Welcome to Session 3

2024 Future-proofing Beef Selection Decisions

Session 3-Part 1
Understanding Methane: From Phenotyping to Selection Opportunities

Tools of a new trade: methane phenotyping for genetic evaluations

Dr. Bailey Engle
USDA-ARS, US Meat Animal Research Center

Brown Bagger

eBEEF.ORG

Tools of a new trade: methane phenotyping for genetic evaluations

Bailey Engle
U.S. Meat Animal Research Center

eBEEF Brown Bagger Webinar Series 2024
Oct. 16, 2024

USDA Agricultural Research Service
U.S. DEPARTMENT OF AGRICULTURE

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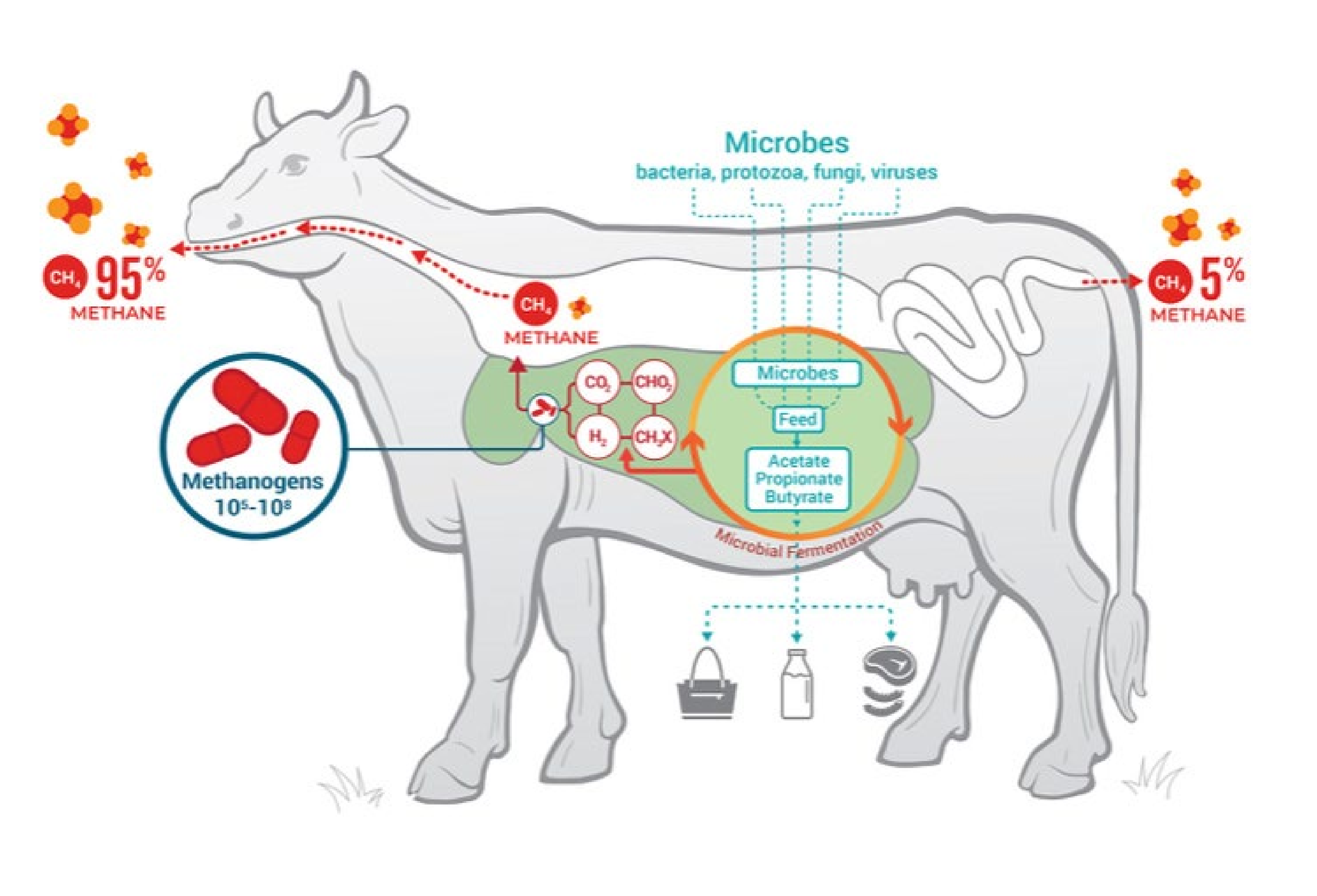
Today's objectives:

