Genomically-Enhanced EPDs: the Basics

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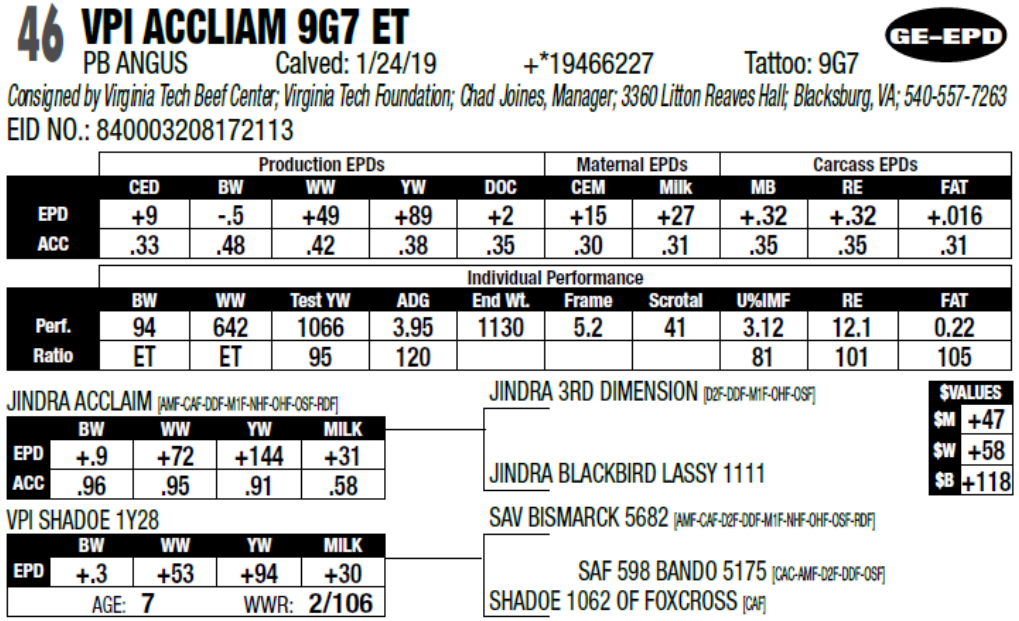
VIRGINIA TECH™

Bull Selection- Job #1

Most (all!) genetic progress is made through sire selection.

EPD = Expected Progeny Differences

- Estimate genetic value of an animal as parent
- Prediction of how an animal's progeny will perform compared to other animals in the same breed
- EPDs available for many important traits
- Calculated and made available through breed associations



46 VPI ACCLIAM 9G7 ET GE-EPD

PB ANGUS Calved: 1/24/19 +*19466227 Tattoo: 9G7

Consigned by Virginia Tech Beef Center; Virginia Tech Foundation; Chad Joines, Manager; 3360 Litton Reaves Hall; Blacksburg, VA; 540-557-7263

EID NO.: 840003208172113

	Production EPDs					Maternal EPDs		Carcass EPDs		
	CED	BW	WW	YW	DOC	CEM	Milk	MB	RE	FAT
EPD	+9	-.5	+49	+89	+2	+15	+27	+.32	+.32	+.016
ACC	.33	.48	.42	.38	.35	.30	.31	.35	.35	.31

	Individual Performance									
	BW	WW	Test YW	ADG	End Wt.	Frame	Scrotal	U%IMF	RE	FAT
Perf.	94	642	1066	3.95	1130	5.2	41	3.12	12.1	0.22
Ratio	ET	ET	95	120				81	101	105

JINDRA ACCLAIM [AMF-CAF-DDF-M1F-NHF-OHF-OSF-RDF]

	BW	WW	YW	MILK
EPD	+.9	+72	+144	+31
ACC	.96	.95	.91	.58

VPI SHADOE 1Y28

	BW	WW	YW	MILK
EPD	+.3	+53	+94	+30

AGE: 7 WWR: 2/106

JINDRA 3RD DIMENSION [D2F-DDF-M1F-OHF-OSF]

JINDRA BLACKBIRD LASSY 1111

SAV BISMARCK 5682 [AMF-CAF-D2F-DDF-M1F-NHF-OHF-OSF-RDF]

SAF 598 BANDO 5175 [CAC-AMF-D2F-DDF-OSF]

SHADOE 1062 OF FOXCROSS [CAF]

