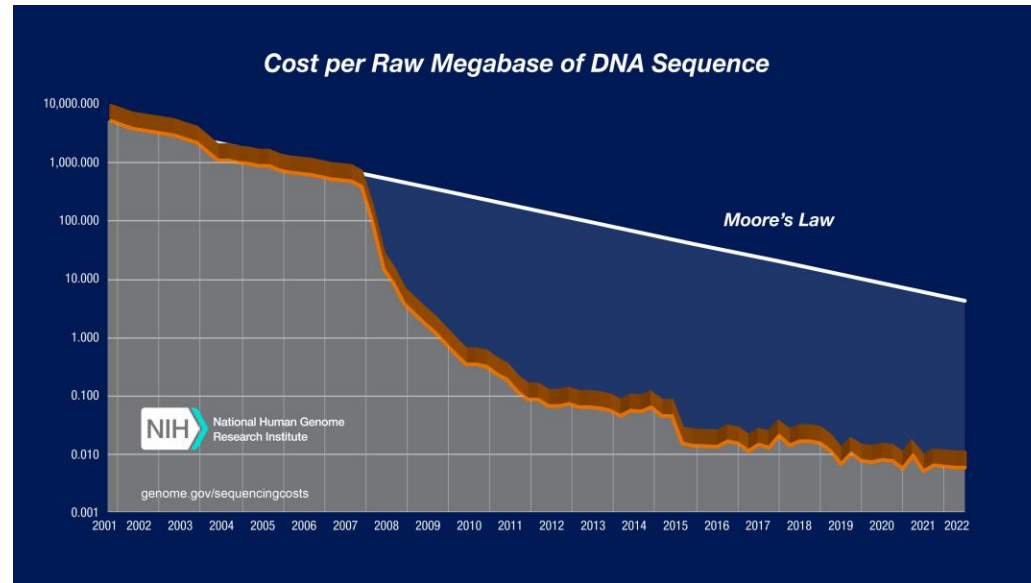# The use of phenomics to improve carcass and meat quality

Manuel Juárez, MVSc, MBA, PhD

The Phenomic Gap

"Phenomics should be recognized and pursued as an independent discipline to enable the development and adoption of high-throughput and high-dimensional phenotyping."

"A 'genotype–phenotype' map is inaccessible without the detailed phenotypic data."

Houle, Govindaraju & Omholt.
Phenomics: the next challenge
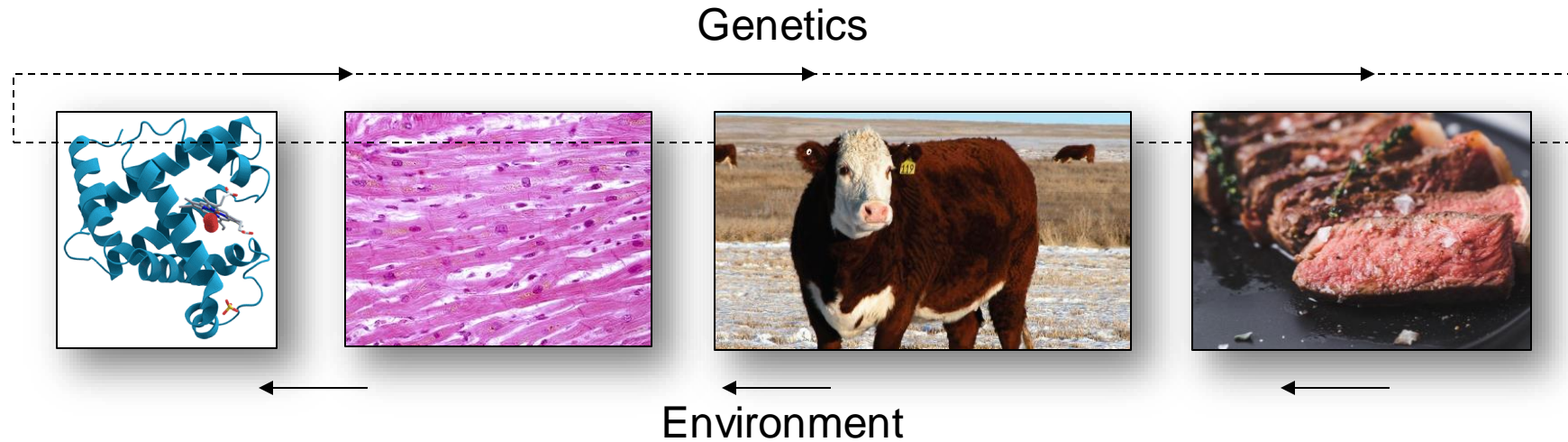Nature Reviews Genetics 11, 855-866 (2010)