1. Share current approaches for methane phenotyping

2. Discuss pros and cons of each approach

3. Get into emerging tech for methane phenotyping

Enteric methane

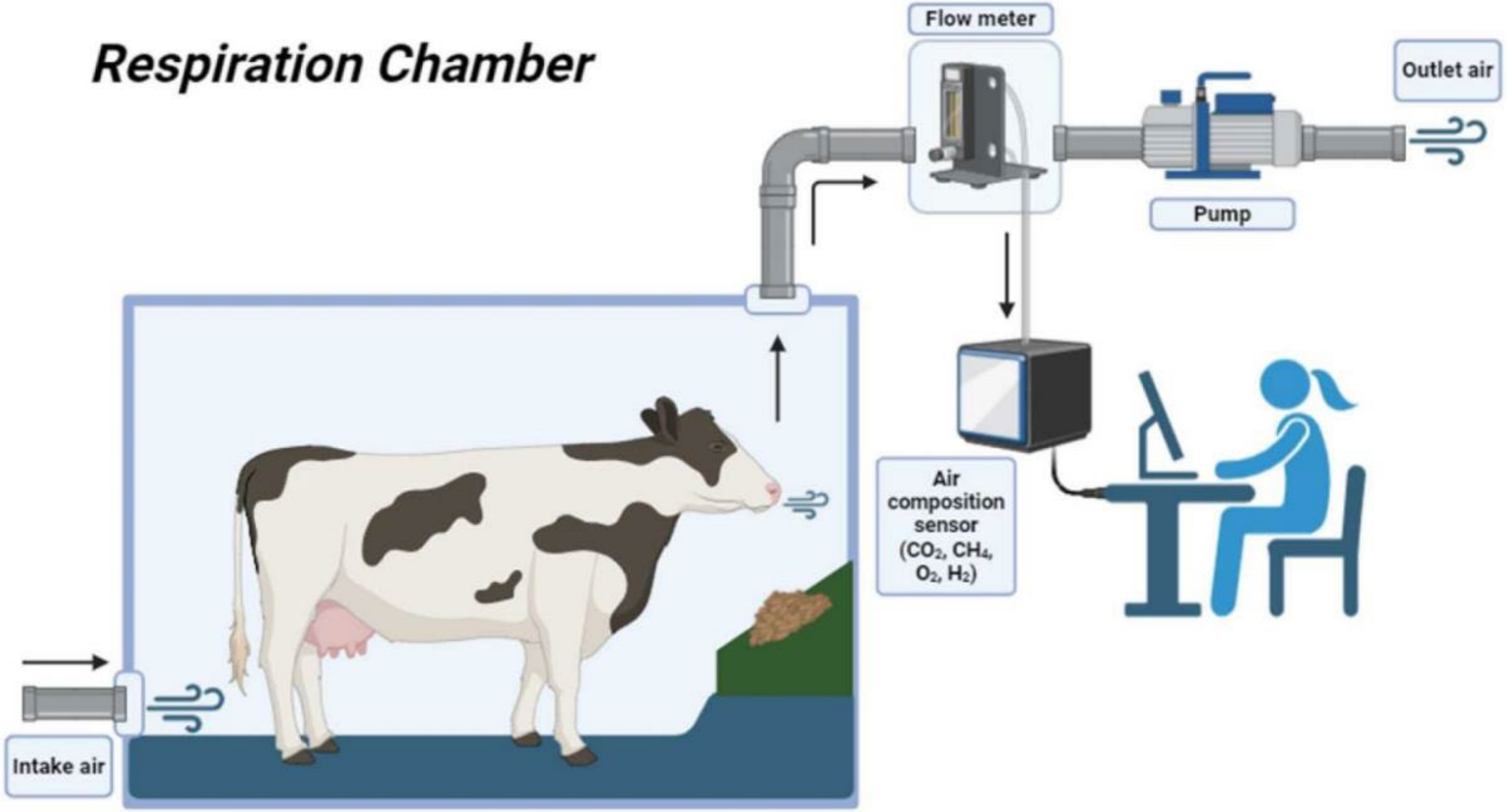


Palangi & Lackner, 2022. Animals

What makes a good phenotyping tool?

