World Conference
The world of Holstein meets in France

Holstein as the breed of choice

Dr. Tom Lawlor

Holstein Association USA, Inc.

U.S. Registered Holsteins
FOR MAXIMUM PROFIT

World Holstein Friesian Federation
WHFF

PHF
Association d'éleveurs

T

What dairy breed is the number one dairy breed in the world ?

Google

The Holstein-Friesian is the most widespread cattle breed in the world; it is present in more than 150 countries.

Source:

Food and Agriculture Organization of the United Nations

ChatGPT

Chat Generative Pre-trained Transformer

You have a conversation with it.

T

What dairy breed is the number one dairy breed in the world ?

The number one dairy breed in the world is the Holstein cow.

Why are Holsteins the breed of choice?

Holstein cows are often the breed of choice for dairy farming for several reasons:

1. High Milk Production: Holsteins are renowned for their exceptional milk production capabilities. They have the highest average milk yield among all dairy breeds. This makes them a top choice for dairy farmers who aim to maximize milk production and, subsequently, their profitability.
2. Efficiency in Milk Production: Holsteins can convert feed into milk more efficiently than some other dairy breeds, which can result in a higher economic return for dairy farmers.
3. Consistency in Milk Composition: Holstein milk tends to have a consistent composition, which is favorable for dairy processing and cheese making. This consistency is valuable to dairy processors.
4. Global Popularity: Holsteins are widely recognized and accepted worldwide. Their genetics are well-documented and available in many countries, making it easier for farmers to source breeding stock and genetic material.
5. Genetic Improvement Programs: There are extensive genetic improvement programs in place for Holsteins, with a focus on breeding for higher milk production and improved health traits. These programs have led to continuous advancements in the breed's genetics.
6. Strong Breeding Programs: Holstein associations and organizations have developed strong breeding programs that emphasize traits such as milk yield, longevity, and health, enabling dairy farmers to select animals that best suit their specific goals.

ChatGPT

Why are Holsteins the breed of choice?

1. High Milk Production
2. Efficiency in Milk Production
3. Consistency in Milk Composition
4. Global Popularity
5. Genetic Improvement Programs
6. Strong Breeding Programs

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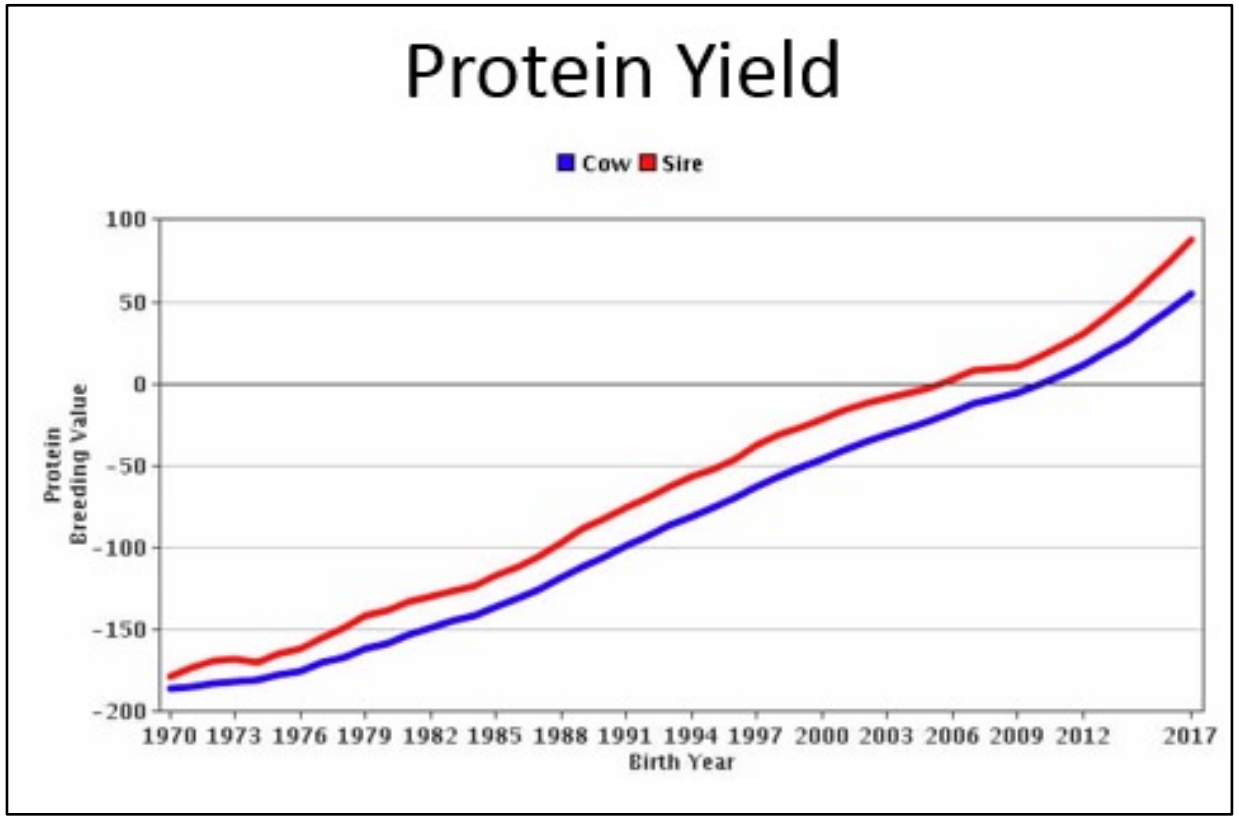
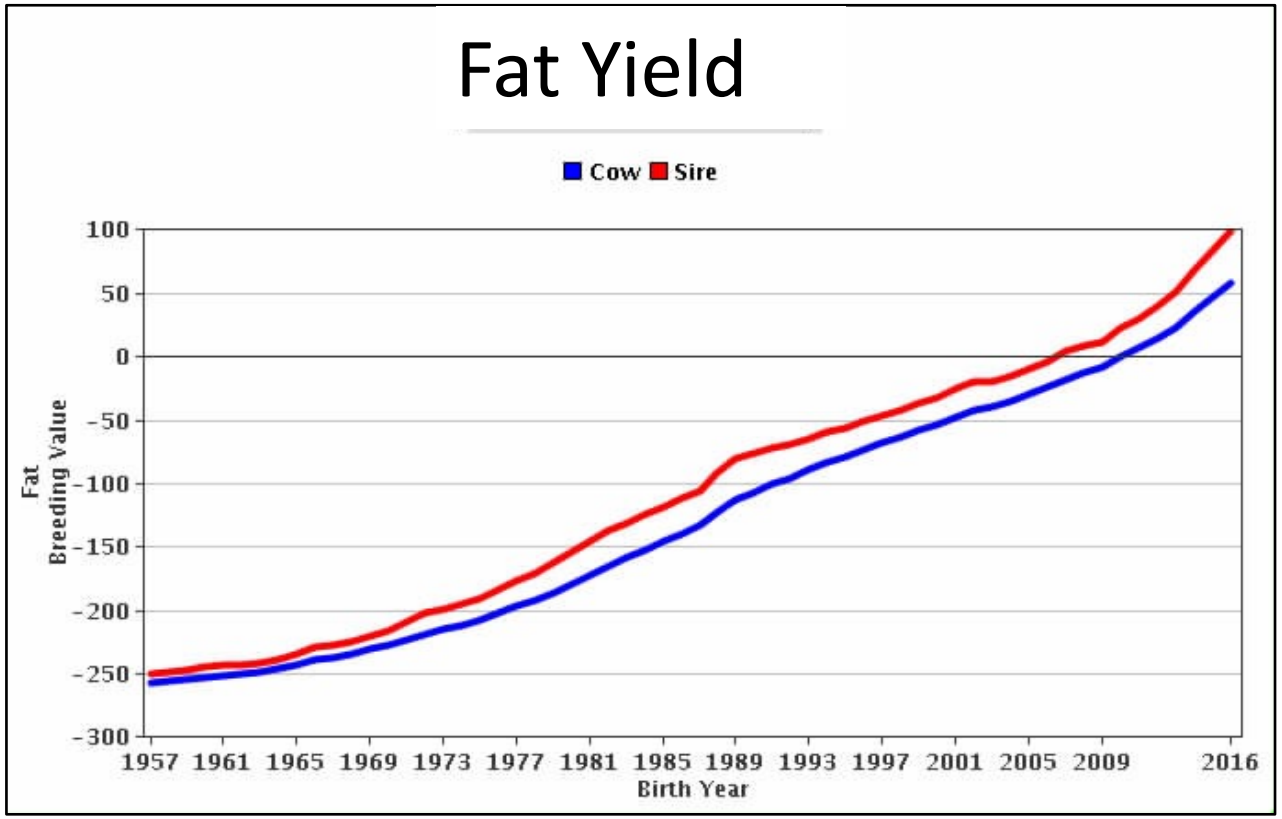
What is the biggest challenge to breeding Holsteins?

