The Ten-Year Genomics Report Card

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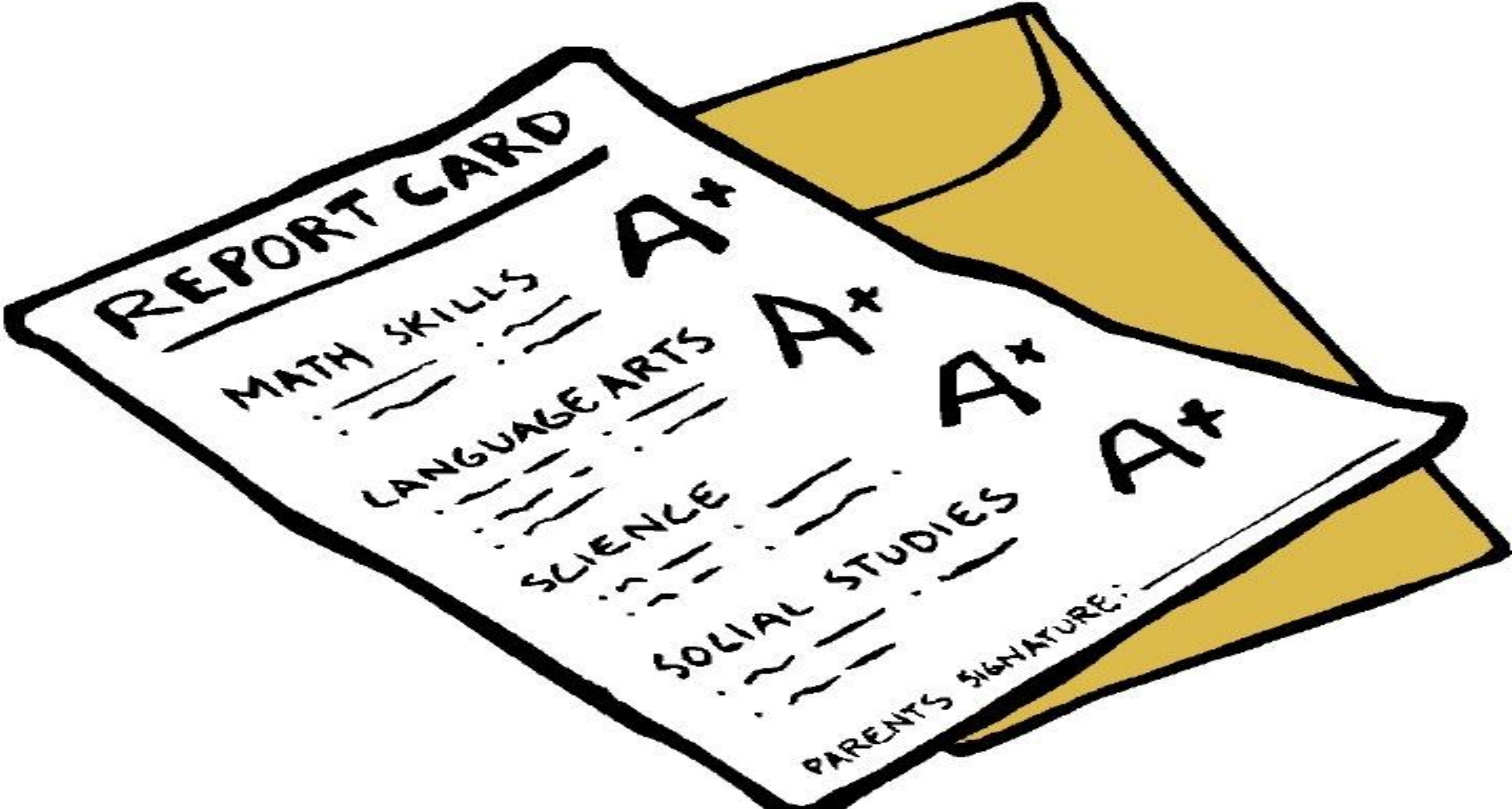
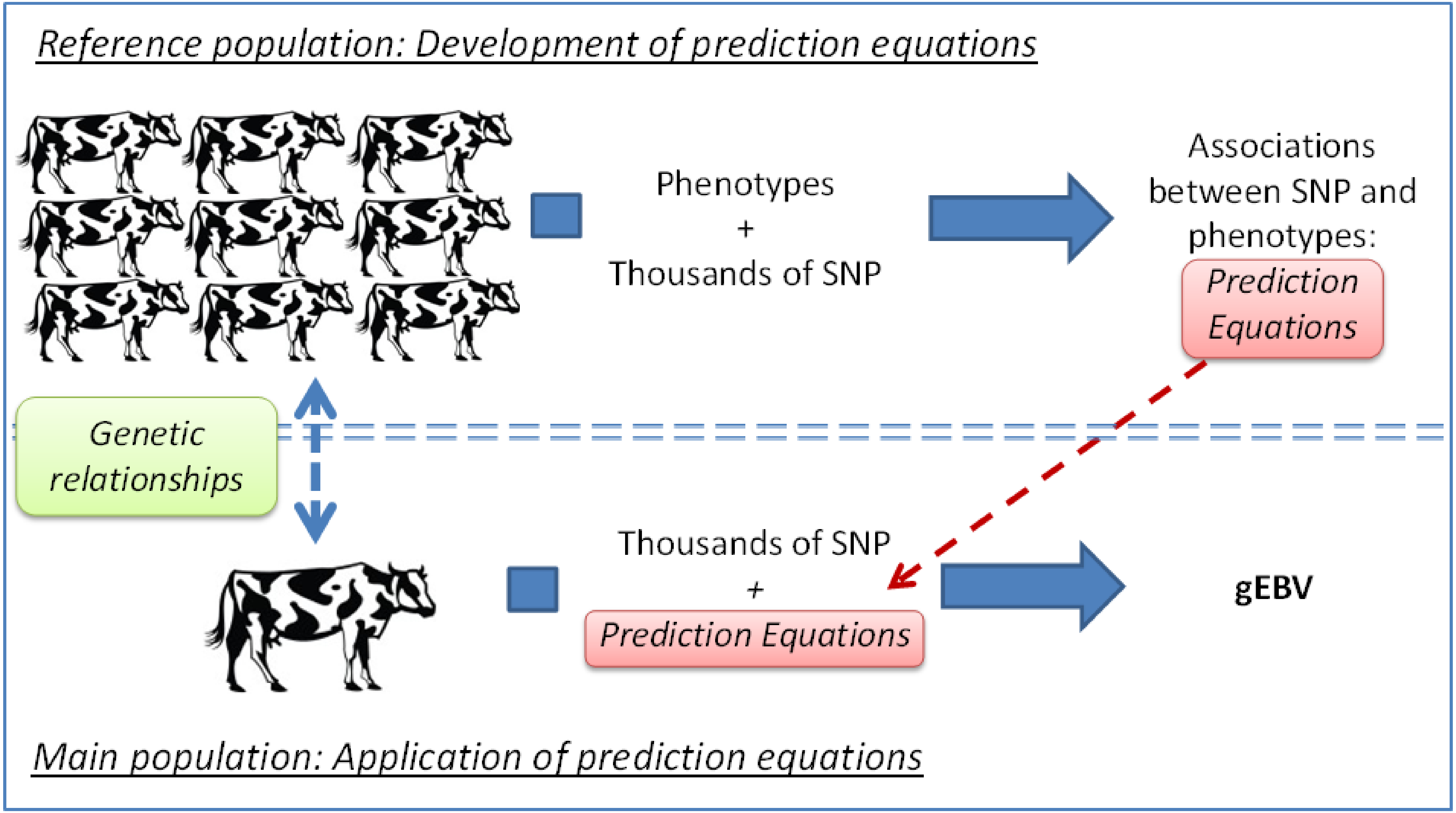
VP, Research & Innovation, Semex

National Genetics Conference. Appleton, Wisconsin (June 26-27, 2019)


REPORT CARD
MATH SKILLS
A+
LANGUAGE ARTS
A+
SCIENCE
A+
SOCIAL STUDIES
A+
PARENTS SIGNATURE:

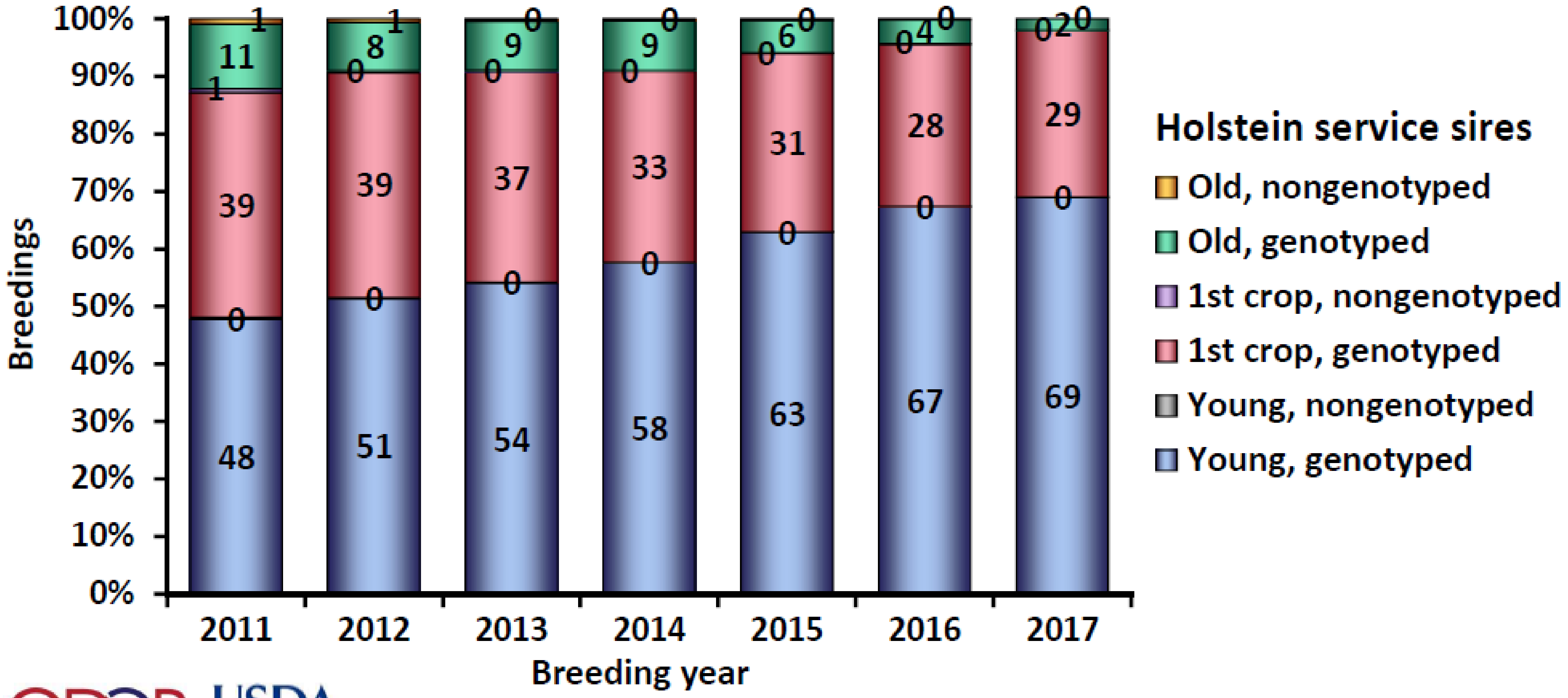
Subject	Credits	Objective
Genomic Evaluation	**6**	• **Provide *relatively* accurate genomic rankings**
Genetic Improvement	**6**	• **Make faster genetic improvement**
On-Farm Testing	**6**	• **Develop genomic tests for on-farm use**
Genetic Diversity	**3**	• **Preserve genetic variation for future use**
Understanding Genotype to Phenotype	**3**	• **Identify genotypes that change phenotype**
Meeting Consumer Expectations	**6**	• **Produce products that consumers value**

Subject	Grade	Comments
Genomic Evaluation		

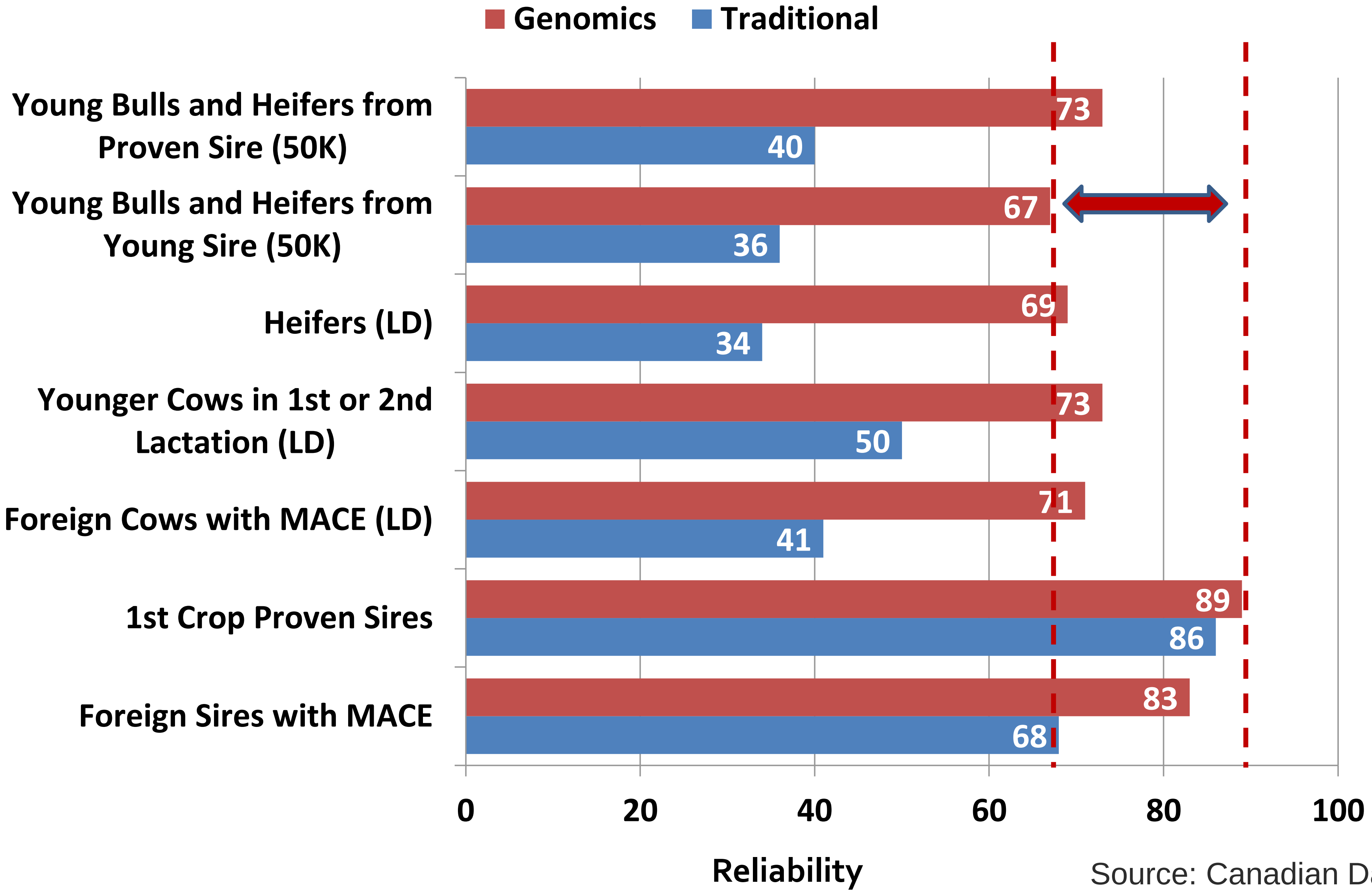


Source: Kor Oldenbroek and Liesbeth van der Waaij, 2015. Textbook Animal Breeding and Genetics for BSc students. Centre for Genetic Resources The Netherlands and Animal Breeding and Genomics Centre, 2015.