- High accuracy
- Low cost
- High throughput
- Non-invasive
- Low labor

Respiration chamber



Wisconsin Diary Extension, A. Pfau; Cornell Univ.; ILRI

USDA ARS; Univ. Nebraska - Lincoln

Respiration headboxes


AgResearch NZ

Portable accumulation chamber

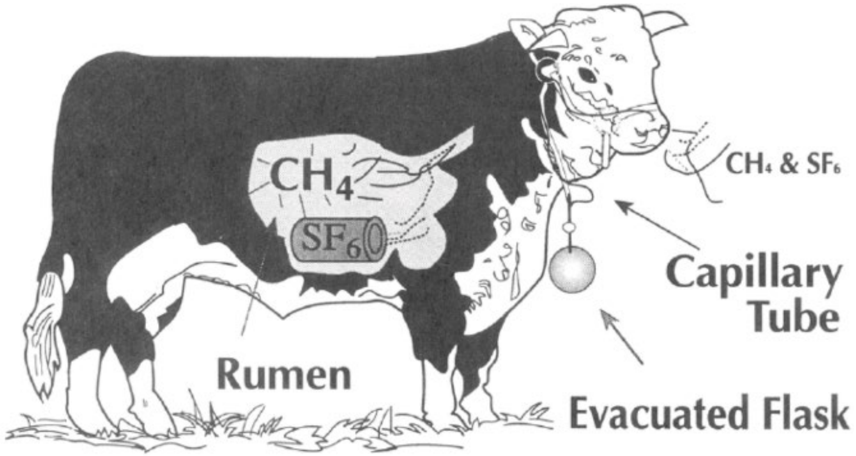
AgResearch NZ

Portable accumulation chamber

Chamber & headbox approaches

- Pros: Gold Standard for accuracy
  - Controlled environment
  - Measures methane flux
  - Ruminal and hindgut CH_4 emissions are captured*
- Cons: Expensive
  - Labor intensive
  - Significant animal training required
  - Low throughput
  - Controlled environment