The Phenomic Gap
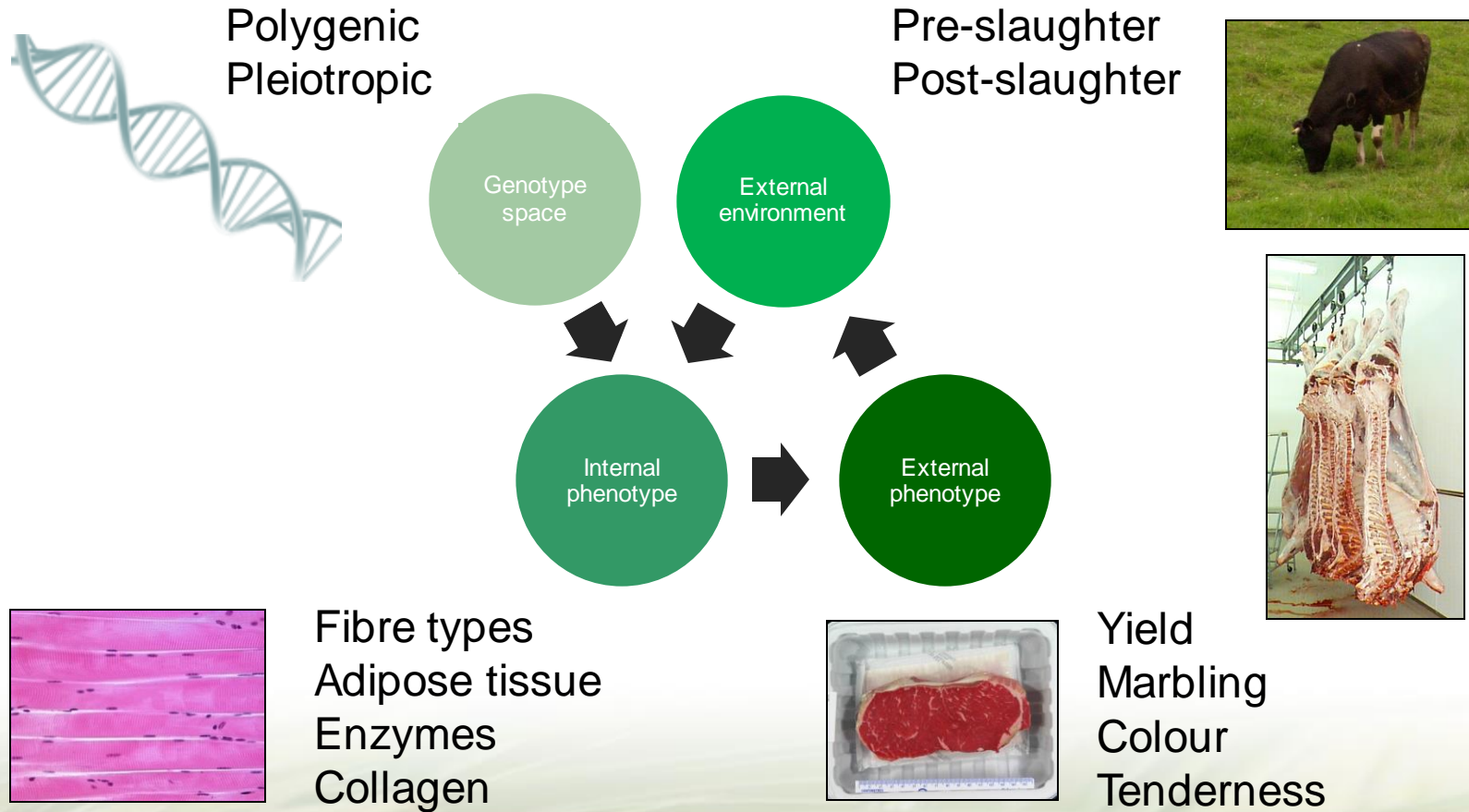

"In the age of the genotype, phenotype is king."

Mike Coffey

Intro to Livestock Phenomics

Genetics

Environment

Phenome: "Set of all phenotypes expressed by a cell, tissue, organ, organism, or species"
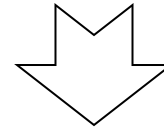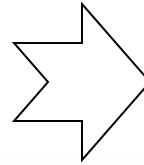
Genotypic-phenotypic map

Livestock Phenomics

"Systematic acquisition of high dimensional phenotypic data on a genome-wide scale."
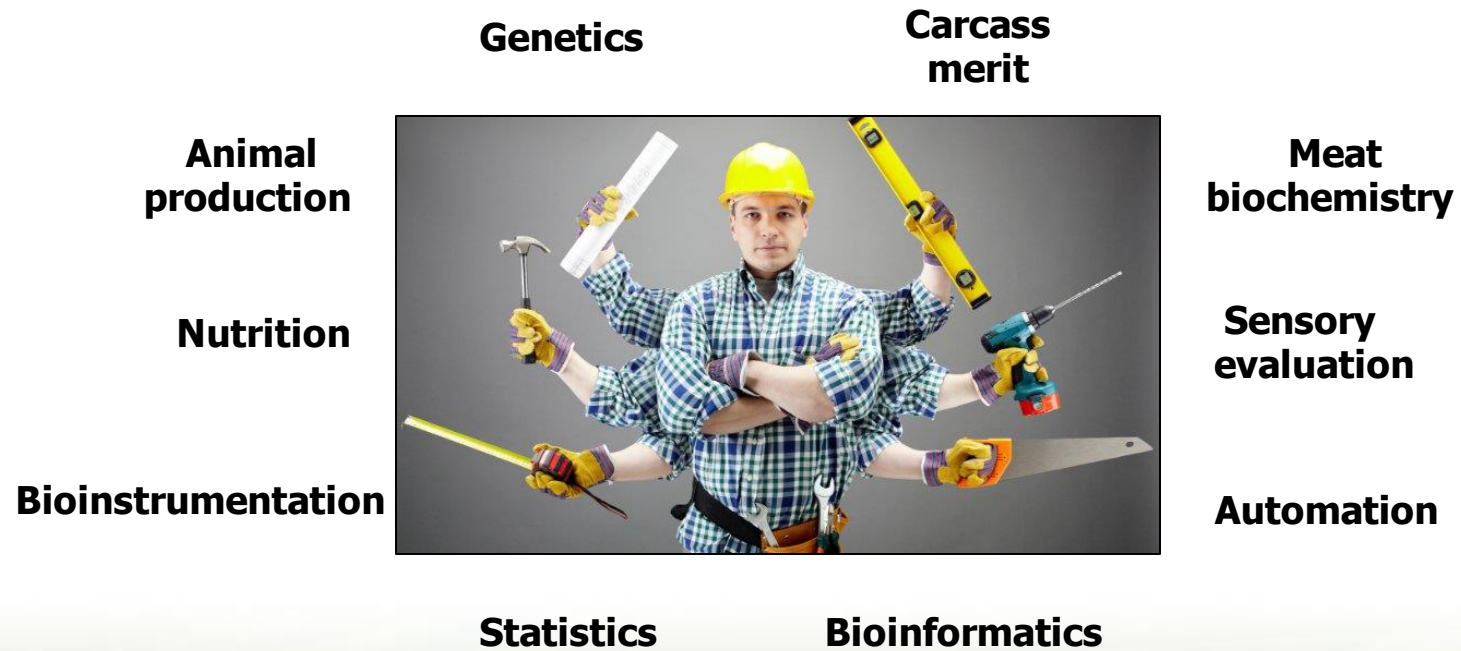"Measurement of phenomes as they change in response to genetic mutation and environmental influences."