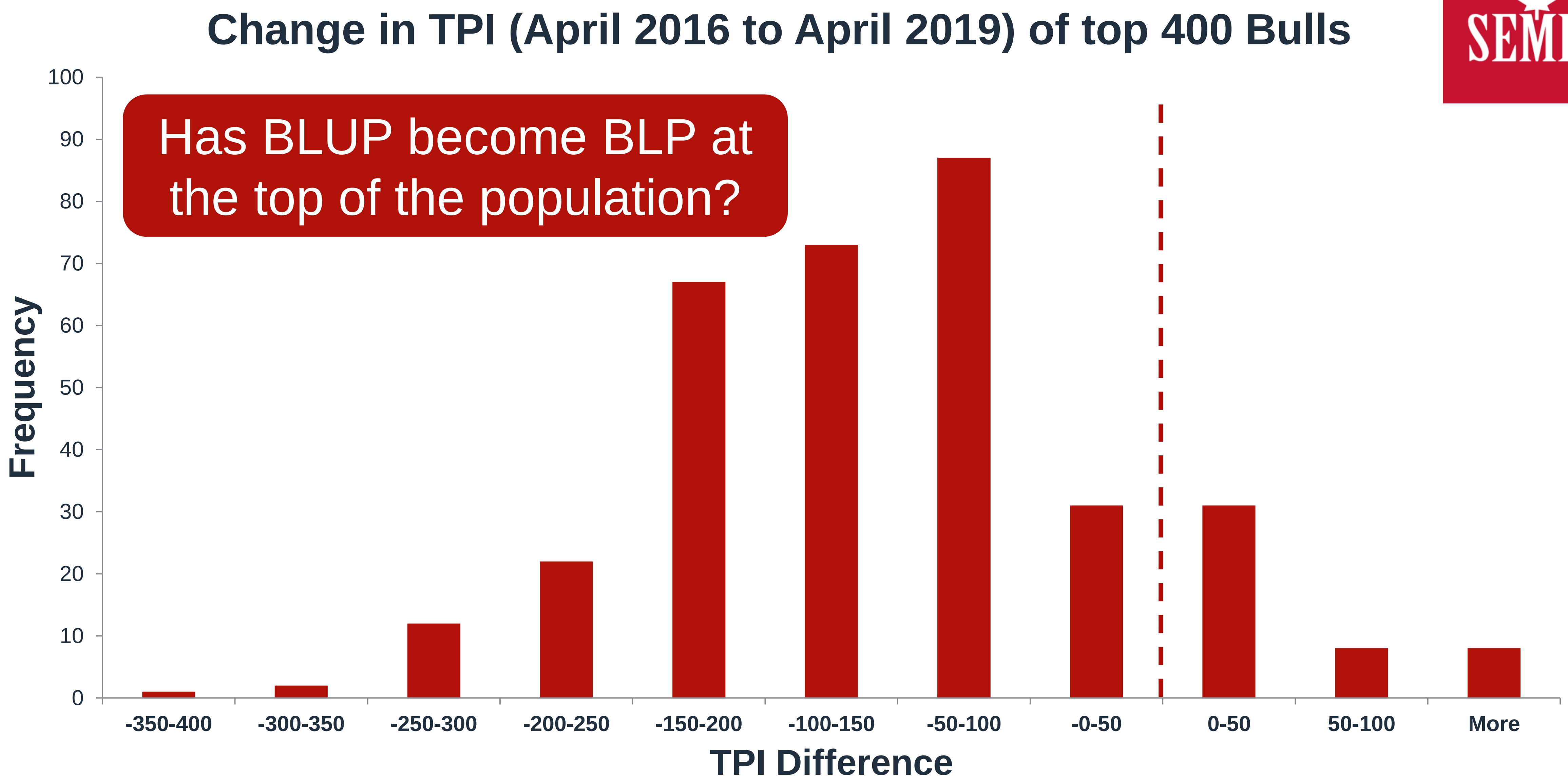
AI breedings to genomic bulls



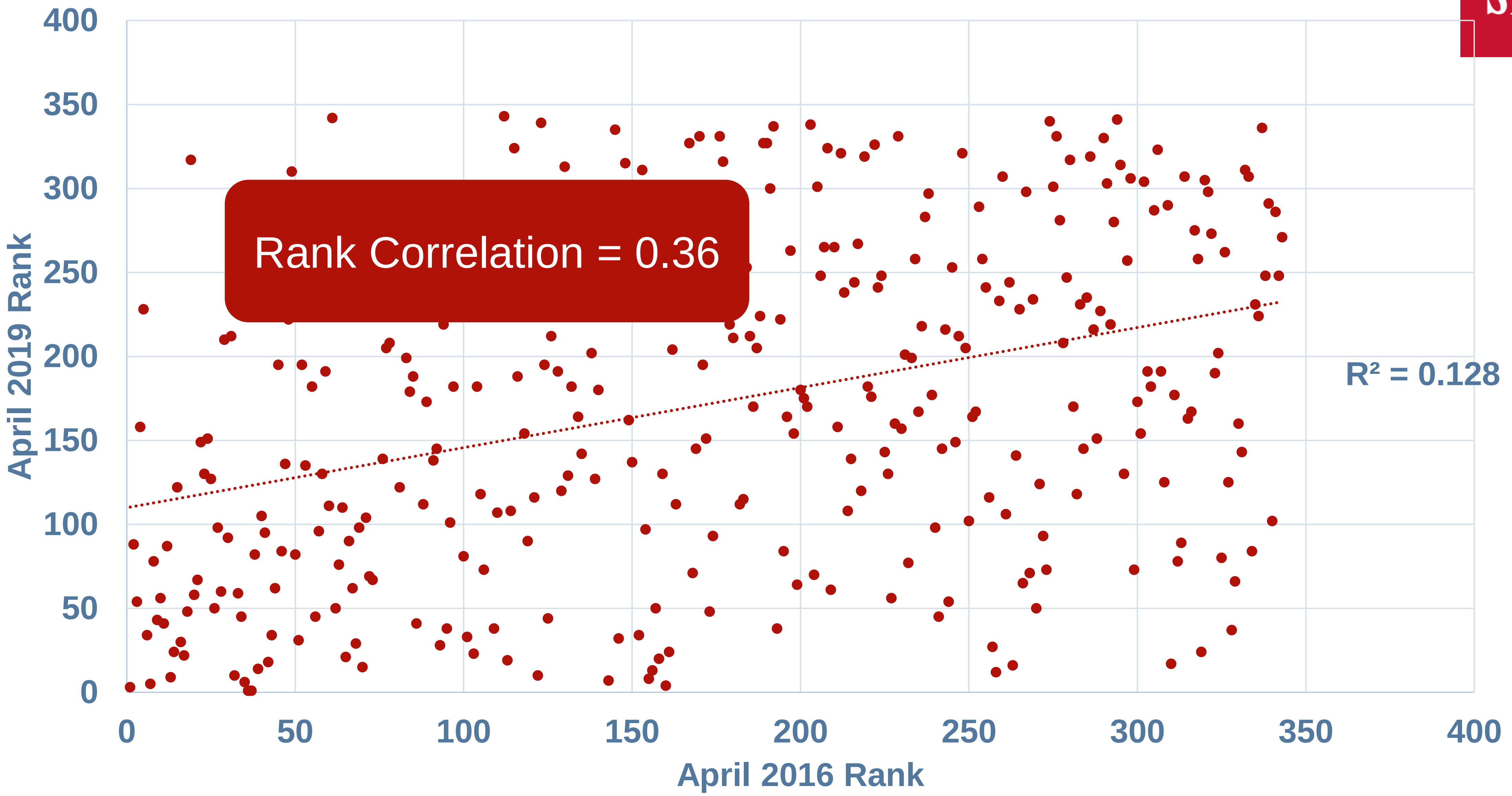
Gain in Reliability with Genomics



Source: Canadian Dairy Network


Change in TPI (April 2016 to April 2019) of top 400 Bulls
Has BLUP become BLP at the top of the population?
Frequency
100
90
80
70
60
50
40
30
20
10
0
-350-400
-300-350
-250-300
-200-250
-150-200
-100-150
-50-100
-0-50
0-50
50-100
More
TPI Difference

Top 400 TPI bulls in Apr. 2016 (vs. Apr. 2019 rank)



Subject	Grade	Comments
Genomic Evaluation	*A-*	• *Application of theory relatively quick* • *Very quick uptake of new technology!* • *Perhaps too much instability in top animals*

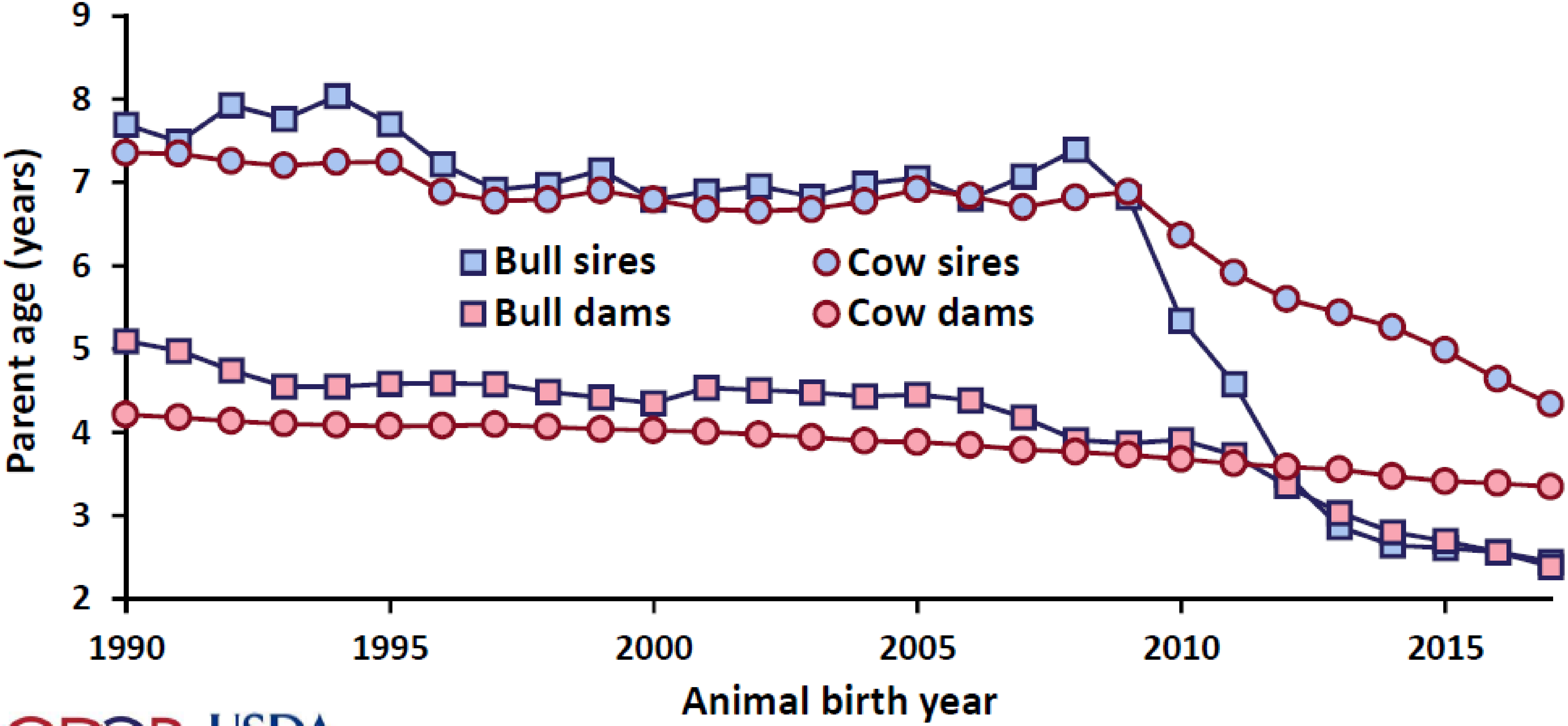
Subject	Grade	Comments
Genomic Evaluation	A-	• Application of theory relatively quickly • Very quick uptake of new technology! • Perhaps too much instability in top animals
Genetic Improvement		