1. Maintaining Reproductive Efficiency
2. Managing Health and Longevity
3. Balancing Milk Yield and Components
4. Reducing Feed Costs
5. Selecting the right sires and dams
6. Reducing greenhouse gas emissions
7. Adaptability

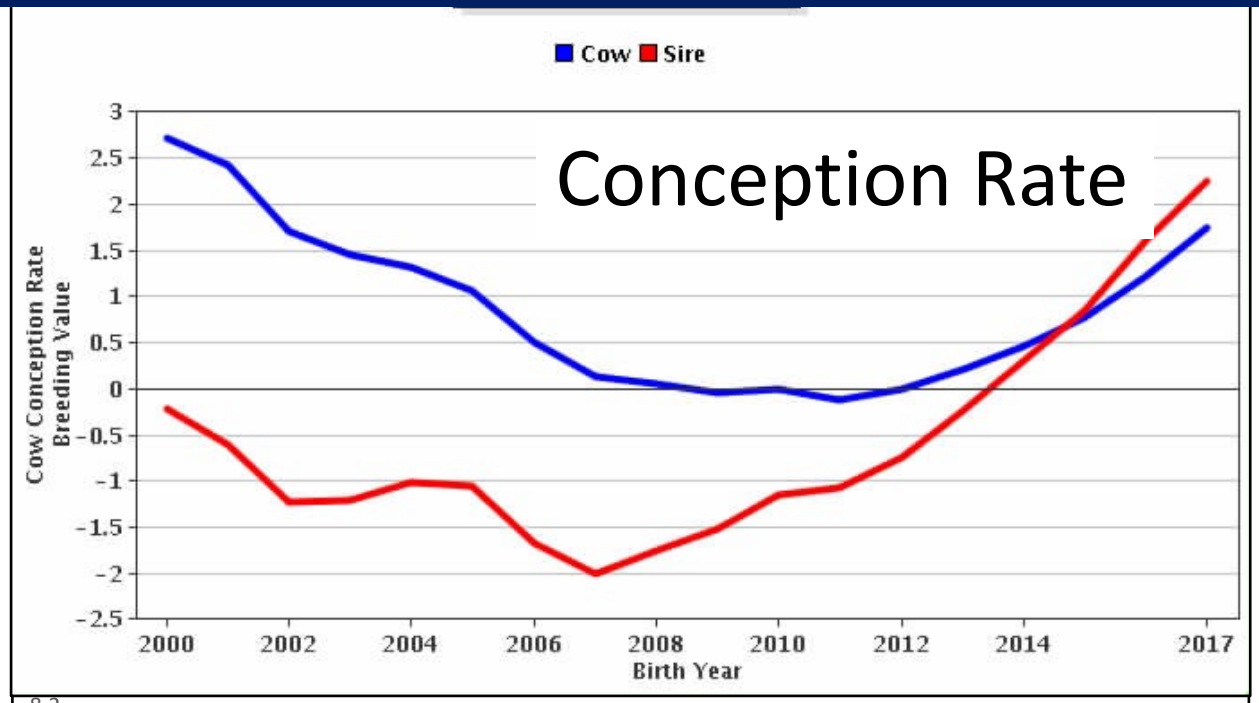
Increasing Milk Components

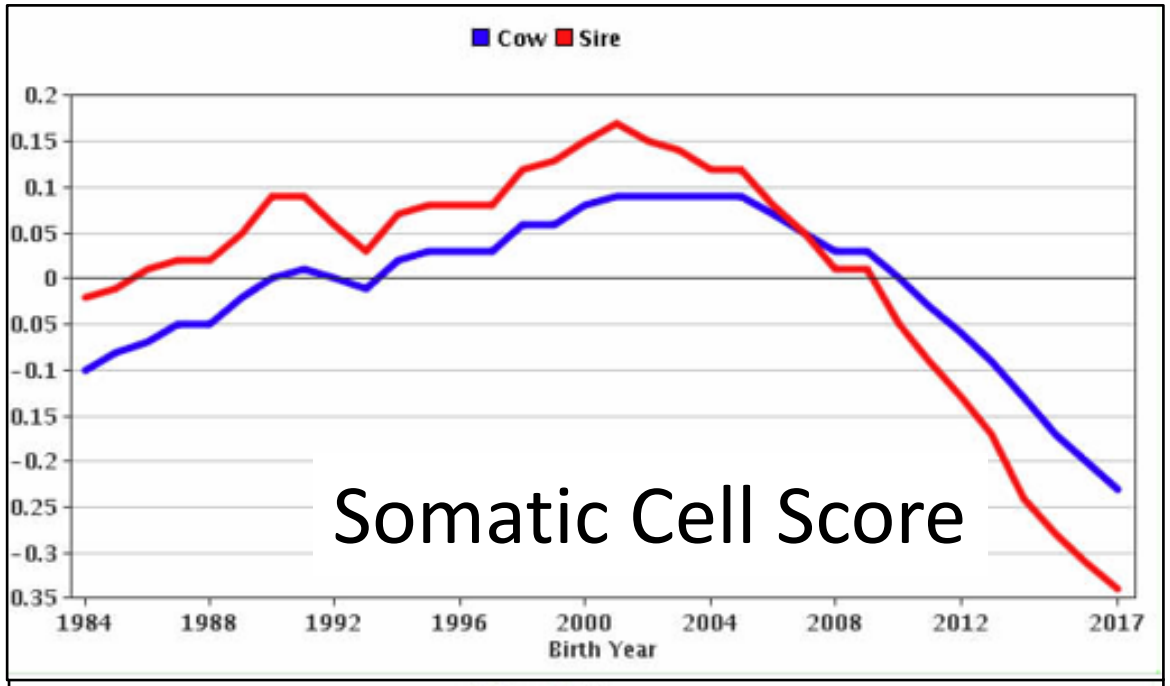


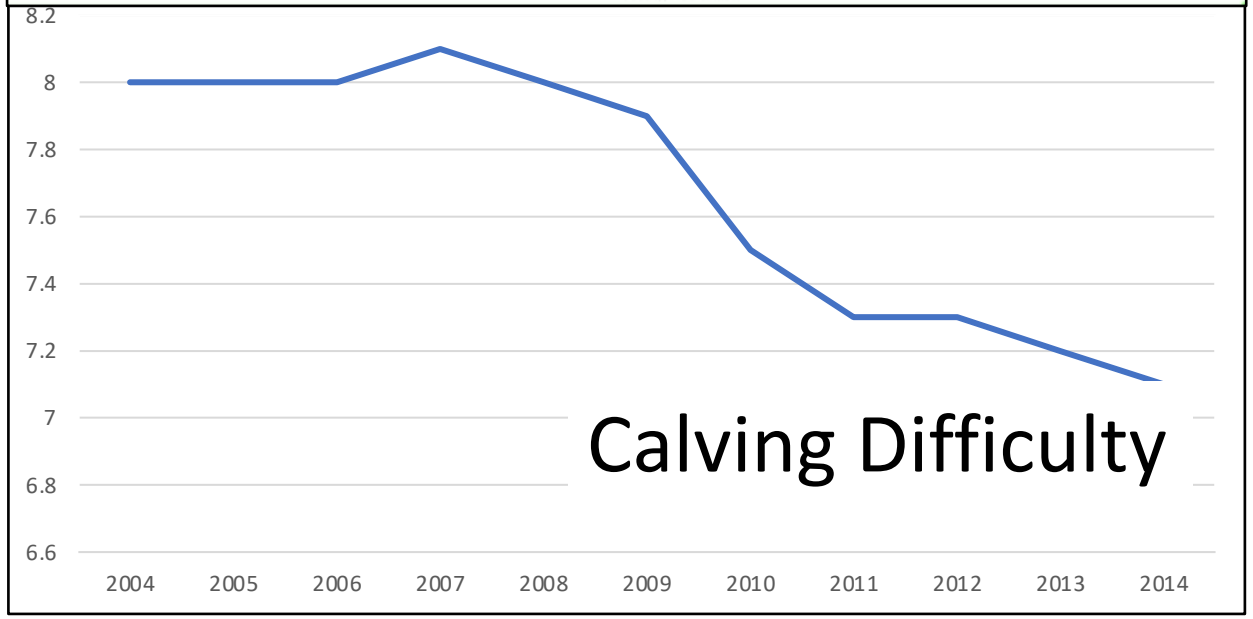


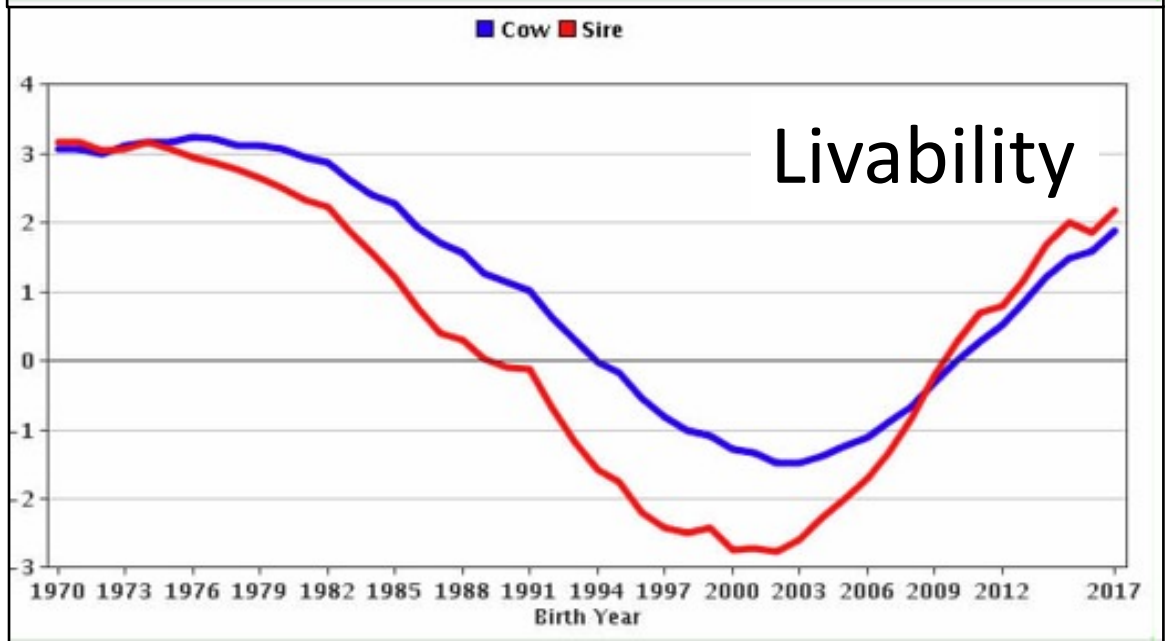
Milk fat above 4% is the new normal

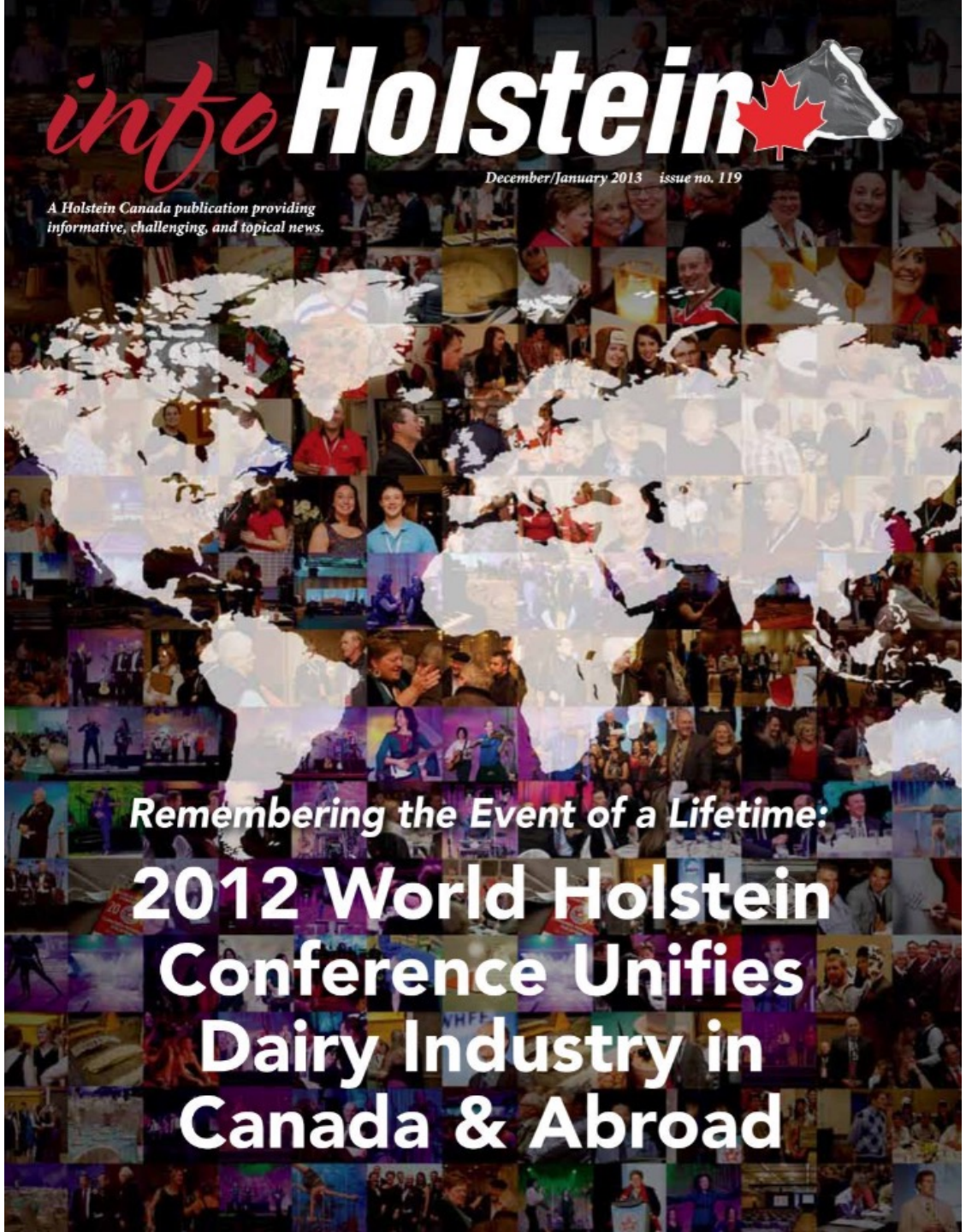
We have responded well to past problems and challenges











We are a science-based community.

World Holstein Conference 2012 Congrès mondial Holstein

Action items identified as needing more work have become our agenda items in 2023

2012

2023

Items identified as needing more work

1. Reducing Feed Costs
2. Reducing greenhouse gas emissions
3. Adaptability

WHFF agenda

Feed efficiency
Phenotyping for feed efficiency