Sulfur hexafluoride (SF_6) tracer technique

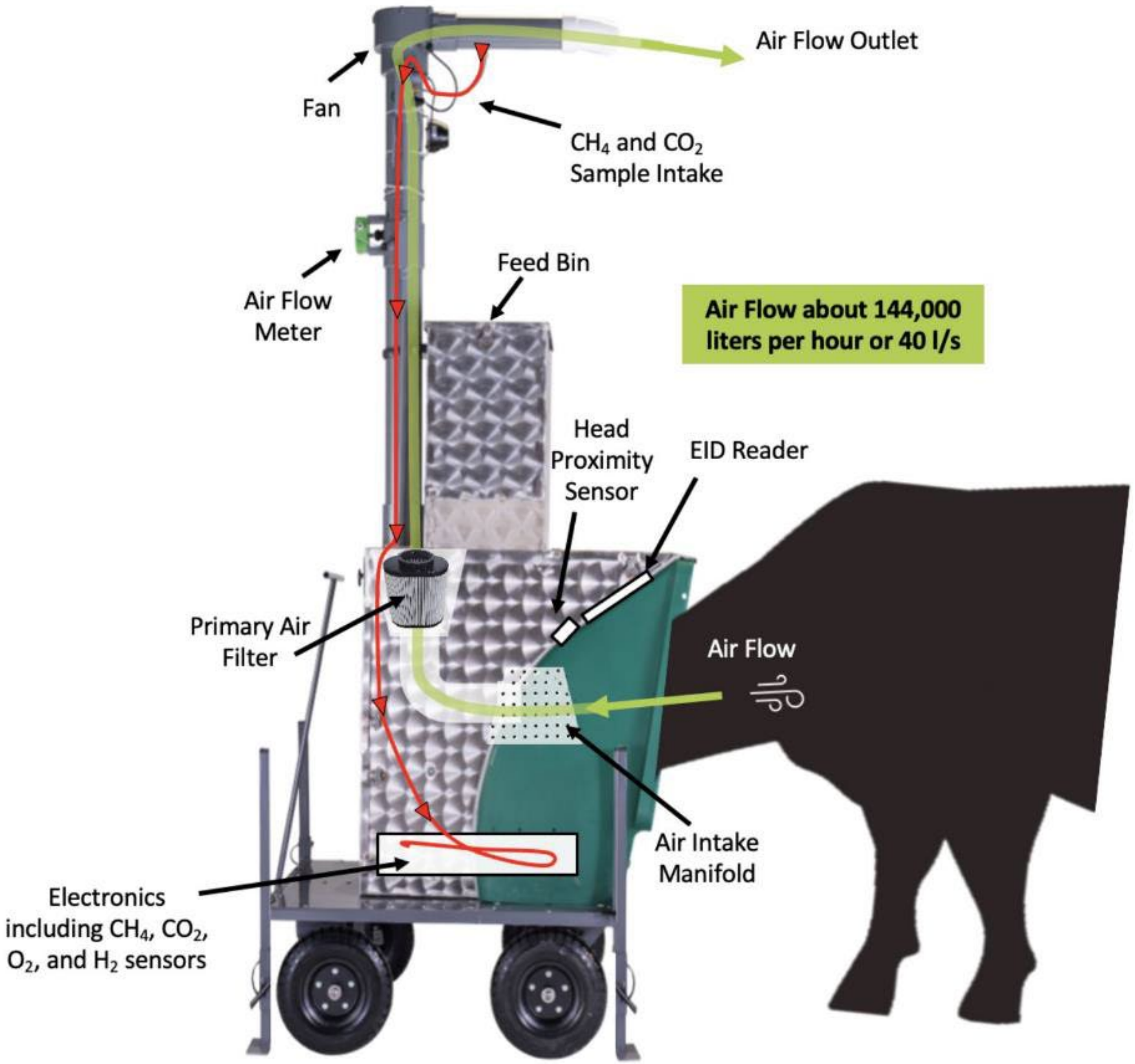


Johnson et al., 1995, Environ. Sci. Technol.; Univ. of Queensland

Sulfur hexafluoride (SF_6) tracer technique

- Pros:
  - Allows for natural behavior
  - On pasture measurement
  - Accurate
- Cons:
  - High level of animal interactions & labor
  - Large training requirements
  - Some challenges with use

Univ. of Queensland



C-Lock, Inc.

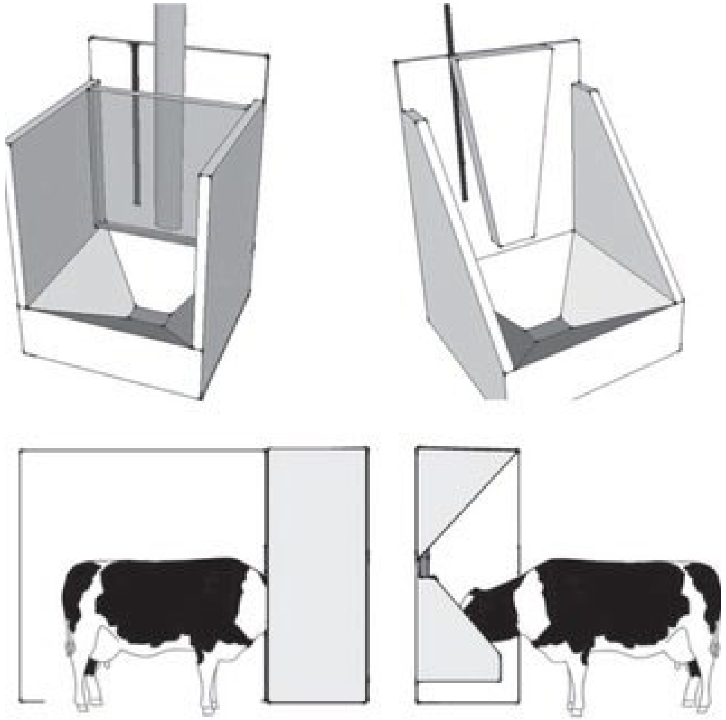
GreenFeed System

GreenFeed System

- Pros: Measure animals in pasture
  - Relatively low levels of animal handling
- Cons: Expensive
  - Requires animal training