- Genomics
- Proteomics
- Metabolomics
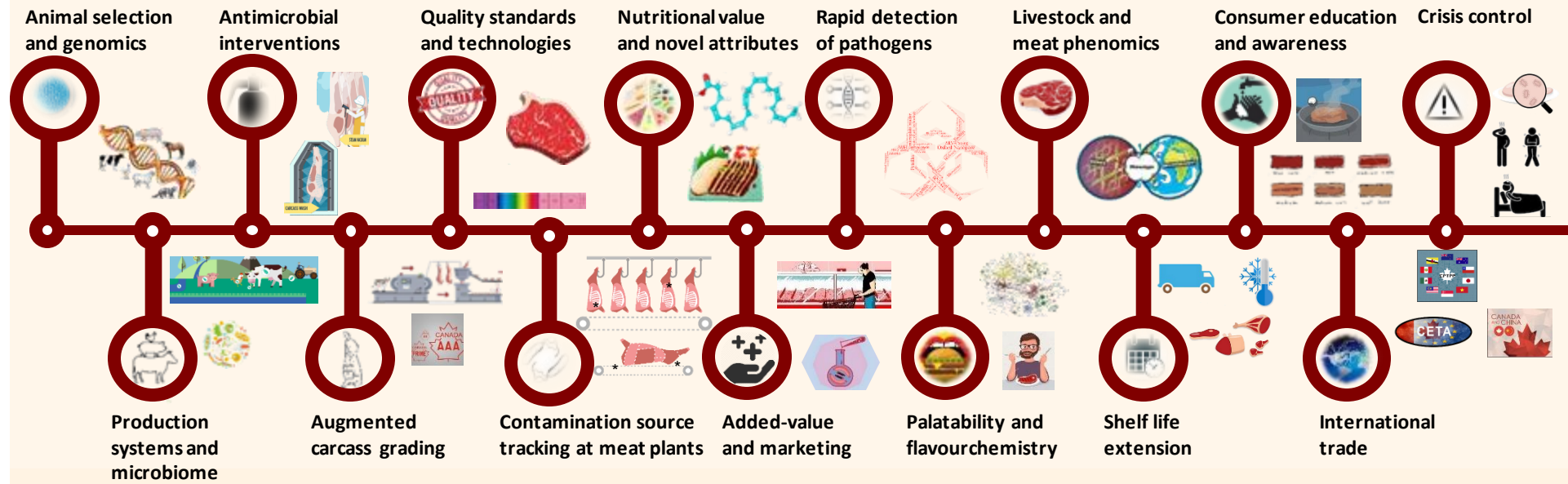- Interactomics
- Microbiome
- …

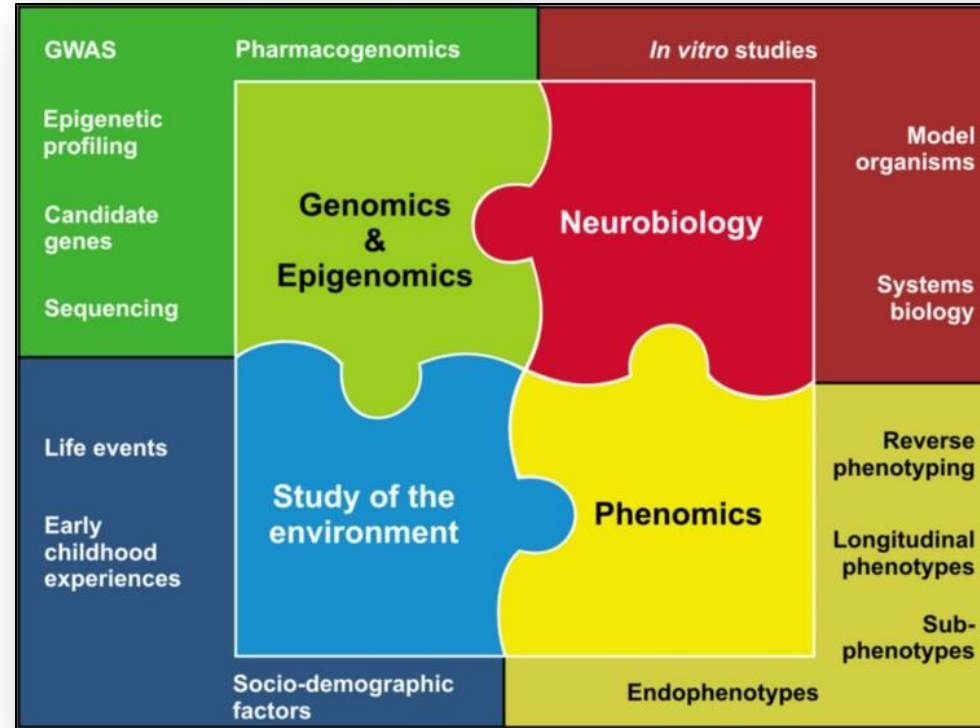# Livestock Phenomics

"Jack of all trades, master at none"

Integrated Meat Science. Research continuum at the AAFC-Lacombe RDC
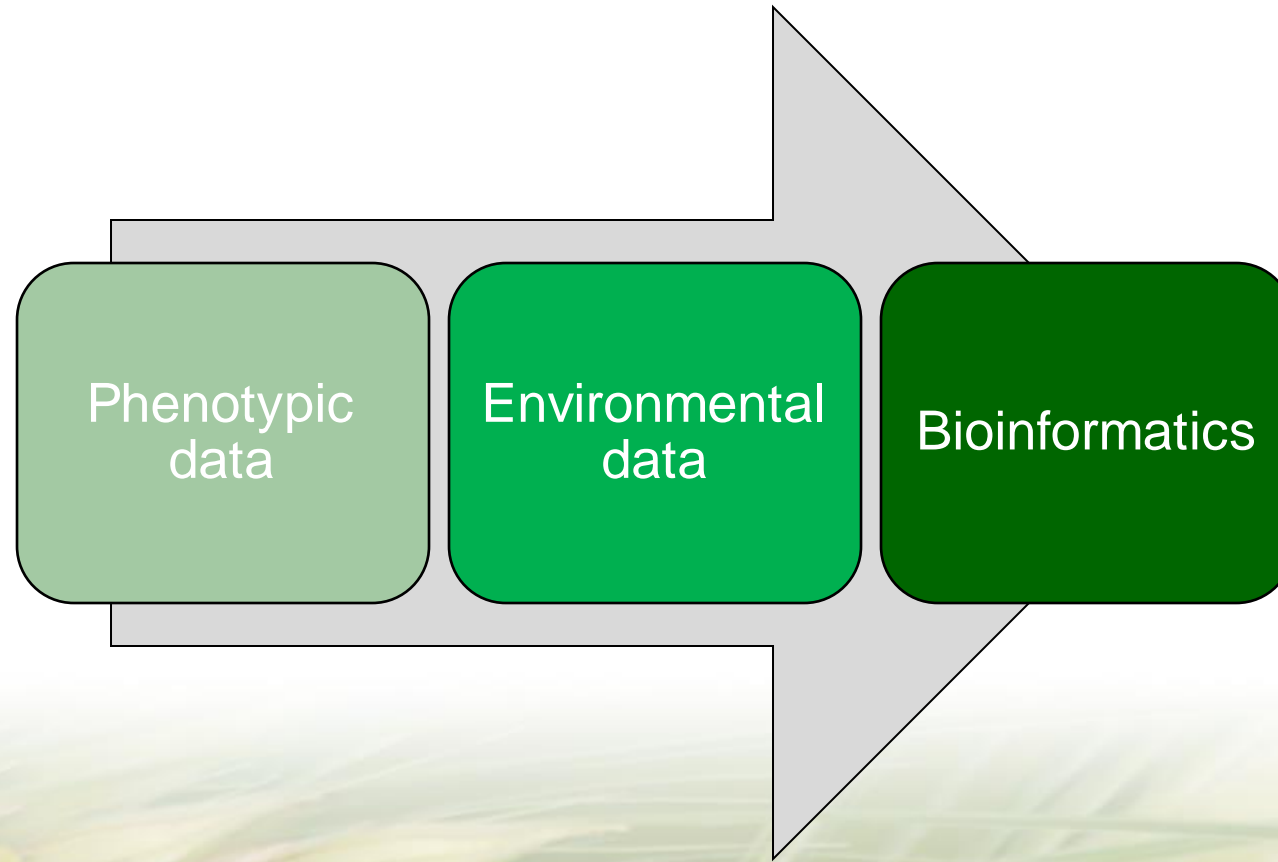
First approach from Psychology