Genetic Improvement

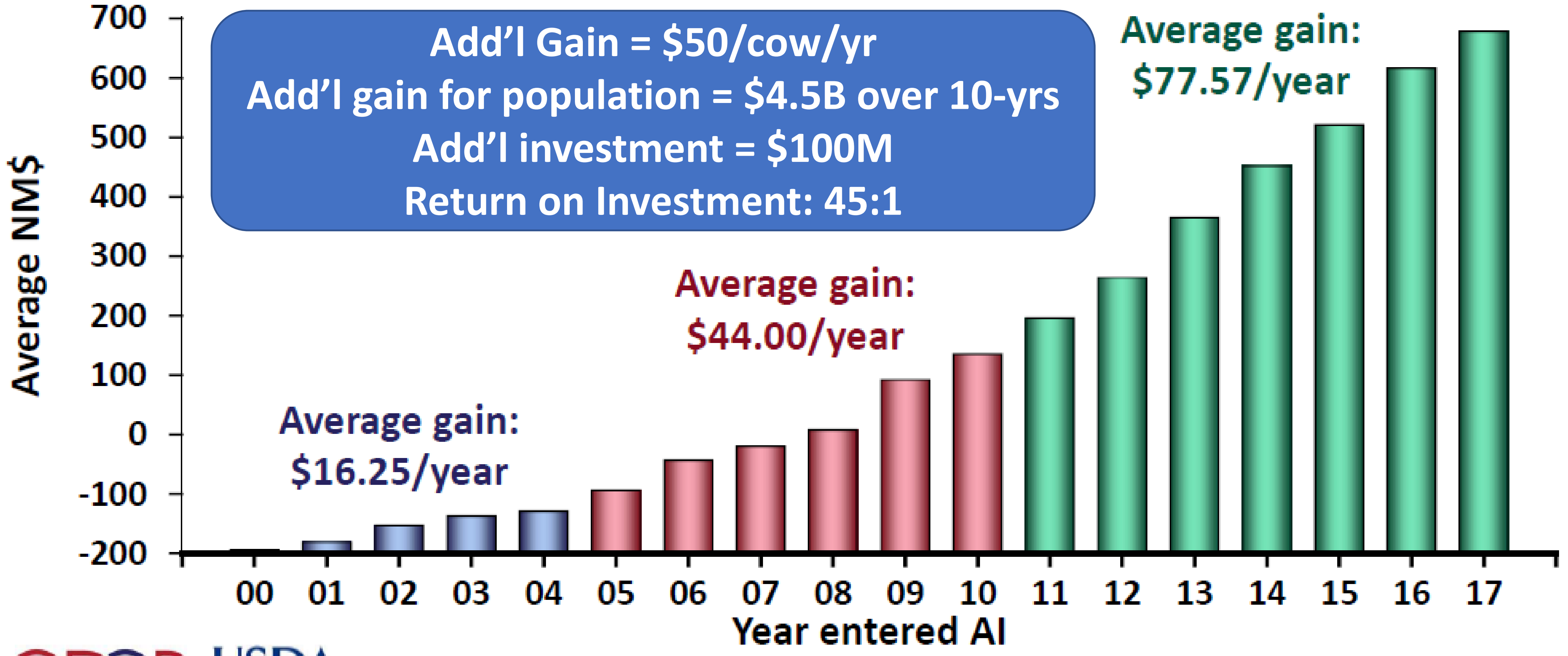
$$\Delta G = i * r * \sigma g / L$$

ΔG = genetic progress per year
i = intensity of selection (% of selection candidates retained as parents)
r = accuracy of selection (the square root of reliability)
σg = amount of genetic variation in the population
L = generation interval (age of parents when replacement progeny are born)

