THE Resilient Dairy GENOME PROJECT

**Herd'23:**
March 16th, 2023, All Seasons Resort Hotel, Bendigo Australia
*@BaesC1*

# The Future of Genetic Evaluation in Canada: A Research Perspective

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IMPROVE LIFE.

CGIL

DAIRY at GUELPH
CANADA'S DAIRY UNIVERSITY

# What is a resilient cow?

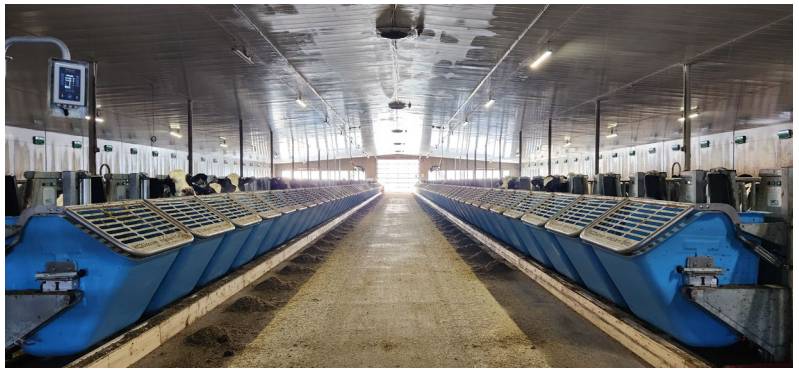
an animal able to adapt rapidly to changing conditions
without compromising its productivity, health or fertility
while becoming more resource-efficient
and reducing its environmental burden.

# Past,Current and Potential Future Projects

THE Efficient Dairy GENOME PROJECT

THE Resilient Dairy GENOME PROJECT

- International database for Feed Efficiency and Methane Emissions
- Genomic Evaluations for Feed Efficiency launched by Lactanet 2021
- Genomic Evaluations for Methane April 2023
- Resiliency Index (novel fertility, health, and efficiency traits) expected 2024



**FUNDED:**

**Alberta RDAR** project ~$2M

Sunalta Feed Bins & Sniffer prototypes at Elora

**AFC Alberta Milk** project $892K

Alberta $CH_4$ Sniffers, KTT, weight scale at Sunalta

**UNDER REVIEW:**

- **MAPAQ & Dairy Farmers of Quebec PLQ** project ~$3.17M
  - Quebec $CH_4$ Sniffers, Nutrition R&D & trainees
- **BC Dairy** project $136K
- **Dairy Cluster** project $980K
- **DFO Cash** support $160K + $10K IK
- **Genome Canada ICT** ~$16M