Components of Livestock Phenomics
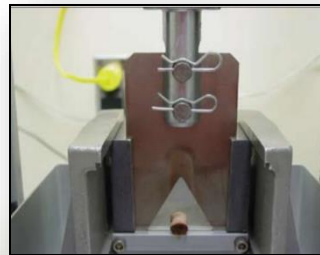
Carcass and meat quality traits

Carcass quality

- Conformation

- Lean meat yield

- Rib-eye area

- Carcass composition

- Primal composition

Meat quality

- pH

- Colour

- Marbling/IMF

- Firmness

- Safety

- Texture

- Flavour, juiciness…

- Fatty acid composition

- Nutritional value

- …

Factors impacting quality traits

Pre-mortem

- Species and domestication

- Genotype/Breed

- Production system

- Diet

- Growth promotants

- Age at slaughter

- Transportation/Stress

- ...

Post-mortem

- Slaughter

- Chilling and spraying

- Suspension/ES

- Packaging

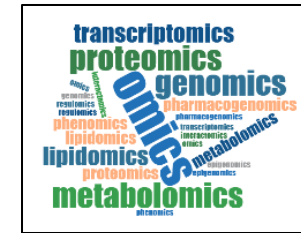- Refrigeration/Freezing

- Ageing

- Cooking

- ...

Collecting Phenotypic Data

Full phenome unachievable → prioritize

Interdisciplinary disciplines

- Standardization: necessary to combine data

- Ontology: common language for researchers

- Automation: real-time data collection

- Deep phenotyping: -omics may be required

- Not always real-time

High-throughput phenotyping

Carcass quality
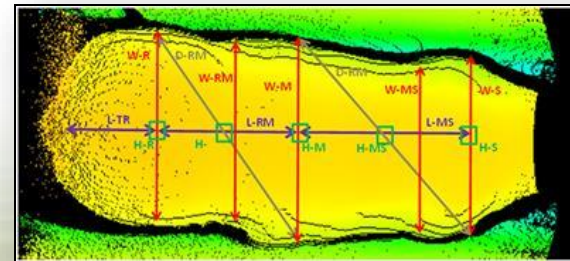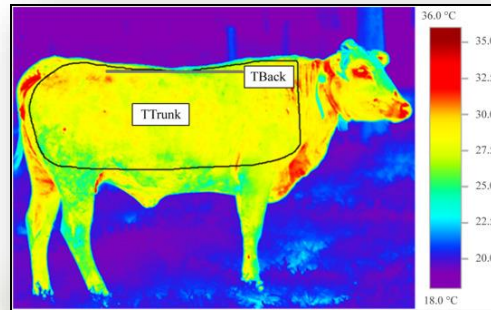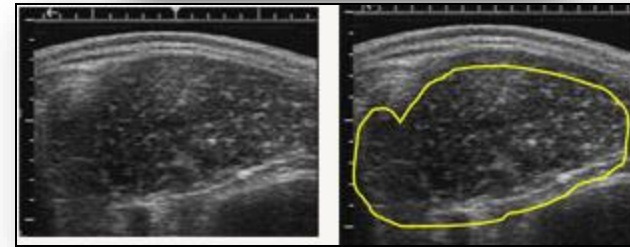
- Live animal prediction

- Video image analysis

- Dual energy X-ray absorptiometry

- Computed tomography

High-throughput phenotyping

Carcass quality

- Live animal prediction

- Video image analysis

- Dual energy X-ray absorptiometry
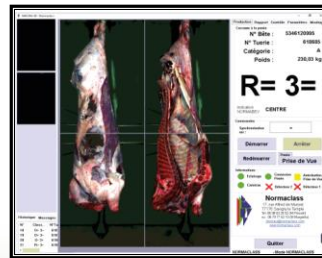
- Computed tomography

High-throughput phenotyping

Carcass quality

- Live animal prediction

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- Computed tomography
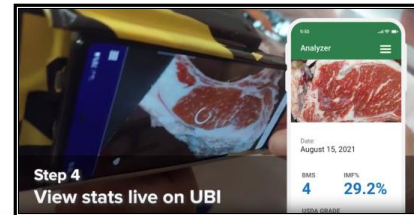
High-throughput phenotyping

Carcass quality

- Live animal prediction

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High-throughput phenotyping

Carcass quality

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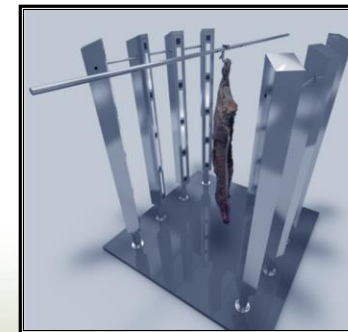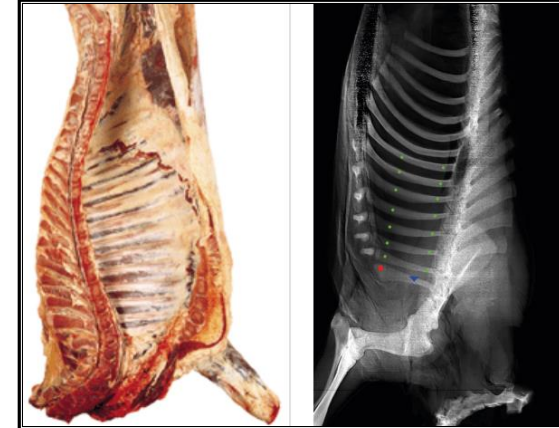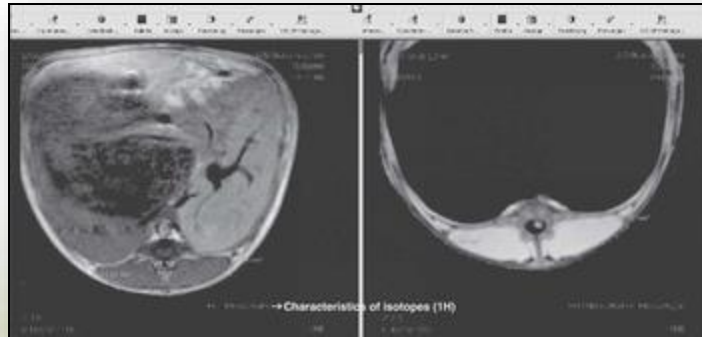
- Dual energy X-ray absorptiometry