Generation interval – Holstein

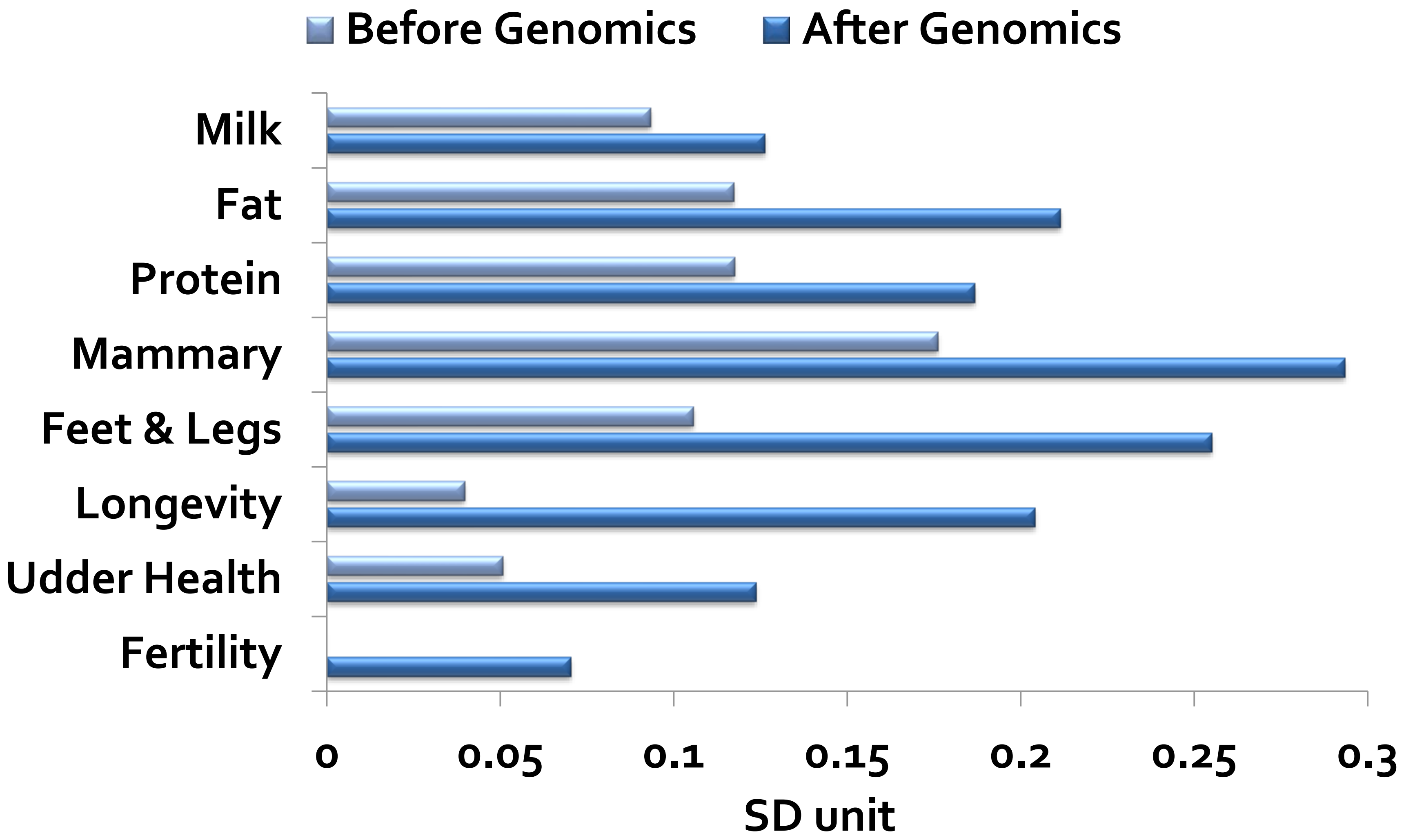


Genetic merit of marketed Holstein bulls



CDCB COUNCIL ON DAIRY CATTLE BREEDING USDA

Annual Genetic Progress – Major Traits

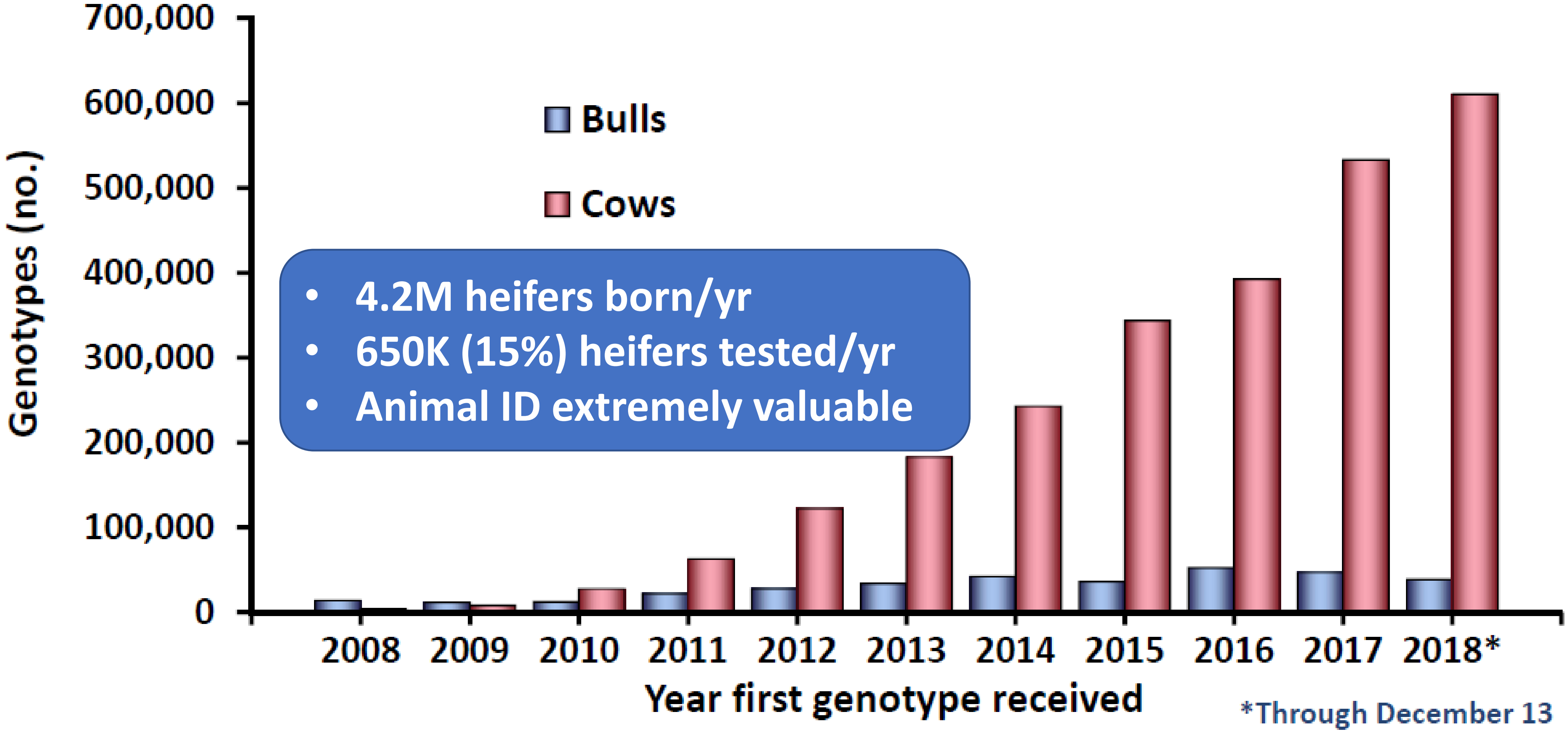


Source: Canadian Dairy Network

Subject	Grade	Comments
Genomic Evaluation	A-	• Application of theory relatively quickly • Very quick uptake of new technology! • Perhaps too much instability in top animals
Genetic Improvement	A+	• Doubled or tripled genetic progress! • Most significant progress on low h^2 traits • Great return on investment!

Subject	Grade	Comments
Genomic Evaluation	A-	• Application of theory relatively quickly • Very quick uptake of new technology! • Perhaps too much instability in top animals
Genetic Improvement	A+	• Doubled or tripled genetic progress! • Significant progress on low h^2 traits • Great return on investment!
On-Farm Testing		

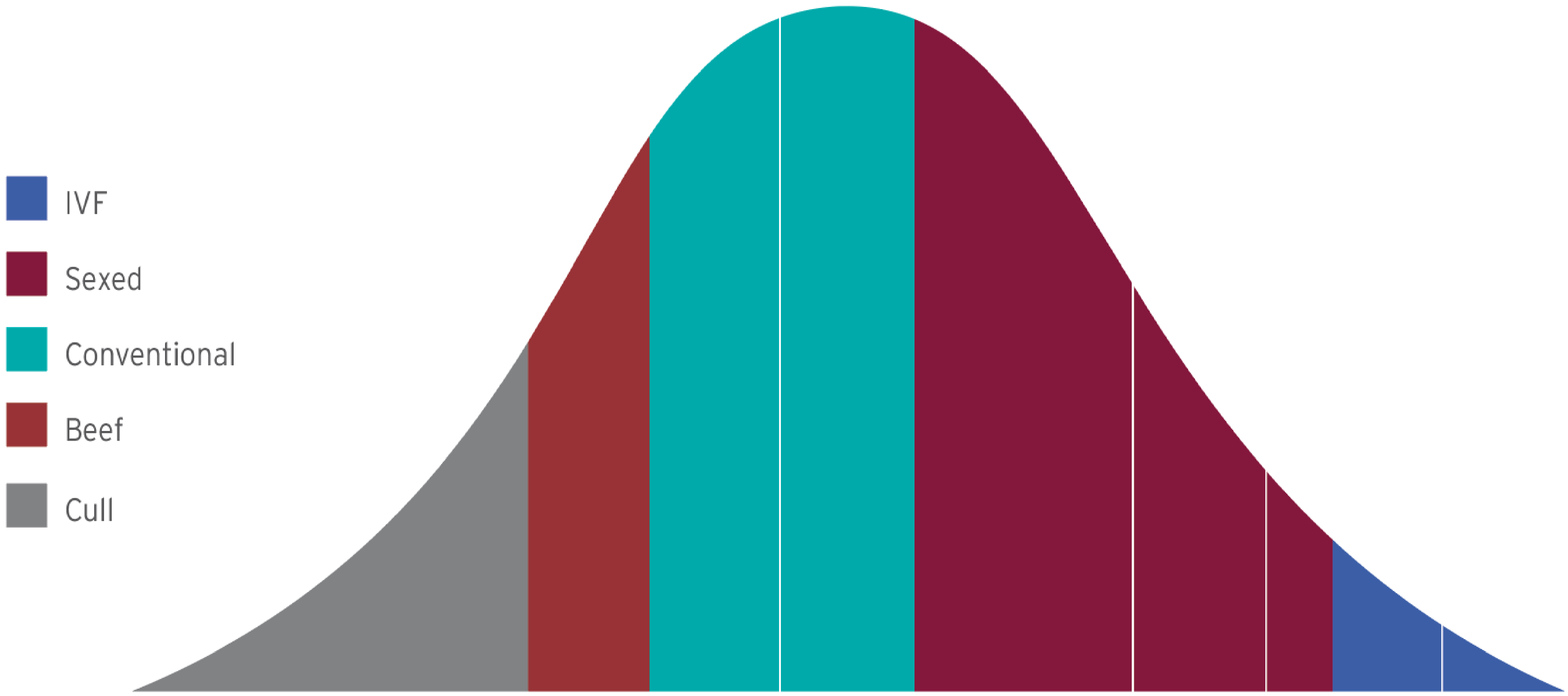
CDCB usable genotype counts/year by animal sex



- 4.2M heifers born/yr
- 650K (15%) heifers tested/yr
- Animal ID extremely valuable

*Through December 13

Genotype-Aided Decisions



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Genetic Improvement	A+	• Doubled or tripled genetic progress! • Significant progress on low h^2 traits • Great return on investment!
On-Farm Testing	**C**	• **Improved animal ID** • **Many farms only using results for culling** • **On-farm genomic testing is still underused**

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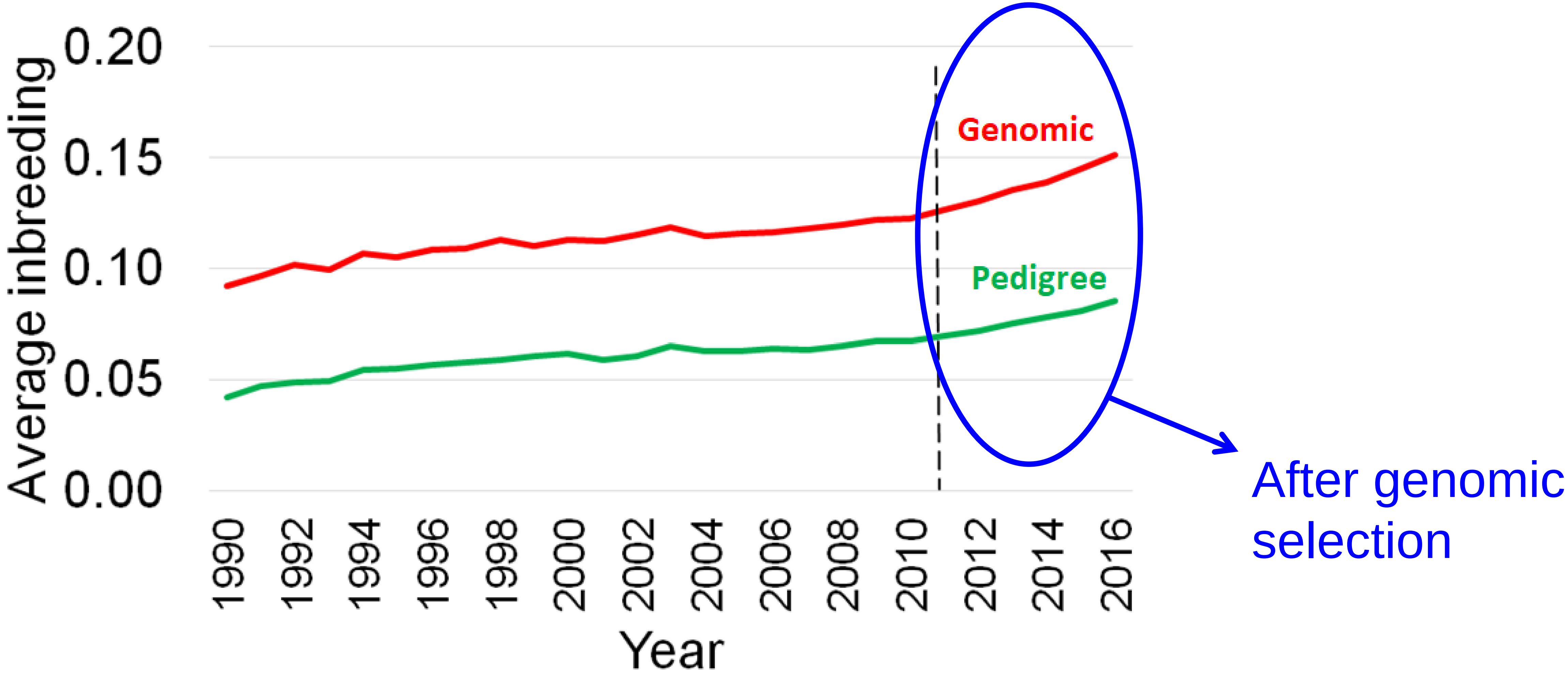
Genetic Diversity		

