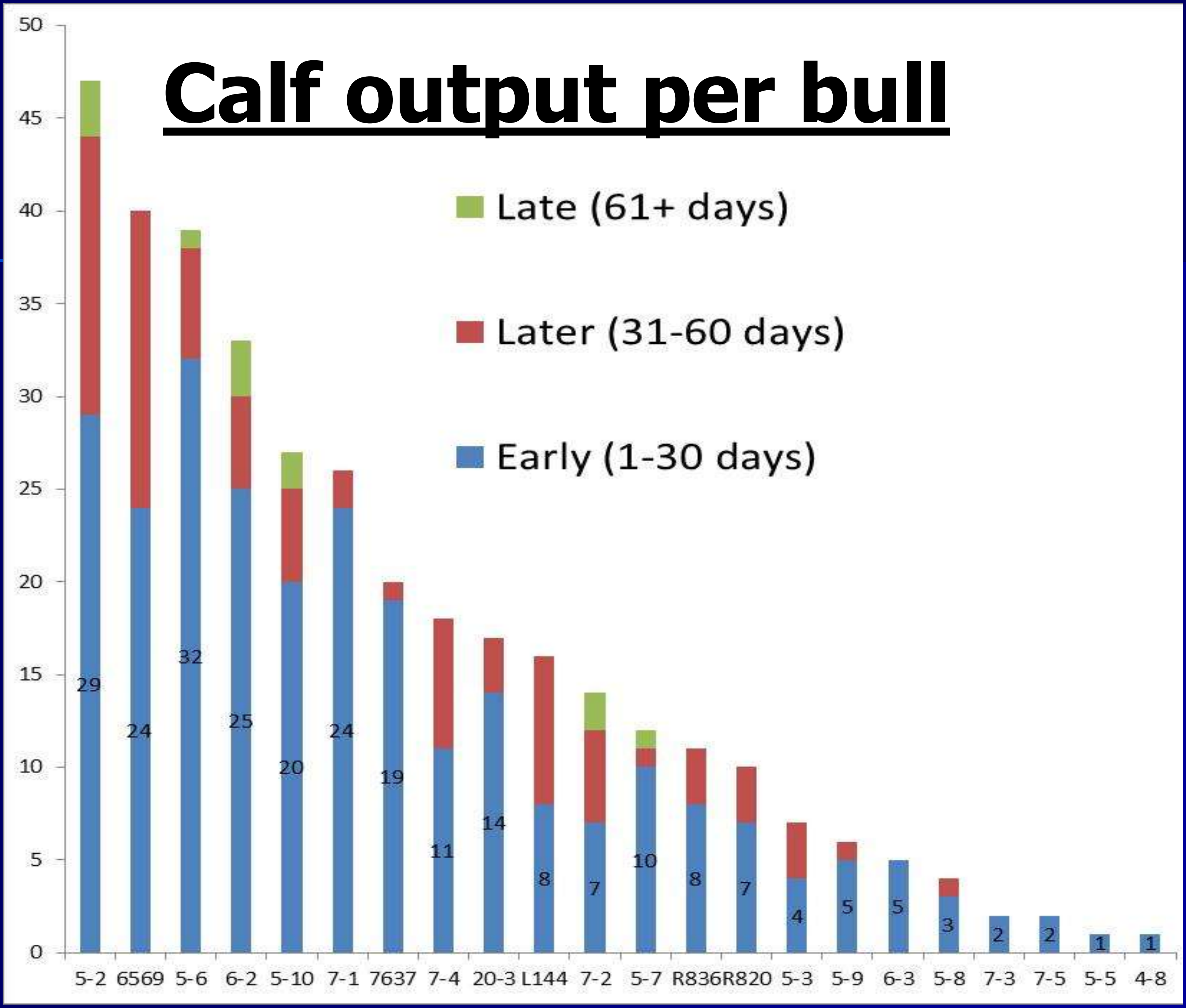
Benefits of DNA-based parentage identification

- Correct pedigree errors thereby improving the rate of genetic gain
- Enables the use of multi-sire breeding pasture
  - Higher fertility
  - Elimination of sire failure
  - Tighter calving season
- Reduces the need for different breeding pastures
  - Allows for better pasture management
  - Less sorting and working of animals into different groups
- Reduces the need to disturb newborn animals
  - Labor savings so can focus on concentrate on offspring survival
  - Worker safety improvement
  - Better bonding of offspring with dam
- Enables the development of commercial-ranch genetic evaluations

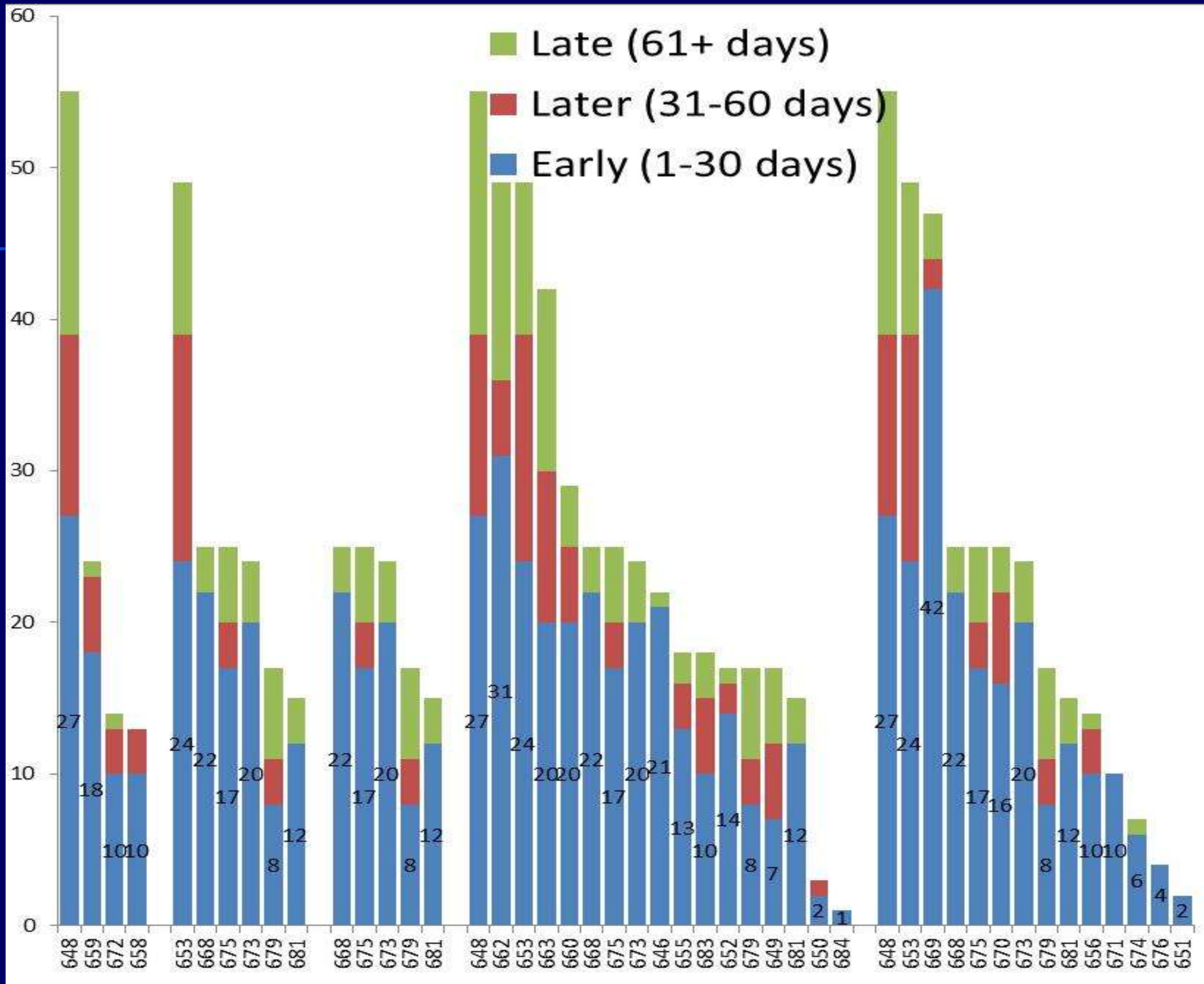
McEwan, J. C. 2007 Current status and future of genomic selection. Proceedings of the New Zealand Society of Animal Production 67: 147-152.