Sniffers

CRV; Madsen et al., 2010; Gansworthy et al., 2012

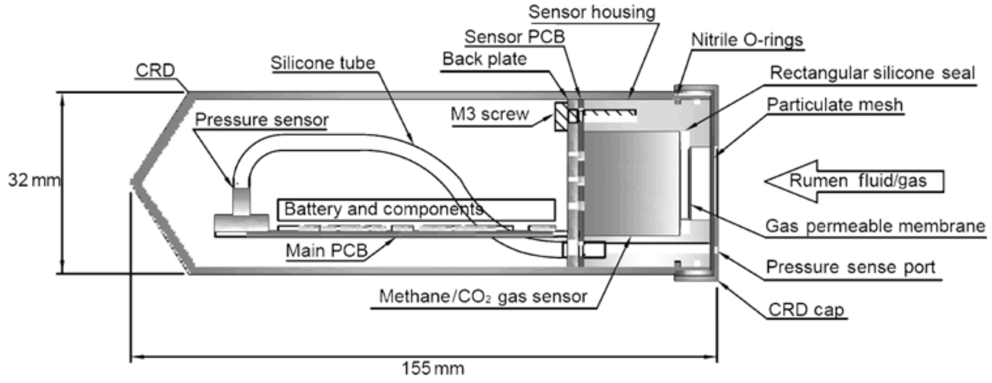


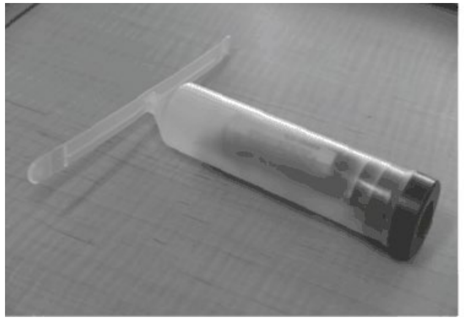
Sniffers

- Pros: Passive collection
  - High throughput
- Cons: Lower accuracy
  - More sensitive to microenvironmental differences
  - Requires a large number of spot samples

Real-time, intra-ruminal monitoring

Measures: pH, activity, temperature





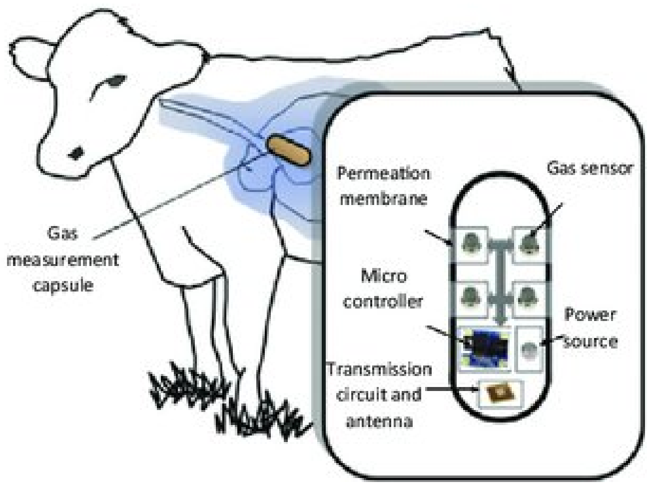
Measures: gas concentrations

Moonsyt International Ltd. & smaXtec animal care GmbH.