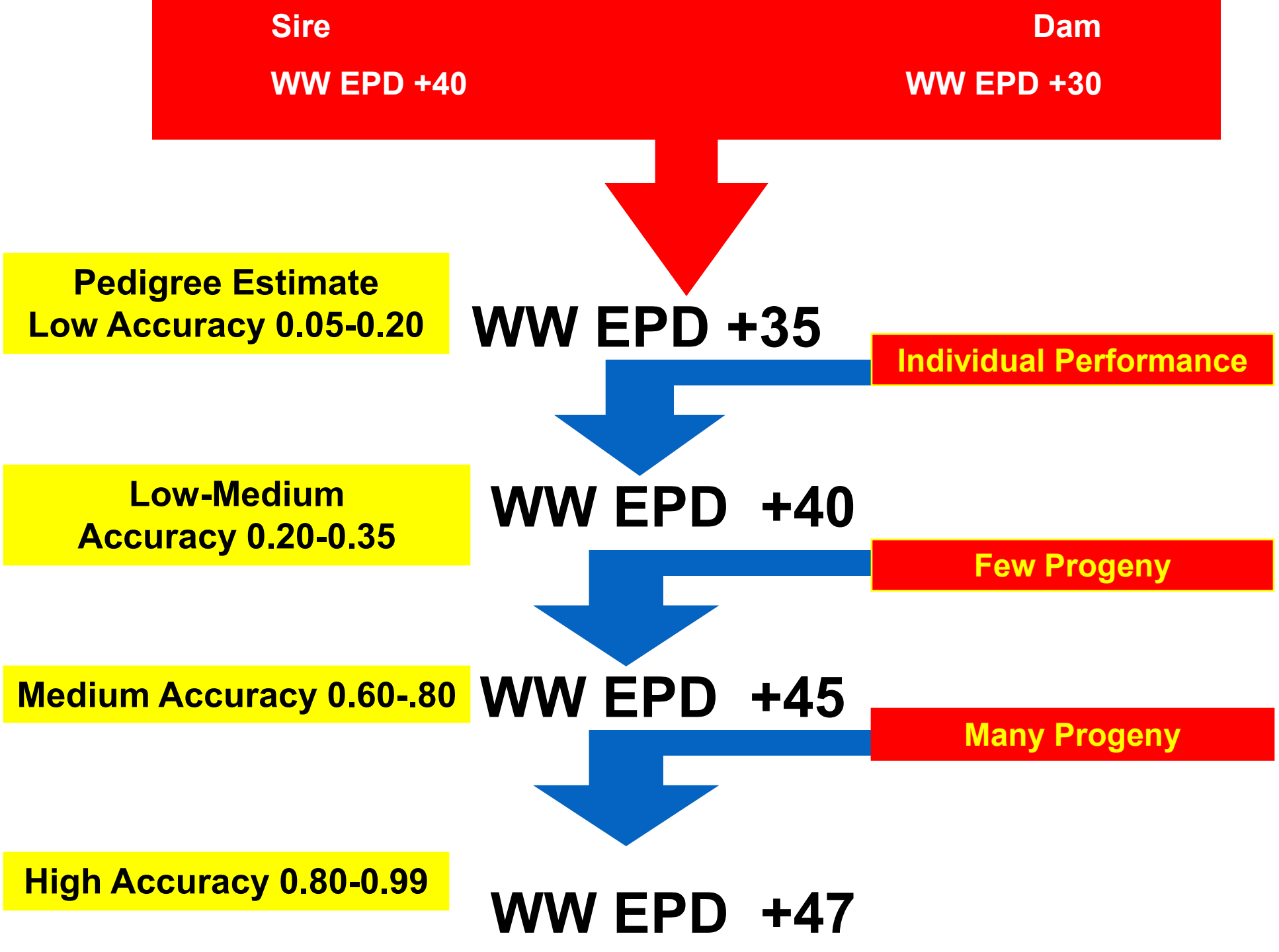
$VALUES	
$M	+47
$W	+58
$B	+118

How are EPDs different than actual performance records?

- Actual Performance Records – what did they weigh or measure? (Birth Weights, Weaning Weights, Feedlot ADG, Carcass Traits, etc.)
  - Actual performance records measure an animals performance
    - Influenced by the animals genetics
    - Influenced by the environment (feeding program/nutrition, season of the year, geographical location, etc.)
    - ……. so only a portion of an animals own actual performance is due to genetics (genetics are passed to offspring)
- EPDs
  - Estimate of genetics only – only reflect what will be passed to offspring
  - Based on actual records – but calculations remove the “non-genetic” parts of actual records

Calculating EPDs – how do we get the numbers?

- Performance Records (actual measurements)
  - Animal's own performance
  - Sire and Dam
  - Other relatives (siblings, half-sibs, cousins)
  - Progeny
- Pedigree relationships (close and distant relatives)
- Account for non-genetic factors
  - Management differences
  - Geographic location
- Genetic relationships between traits


Sire
WW EPD +40
Dam
WW EPD +30
Pedigree Estimate
Low Accuracy 0.05-0.20
WW EPD +35
Individual Performance
Low-Medium
Accuracy 0.20-0.35
WW EPD +40
Few Progeny
Medium Accuracy 0.60-.80
WW EPD +45
Many Progeny
High Accuracy 0.80-0.99
WW EPD +47

Challenges with bull selection

- Infrequent occurrence
- Decisions not immediately visible
- Young/unproven sires- accuracy

Possible Change

- EPDs are estimates of true value
- EPD +/- possible change gives an idea of how EPD could change
- Bull 1 WW 45 Acc 0.50
  - 68% of time true progeny difference between 37 and 53
  - 95% of time true progeny difference between 29 and 61
  - 99% of time true progeny difference between 11 and 69

Accuracy and Possible Change

Accuracy	CED	BW	WW	YW
.05	9.7	2.55	14.9	24.3
.10	9.2	2.42	14.1	23.0
.15	8.7	2.28	13.3	21.7
.20	8.2	2.15	12.6	20.5
.25	7.7	2.02	11.8	19.2
.30	7.2	1.88	11.0	17.9
.35	6.7	1.75	10.2	16.6
.40	6.2	1.61	9.4	15.4
.45	5.6	1.48	8.6	14.1
.50	5.1	1.34	7.9	12.8
.55	4.6	1.21	7.1	11.5
.60	4.1	1.08	6.3	10.2
.65	3.6	.94	5.5	9.0
.70	3.1	.81	4.7	7.7
.75	2.6	.67	3.9	6.4
.80	2.1	.54	3.1	5.1
.85	1.5	.40	2.4	3.8
.90	1.0	.27	1.6	2.6
.95	.5	.13	.8	1.3

www.angus.org

Possible Change

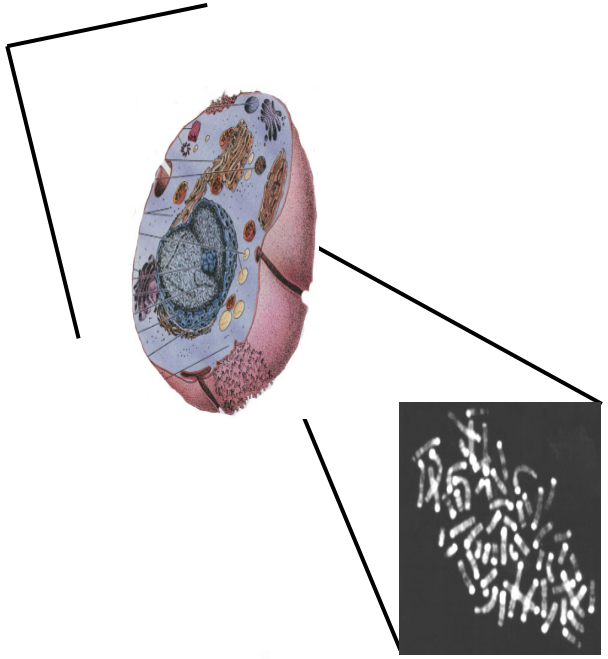
- Bull 1 WW 53 Acc 0.10
- Bull 2 WW 53 Acc 0.50
- Bull 3 WW 53 Acc 0.90