Calf output per bull

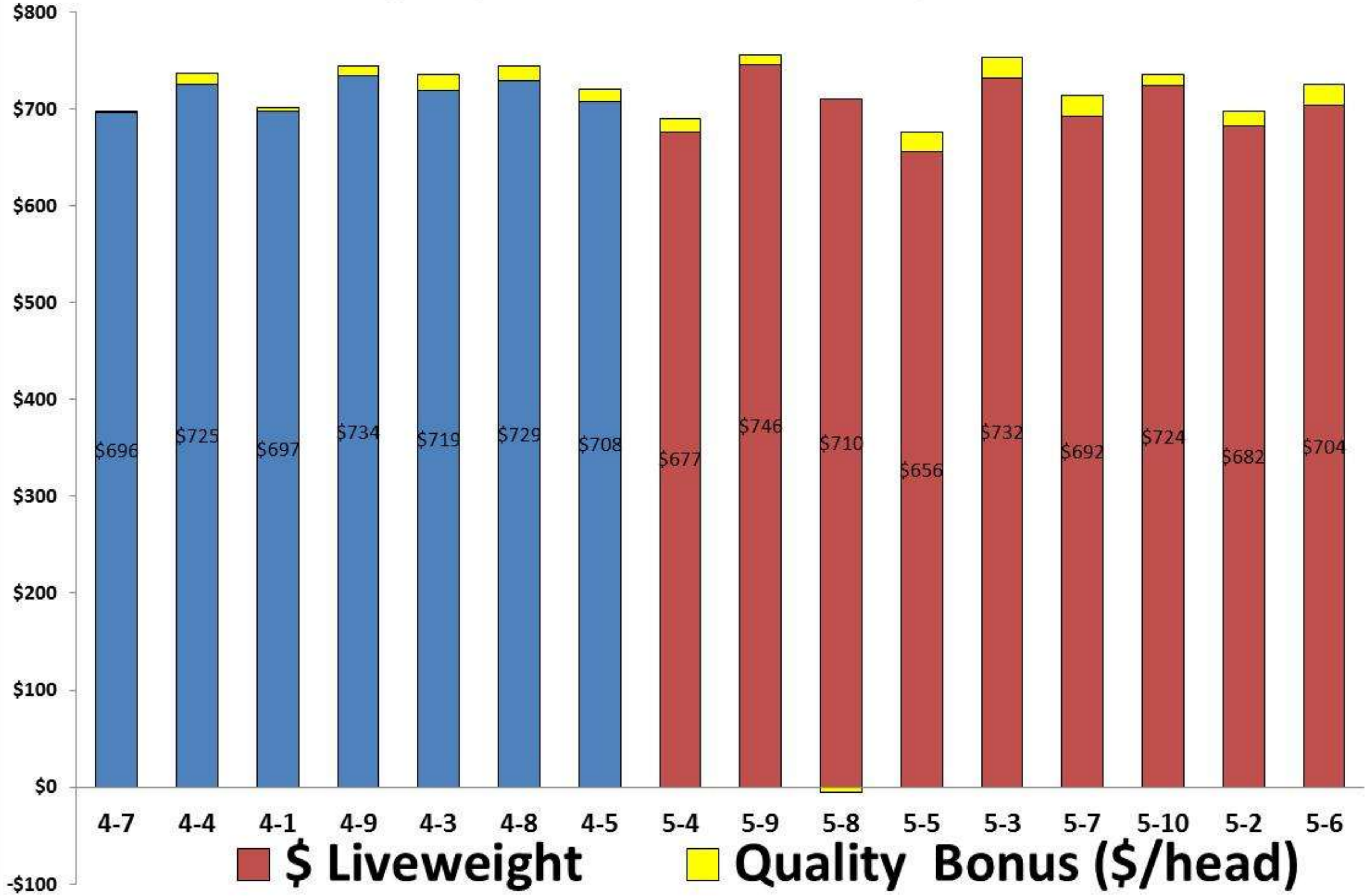
of calves born/bull – Fall 2009 calving

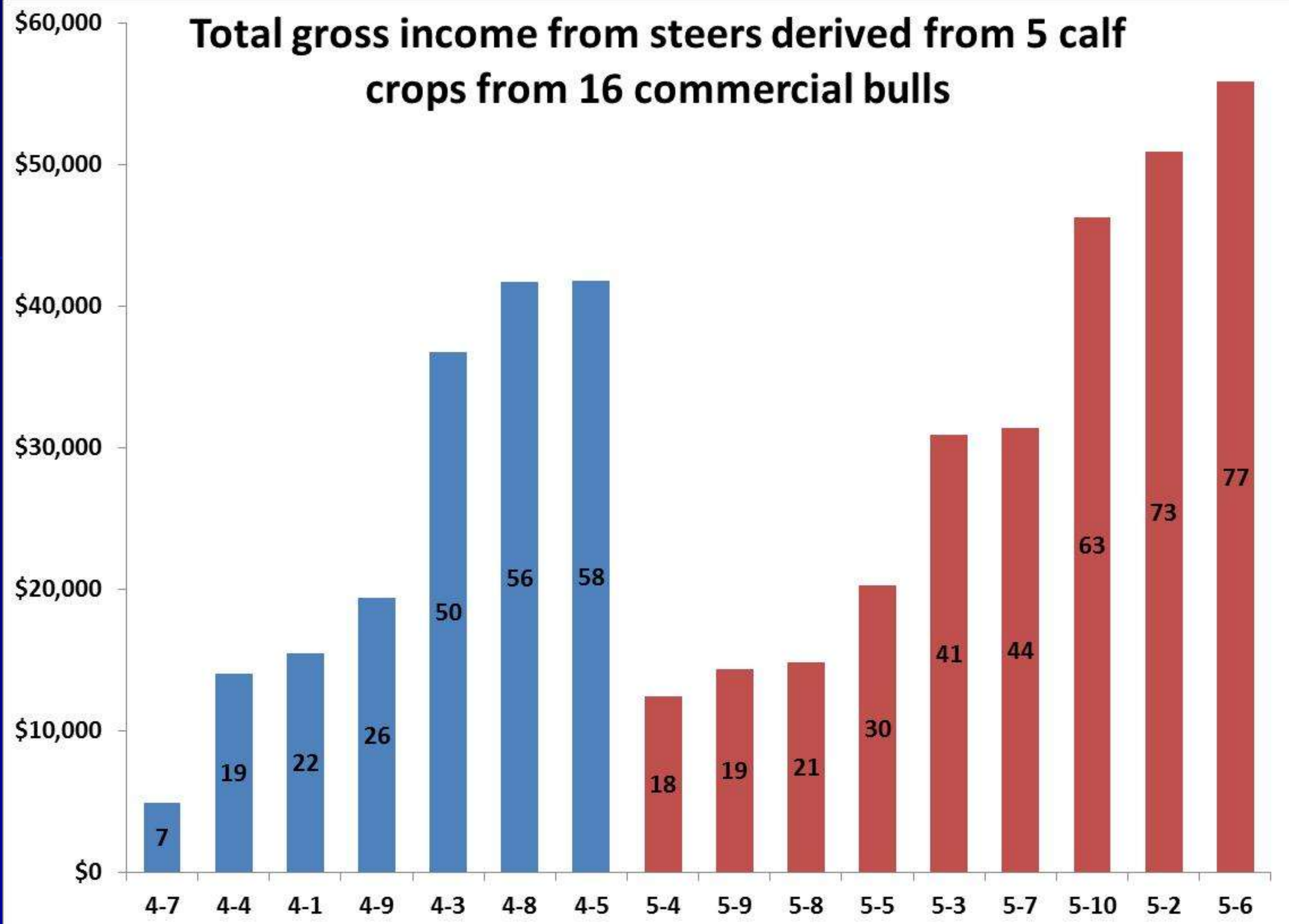


of calves born/bull – Fall 2009 calving



Average price received per steer ($)





Total gross income from steers derived from 5 calf crops from 16 commercial bulls
$60,000
$50,000
$40,000
$30,000
$20,000
$10,000
$0
7
19
22
26
50
56
58
18
19
21
30
41
44
63
73
77
4-7
4-4
4-1