- Computed tomography

High-throughput phenotyping

Meat quality

- Video image analysis

- Near infrared spectroscopy

- Hyperspectral imaging

- Raman spectroscopy

High-throughput phenotyping

Meat quality

- Video image analysis

- Near infrared spectroscopy

- Hyperspectral imaging

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High-throughput phenotyping

Meat quality

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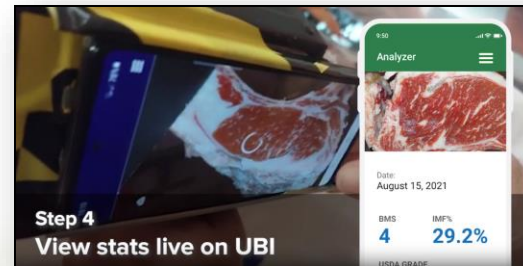
- Hyperspectral imaging

- Raman spectroscopy

High-throughput phenotyping

Meat quality

- Video image analysis

- Near infrared spectroscopy

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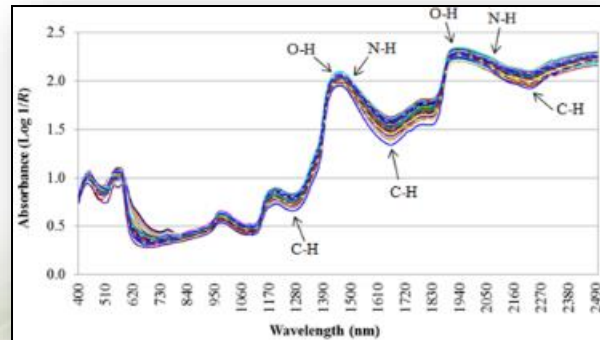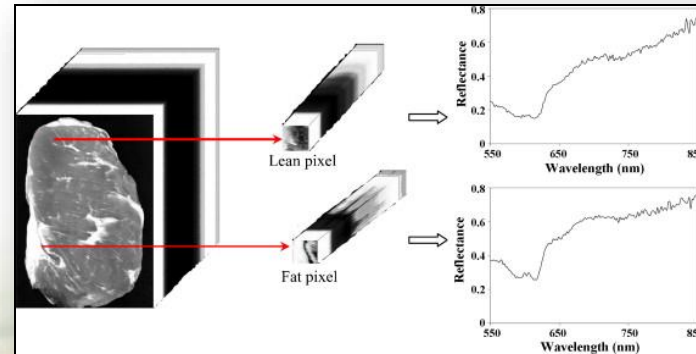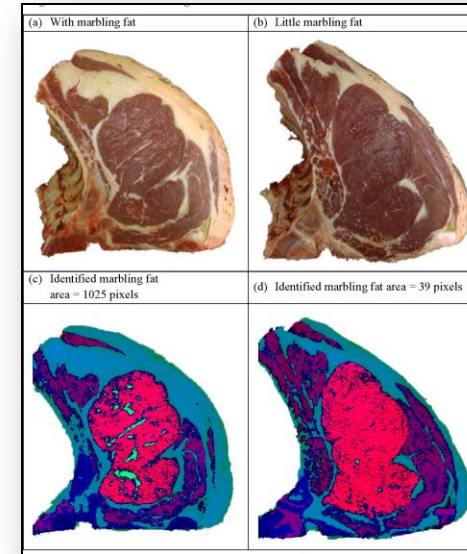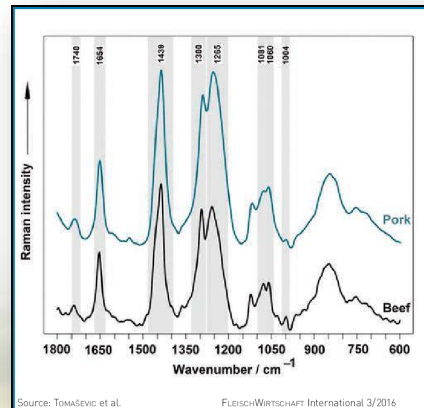
High-throughput phenotyping

Meat quality

- Video image analysis

- Near infrared spectroscopy

- Hyperspectral imaging

- Raman spectroscopy

High-throughput phenotyping

New technologies available for livestock carcass classification and grading

Óscar López-Campos*, Nuria Prieto, Manuel Juárez and Jennifer. L. Aalhus

Address: Agriculture and Agri-Food Canada, Lacombe Research and Development Centre, 6000 C & E Trail, Lacombe, Alberta, T4L 1W1, Canada.

*Correspondence: Óscar López-Campos. Email: Oscar.lopezcampos@canada.ca

Collecting phenotyping data

- Phenotypic and environmental data range in complexity

- Phenotyping costs balanced with sample sizes

- Details regarding methodologies

- Collaborative frameworks

- Access to commercial data

- Tissue banking

BIXS
BEEF INFOXCHANGE SYSTEM

HERDTRAX
Cattle Record Management

Collecting environmental data

- Conditions external to the genotype

- Extensive vs Intensive production systems

- Controlled conditions?