# National and International Research Partnerships

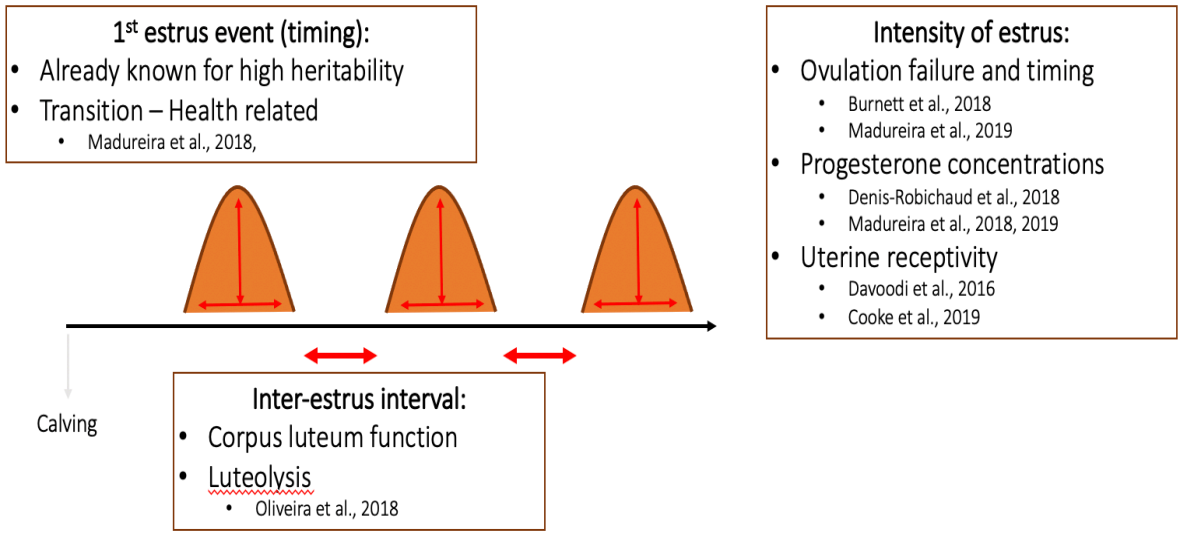
# 1. ‘Closer-to-biology’ fertility

*Dr. Ronaldo Cerri*

THE UNIVERSITY OF BRITISH COLUMBIA

**1. “Closer-to-Biology” Fertility**

- Standardized phenotypes based on automated sensors
- Physiological factors affecting estrous expression and embryo survival
- Genomic markers of estrus expression and fertility
- Size and Position Score (SPS)
- Transmission Ratio Distortion




*Madureira et al., 2022, 2021*
*Martin et al., 2021, 2022*

# 2. Enhanced disease resistance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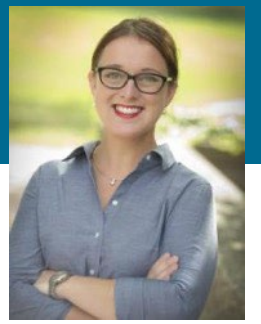
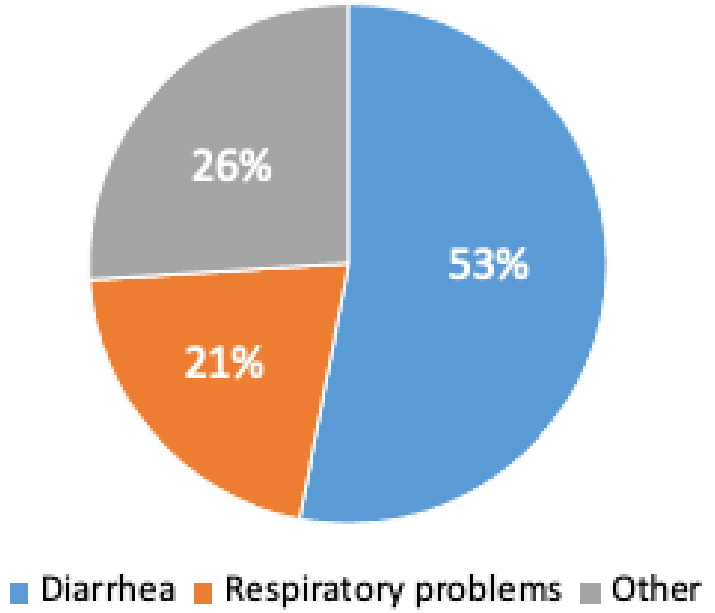


*Dr. Christine Baes*

- Fertility disorders in routine genomic analyses (Lactanet, 2020)
- Develop methods for routine phenotyping of
  - Calf health (Colin Lynch)
  - Leukosis (Renee Bongers)
  - Feed efficiency of calves (Kyle Hoeksema)
  - Johne's disease (Aisha Fong / Chrissy Rochus)
  - Effects of homozygosity (Makanjuola / Obari)