Genetic Diversity



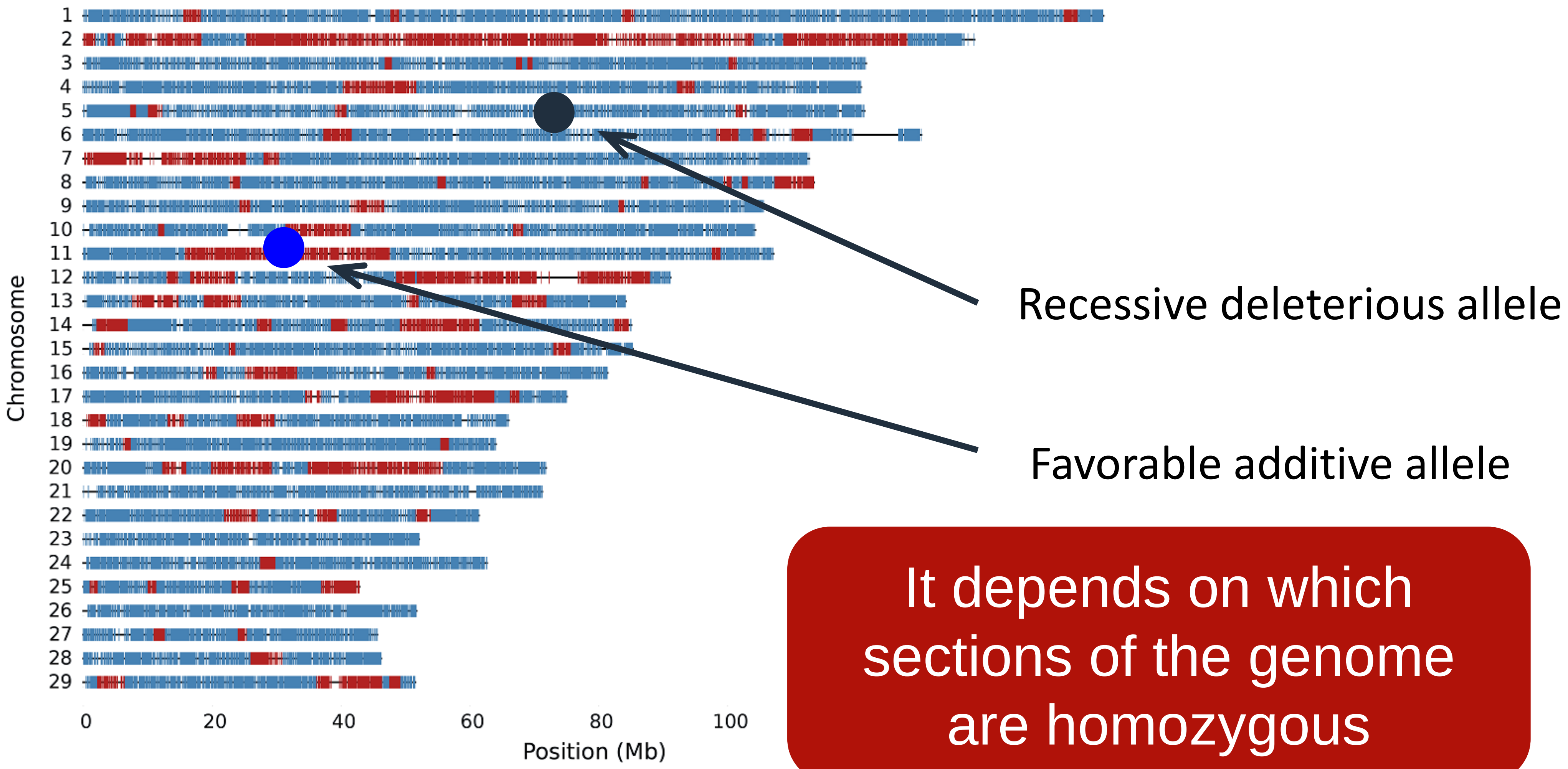
Forutan et al., BMC Genomics 2018

Inbreeding Depression

Trait	Loss per 1% inbreeding
Fat yield (kg)	1.1
Protein yield (kg)	0.5
Conformation (points)	0
Days open (days)	1.4
Calf survival 1st calving (%)	0.5
Productive life (days)	13

(Van Doormaal, 2008. CDN report. March 2008)

Is Inbreeding Always Bad?



It depends on which sections of the genome are homozygous

Is Inbreeding always bad?

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Bad

- Inbreeding depression
- Reduced fertility & production
- Higher probability of genetic defects and disease
- Loss of between-family genetic variation

Good

- More uniformity in best regions
- Most desirable alleles are “fixed”
- Most undesirable alleles are “purged”
- More potential for hybrid vigor in crosses

Effective Pop. Size < 50 → (20% less long-term gain)

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Genetic Diversity	**C-**	• **Too much focus on too few bloodlines** • **Inbreeding is increasing but is it a problem?** • **Probably sacrificing long-term progress**

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Understanding Genotype to Phenotype		

Understanding Genotype to Phenotype

- Genomic improvement still essentially a “black box”
- The genomic SNP profile is only part of the story
- DNA → RNA → Protein pathway variation not well understood (epigenetic, GxE, etc.)
- Non-additive genetic variation is difficult to predict (heterosis/inbreeding depression, GxG interactions)
- Few additional causative mutations have been found

Reducing Freq. of Undesirable Haplotypes

Haplotypes affecting fertility

Name[1]	Chromo-some[2]	ARS-UCD location (Mbp)[3]	Current carrier frequency (%)	Earliest known genotyped ancestor
HH1	5	62.8*	2.6	Pawnee Farm Arlinda Chief
HH2	1	93.5–95.6	2.4	Willowholme Mark Anthony
HH3	8	93.8*	5.3	Glendell Arlinda Chief, Gray View Skyliner
HH4	1	2.0*	0.5	Besne Buck
HH5	9	91.8–91.9	4.8	Thornlea Texal Supreme
HH6	16	29.0–29.1	0.9	Gray View Skyliner
JH1	15	15.4*	18.4	Observer Chocolate Soldier
BH2	19	10.8*	13.3	Rancho Rustic My Design
AH1	17	63.7*	22.3	Selwood Betty's Commander
AH2	3	51.1	13.3	Oak-Ridge Flashy Kellogg

[1]BH1 and JH2 discontinued [2]*Bos taurus* (BTA) [3]Mbp = megabase pairs; * = causative mutation known

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Understanding Genotype to Phenotype	**D**	• **Overpromised and underdelivered** • **Genotype to phenotype path is VERY complex** • **Some genes identified for disease traits**

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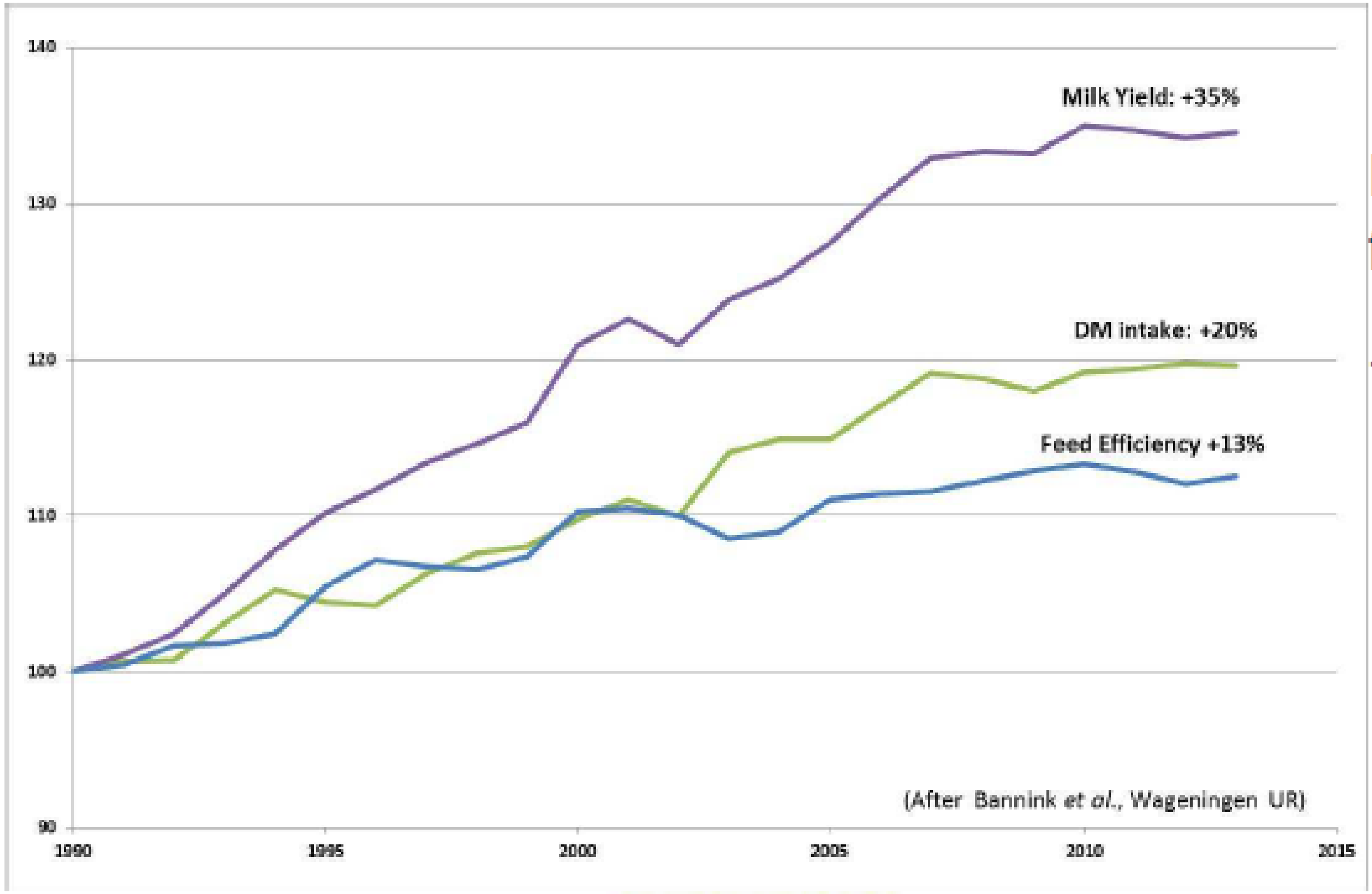
Meeting Consumer Expectations		