4-9
4-3
4-8
4-5
5-4
5-9
5-8
5-5
5-3
5-7
5-10
5-2
5-6

DNA-based tests for cattle

What is working well

– Identification of genetic defects

– Parentage

What is not working so well (at present)

– DNA tests for selection

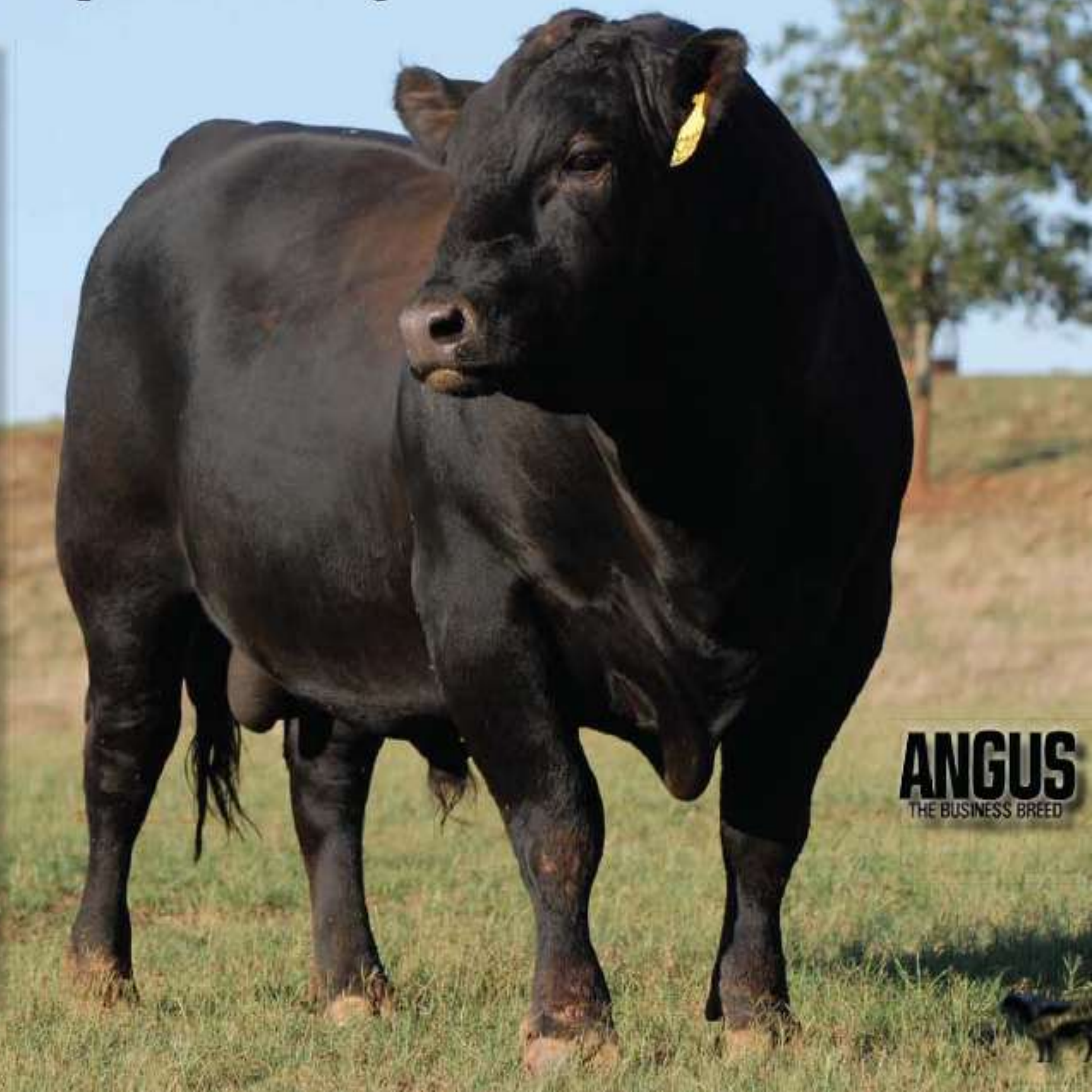
The Power of the IGENITY® profile for Angus

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**



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)