**Causes of pre-weaning mortality**




*Lynch et al., 2021; 2022; 2023*
*Bongers et al., 2023*
*Fong et al., 2023*

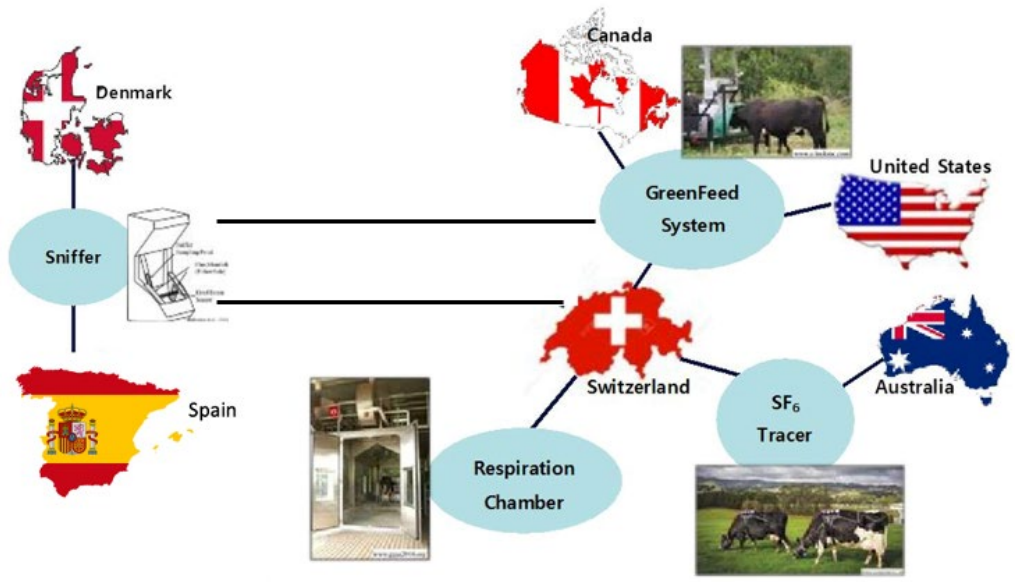
# 3. Feed efficiency and methane emissions

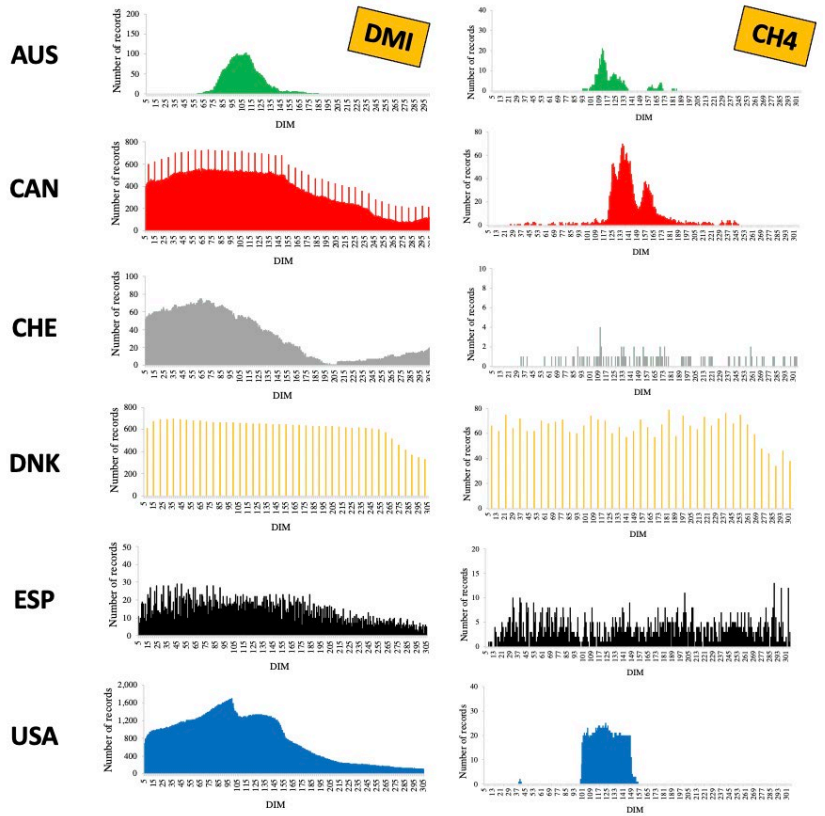
Lactanet

*Dr. Gerrit Kistemaker*

UNIVERSITY of GUELPH

*Dr. Christine Baes*


Enlarging the reference population for

- **Feed efficiency** (17,000 animals)
- **Methane emissions** (7,800 animals)