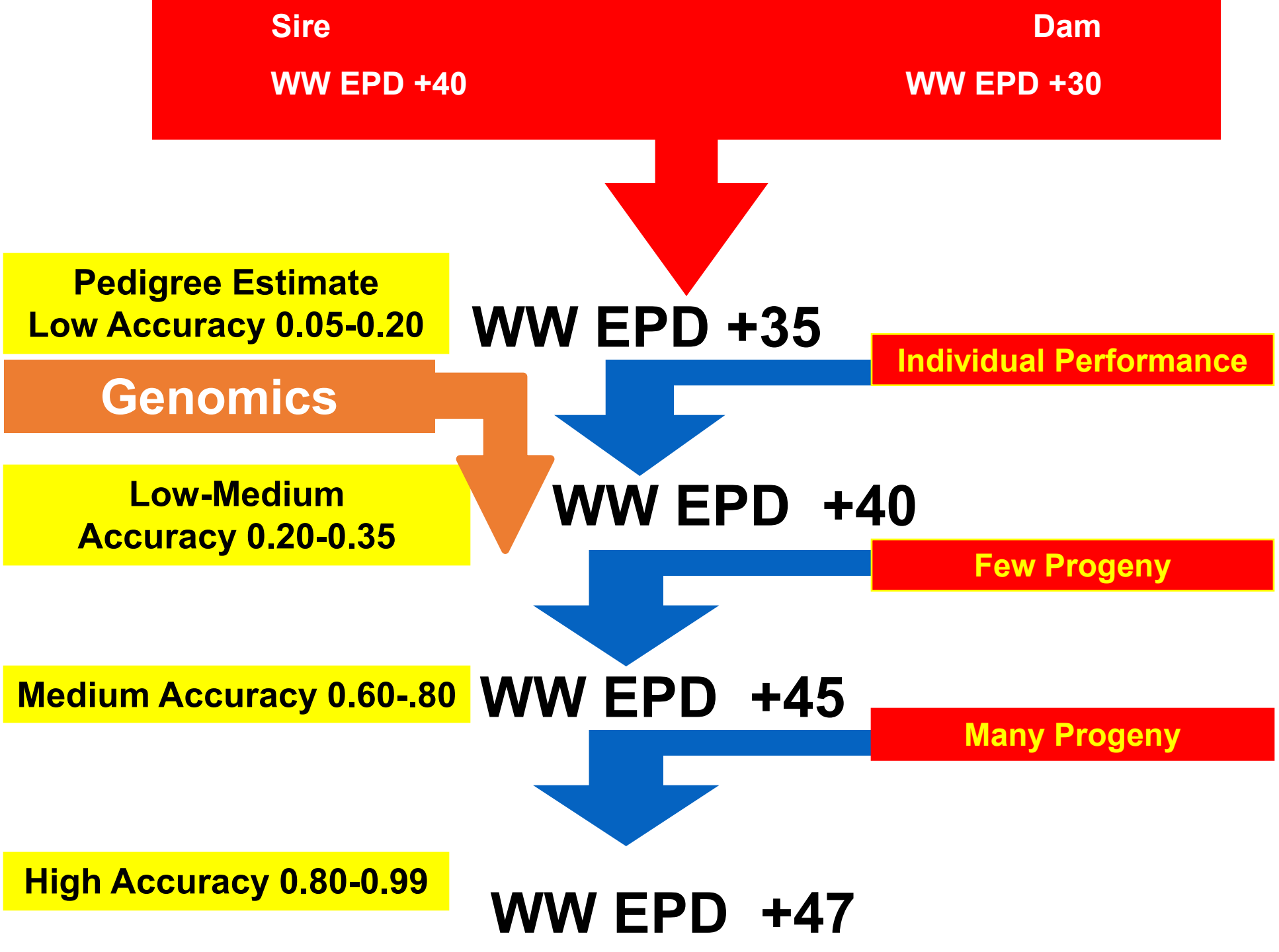
Possible change

Accuracy	CED	BW	WW	YW
.50	5.1	1.34	7.9	12.8
.90	1.0	.27	1.6	2.6

Top Pct	CED	BW	WW	YW
1%	+17	-3.1	+81	+143
2%	+16	-2.6	+78	+138
3%	+15	-2.2	+76	+133
4%	+14	-2.0	+74	+131
5%	+14	-1.8	+73	+128
10%	+12	-1.0	+68	+121
15%	+11	-.5	+65	+115
20%	+11	-.2	+63	+111
25%	+10	+.1	+61	+108
30%	+9	+.4	+59	+104
35%	+9	+.6	+57	+101
40%	+8	+.9	+56	+99
45%	+7	+1.1	+54	+96
50%	+7	+1.3	+53	+93
55%	+6	+1.5	+51	+90
60%	+5	+1.7	+50	+87
65%	+5	+2.0	+48	+84
70%	+4	+2.2	+46	+81
75%	+3	+2.5	+44	+78
80%	+2	+2.7	+42	+74
85%	+1	+3.1	+39	+69
90%	+0	+3.5	+35	+62
95%	-2	+4.2	+28	+49

What are Genomic Enhanced Estimated Breeding Values (GEBV)?

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Medium Accuracy 0.60-.80
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Many Progeny
High Accuracy 0.80-0.99
WW EPD +47

How are GEBVs Derived?

Reference population of animals with genotypes and phenotypes

Genotype animal from outside reference population

Use reference population to describe genetic merit of genotype of new animal – genomic test result, along with define genomic relationships

Use reference population to find SNPs of interest and associations with variation in performance