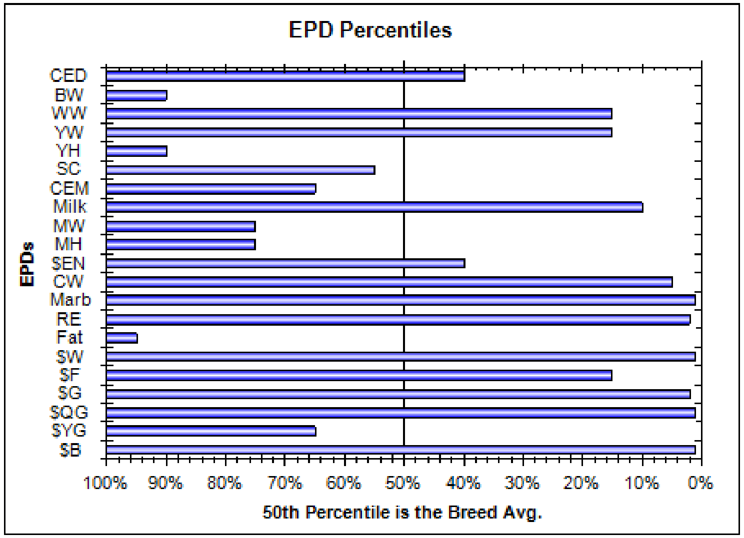
Pfizer Animal Health
Animal Genetics

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

Black Angus Sire

G A R Predestined

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



Current Sires Percent Breakdown

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

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

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

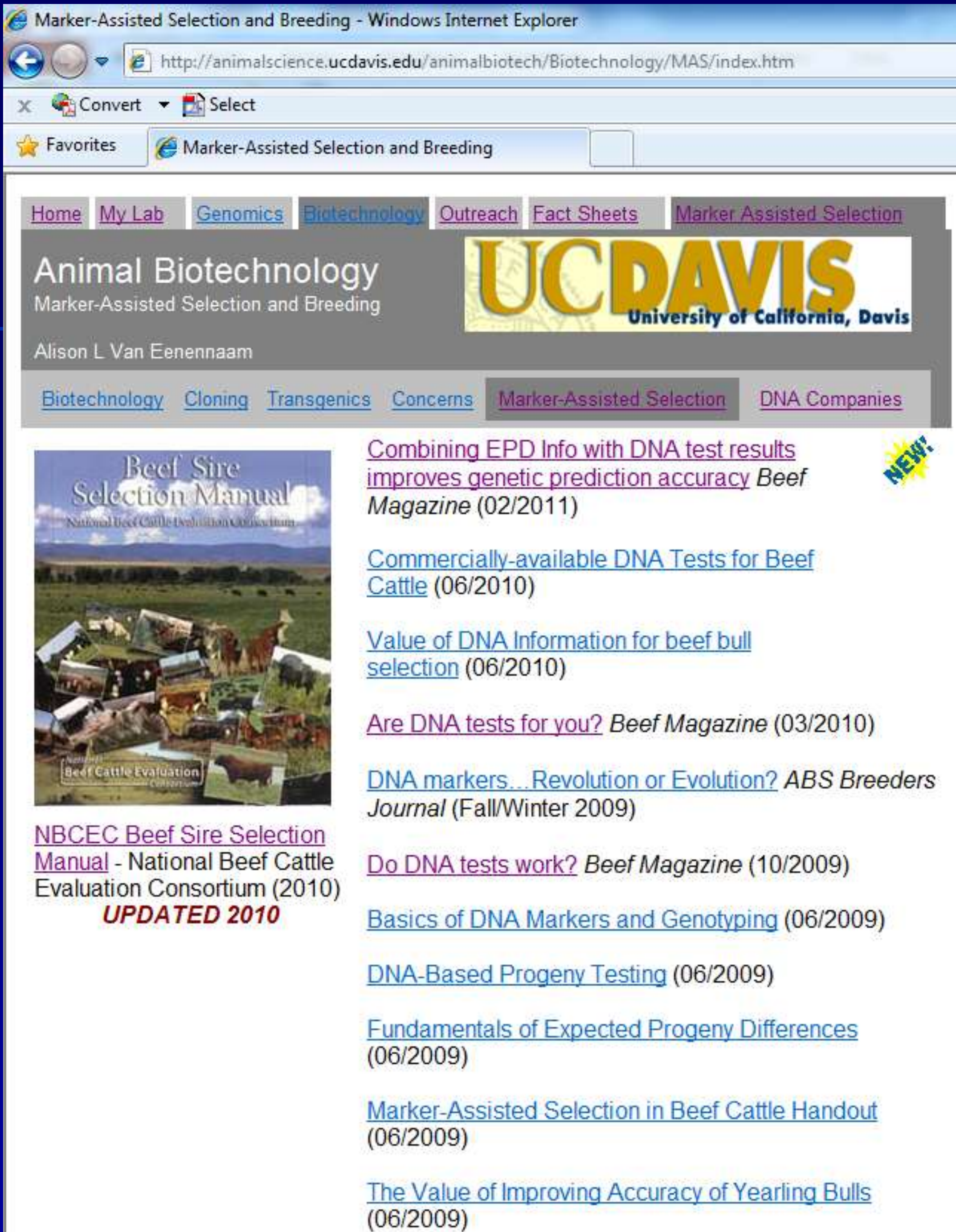
EPDs (CW, Marb, RE, Fat) are enhanced by genomic profiles generated by igenity.

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**

Beef Improvement Federation (BIF)

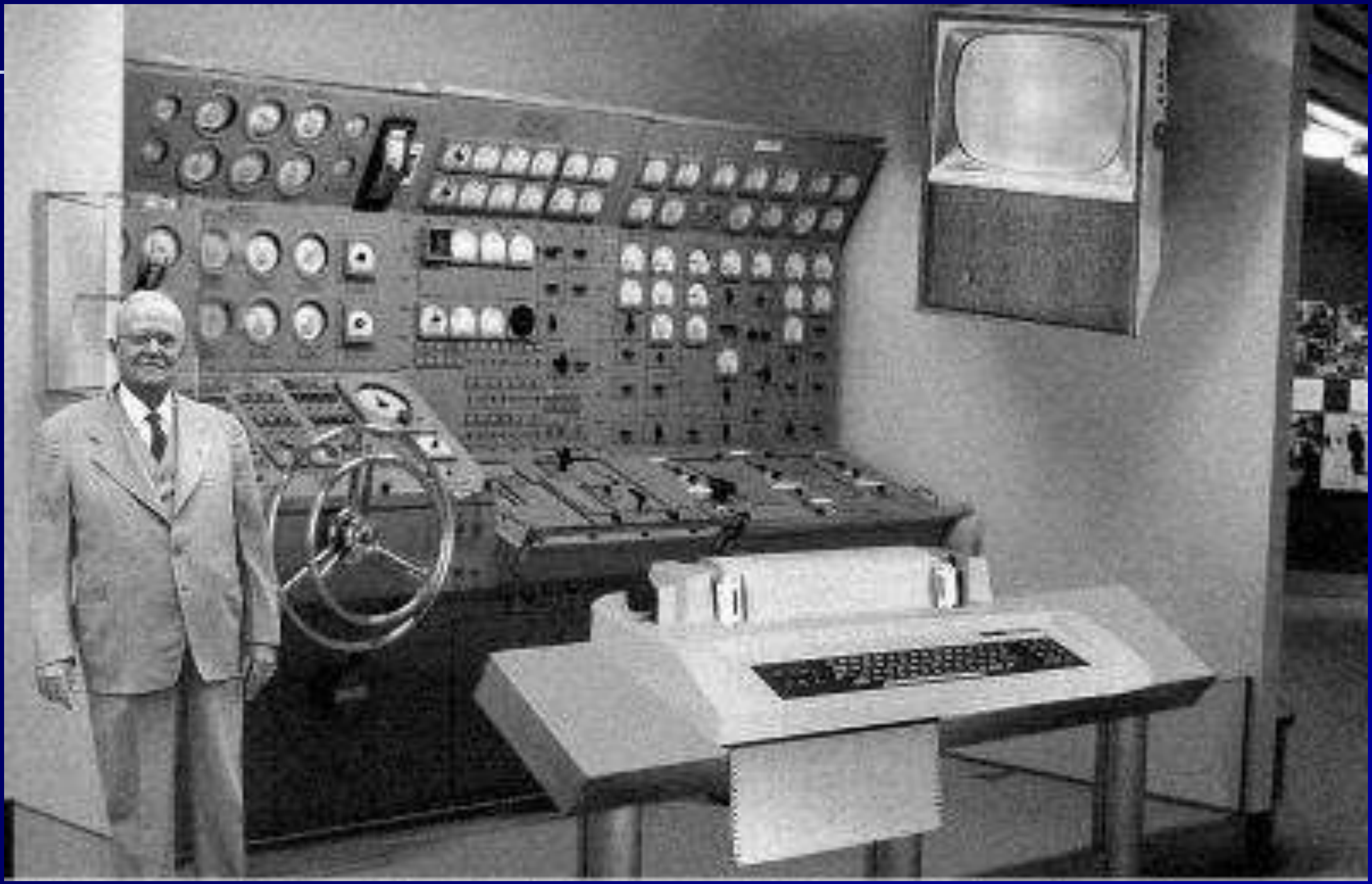
"BIF believes that information from DNA tests only has value in selection when incorporated with all other available forms of performance information for economically important traits in NCE, and when communicated in the form of an EPD with a corresponding BIF accuracy."