Meeting Consumer Expectations

- Safe & affordable ✓
- Good for environment ✓
- Hormone/antibiotic-free ?
- Not cruel to animals ?
- More choice
  - Taste, Variety, Local
  - Digestibility & health claims ?
  - Production methods

Dairy – production efficiency

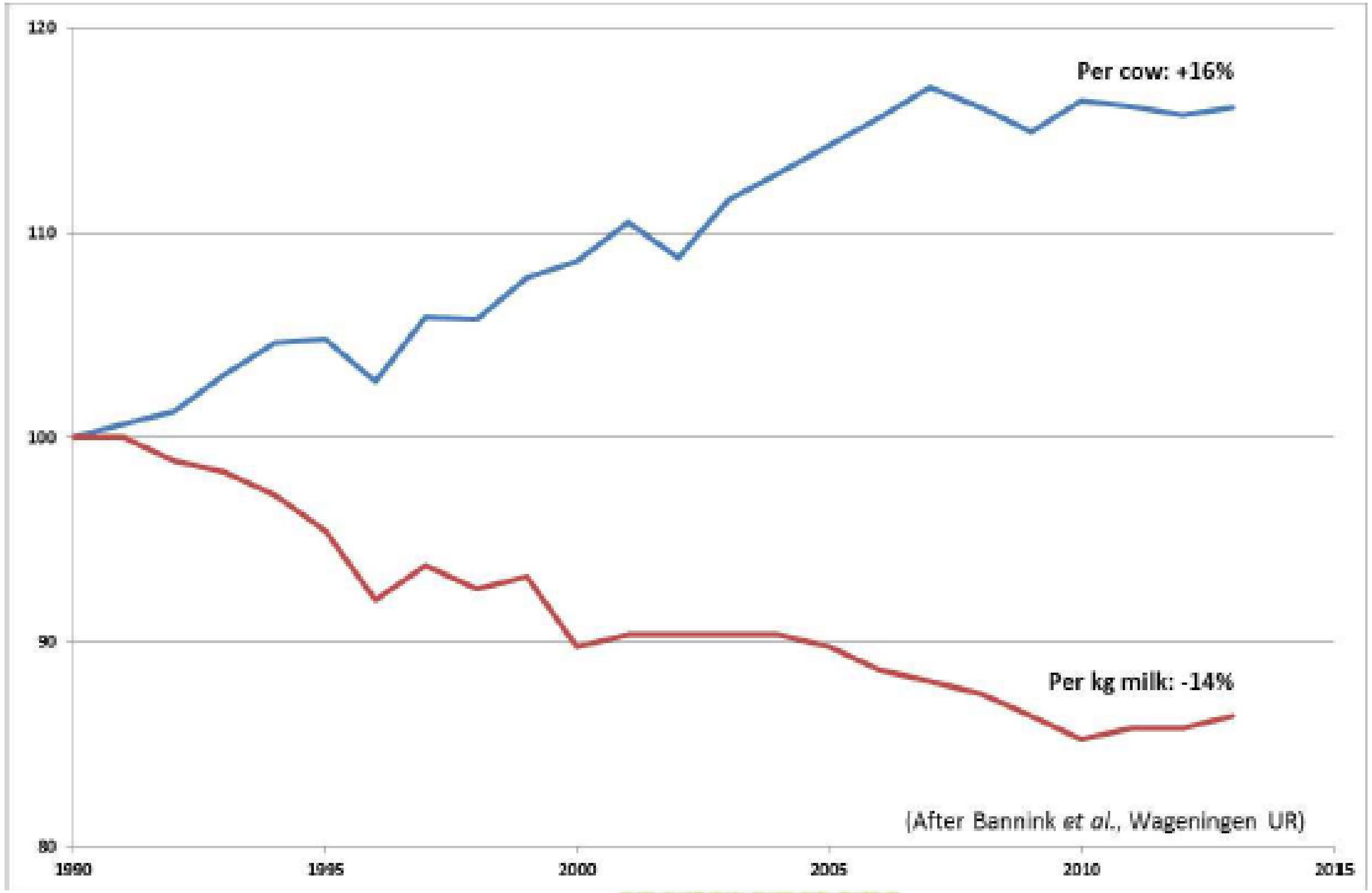


Milk yield increased faster than DM intake

-> better feed efficiency

Bannink et al, 2011 and
pers.comm. J. Dijkstra, Wageningen UR

Dairy – enteric CH_4 emission



Increased per cow

Decreased per kg milk

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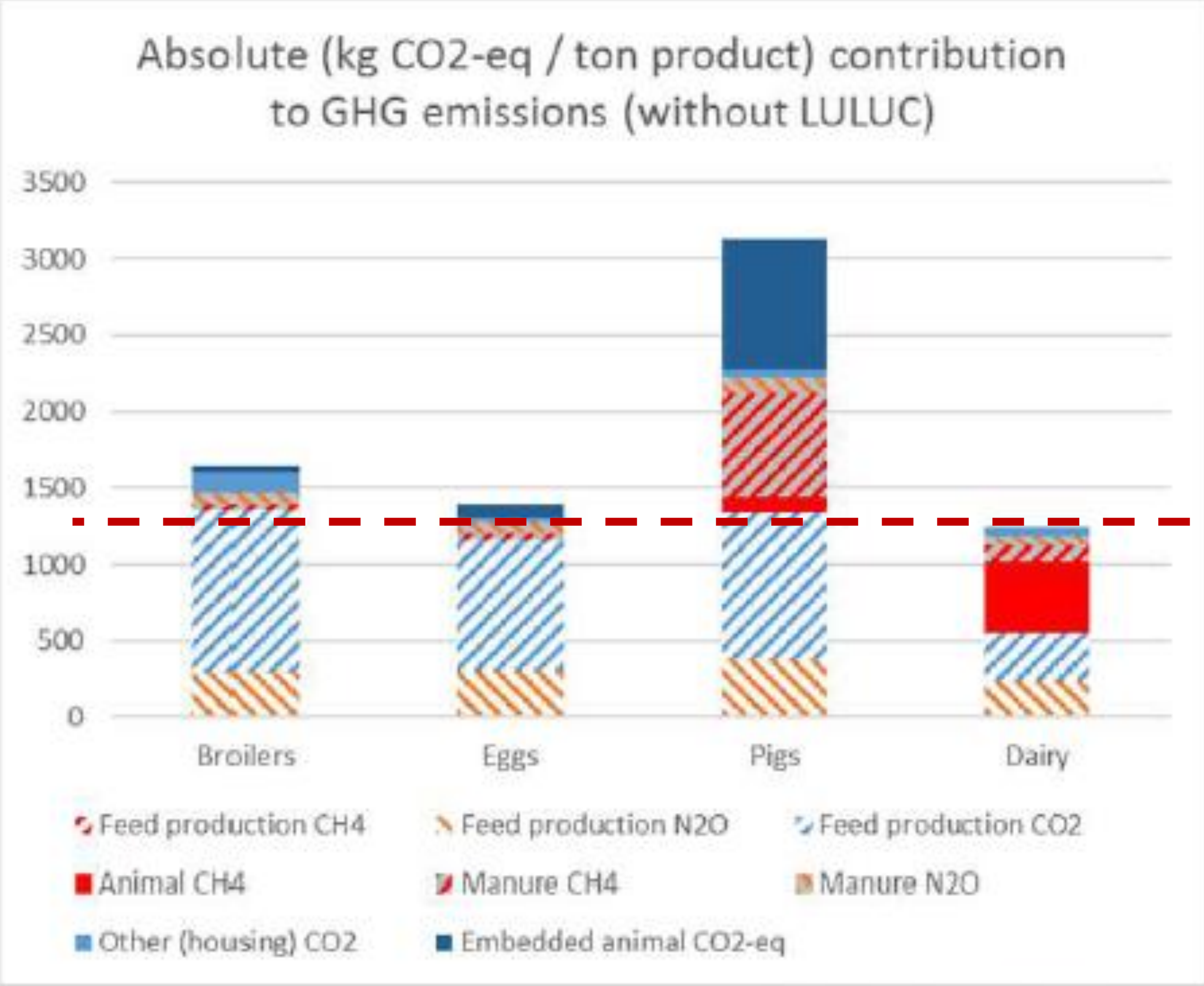
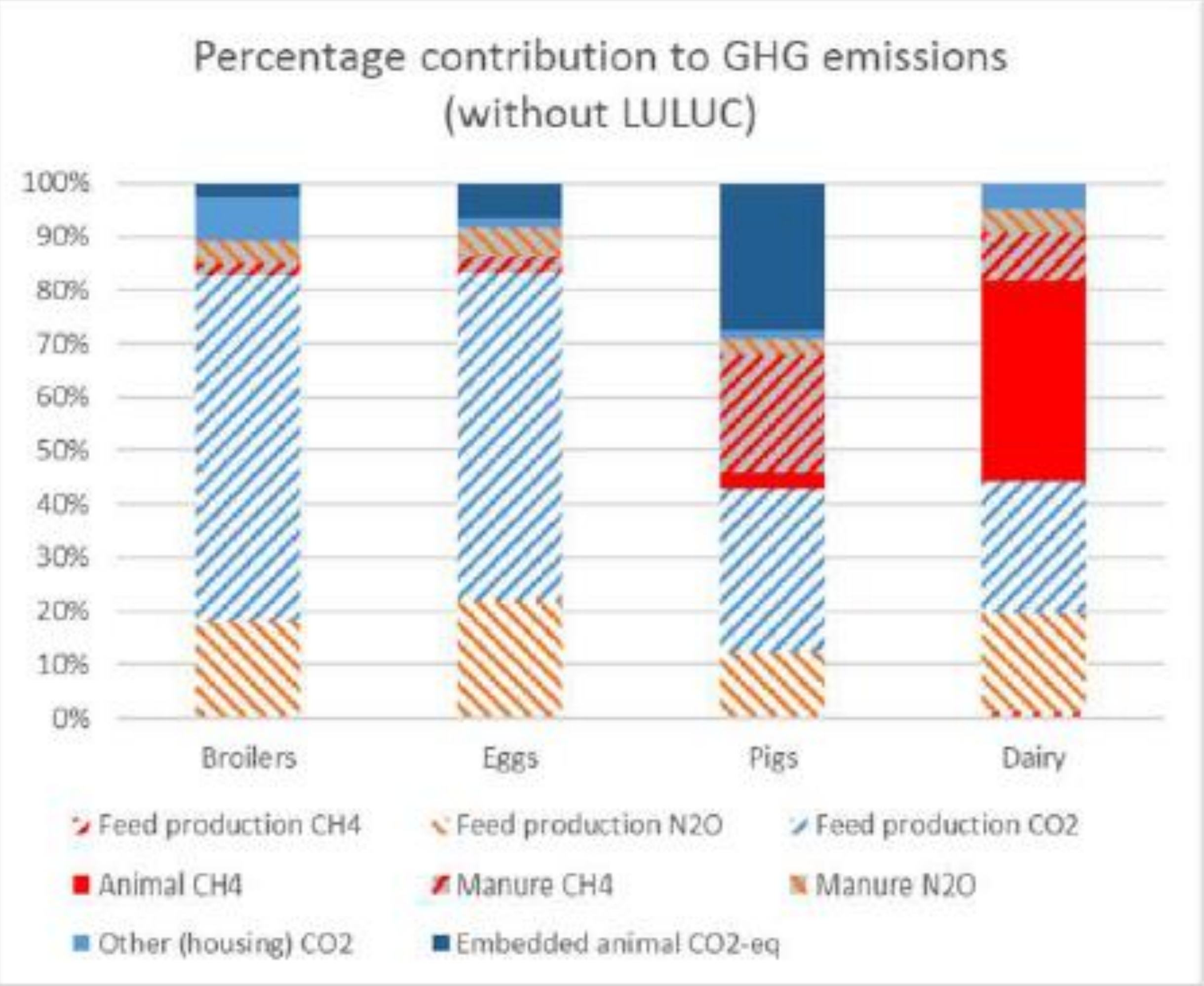
Bannink et al, 2011 and
pers.comm. J. Dijkstra, Wageningen UR

GHG emissions of different species





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Source: FeedPrint 2015.03 (Vellinga et al., 2013; WLR, 2015)