- High-throughput - Automation

- From live animal to final product
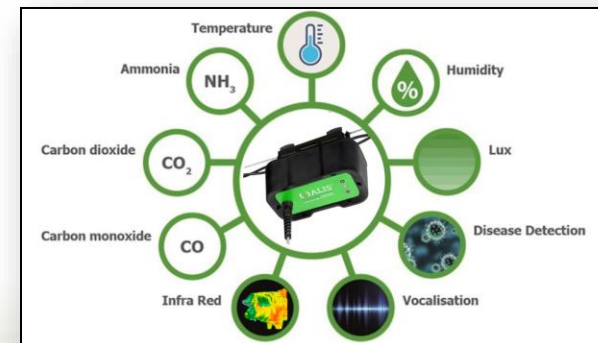
Integrating bioinformatics

- Heterogeneous, fragmented data

- Conceptual computational dimensions

- Storage limitations

- Need for software

- High dimensional datasets

- Statistical approaches

- Longitudinal approaches

- Data mining – Neural networks
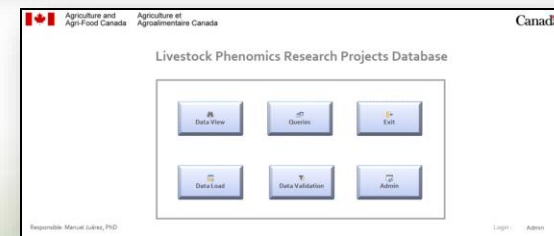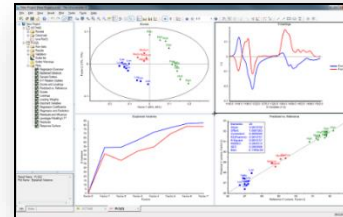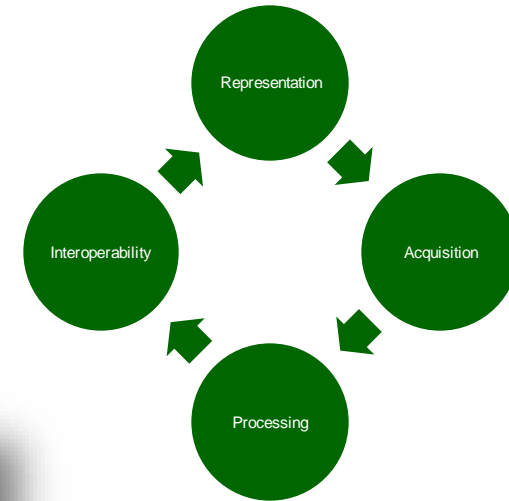
Addressing the phenomic gap

Pre-mortem factors

- Biotype (% British/Continental)
- Production system (Calf- Yearling-fed)
- Growth implant
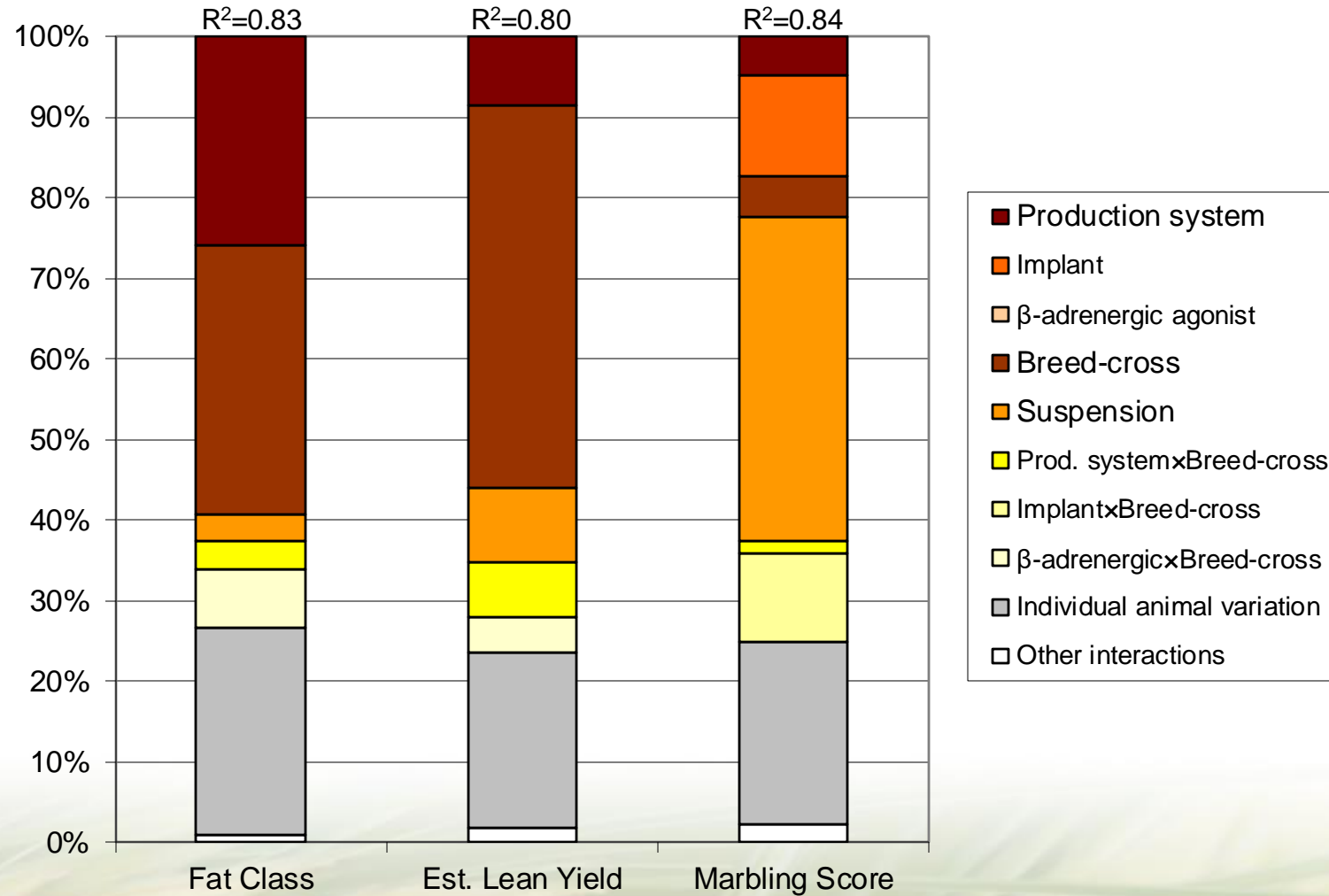- β-adrenergic agonist

Post-mortem factors

- Carcass suspension (Y1)
- Electrical stimulation (Y2)
- Ageing time (2, 7, 14, 21, 28 d)