http://animalscience.ucdavis.edu/animalbiotech/Biotechnology/MAS/index.htm

What does the future hold?

"1954 version of what 'home computers' might look like in 50 years time (i.e. 2004)"



Wrong Expert Predictions

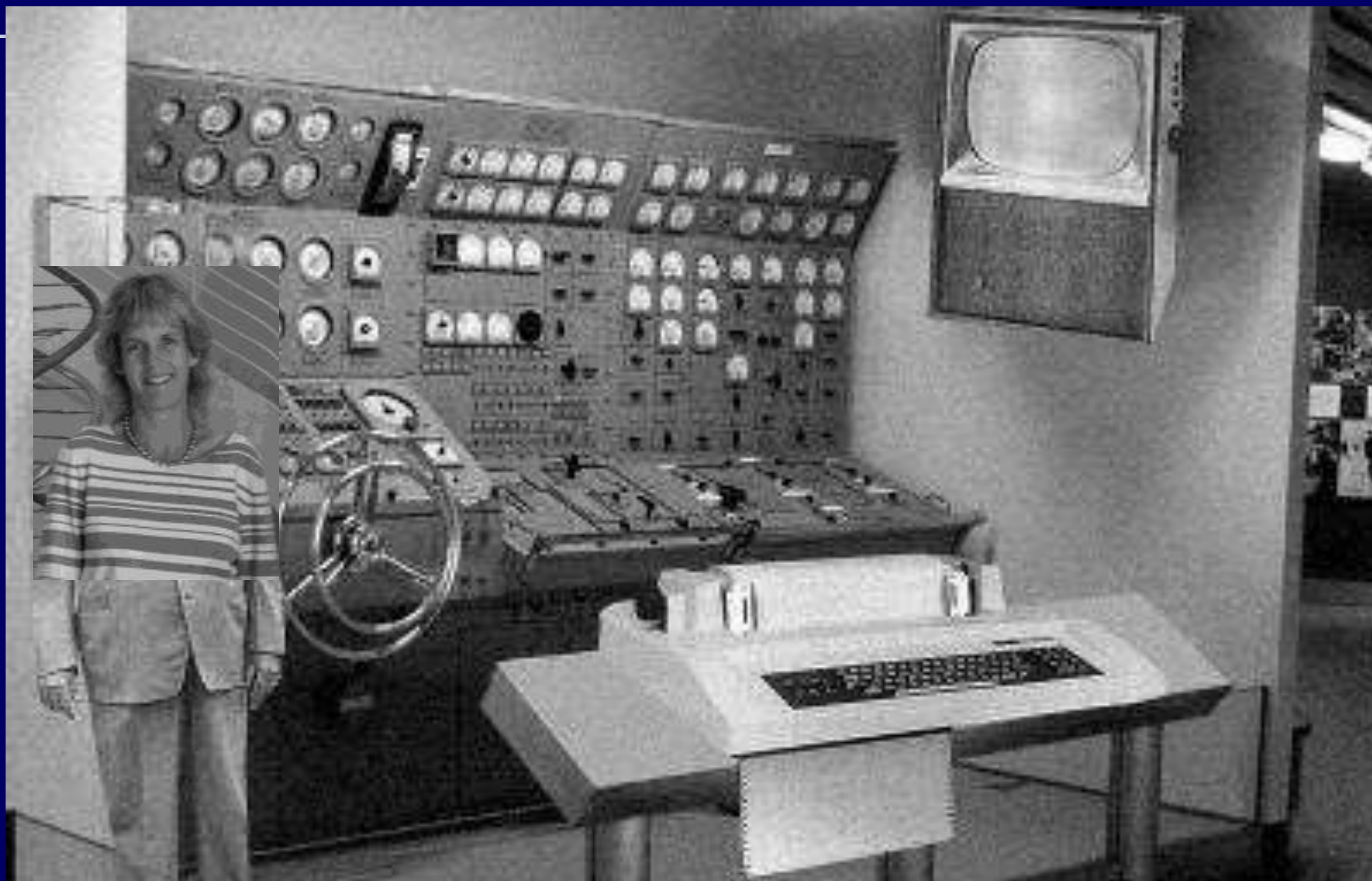
I think there's a world market for about five computers.

Thomas J. Watson, chairman of the board of IBM. 1943

There is no reason anyone would want a computer in their home.

Ken Olson, president of Digital Equipment Corp. 1977

“what escaped their vision was that science might come up with new and different ways of commercializing and using new technologies.”