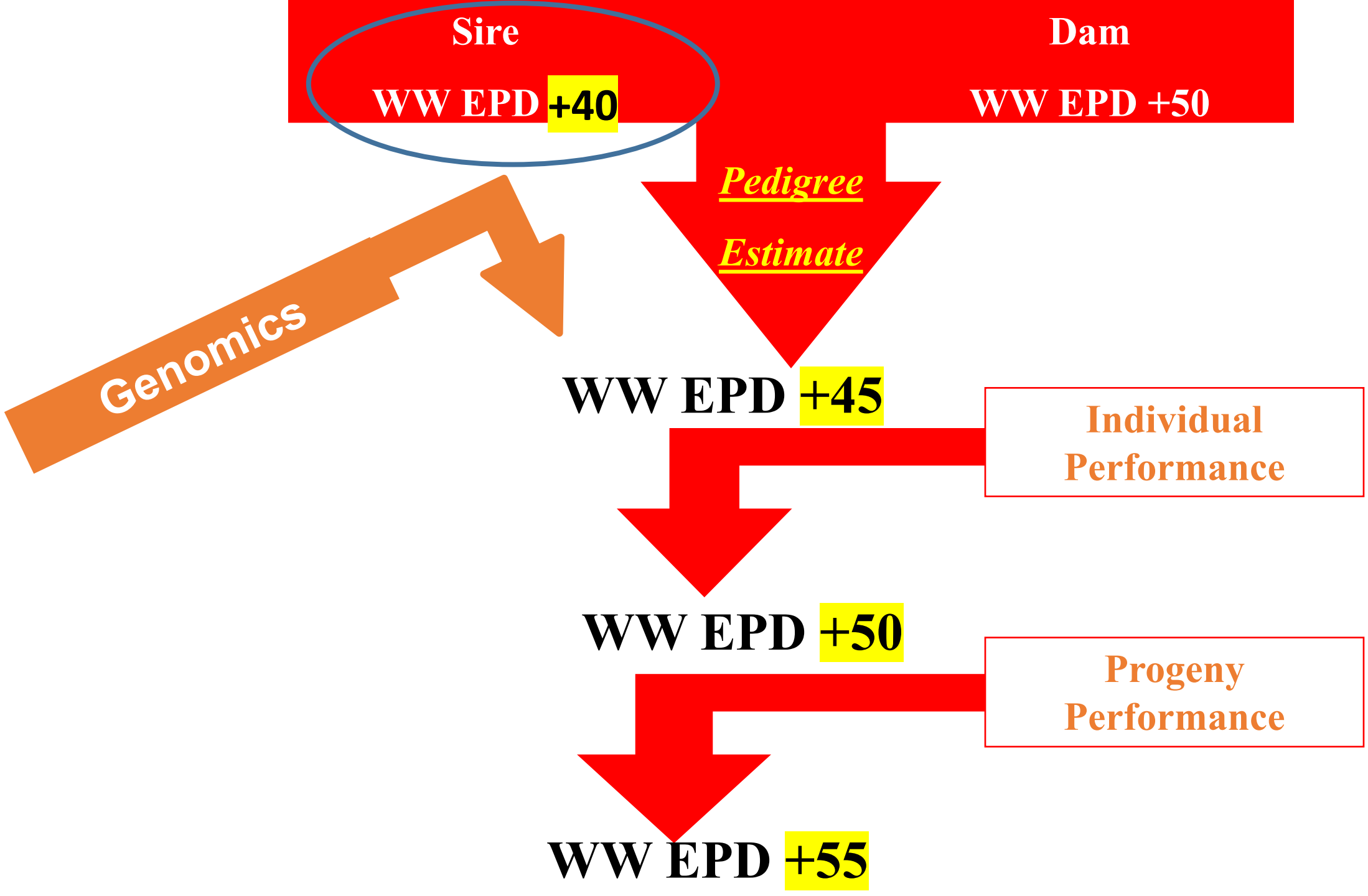
Genetic Improvement

$$\Delta G = \frac{accuracy * intensity * genetic\ variation}{generation\ interval}$$

- Accuracy
  - Correlation between the estimated and true breeding value
- Intensity
  - Superiority of the selected animals compared to flock average
- Genetic variation
  - Variation in breeding values within population
- Generation Interval
  - Average age of parents when offspring are born

Accuracy: Parentage Verification

- Pedigree serves as the foundation for EBV calculation
- Both sire and dam relevant


Sire
WW EPD +40
Dam
WW EPD +50
Pedigree
Estimate
Genomics
WW EPD +45
Individual Performance
WW EPD +50
Progeny Performance
WW EPD +55

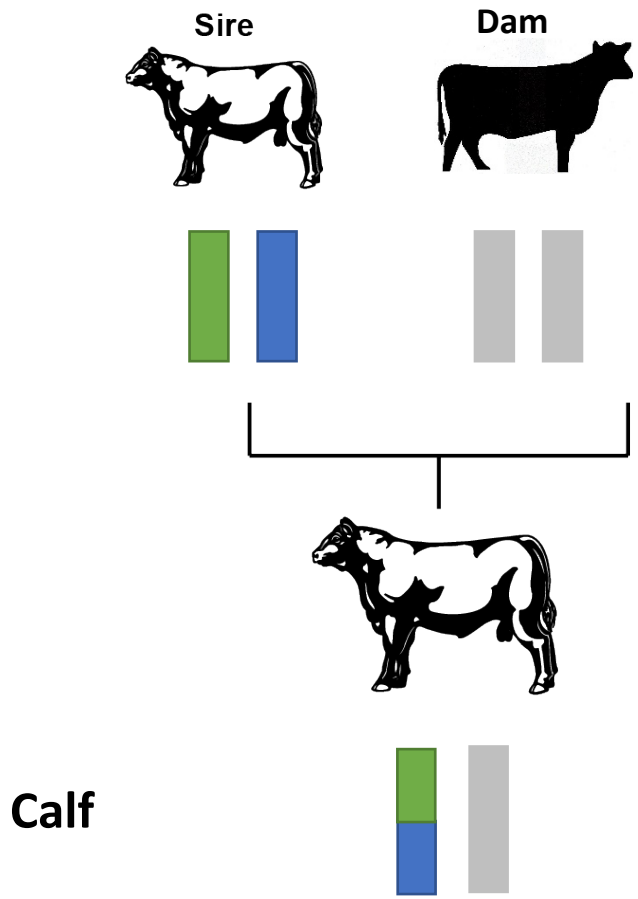
Accuracy: Parentage Verification

- Pedigree serves as the foundation for EPD calculation
- Both sire and dam relevant
- How do parentage errors occur?
  - AI vs. Natural service identification
  - AI semen ID
  - Multi-sire breeding groups
  - Record-keeping errors