Methane emissions

Breeding for resilience
Hoof health
Paratuberculosis
Immunoglobulin content in colostrum

And we’re forward-thinking in 2023

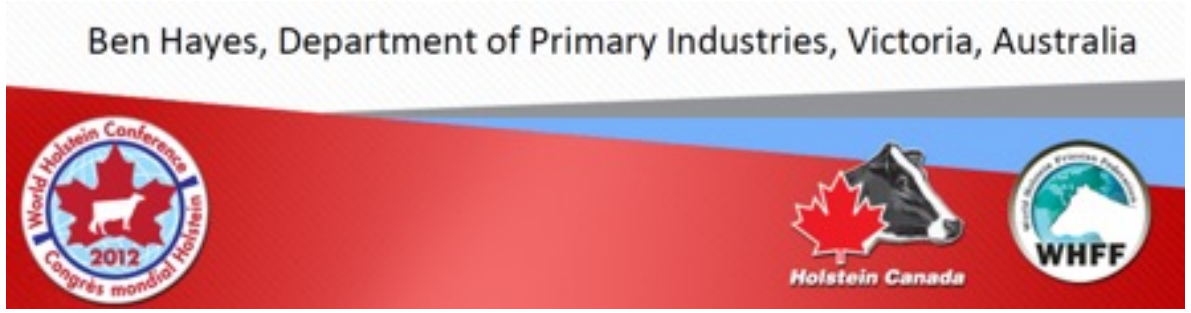
Rethinking Breeding Strategies in Dairy Cattle

Data ownership and integrated use

Digitization and the Consequences of Data Ownership

Sensors and Digitalization on farm –
Challenges and Opportunities for Breed Organizations

2012: major topic was GENOMICS



What's coming next in genomics?

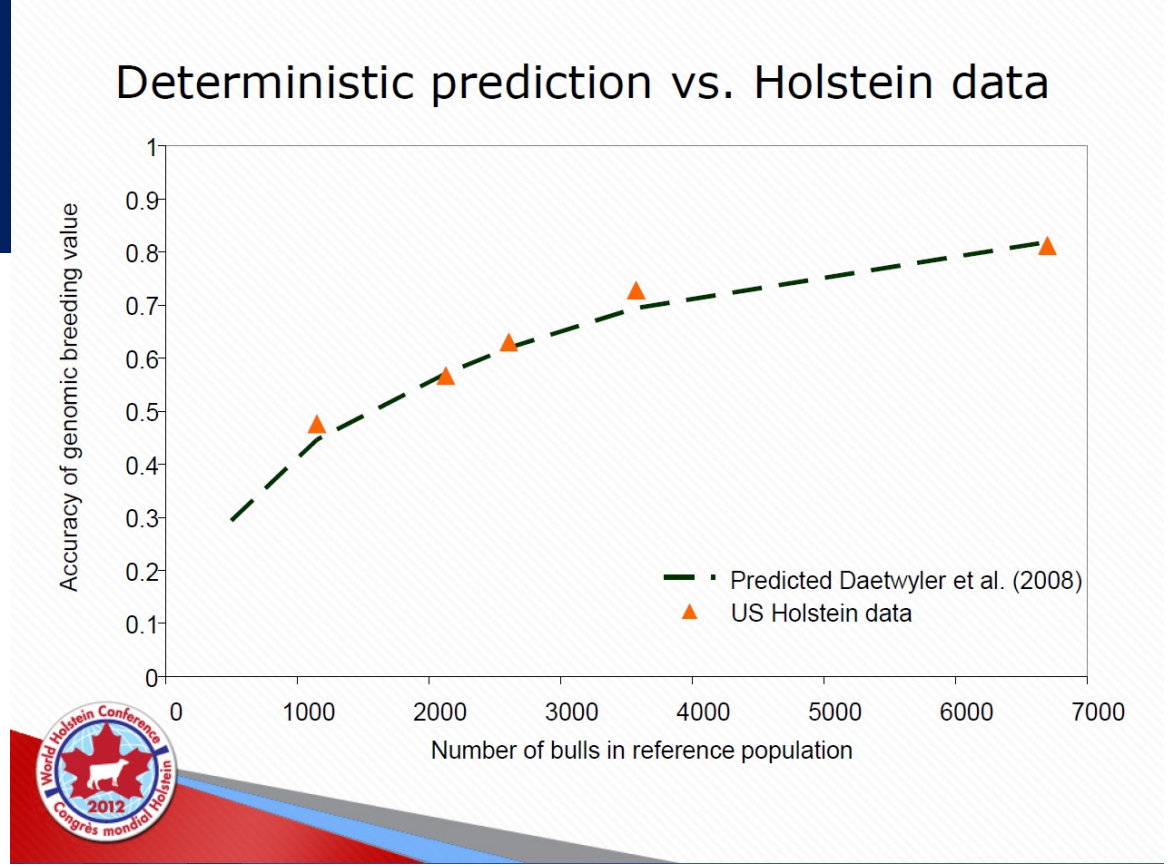
Genomic Developments:
Past, Present, Future

Dr. Josef Pott

How Genomics is changing Business and Services of Associations

Large reference populations gives you higher accuracy

Ben Hayes



Didier Boichard

Reference population sharing

1) The bigger, the better
2) Examples of the North American or the EuroGenomics consortia => a way to maximize accuracy while sharing the investments