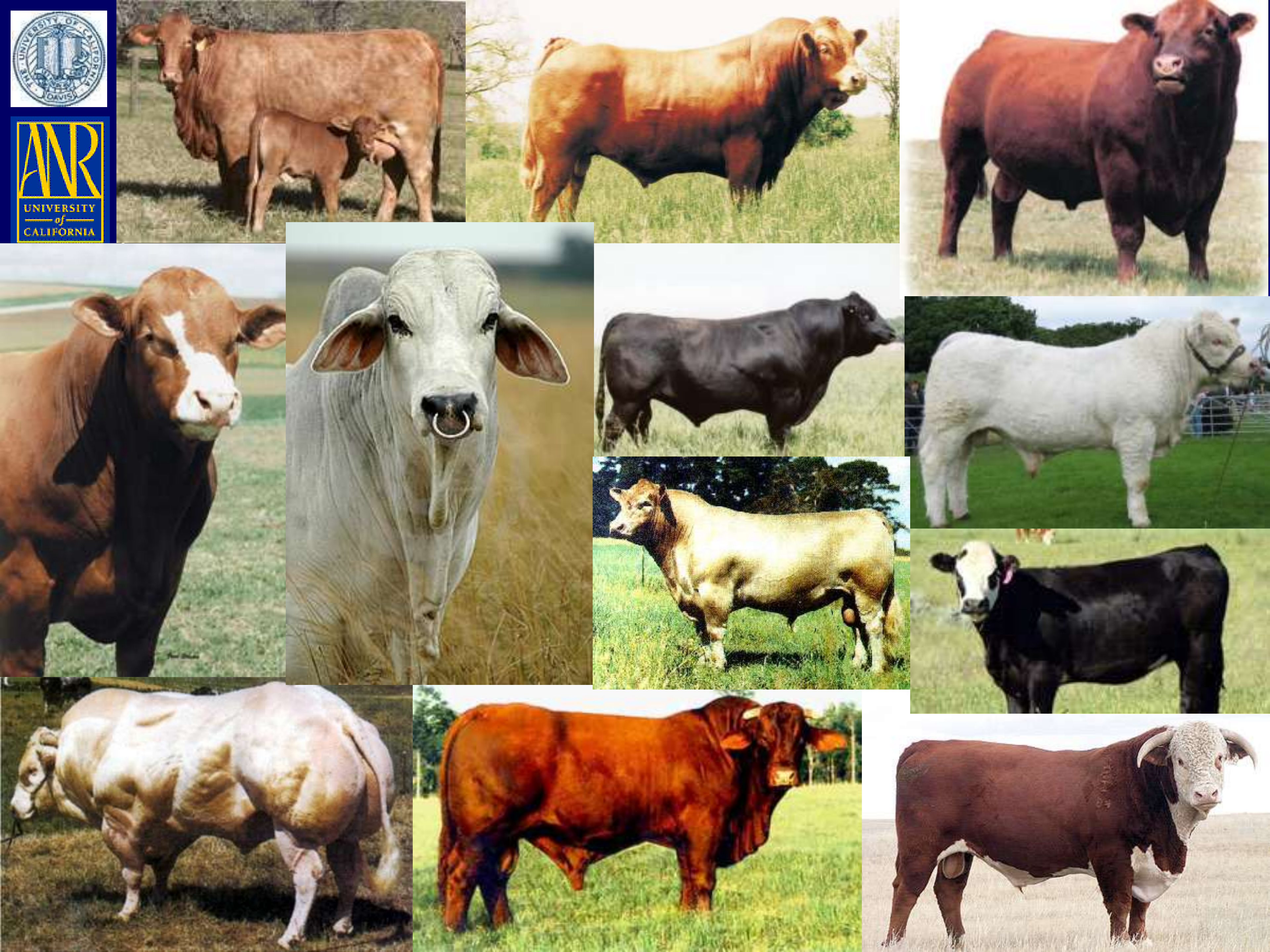


Actual Email correspondence from a US producer

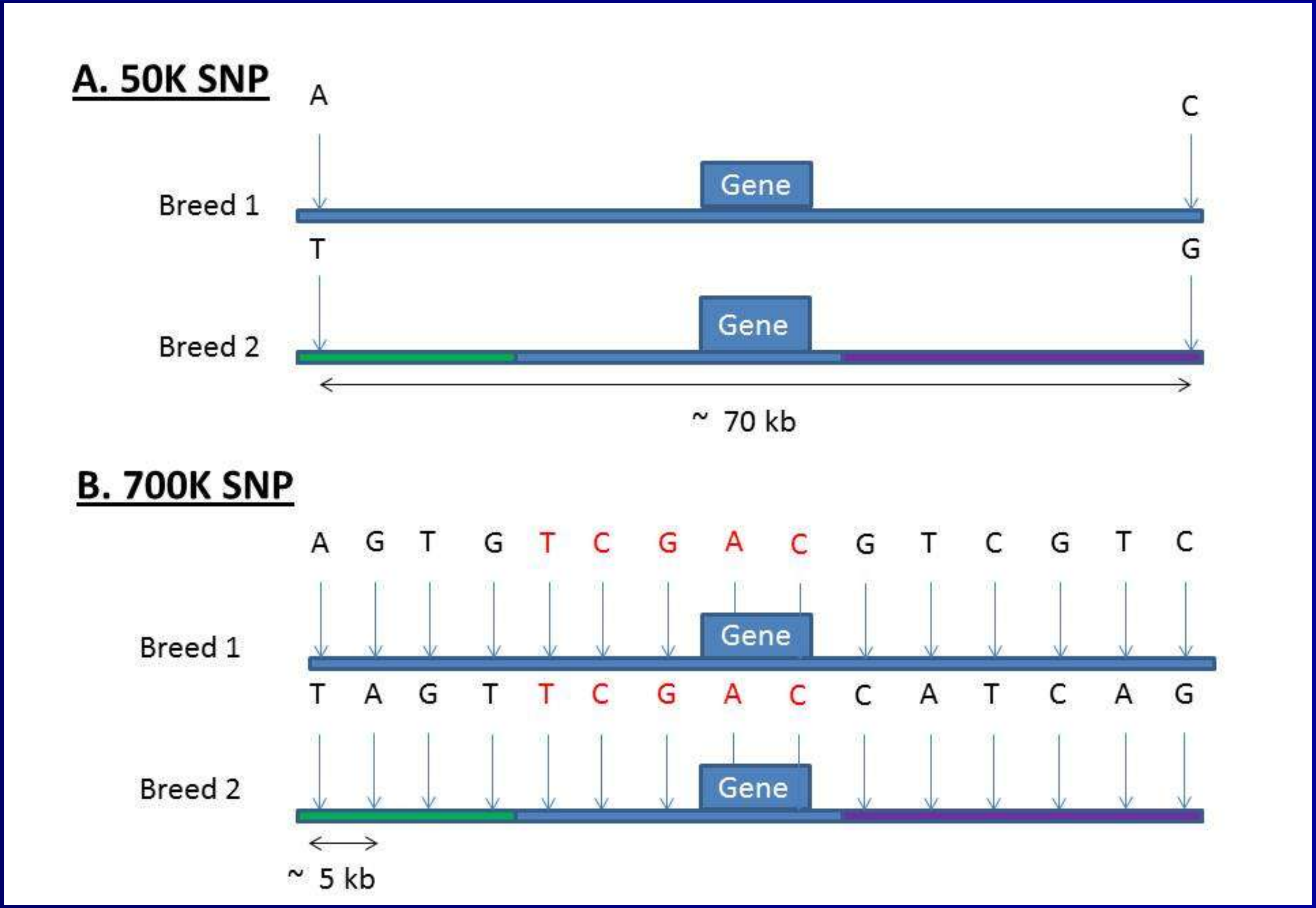
"Good morning.