Accuracy: Pedigree Lineage

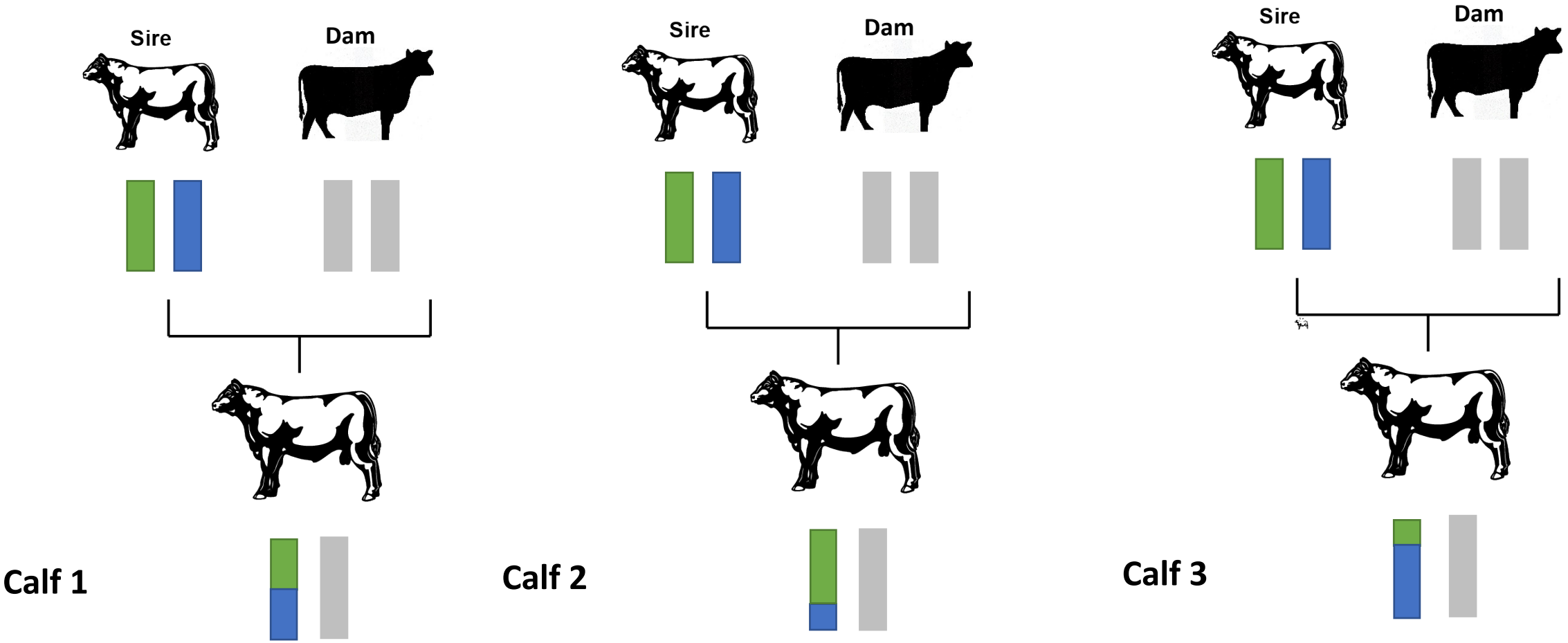
- Genomics allows for computation of the specific relationship, or DNA inheritance, between an individual animal and animals in its pedigree
- Historically, relationships obtained through pedigrees are average (or expected) values

Genetic Relationships



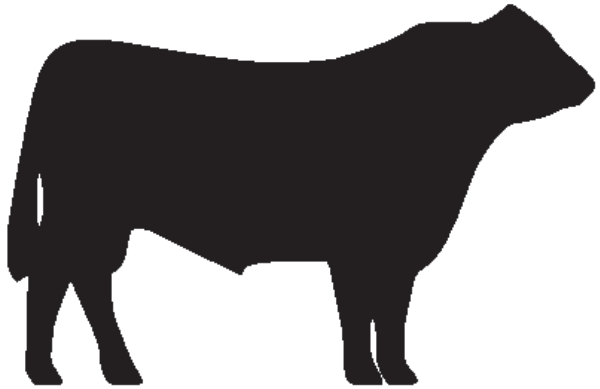
- Calf received ½ of its DNA from sire, ½ from dam
- Therefore, ¼ from paternal grandsire, ¼ from paternal granddam, etc. **on average**

Genetic Relationships



Angus Example

- Comparing 2 full sibling calves sired by VAR Reserve 1111
- Pedigree relationships indicate these calves have the same BW EPD
  - Calf A has BW EPD of 1.6
  - Calf B has BW EPD of 2.5
- Tracking pedigree and genomic relationships with male ancestors



Miller, AAA, 2018 Beef Improvement Federation

		Schearbrook Shoshone	AAA #7011424 [CAF-D2F-XF]
	VDAR Shoshone 548		AAA #9389965
		VDAR Polly 308	AAA 8720142
	AAR New Trend		AAA #9958634 [OSF]
		Candolier Forever 376	AAA #7501542
	Donna AAR74		AAA 8324606
		Donna 244 GDAR	AAA 7473425
Boyd New Day 8005			AAA #+13050780 [AMF-CAF-XF]
		N Bar Emulation EXT	AAA #10776479 [AMF-CAF-XF]
	Leachman Right Time		AAA #+11750711 [D2F-M1F-OSF]
		Leachman Erica 0025	AAA 11382472
	SVF Forever Lady 57D		AAA 12133159
		Skarship Saratoga	AAA #+10351162 [OHF]
	SVF Forever Lady 1128		AAA +11699928
		Forever Lady 163 GDAR	AAA #9995297
B/R New Day 454			AAA #14675445 [DDC-AMF-XF]
		VDAR New Trend 315	AAA #11105489 [AMF-CAF-XF]
	B/R New Design 036		AAA #11418151 [DDC-AMF-XF]
		B/R Blackcap Empress 76	AAA 10970296
	B/R New Design 323		AAA #11928774 [DDC]
		VDAR Pine Drive 251	AAA 10960004
	B/R Ruby of Tiffany 155		AAA 11563271
		Tiffany BR	AAA 10099738
B/R Ruby 1224			AAA 13879911 [DDC]
		Traveler 124 GDAR	AAA #9995349
	SVF Gdar 216 LTD		AAA #+12309326
		GDAR Forever Lady 718	AAA +10989615
	HF Ruby 036-951		AAA +13324497
		B/R New Design 036	AAA #11418151 [DDC-AMF-XF]
	B/R Ruby 624		AAA 12569809
		B/R Ruby 492	AAA 12103654
SIRE	VAR Reserve 1111		AAA +16916944 [AMF-CAF-XF]