*van Staaveren et al., submitted*

# 4. Genomic and environmental relationships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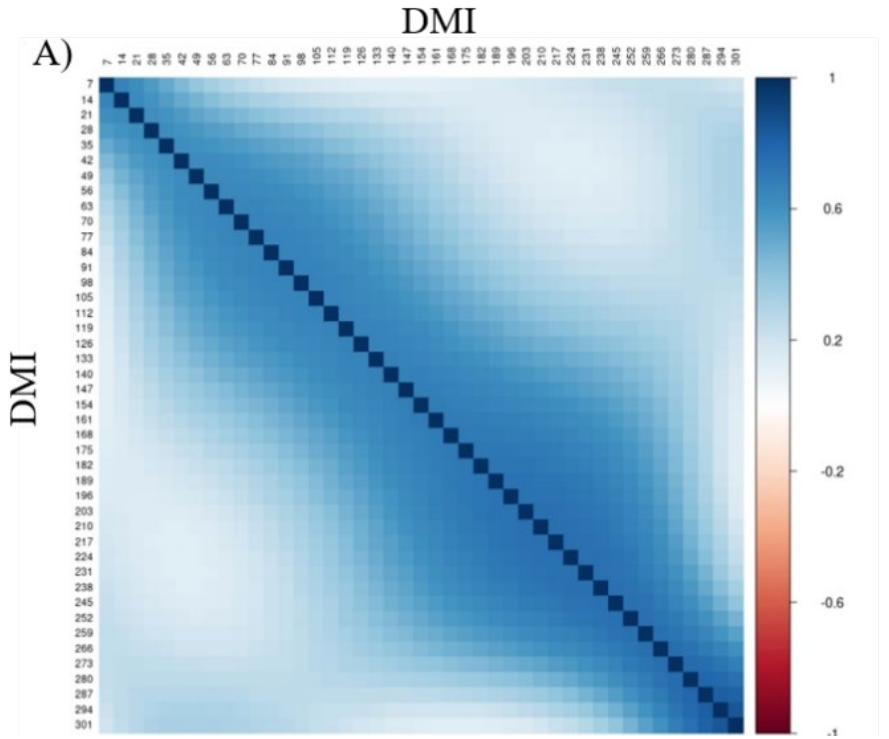
*Dr. Flavio Schenkel*

Genetic parameters and prediction of EBVs of resilience traits

- Multi-trait analysis to identify genomic regions with pleiotropic effects on resilience traits
- Genomic predictions for resilience indicator traits using copy number variants
- Investigate the effects of heat stress on important traits




*Houlahan et al., submitted*

# 4. Genomic and environmental relationships

## *Fertility*

- **Alcantara et al., 2022.** Machine learning classification of hormonal synchronization protocols for Canadian Holsteins cows. *JDS* (in review)
- **Martin et al. 2022.** Reproductive tract size and position score: Estimation of genetic parameters for a novel fertility trait in dairy cows. *JDS* (in review).
- **Oliveira at al. 2022**. Genome-Wide Association Analyses Reveals Copy Number Variant Regions Associated with Fertility and Disease Traits in Canadian Holstein Cattle, *PAG 2022*

## *Heat Stress*

- **Campos et al. 2022**. Using publicly available weather station data to investigate the effects of heat stress on milk production traits in Canadian Holstein cattle, *CJAS* https://doi.org/10.1139/cjas-2021-0088
- **Rockett et al. 2022**. Estimation of genetic parameters and prediction for heat tolerance in Holsteins using test-day production records and NASA POWER weather data. *JDS* (in review).

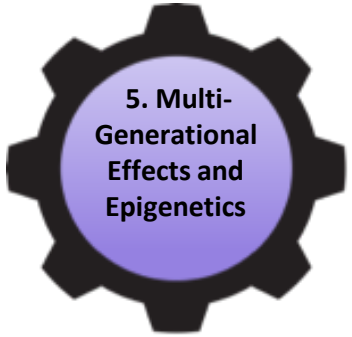
## *Calf Health*

- **Bongers et al. 2022**. Incorporation of enhanced disease resistance into genetic evaluations. 2022 Interbull meeting.
- **Bongers et al. 2022**. Genetic analysis of leukosis milk ELISA test records in Holstein cows. 2022 ADSA meeting.
- **Lynch et al. 2022**. A Canadian genetic evaluation for calf health: preliminary analysis. 2022 WCGALP.