Bishop-Hurley, et al., 2016, Anim Prod Sci

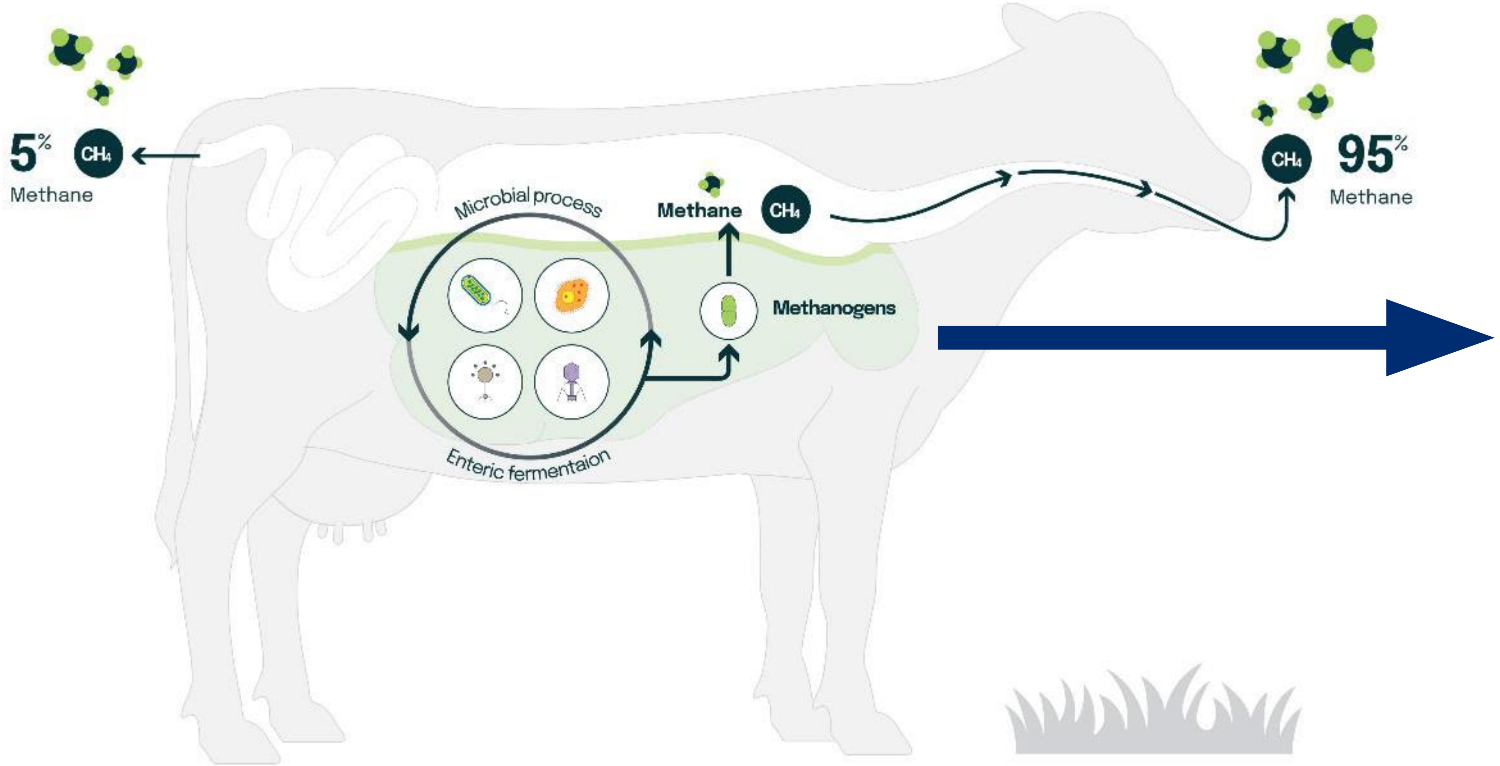
Real-time, intra-ruminal monitoring

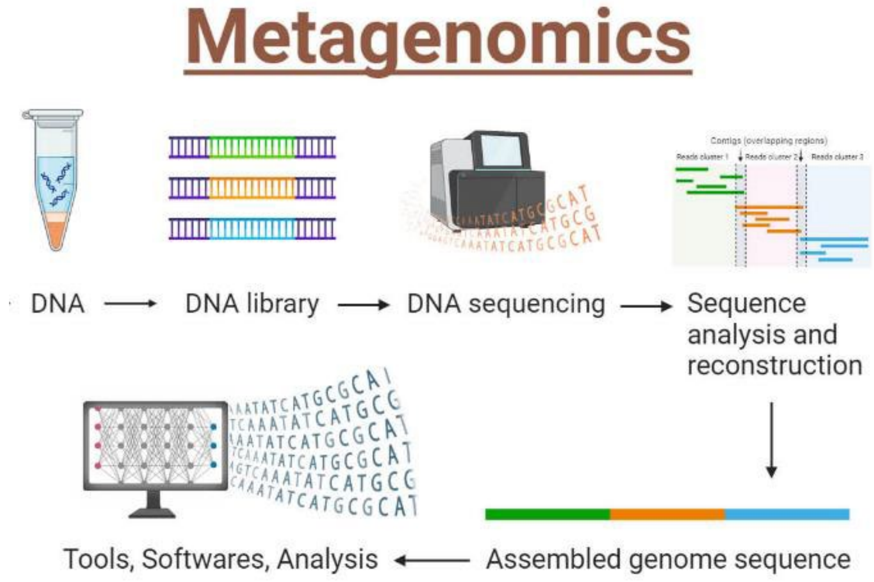
- Pros: Continuous recording
- Cons: One time use of device
  - Variable battery life
  - Relies on correlated indicators and prediction equations
  - Only measures concentrations in rumen, vs emitted gas