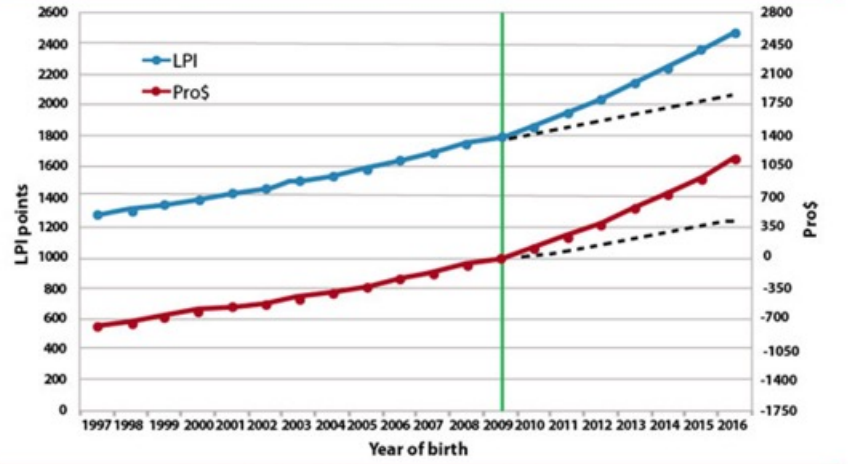
Progress around the world

The Bullvine
INFORMATIVE AND THOUGHT PROVOKING NEWS AND ARTICLES FOR THE DAIRY INDUSTRY

Genomics revolution lift dairy farm production
Monday, May 20th, 2019

Canada

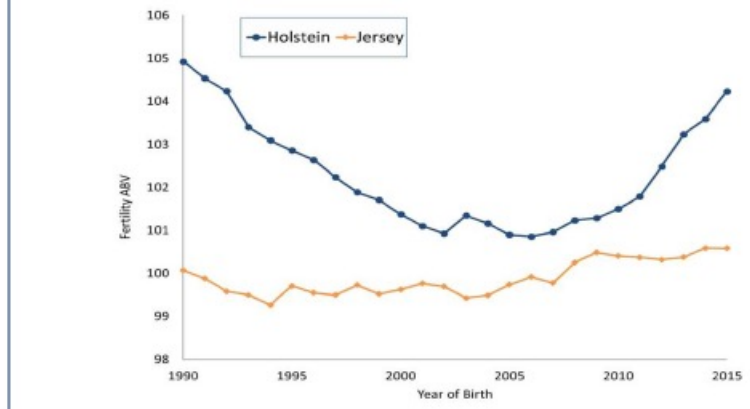
FIGURE 1 Genetic trend realized for LPI and Pro$ in Canadian Holsteins before and after genomics



Source: Proceedings of the 2018 Western Canadian Dairy Seminar, Volume 30.

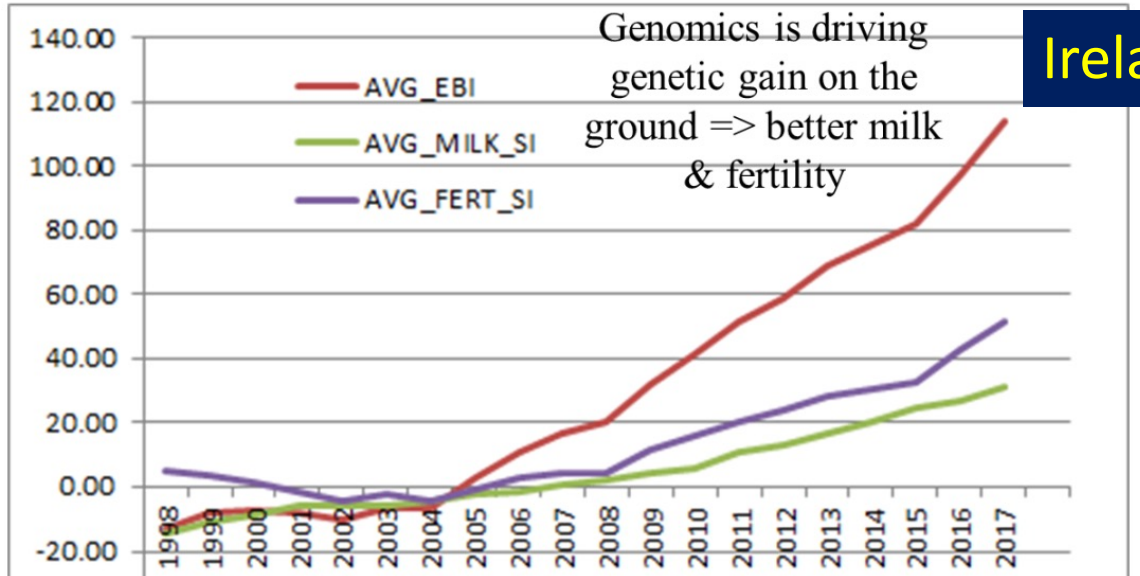
Australia

Genomic selection – genetic gain daughter fertility



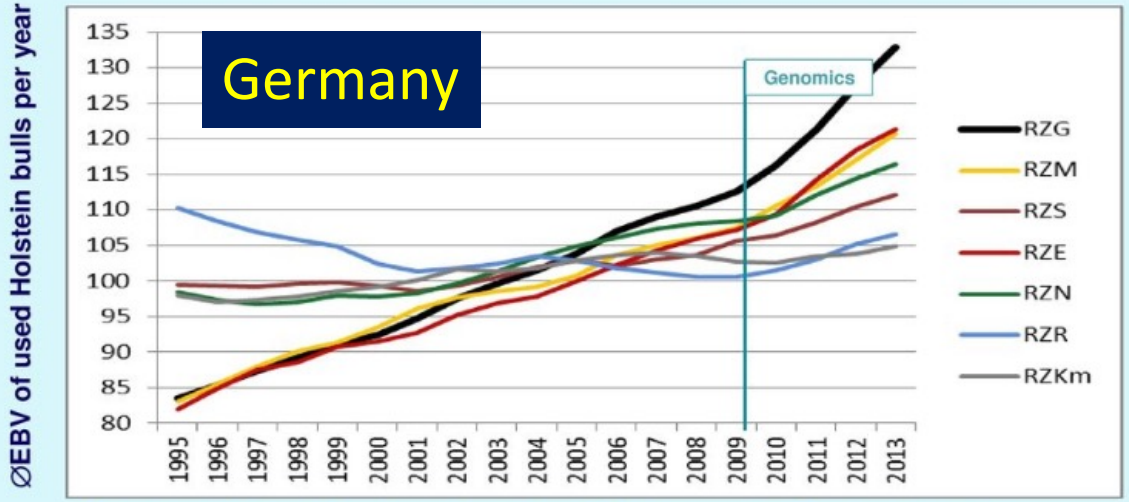
Genetic Trends – Aug 2017.

Ireland



Germany

Genetic gain in German Holsteins (F. Reinhadt, VIT Verden, 2014)

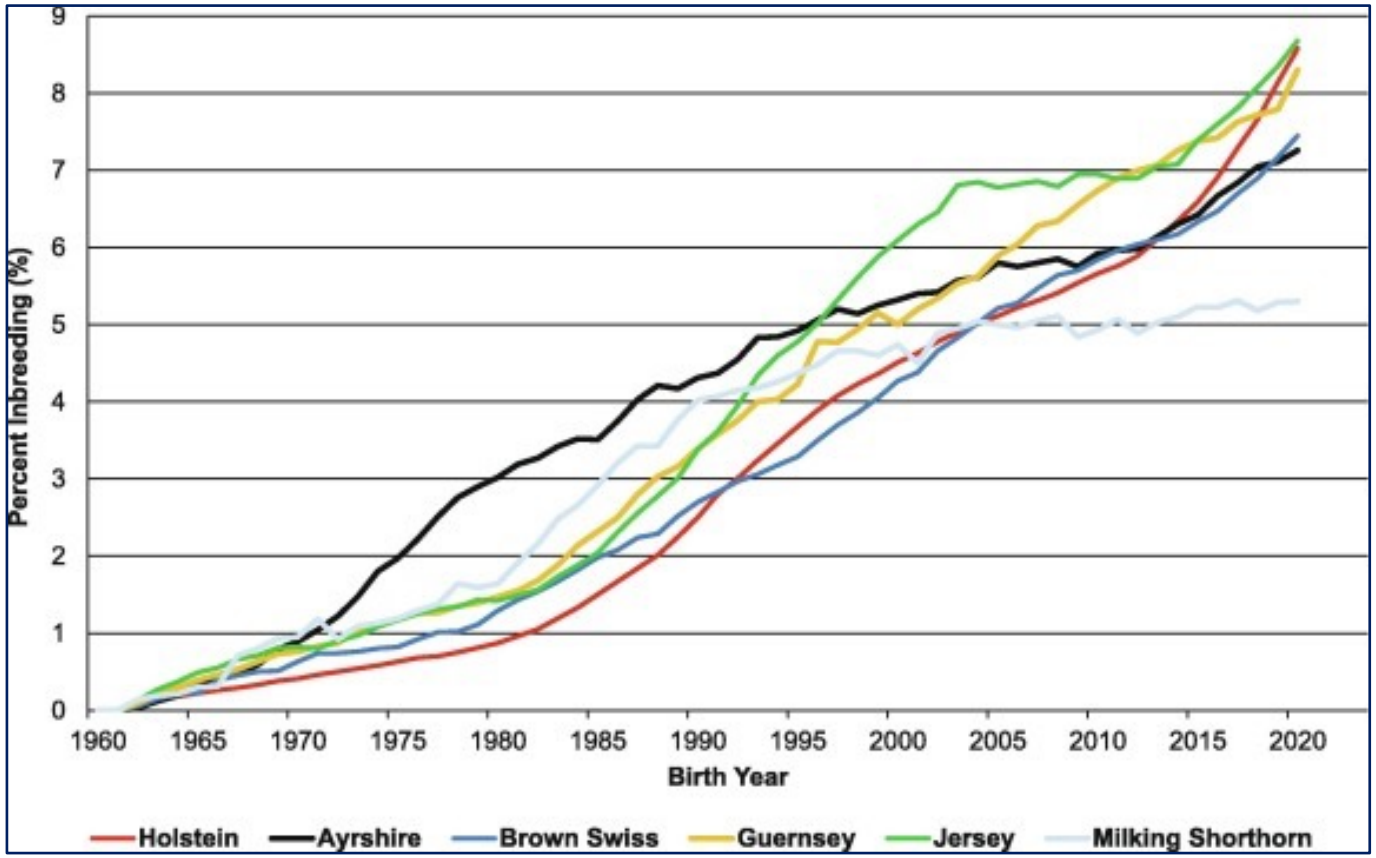


Genomic selection is doubling genetic progress
RZG 1995-2008 – Ø +2.1 per year (≈ 0.2 s)