1/64 Expected Relationship of Schearbrook Shoshone to calf

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Ancestor	BW EPD	Pedigree Relationship	Difference in Genomic Relationships	Deviation of Genomic from Pedigree
G A R Grid Maker	5.5	0.0625	0.0297	0.48
Ideal 1418 of 8103 4286	5	0.0156	-0.0161	1.03
Rito 2100 G D A R	4.6	0.0156	0.0332	2.13
Schearbrook Shoshone	4.3	0.0508	0.0110	0.22
V D A R New Trend 315	3.5	0.0859	0.0367	0.43
B/R New Frontier 095	2.9	0.2500	-0.0093	0.04
G D A R Traveler 044	2.4	0.0313	-0.0206	0.66
B/R Ruby 1224	2.3	0.1250	0.0517	0.41
Boyd New Day 8005	2.1	0.1250	0.0150	0.12
Altune of Conanga 6104	2	0.0625	-0.0059	0.09
B/R New Design 036	1.5	0.1875	0.0326	0.17
P S Power Play	1.4	0.0527	-0.0053	0.10
N Bar Emulation EXT	1.4	0.0156	0.0055	0.35
G A R Precision 1680	1.2	0.1563	-0.0361	0.23
Riverbend Blackbird 4301	1.1	0.1250	-0.0047	0.04
Connealy Dateline	0.7	0.1563	-0.0457	0.29
V A R Reserve 1111	0.7	0.5000	0.0217	0.04
S A F Fame	0.6	0.0156	-0.0016	0.10
S A F Focus of E R	0	0.0313	-0.0152	0.48
Q A S Traveler 23-4	-0.9	0.0469	-0.0244	0.52
Tehama Bando 155	-1.5	0.0938	-0.0342	0.36
Band 234 of Ideal 3163	-1.6	0.0469	-0.0230	0.49

VIRGINIA TECH

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Boyd New Day 8005	2.1	0.1250	0.0150	0.12
Altune of Conanga 6104	2	0.0625	-0.0059	0.09
Average		**0.08**	**.01**	**0.15**

Calf with higher BW EPD is 15% **MORE** related to the **higher** BW EPD Ancestors

Ancestor	BW EPD	Pedigree Relationship	Difference in Genomic Relationships	Deviation of Genomic from Pedigree
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Tehama Bando 155	-1.5	0.0938	-0.0342	0.36
Band 234 of Ideal 3163	-1.6	0.0469	-0.0230	0.49
Average		**0.12**	**-.02**	**-.13**

Calf with higher BW EPD is 13% **LESS** related to the **lower** BW EPD Ancestors

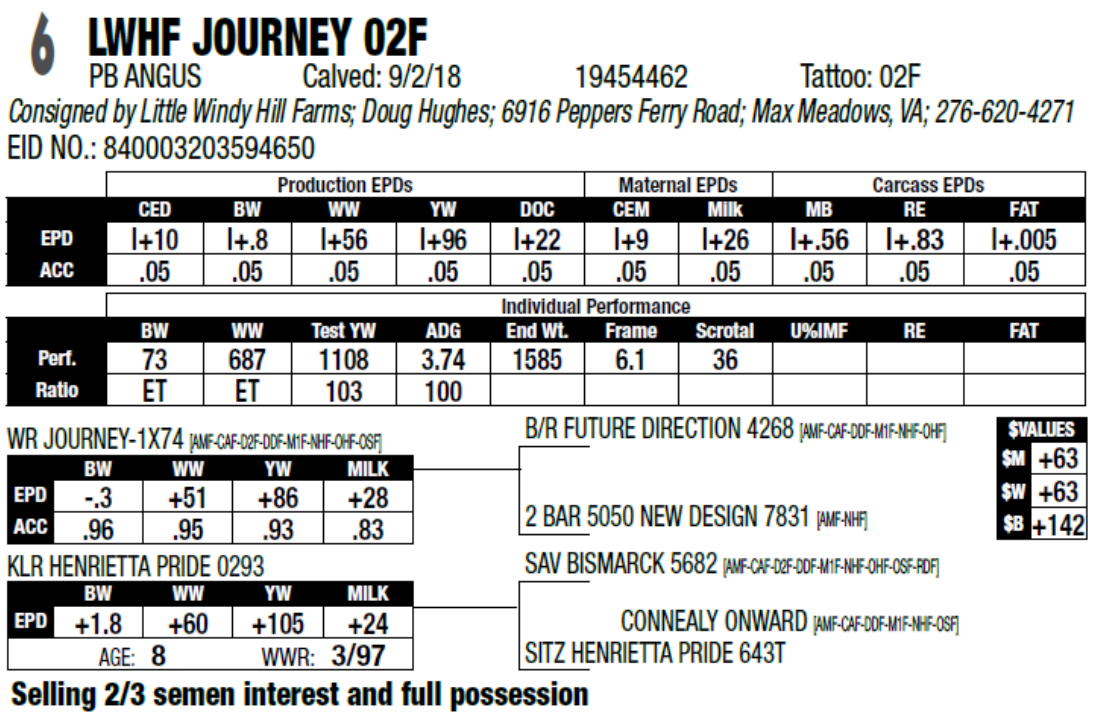
Accuracy: Traits of Economic Importance

- Traits expressed in one sex
  - Heifer pregnancy
  - Stayability
- Traits measured later in life
  - Longevity
  - Stayability
- Expensive or difficult traits to measure
  - Feed efficiency
  - End product- tenderness, eating quality
- Lowly heritable traits
  - Reproduction
  - Fitness
  - Disease/health

Genomics: Causative Genes

- Polled/Horned
- Coat Color
- Genetic Defects

Value of genomics- ET beef bull example



6 LWHF JOURNEY 02F

PB ANGUS Calved: 9/2/18 19454462 Tattoo: 02F

Consigned by Little Windy Hill Farms; Doug Hughes; 6916 Peppers Ferry Road; Max Meadows, VA; 276-620-4271

EID NO.: 840003203594650

	Production EPDs					Maternal EPDs		Carcass EPDs		
	CED	BW	WW	YW	DOC	CEM	Milk	MB	RE	FAT
EPD	I+10	I+.8	I+56	I+96	I+22	I+9	I+26	I+.56	I+.83	I+.005
ACC	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05

	Individual Performance									
	BW	WW	Test YW	ADG	End Wt.	Frame	Scrotal	U%IMF	RE	FAT
Perf.	73	687	1108	3.74	1585	6.1	36			
Ratio	ET	ET	103	100						

WR JOURNEY-1X74 [AMF-CAF-D2F-DDF-M1F-NHF-OHF-OSF]

	BW	WW	YW	MILK
EPD	-.3	+51	+86	+28
ACC	.96	.95	.93	.83

B/R FUTURE DIRECTION 4268 [AMF-CAF-DDF-M1F-NHF-OHF]