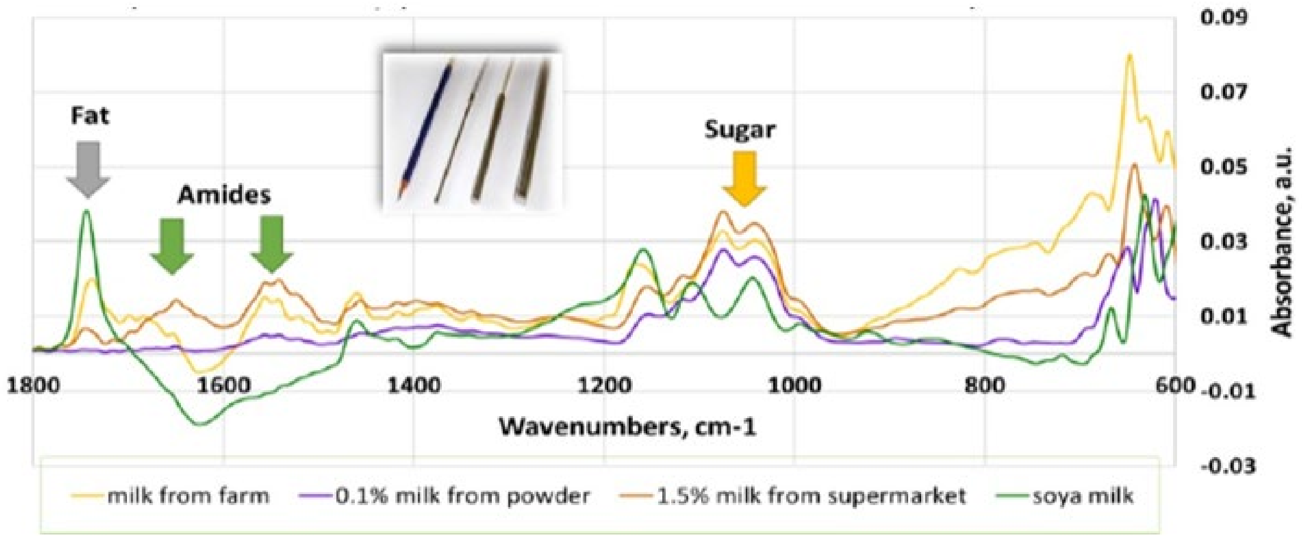
Hill et al., 2015, Trend in Biotech

CH_4 proxy: Rumen metagenomic profile





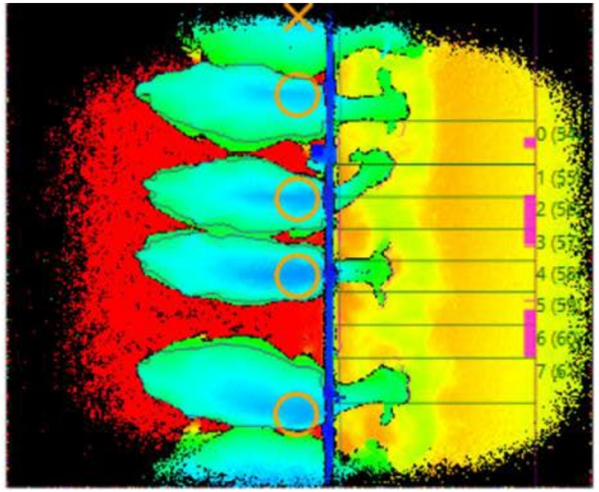
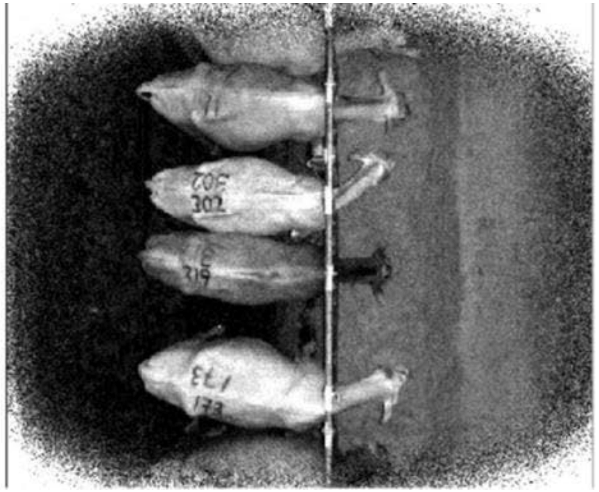
CH_4 proxy: Milk mid-infrared spectroscopy



CH_4 proxy: Feed efficiency





Calan; Vytelle; Hokofarms Group; Lassen et al., 2023, Journal of Dairy Science

Proxy phenotypes

- Pros: Often more easily accessible
  - Often more cost effective
  - Data collection may already be routine
- Cons: Still need to be related back to direct methane
  - Variable correlations with CH_4
  - Reduced accuracy

New and emerging

Optiweigh x AgScent

Summary

Method	Purchase cost	Running Cost	Labor & Maintenance	Repeatability	Behavior Alteration	Animal Throughput
Respiration chamber	High	High	High	High	High	Low
Respiration headbox	Medium-high	Medium-high	High	High	High	Low
SF_6 technique	Medium	Medium	High	Medium	Medium	Medium
Sniffer	Low	Low	Low	Medium	None	High
Greenfeed	Medium	Medium	Low	Medium	Low	Medium
Rumen bolus	Low	Low	Low	???	None	Low

Adapted from Garnsworthy et al., 2019, Animals

Thank you!