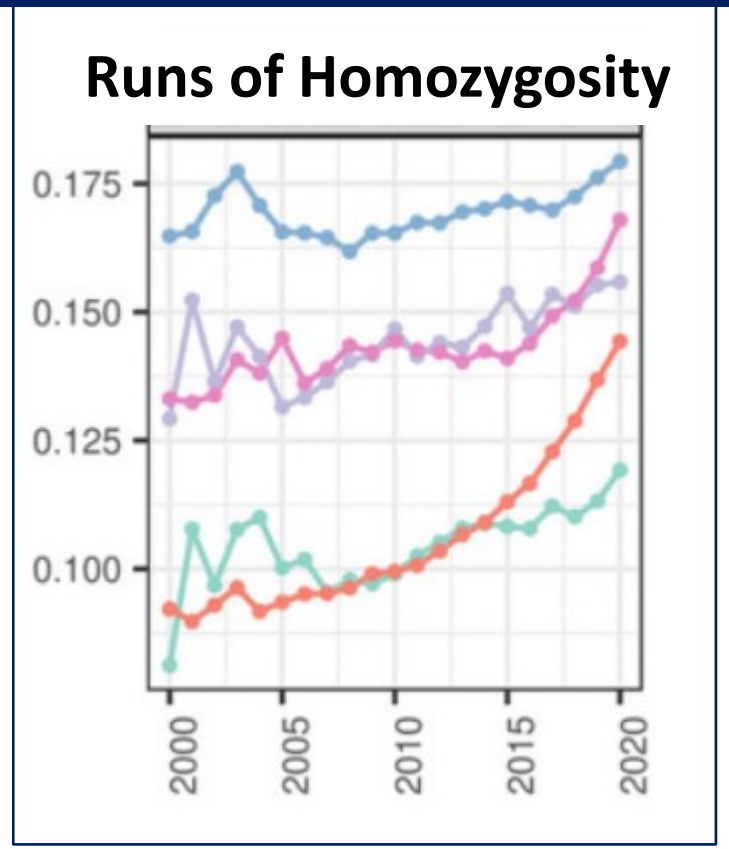
We’re happy with our past success, but, as farmers you’re interested in the future.

Will our children and grandchildren be milking a herd of purebred Holsteins ?

Increasing rate of inbreeding in all breeds.



Brito et al, 2021



Lozada-Soto et al, 2022

We need to create some Genetic Diversity

Genomics has created this challenge.

Genomics can provide a solution.

Genomics 2.0

New biological insights

Gene regulation

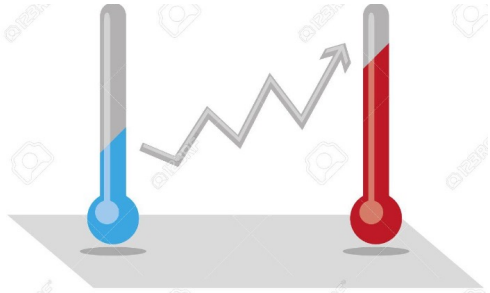
Key to phenotypic differences.

Genetic Redundancy

Many different gene combinations are used.

Evolve and Resequence

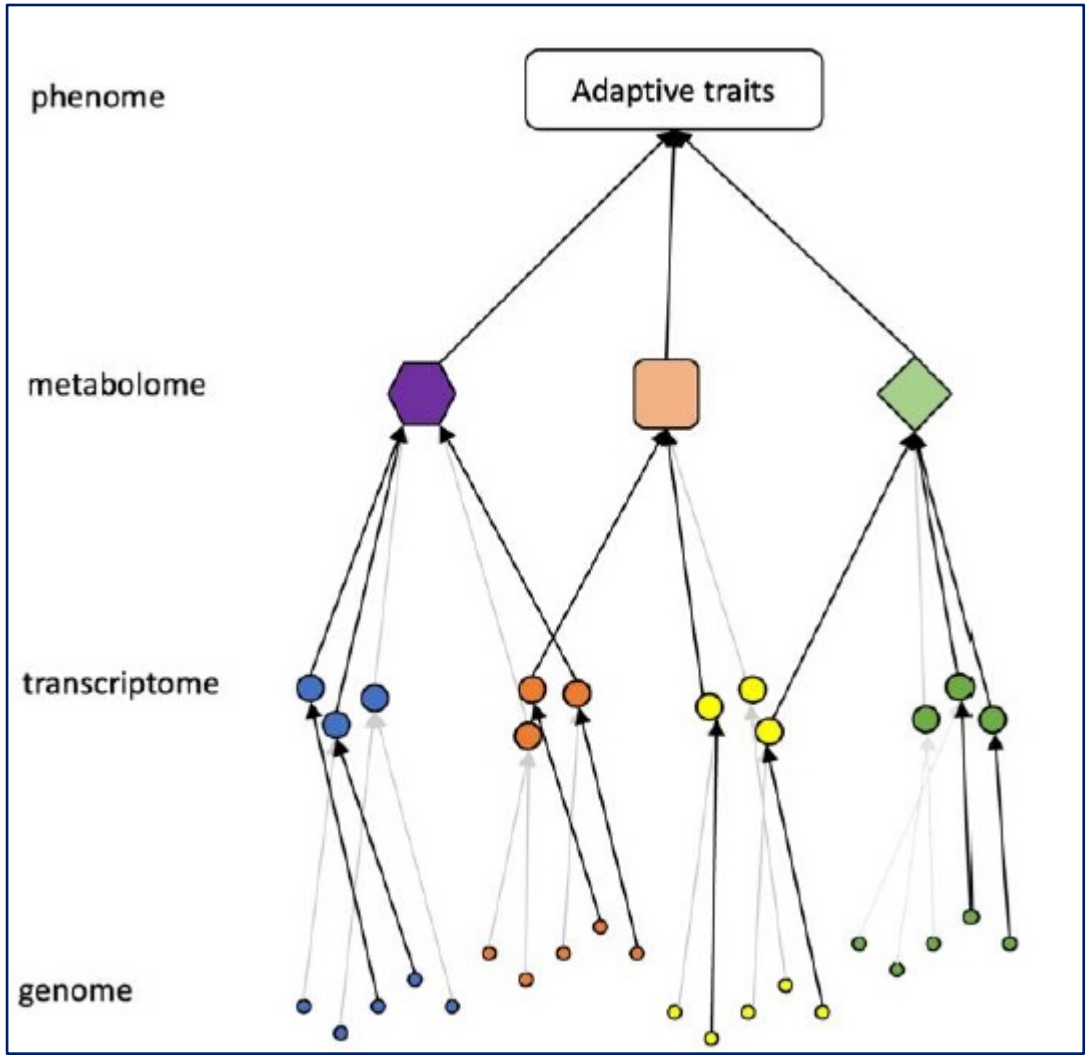
Barghi et al., 2019



A single population was divided
into ten sub-populations.
Then exposed to HIGHER TEMPERATURES.

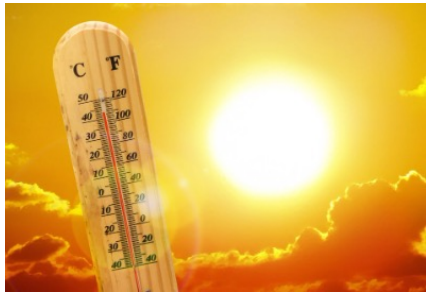
Differences in the genetics of the original founders
steers the subpopulation towards using a different set of SNPs
to achieve the same phenotypic goal.

Genetic redundancy fuels adaptation in *Drosophila*

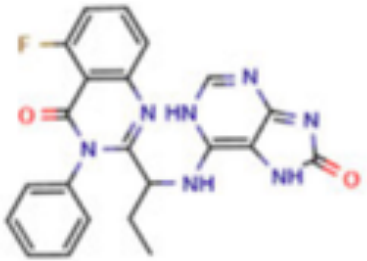


Genome Biol. Evol. 2023

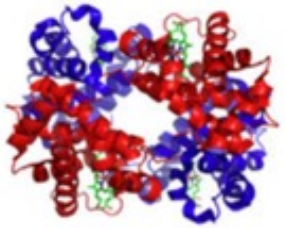
Adaptation



Metabolites



Protein



RNA

DNA

Gene regulation
is the major driver of genetic change.

Same goal

Adaptation to higher temperatures.

Different transcripts

results in different types and quantity of proteins being made.

Many different SNPs

are involved in controlling which transcripts are created

The Genome Response to Artificial Selection: A Case Study in Dairy Cattle

Holstein

Montbéliarde

Normande

These three breeds are genetically different from each other.

F_{st} measures allele frequency differences between populations.