2 BAR 5050 NEW DESIGN 7831 [AMF-NHF]

KLR HENRIETTA PRIDE 0293

	BW	WW	YW	MILK
EPD	+1.8	+60	+105	+24

AGE: 8 WWR: 3/97

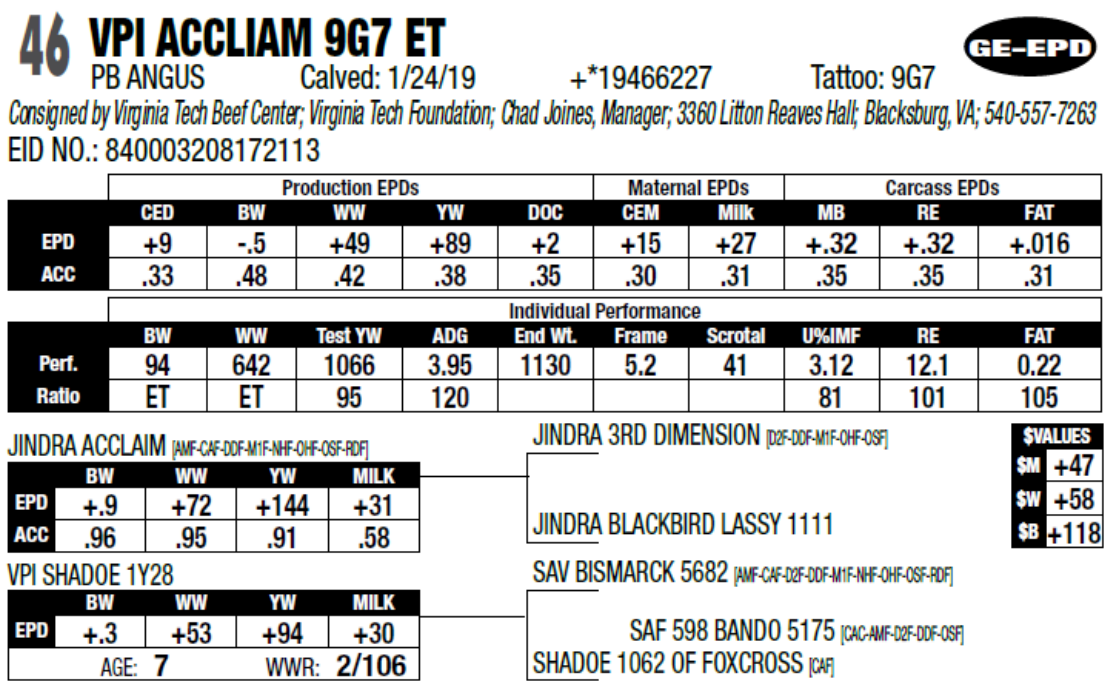
SAV BISMARCK 5682 [AMF-CAF-D2F-DDF-M1F-NHF-OHF-OSF-RDF]

CONNEALY ONWARD [AMF-CAF-DDF-M1F-NHF-OSF]

SITZ HENRIETTA PRIDE 643T

$VALUES	
$M	+63
$W	+63
$B	+142

Selling 2/3 semen interest and full possession



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JINDRA 3RD DIMENSION [D2F-DDF-M1F-OHF-OSF]

JINDRA BLACKBIRD LASSY 1111

VPI SHADOE 1Y28

	BW	WW	YW	MILK
EPD	+.3	+53	+94	+30

AGE: 7 WWR: 2/106

SAV BISMARCK 5682 [AMF-CAF-D2F-DDF-M1F-NHF-OHF-OSF-RDF]

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SHADOE 1062 OF FOXCROSS [CAF]

$VALUES	
$M	+47
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$B	+118

- Both bulls top ~25% breed for CED EPD
- Lot 6- Acc .05 = CE EPD range +1 to +19
- Lot 46- Acc .33 = CE EPD range +4 to +14 (good as we will do on Acc with a young, unproven bull)

Misconceptions About Genomics

- Reduces need for collecting phenotypes
  - Phenotypes necessary for association with SNPs
  - Need for even more phenotypes!
  - Lifetime performance records remain important
- Genotyping improves EPD
  - Estimate of genetic merit may increase or decrease
- Only genotype best animals
  - Advantages of genomics best realized when large numbers genotyped and have phenotypes
- Need for genotyping will decline after reference population is established
  - Need continue over time to maintain closeness of genetic relationships (further “away” from relatives decreases value of genomic information)

Examples: Benefits of Genomics

- Improved accuracy of EPD estimate in young animals
- Differentiating full sibs or ET calves
- Keep/cull decisions on bull calves earlier in life
- Animals with issues/challenges to their data or contemporary group structure

Influence of Information on EPDs and Accuracy

Yearling Angus Bull- pedigree + own CE, BW, WW, YW (lots of valid data behind bull)

	CED EPD	BW EPD	WW EPD	YW EPD	Milk EPD
	+11	**+0.3**	**+71**	**+113**	**+34**
	0.28	0.36	0.28	0.27	0.15

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	CED EPD	BW EPD	WW EPD	YW EPD	Milk EPD
	+11	+0.3	+71	+113	+34
	0.28	0.36	0.28	0.27	0.15
+ genomics	+8	+0.9	+73	+118	+35
	0.35	0.42	0.32	0.35	0.18

Influence of Information on EPDs and Accuracy

Yearling SimAngus Bull- pedigree + own CE, BW, WW, YW (smaller amount of data)