Dairy – reduction of GHG[1]

Carbon footprint dairy

1990: 2.06 kg CO_2-eq. / kg milk
2012: 1.42 kg CO_2-eq. / kg milk
-31%

Similar reductions (30-50%) are possible via nutrition (e.g. 3-nitrooxypropanol (3NOP)

K. Beauchemin, AAFC

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[1]Kool et al., 2014. Report Blonk Consultants

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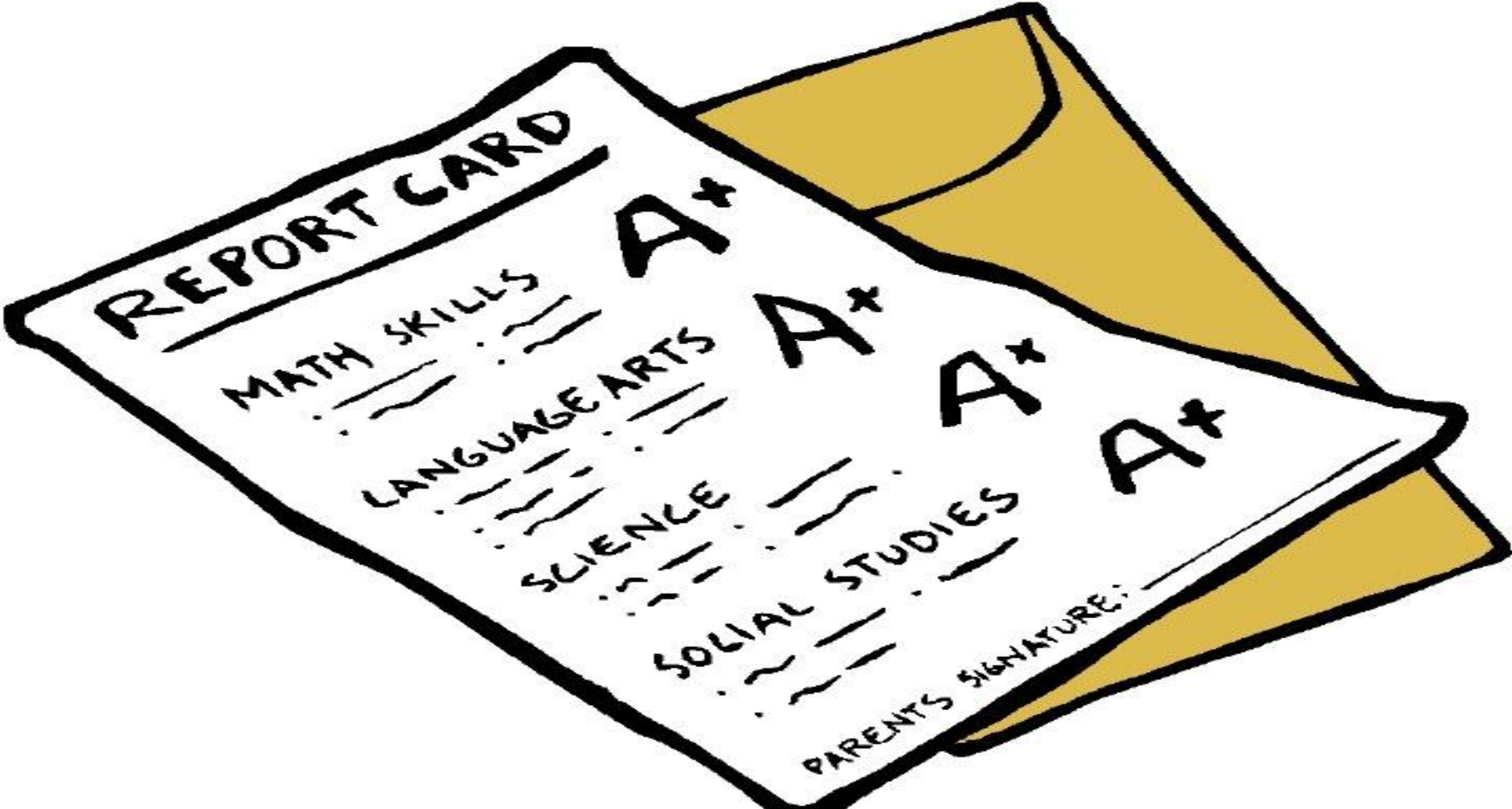
Understanding Genotype to Phenotype	D	• Overpromised and underdelivered • Genotype to phenotype path is VERY complex • Some genes identified for disease traits
Meeting Consumer Expectations	D-	• Improved health & repro… but little effort on direct value for consumers (A2A2 is exception) • Made milk more sustainable (unintentionally)



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Thank You
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