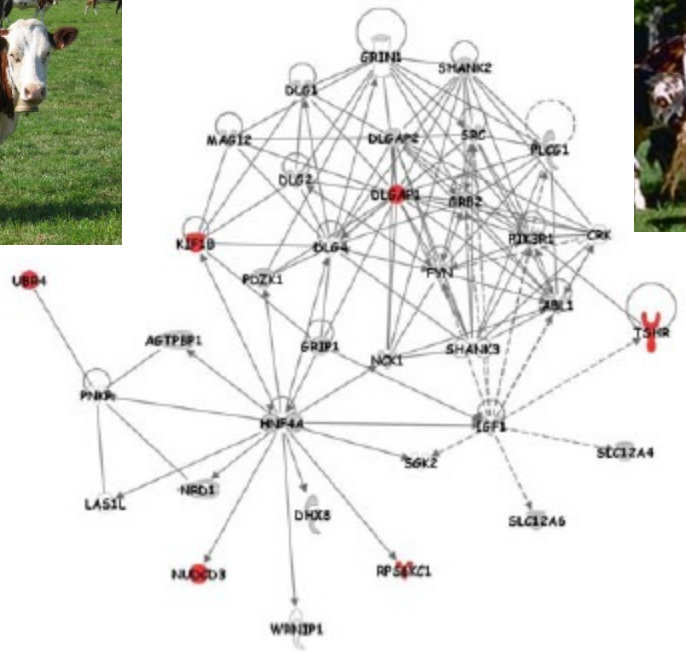
F_{st} = 0 same breed

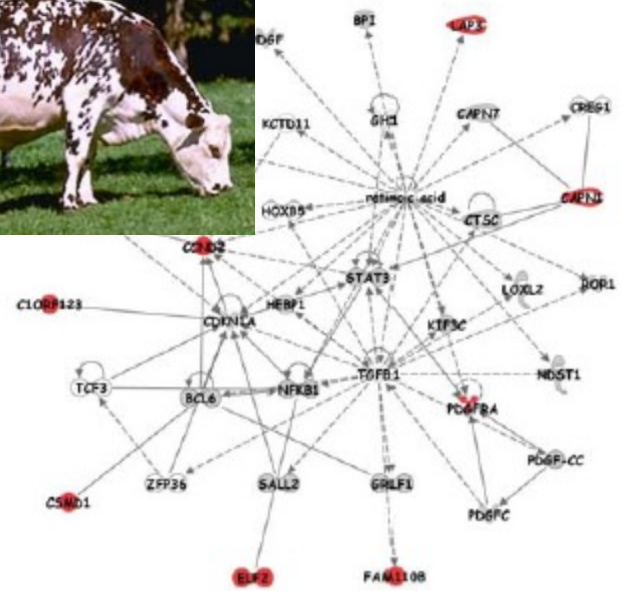
F_{st} = 0.07 different dairy breeds

F_{st} = 0.15 dairy breed compared to a beef breed

PLoS ONE 4(8): e6595.

Each of the breeds has found its own genetic solution





"Although centered on the same physiological pathways, set of differentiated genes were almost not overlapping among the breeds. This suggests a kind of plasticity in the genome allowing different solutions to respond to a similar breeding goal."

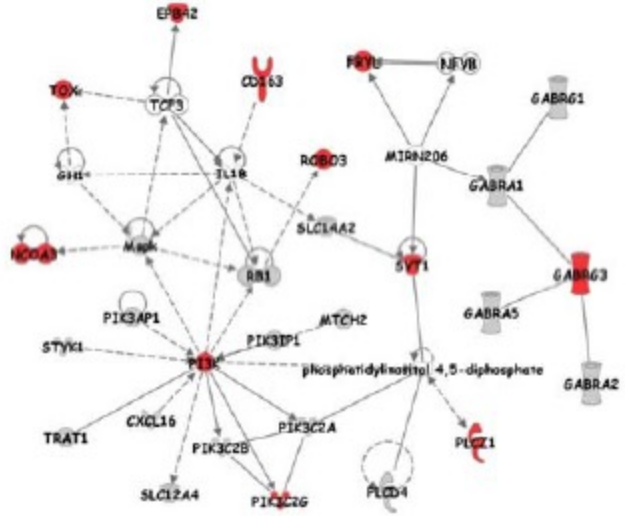
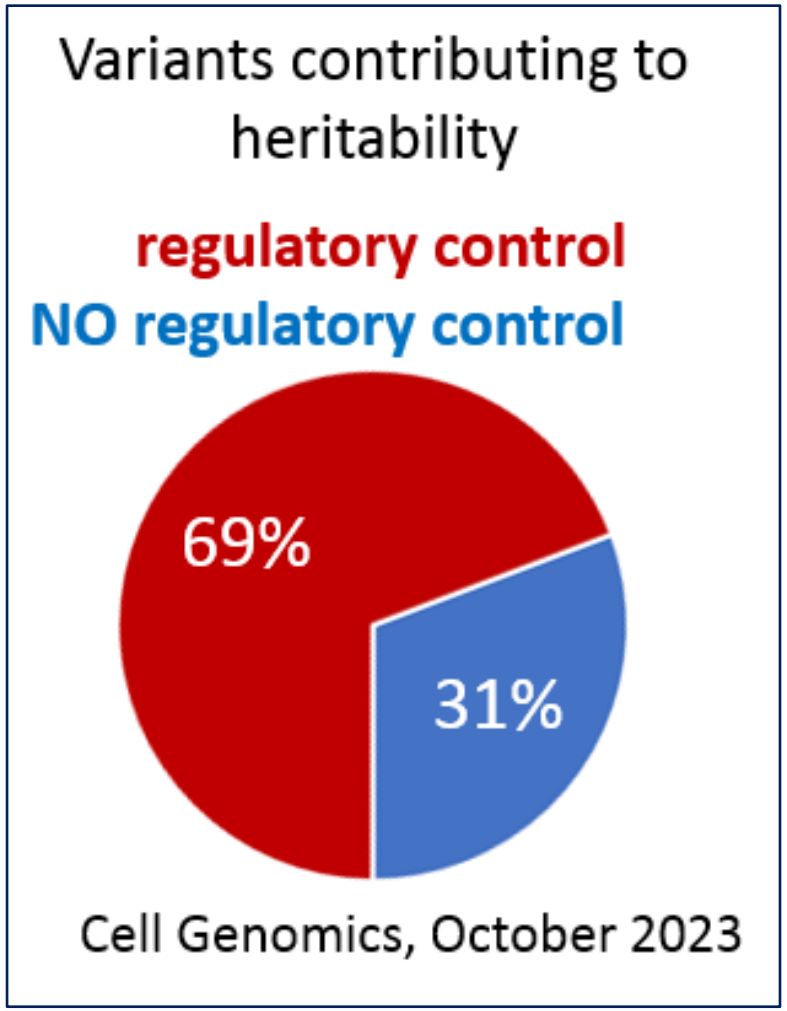


Figure 5. Representation of the gene networks N_MON (A), N_NOR (B) and N_HOL (C). Symbols corresponding to candidate genes are colored in red. Genes colored in grey were represented in our study but did not display any evidence of selection.

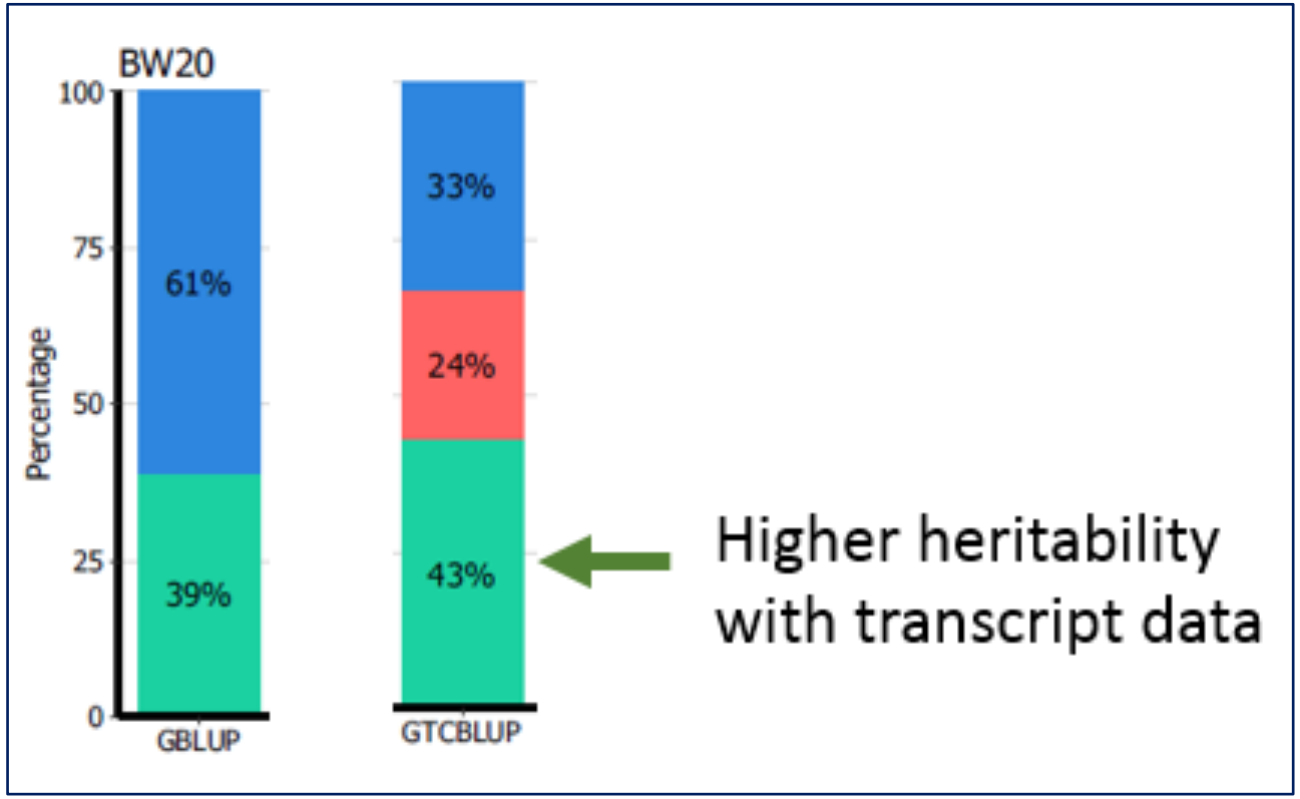
Gene regulation explain large proportions of the heritability for complex traits in cattle