	CED EPD	BW EPD	WW EPD	YW EPD	Milk EPD
	+10.2	+0.6	+61	+98	+26
	0.11	0.12	0.10	0.10	0.10

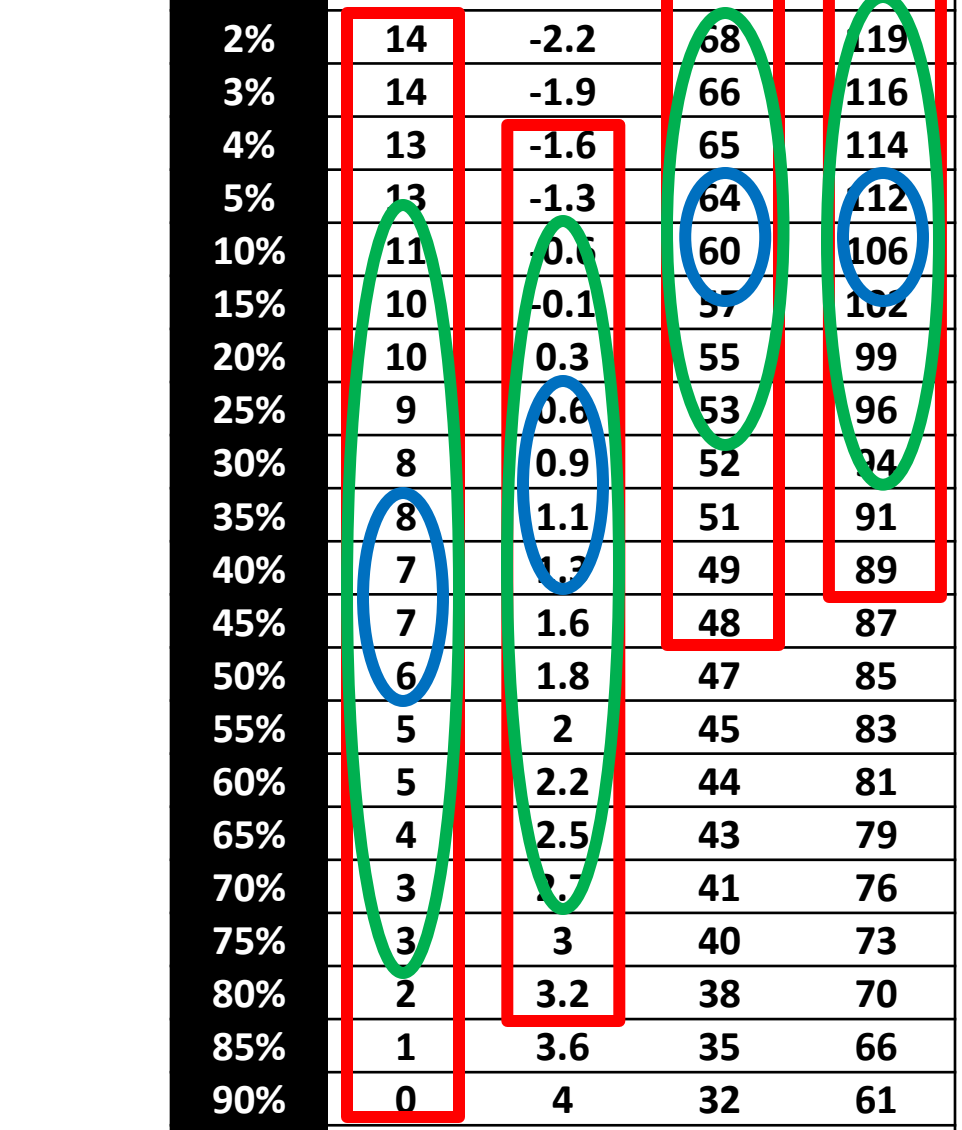
Influence of Information on EPDs and Accuracy

Yearling SimAngus Bull- pedigree + own CE, BW, WW, YW (smaller amount of data)

	CED EPD	BW EPD	WW EPD	YW EPD	Milk EPD
	+10.2	+0.6	+61	+98	+26
	0.11	0.12	0.10	0.10	0.10
+ genomics	+9.5	+1.2	+64	+106	+24
	0.20	0.30	0.23	0.26	0.15

VIRGINIA TECH

Top Pct	CED	BW	WW	YW
1%	15	-2.9	71	124
2%	14	-2.2	68	119
3%	14	-1.9	66	116
4%	13	-1.6	65	114
5%	13	-1.3	64	112
10%	11	-0.6	60	106
15%	10	-0.1	57	102
20%	10	0.3	55	99
25%	9	0.6	53	96
30%	8	0.9	52	94
35%	8	1.1	51	91
40%	7	1.3	49	89
45%	7	1.6	48	87
50%	6	1.8	47	85
55%	5	2	45	83
60%	5	2.2	44	81
65%	4	2.5	43	79
70%	3	2.7	41	76
75%	3	3	40	73
80%	2	3.2	38	70
85%	1	3.6	35	66
90%	0	4	32	61
95%	-3	4.7	27	51



Accuracy 0.05-0.10

Accuracy 0.29-0.35

Accuracies >0.90

Value of Genomics- Beef

Table 1. Progeny equivalents (PE) – Carcass trait PE equate to actual carcass harvest data not ultrasound scan equivalents.

Trait	PE	Trait	PE
Calving Ease Direct	26	Heifer Pregnancy	17
Birth Weight	23	Calving Ease Maternal	20
Weaning Weight	27	Milk	36
Yearling Weight	23	Mature Weight	15
Dry Matter Intake	12	Mature Height	9
Yearling Height	17	Carcass Weight	15
Scrotal Circumference	15	Carcass Marbling	11
Docility	12	Carcass Ribeye	17
Claw Angle	10	Carcass Fat	14
Foot Angle	10		

AAA, Angus Genetics 2018

Bull Selection- Job #1

Most (all!) genetic progress is made through sire selection.

GENOMICS DOES NOT CHANGE HOW WE USE EPDs- JUST ENHANCES OUR CONFIDENCE IN THE VALUES!

- Have a plan! Concentrate on traits which pay the bills! (capitalize on strengths, improve weaknesses)
- Do your homework! (before looking at the bulls or attending sale)
- Bull purchase is an investment!

Commercial Herd Genomic Test

- Use same technology as seedstock genomic tests
- Applicable to commercial crossbred heifers and feeder steers

Igenity Beef

- Genomic profile designed for crossbred commercial cattle
  - Results reported as Igenity Scores (1-10)
- Maternal: Birth weight, calving ease direct, calving ease maternal, stayability, heifer pregnancy, docility, and milk
- Performance: Residual feed intake, average daily gain, weaning weight, and yearling weight
- Carcass: Tenderness, marbling, ribeye area, fat thickness, and hot carcass weight
- Parentage
- Cost $29

GeneMax Advantage

- Genomic profile designed for commercial cattle >75% Angus
  - Results- economic index scores, individual genomic trait scores
- Cow Advantage – Predicts differences in profitability from heifer development, pregnancy and calving, to the sale of weaned progeny, Calving Ease Total Maternal, Weaning Weight, Milk, Heifer Pregnancy, Mature Weight
- Feeder Advantage – Predicts differences in net return of feeder calf progeny due to growth, feed efficiency and CAB carcass merit, Gain, Carcass Weight, Marbling, Ribeye Area, Fat
- Total Advantage – Predicts differences in profitability from genetic merit across all economically relevant traits captured in the Cow and Feeder Advantage index scores
- Sire verification
- Cost $28

Key Points

- Genomics enhances selection largely through enhanced accuracy of EPDs earlier in life
- Performance data remains the foundation!!!
- DNA collection will not replace our need for record books, scales, and other measurement tools