## *Feed Efficiency / Methane*

- **Shadpour et al., 2022.** Predicting dry matter intake in Canadian Holstein dairy cattle using milk MIR and other predictors via ANN. *Accepted, JDS*
- **Shadpour et al., 2022.** Predicting methane emission in Canadian Holstein dairy cattle using milk MIR and other predictors via ANN. *Accepted, JDS*
- **Lopes at al. 2022.** Estimates of genetic parameters for environmental efficiency traits for first lactation Holsteins. *2022 ICAR & WCGALP meetings*
- **Houlahan et al. 2022**. The dynamic behavior of genomic predictions for feed efficiency over lactation. *2022 ICAR & WCGALP meetings*

# 5. Multi-generational effects and epigenetics

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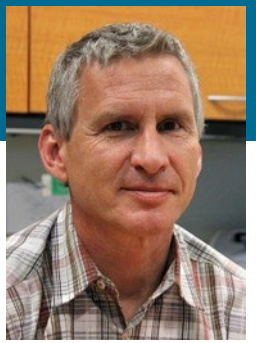


*Dr. Marc-André Sirard*

- Quantify effect of early environment (i.e., cow's production) on resilience of daughters
- Survey for epigenetic signature on precisely phenotyped animals
  - Whole Genome Bisulfite Sequence
    - 24 healthy (good)
    - 24 with mastitis, poor performance, infertility, lameness (bad)


*Methylation level of C_16_22592086 (on the y-axis) and C_8_101832167 (on the x-axis)*

# 6. Data management


*Dr. Paul Stothard*

Management of project database

- Whole-genome sequence data analysis for variants, genotypes, functional annotations
  - SnakeMake pipeline to call SNPs?
- Genome browser integration of GWAS findings, epigenetic signatures, & annotated sequence variation

SnakeMake pipeline developed for calling SNPs from methylation sequencing – Coverage now 50x

| Sample | Average coverage | Bases with >10X coverage (Mbp) | Filtered SNPs |
|---|---|---|---|
| 2258 | 25.73 | 2.49 | 3,813,056 |
| 2260 | 13.29 | 1.17 | 1,202,679 |
| 2261 | 29.19 | 2.52 | 4,109,577 |
| 2262 | 15 | 1.22 | 1,345,862 |
| 2267 | 5.88 | 0.37 | 274,853 |
| 2268 | 21.46 | 2.42 | 3,216,416 |
| 8761 | 14.5 | 1.72 | 1,634,613 |

Next steps: compare WGBS-called SNPs to SNPs from conventional WGS to gauge performance and utility of this approach.