Australia



Adding gene transcripts into genomic predictions improves accuracy

The Netherlands

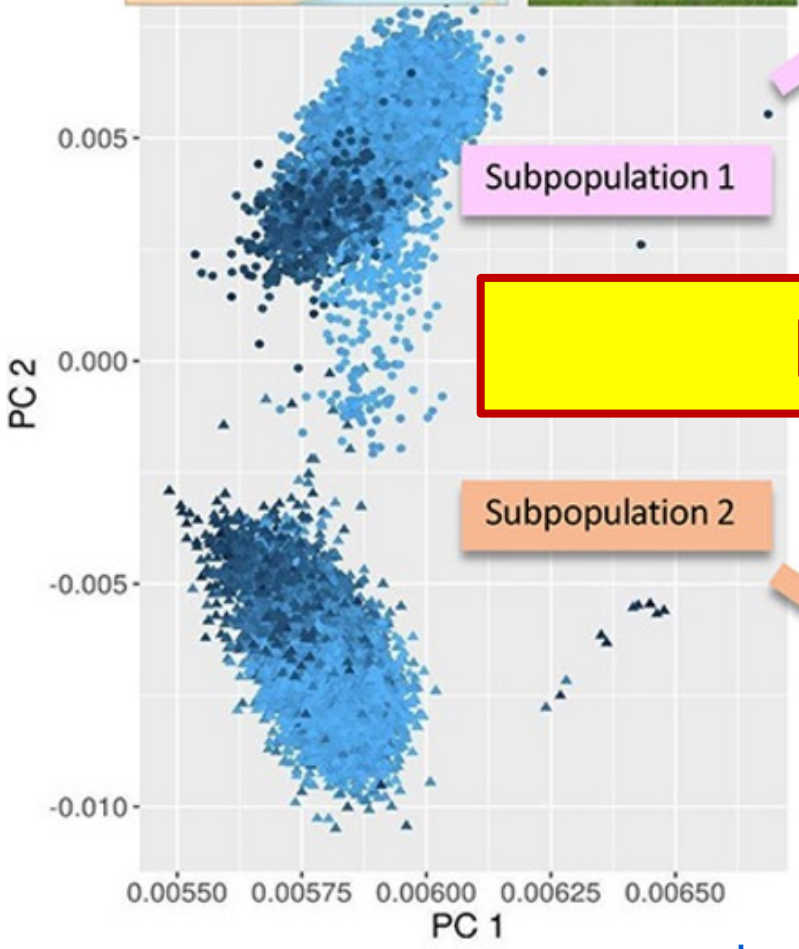


Genes | Genomes | Genetics September 2022

Different subpopulations maintains genetic diversity.

There is genetic redundancy built into our DNA.

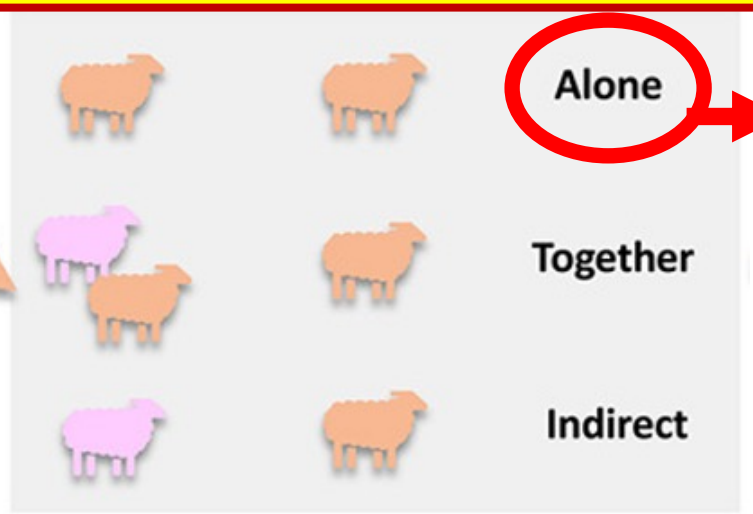
Whereby, different combinations of different SNPs produce the same phonotypic value.



Pooling reference populations together, forces the SNP effects to be “portable”.

That is, you pick SNPs with independent additive gene action.

Different SNP effects



Within population SNP effects better reflect total genetic merit and are more stable over time.

Journal of Dairy Science Vol. 106 No. 8, 2023

Prominent bulls act as **FOUNDERS** of subpopulations (family groups) with their own unique genomic profile

BC

Sire

Cows

Daughters

CC

Sons

BB

Maternal Grandsons

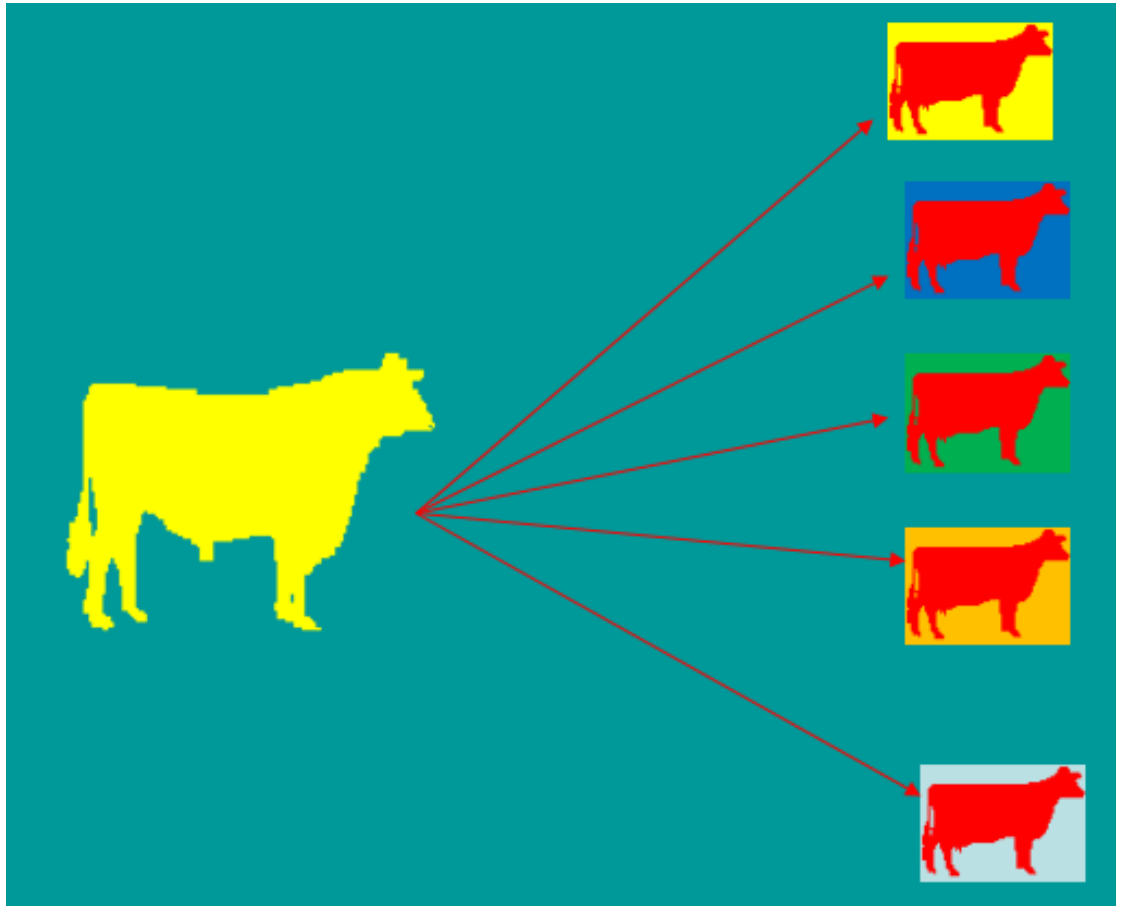
CB

Rendel and Robertson

Four paths of selection

In 2014, U.S. Holsteins could be clustered into 5 subpopulations

Five different subpopulations



Descendants of

Planet

Goldwyn

Shottle

Many different sires

O Man

Using separate SNP effects from 5 different subpopulations

Bulls rank differently

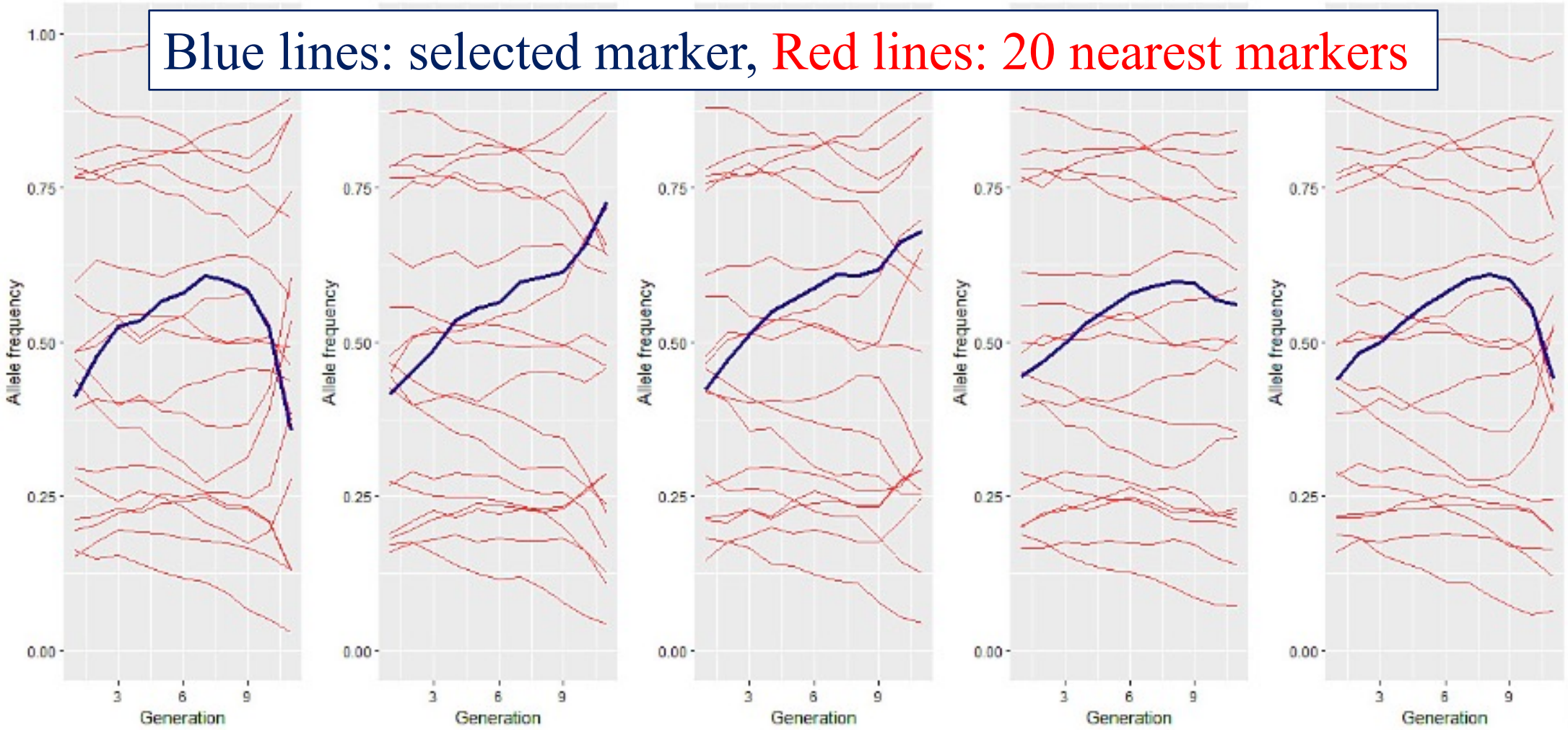
Journal of Dairy Science Vol. 106 No. 4, 2023