Tuesday, February 08, 2011

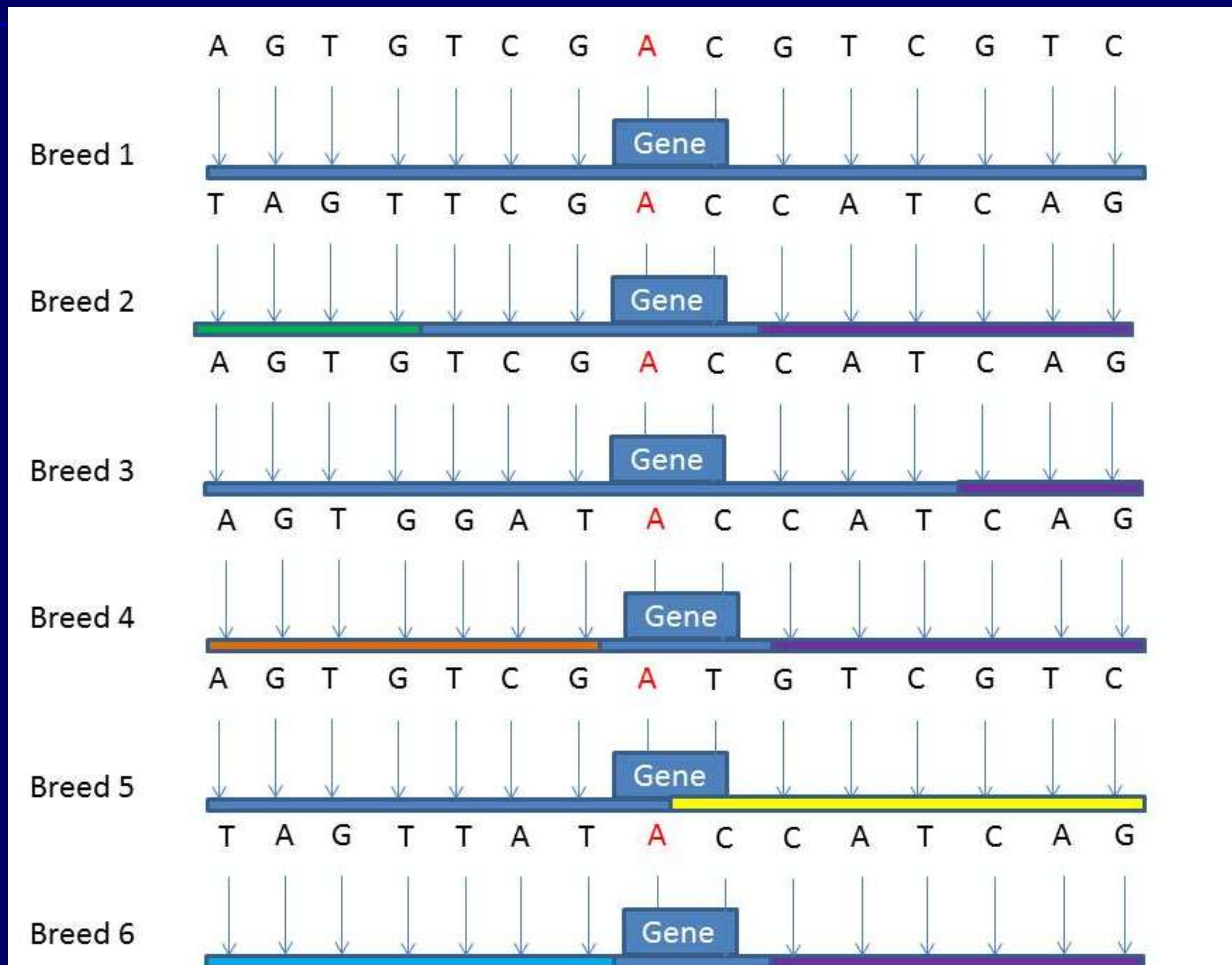
Is there a reason why we <u>wouldn't</u> do the Ingenity DNA test on each of our 62 yearling bulls at $40 per head to get information on birth weight, carcass weight, yield grade, back fat, ribeye area, etc.? I realize our bulls aren't purebreds, but isn't a cow a cow when it comes to DNA testing?"


ANR
UNIVERSITY of CALIFORNIA

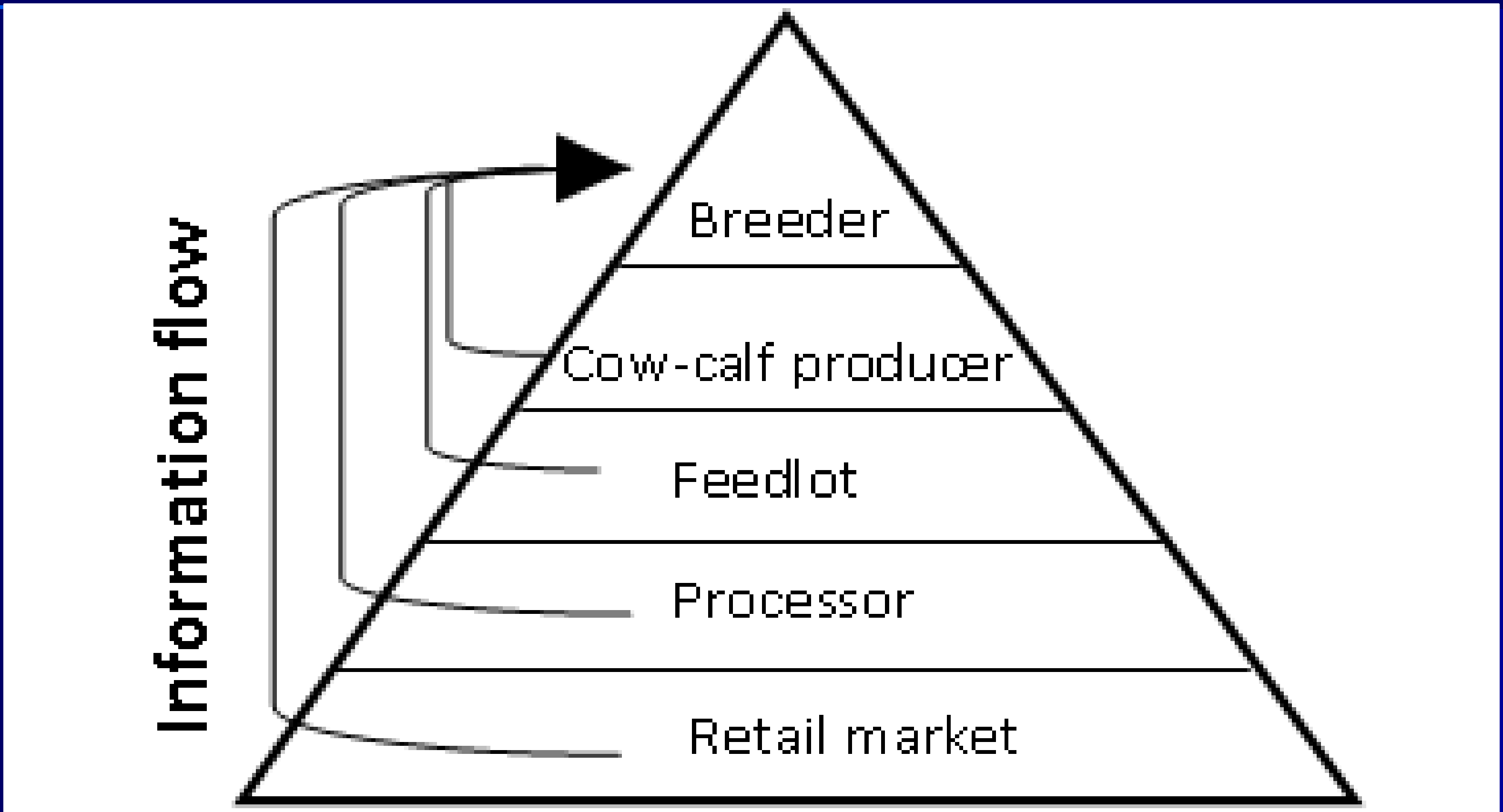
Marker location relative to the gene of interest in two breeds when using the (A) 50K SNP chip assay (markers spaced at ~ 70 kb intervals), or (B) the high density 700 K SNP chip assay (markers spaced at ~ 5 kb intervals)



High density panels offer the opportunity to accelerate discovery of the causal mutations underlying genetic variation – especially if combined with full sequence data on key ancestors