*Herman et al., 2022*

# 7. GE3Ls: sustainability and social acceptance

UNIVERSITY of GUELPH

*Dr. Getu Hailu*

UNIVERSITY OF ALBERTA

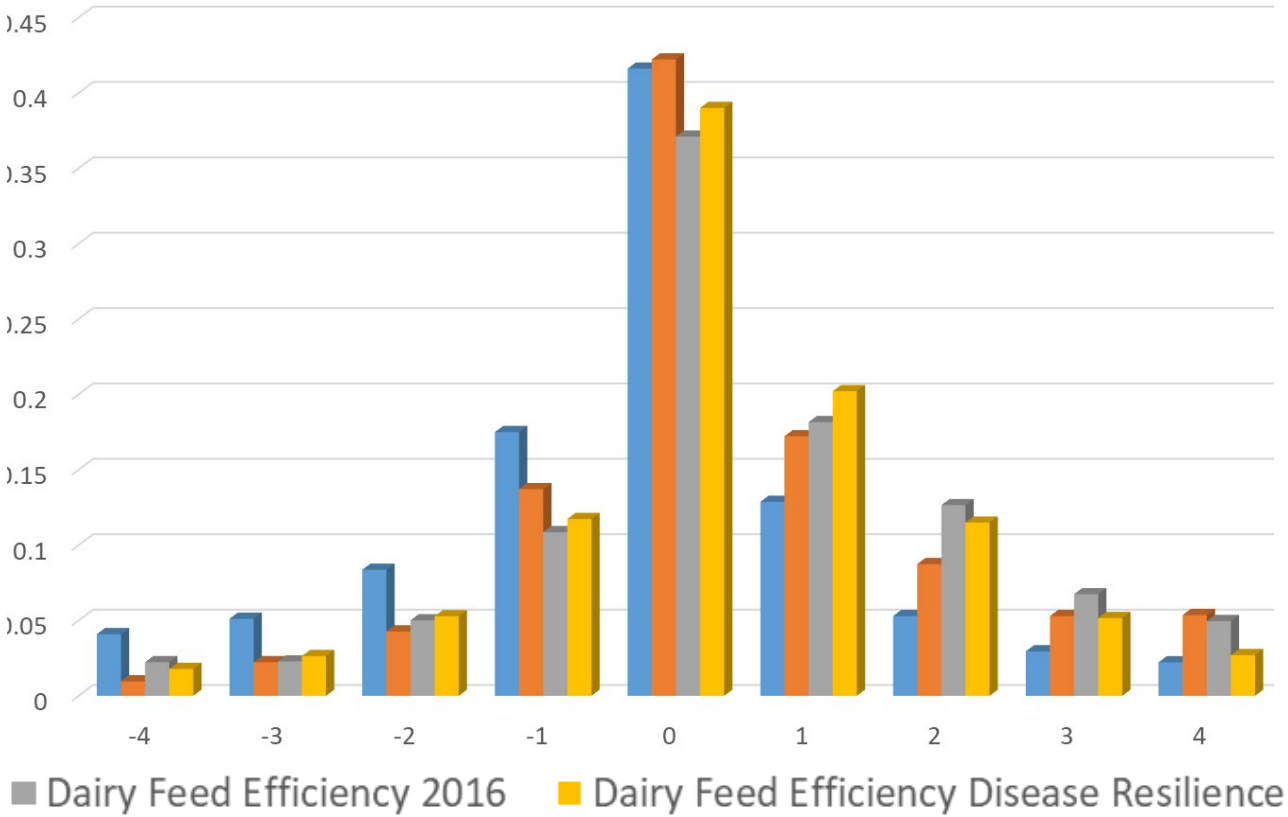
*Dr. Ellen Goddard*

**7. GE$^3$LS: Optimizing traits to maximize sustainability and societal acceptance**

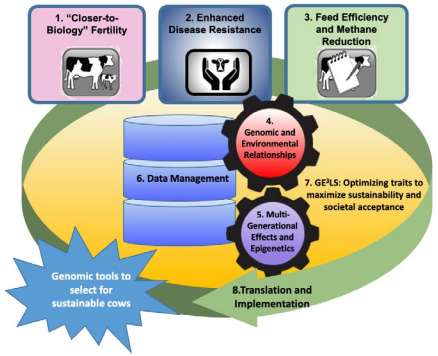
- Farm level decisions about tradeoffs between traits
- Farm/Market level outcomes from selection of resilience traits
- Public acceptance of dairy under different breeding strategies

*Goddard et al., 2022*

Public Perceptions: Benefits of Genomic Selection minus Risks of Genomic Selection