Illustrated for the trait **STATURE**

Rankings for **GOLDWYN descendants** in overall population and the 5 subpopulations							
		Overall Population	Goldwyn	Planet	Shottle	O Man	Multiple
Goldwyn's grandson	**Airlift**	1	3	101	64	276	44
Goldwyn's son	**G.W. Atwood**	22	8	81	150	446	212

SNP frequencies change differently in different families

Blue lines: selected marker, Red lines: 20 nearest markers



Planet	Goldwyn	Shottle	Many different sires	O Man

*We have **NOT** lost genetic variation*

Within each family

The number of SNPs that became fixed

38, 22, 22, 59, and 40

Across the whole population

only 3 SNPs went to a frequency of 100%

3 SNP markers out of **58,990**

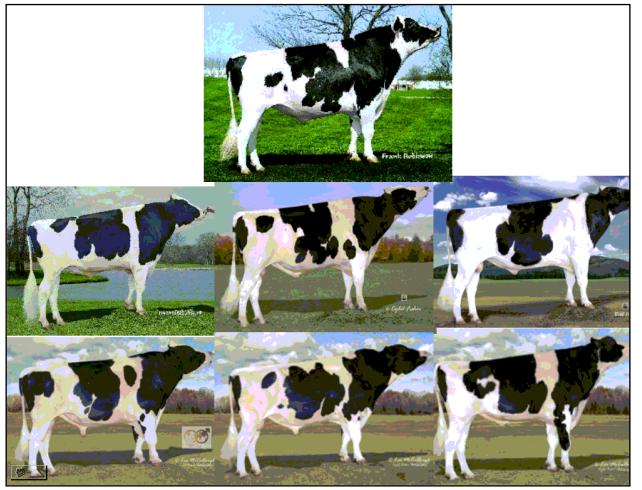
The number of SNPs that

reversed direction*

	Number	Percentage %
Planet	6765	11
Goldwyn	5986	10
Shottle	6238	11
Multiple	2172	4
O Man	6285	11

* 10% change in frequency.

There is more than one path to breeding the next generation of Holstein cows



Different subpopulations changes the frequency of different alleles in different directions ……

Very few alleles become fixed in the global population.

Genetic diversity is preserved for future generations.

Genomics 2.0 – creating the *right* population structure

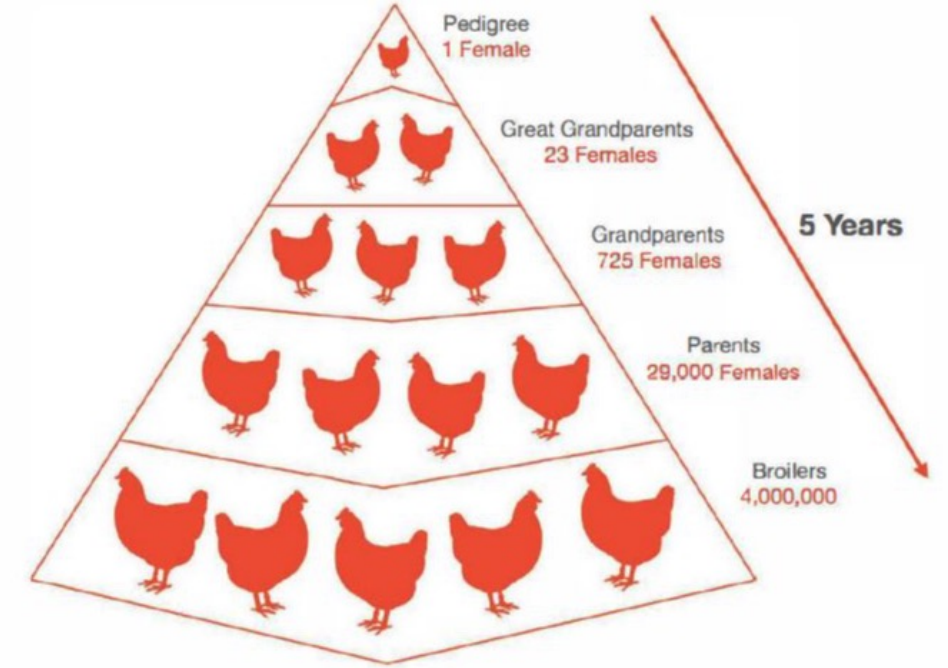
Genomic 2.0 is providing new insights into:

Gene regulation
Genetic variation in transcriptomes
Genetic redundancy
Non-additive gene action
Subpopulations - different founders
Multiple reference populations

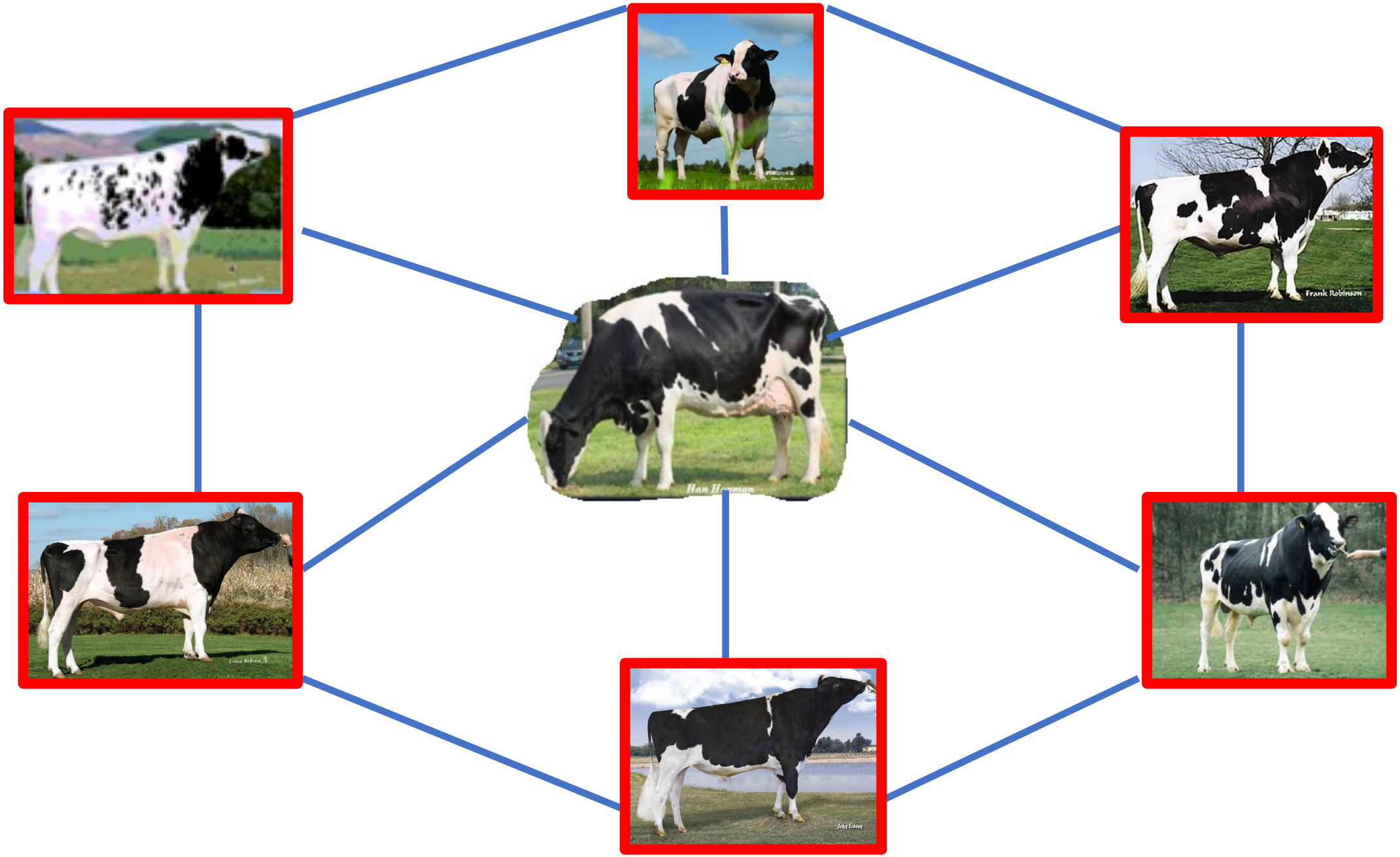
Other species, use multiple “breeds” – selected for different traits.

Farmers then work with crossbred or terminal cross animals.

X



One breed – Same goal - Multiple choices



Breeding groups 2022

U.S. Average

F_{st} = **0.00**

PEAK

F_{st} = **0.04**

SELECT SIRES INC.

F_{st} = **0.02**

German bred

F_{st} = **0.02**

F_{st} = **0.03**

STgenetics

F_{st} = **0.06**

Genus

Farmers and Breed Associations – Managing the population structure

Genetic evaluation centers

several reference populations and new genetic tools.

Breeding companies

genetic products that the farmers want.

Collaboration


Focus on profitability
Decisions are science based
Willingness to address challenges
Shared enthusiasm for the Holstein breed

Merci