The beef industry needs to share data and profit between sectors to most benefit from DNA technologies



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

Currently Situation: DNA tests for selection

Bad News

- Tests are breed specific – only Angus
- Data reporting is varied and hard to interpret
- No independent estimate of test accuracy

Good News

- Larger SNP panels (700+K) might help tests work across breeds and in crossbreds
- DNA information is stating to get integrated into EPDs (Angus)

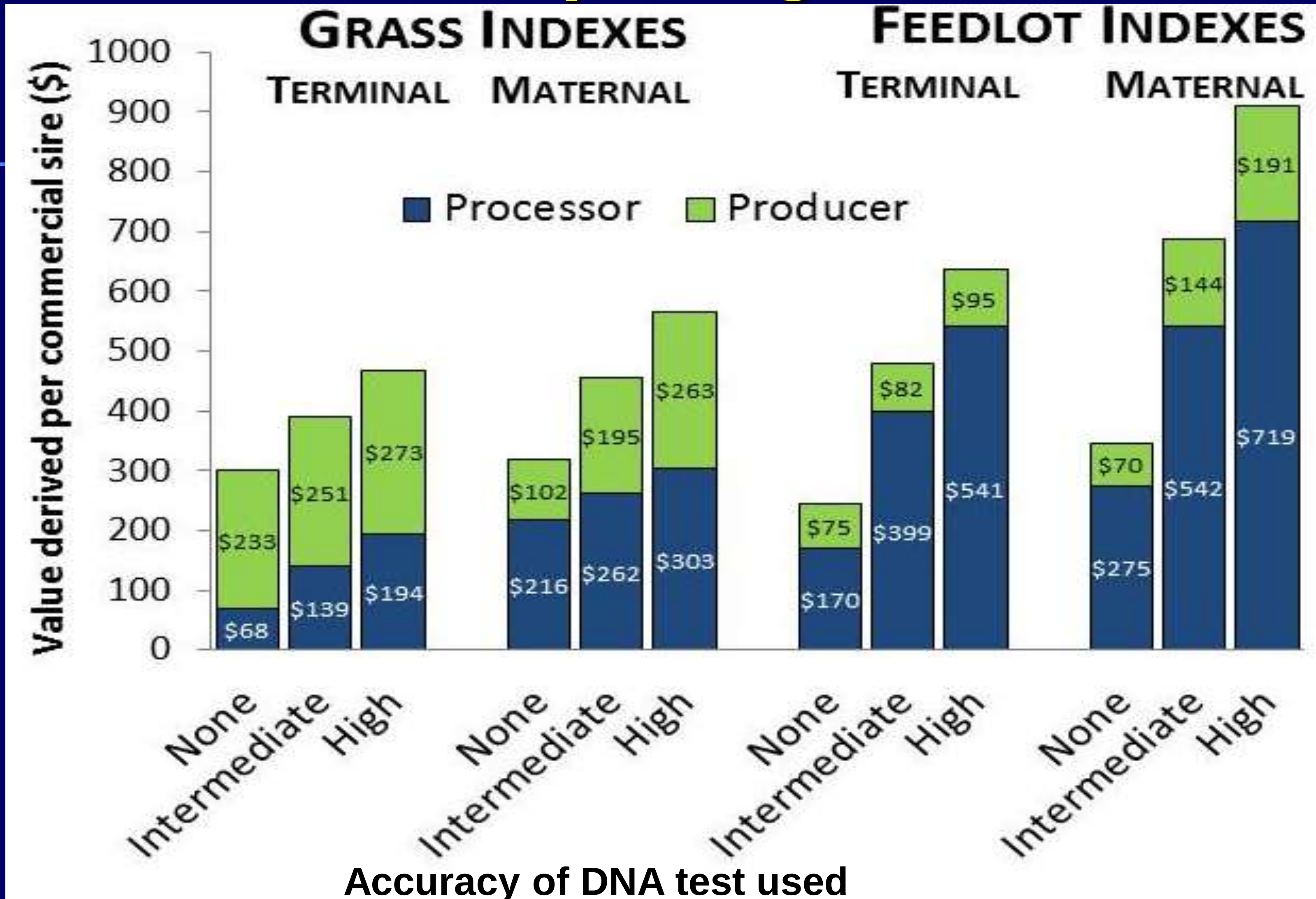

United States Department of Agriculture
National Institute of Food and Agriculture
"This project is supported by National Research Initiative Grant no. 2009-55205-05057 from the USDA National Institute of Food and Agriculture."
Van Eenennaam Sierra 4/9/2011
Animal Genomics and Biotechnology Education


Questions?

Trait	h^2	Igenity® Angus Profile		Pfizer HD 50K for Angus		
		Included	% Genetic variation[1]	Included	% Genetic variation[2]	% Genetic variation [3]
Average Daily Gain	0.28	X	na	X	30	1-10
Net/residual Feed Intake	0.39	X	na	X	12	0
Dry matter intake	0.39			X	11	4-5
Tenderness	0.37	X	na	X	26	na
Calving Ease (Direct)	0.10			X	22	6
Birth weight	0.31			X	28	12-16
Weaning Weight	0.25			X	32	12-19
Yearling Weight	0.60	X	na			
Calving ease (maternal)	0.10	X	na	X	40	4
Milking Ability	0.25			X	27	10-14
Heifer Pregnancy	0.20	X	na			
Stayability	0.10	X	na			
Docility	0.37	X	na			
Yield grade	0.64	X	na			
Carcass weight	0.39	X	29	X	29	6-13
Backfat thickness	0.36	X	25	X	40	14-19
Ribeye area	0.40	X	34	X	29	10-20
Marbling score	0.37	X	42	X	34	4-11
Percent choice		X	na			

[1] MacNeil, et al. 2010. http://www.kongressband.de/wcgalp2010/assets/pdf/0482.pdf
[2] Pfizer Animal Genetics. 2010. http://www.pfizeranimalgenetics.com/sites/PAG/Documents/50K%20Tech%20Summary.pdf
[3] Animal Genetics and Breeding Unit (AGBU). 2010.. http://agbu.une.edu.au/pdf/Pfizer_50K_September%202010.pdf

Industry breakdown of ΔG value derived from increased accuracy from genomic selection



Van Eenennaam, A. L., J.H. van der Werf, and M.E. Goddard. 2011. The economics of using DNA markers for beef bull selection in the seedstock sector. Journal of Animal Science. 89 (2) *In press*.

Value of improved selection response for beef seedstock sector due to DNA-test increase in index accuracy

Variable	Unit	Accuracy of DNA test used	Grass Index		Feedlot Index	
			Terminal	Maternal	Terminal	Maternal
Improvement in selection response	**%**	**Intermediate**	**29**	**46**	**94**	**95**
		High	**54**	**81**	**157**	**158**
Increased value derived from ΔG in commercial sires	$/ DNA test	Intermediate	45	69	118	170
		High	83	124	196	282
Increased value derived from ΔG in stud sires	$/ DNA test	Intermediate	160	203	421	506
		High	297	366	701	836
Total value per test to seedstock operator	**$/ DNA test**	**Intermediate**	**$ 204**	**$ 272**	**$ 539**	**$ 676**
		High	**$ 380**	**$ 490**	**$ 897**	**$1119**

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