# 8. Translation and Implementation

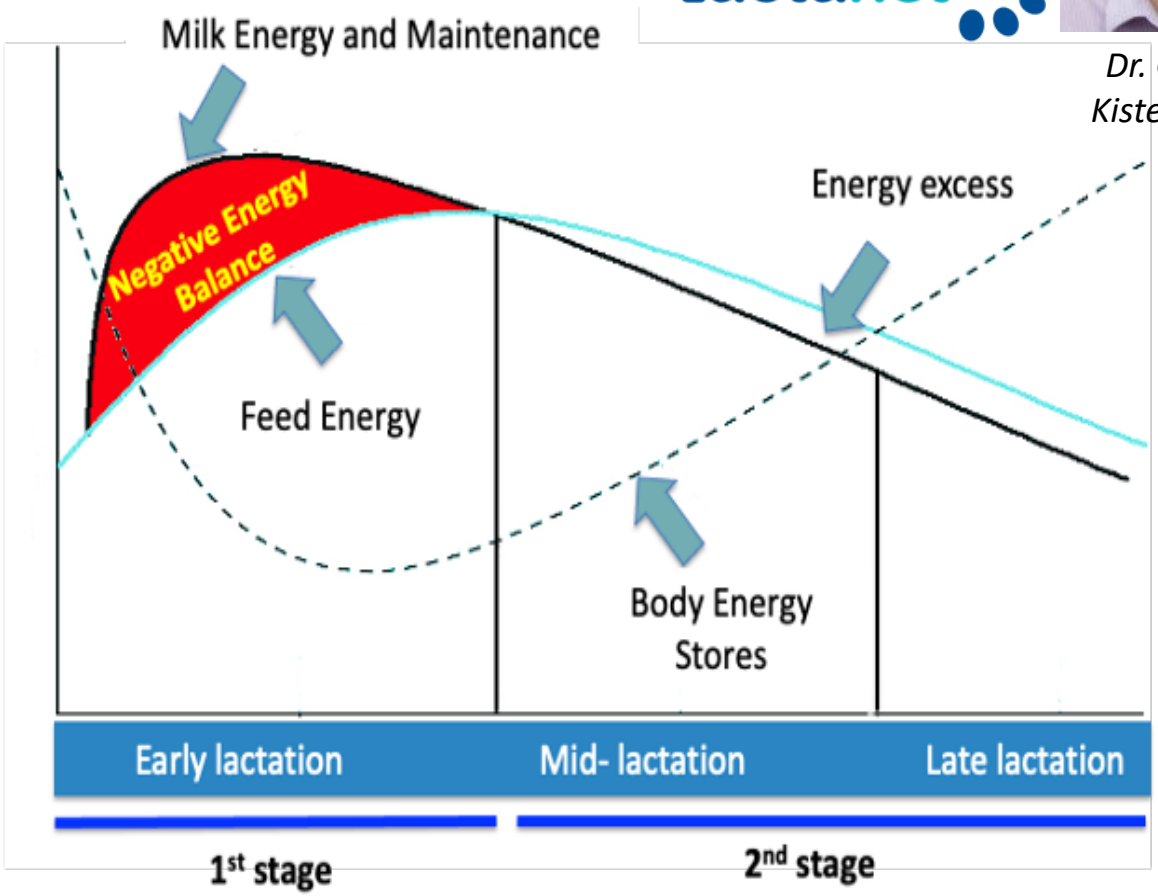



Implement fertility disorder evaluations (done 2020)

Feed efficiency evaluations (2022)

Methane evaluations (2023)

Develop resiliency index




Lactanet

*Dr. Gerrit Kistemaker*

**Overall aim is to select for cows that use less feed at the same level of production and body size after peak of lactation**

# Final remarks: Environmental Efficiency

- RDGP data base is sizeable and growing
  - Canada, US, Denmark, Switzerland, Germany, Spain, Australia
  - About 3,200 cows for methane emissions
- CH4 sniffers installed soon in multiple commercial farms
- CH4 emissions predicted **accurately** (~0.85) using milk MIR
  - Evaluations for **CH4 emissions** ready to be launched in April 2022
- New Genome Canada proposal underway
  - GHG mitigation roadmap using genetic and nutrition strategies
  - Reduce GHG emissions by 54% (6.72 Mt CO2-eq)

Climate-Smart Agriculture and Food Systems – Interdisciplinary Challenge Team:

# Leveraging Genomics to Achieve Dairy Net-Zero

*Baes, Miglior, Gervais and Stothard*

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# Leveraging Genomics to Achieve Dairy Net-Zero:
## Proposal Activities


Results from other studies for augmenting genomic evaluations

Forages, legumes, plant-soil interactions or feedstuffs data

Microbiome samples

Plants, soils, or ruminant data

Adaptation of ruminant agrifood systems

# Leveraging Genomics to Achieve Dairy Net-Zero: Deliverables

- A roadmap (overall goal) and embedded toolbox for GHG reduction
- Quantify impact and uncertainty surrounding GHG mitigation strategies
- Understanding biological architecture to deliver novel mitigation tools for methane emissions
- Reports on:
  - broad context of emissions reductions
  - public and wider stakeholder attitudes to such reductions
  - producer engagement to help ensure uptake of mitigation approaches
- Accurate and robust method for estimating individual animal and herd-level GHG emissions for use in national policy and GHG inventories

# Acknowledgements

































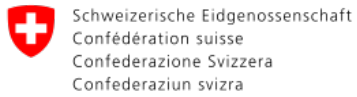





























18

# Thanks to a fantastic team!

www.resilientdairy.ca/

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