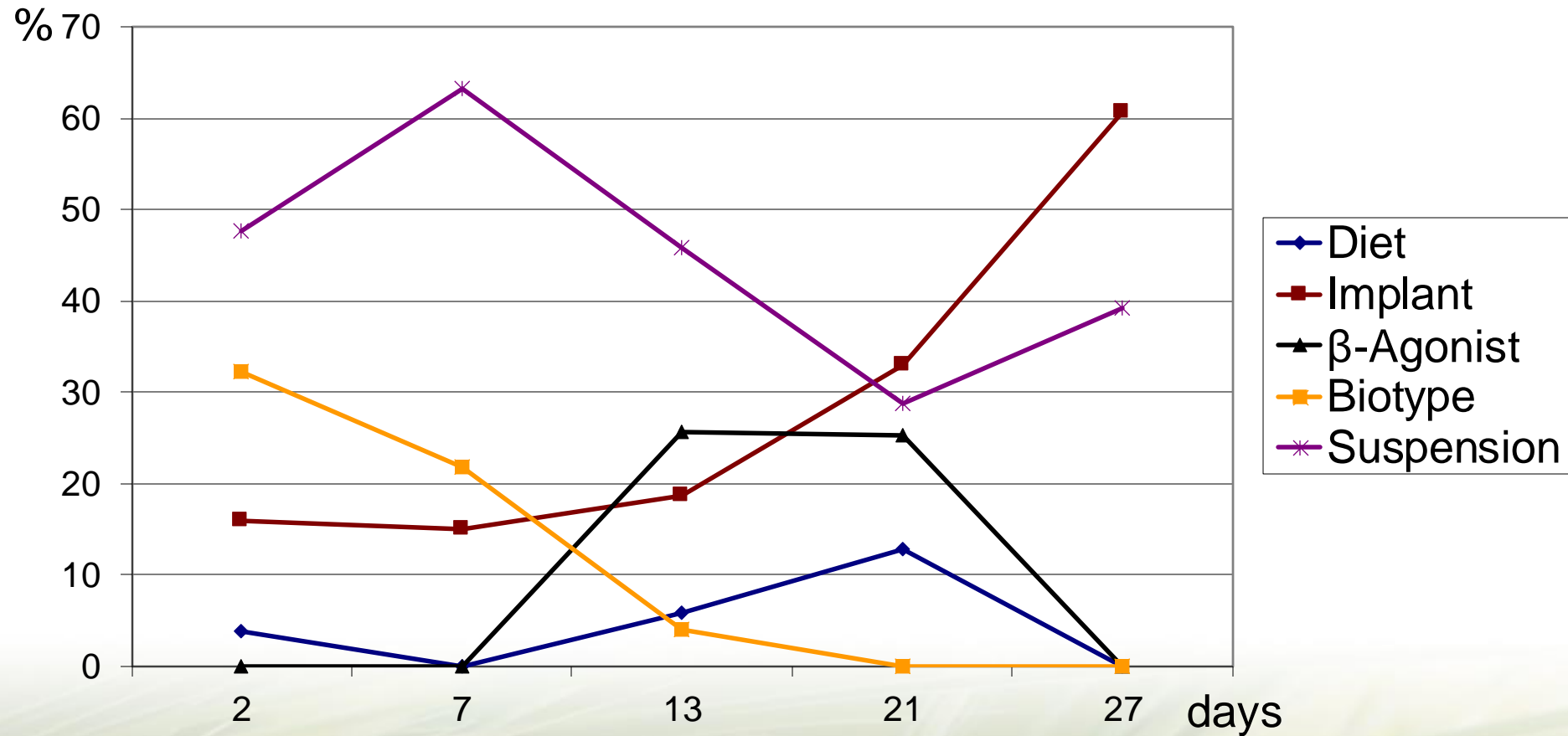**Carcass and meat quality**

- Carcass
  - Fat class
  - Estimated lean yield
  - Marbling score

- *Longissimus*
  - Sarcomere length
  - Drip loss
  - Proximate analysis
  - Panel tenderness
  - Colour
  - Shear force

Relative contribution to carcass traits

Relative contribution to shear force
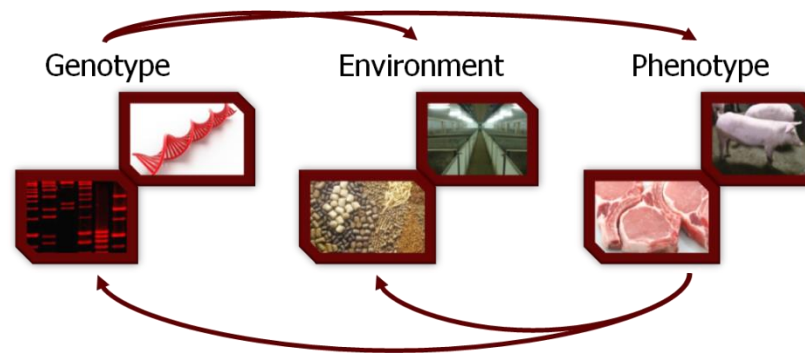
Phenotypic-genotypic data integration

"Linking genotypic and phenotypic information is one of the greatest challenges of current genetics research"

Nuzzo et al., 2009

Requirements:

- Bioinformatics
- Collaboration
- Expertise

Genotype   Environment   Phenotype
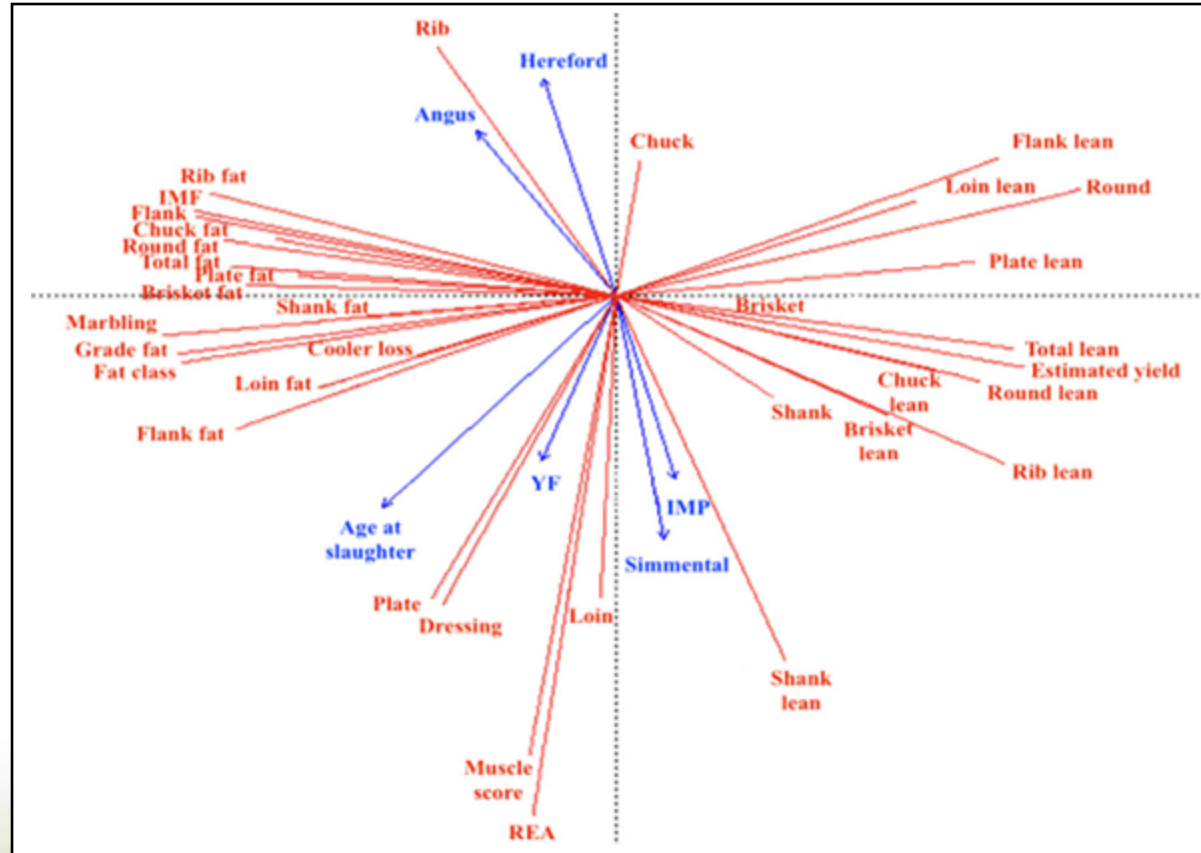
Beef carcass primal composition

- 5,000+ animals
- 1,000+ full phenotypes
- Environmental and performance info
- Detailed carcass and meat quality
- Focus on primal cuts
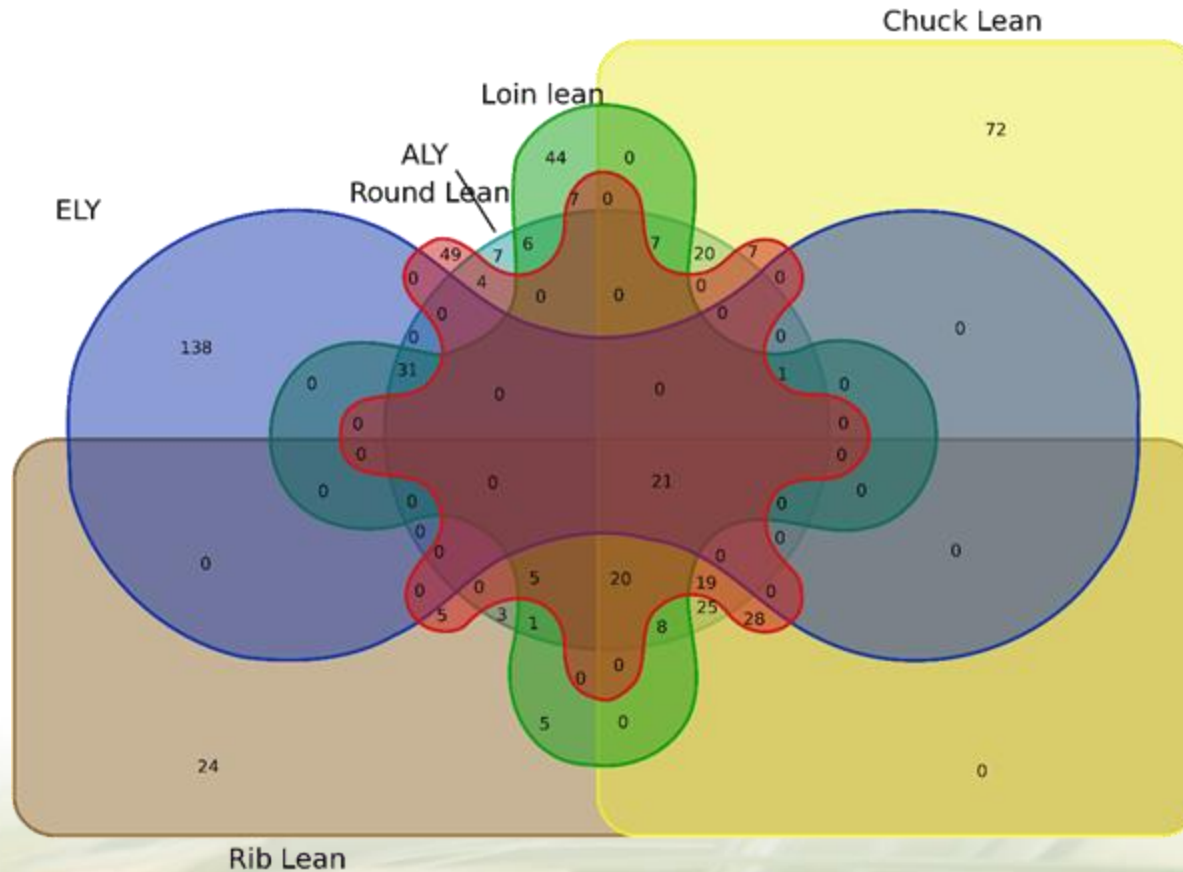- 100K SNPs

Beef carcass primal composition

Relationships related to carcass/primal composition
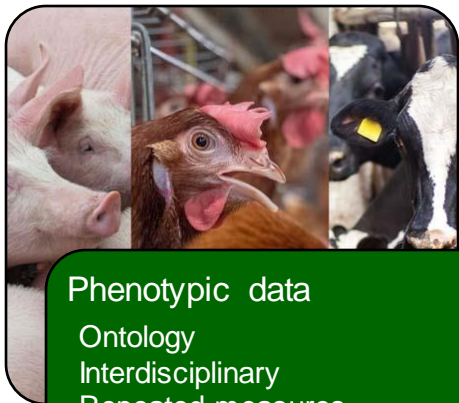

Sood et al., 2022

Beef carcass primal composition

Genes explaining beef carcass/primal composition

Sood et al., 2023

Livestock Phenomics

Phenotypic data
Ontology
Interdisciplinary
Repeated measures
High-throughput
Omics

Environmental data
- Intensive/Extensive
- Pre-harvest
- Post-harvest
- Automation

Bioinformatics
- Computable data
- High-dimensional
- Storage
- Integration
- New approaches

Thank you!

For more information, please contact:
manuel.juarez@agr.gc.ca