Bailey Engle – bailey.engle@usda.gov

Session 3-Part 2

Understanding Methane: From Phenotyping to Selection Opportunities

Selecting for Methane Emissions: Global examples and opportunities in the US beef industry

Dr. Troy Rowan
University of Tennessee

Selecting for Methane Emissions: Global examples and opportunities in the US beef industry

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Troy Rowan
2024 Brown Bagger Webinar Series
October 16, 2024

Rowan Lab
beef cattle genomics

Genetics and the Methane Conversation

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If we can measure a trait…

We can make genetic predictions

With predictions…

We can accelerate genetic progress

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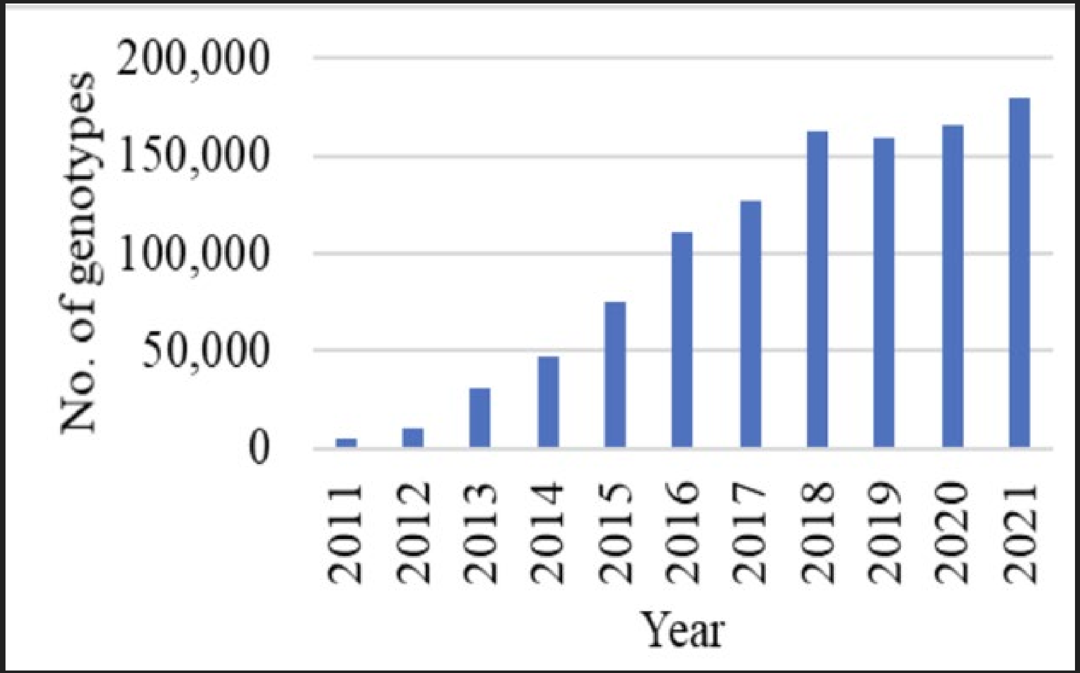
“In the age of genotyping, Phenotype is king!” – Prof. Mike Coffey



AAA genotypes added per year (Retallick et al. 2022)

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Some Good News

- Methane production is heritable
  - h^2 = ~0.2 - 0.3 (similar to weaning weight) [Dressler et al. 2024]

- Continued genetic progress across efficiency traits is reducing emission intensity
  - Growth & productivity
  - Cow-centric traits

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Some big questions:

- Genetic correlations with other ERTs unclear
  - DMI favorably correlated
  - Larger animals make more methane (generally)
  - r_G with feed efficiency is unclear [Lakamp et al. 2024]

- Market signals are unclear
- Insets vs offsets (i.e., is increasing productivity enough)
- Concentrate vs. forage (different traits?)

Our Challenge

- **How do we capture a phenotypes?**
    - Cost prohibitive to producers
    - Infrequent interactions in extensive systems
    - Data sharing of limited phenotypes

What is the cost of a single CH_4 phenotype with a GreenFeed?

Conservatively: $75-$100

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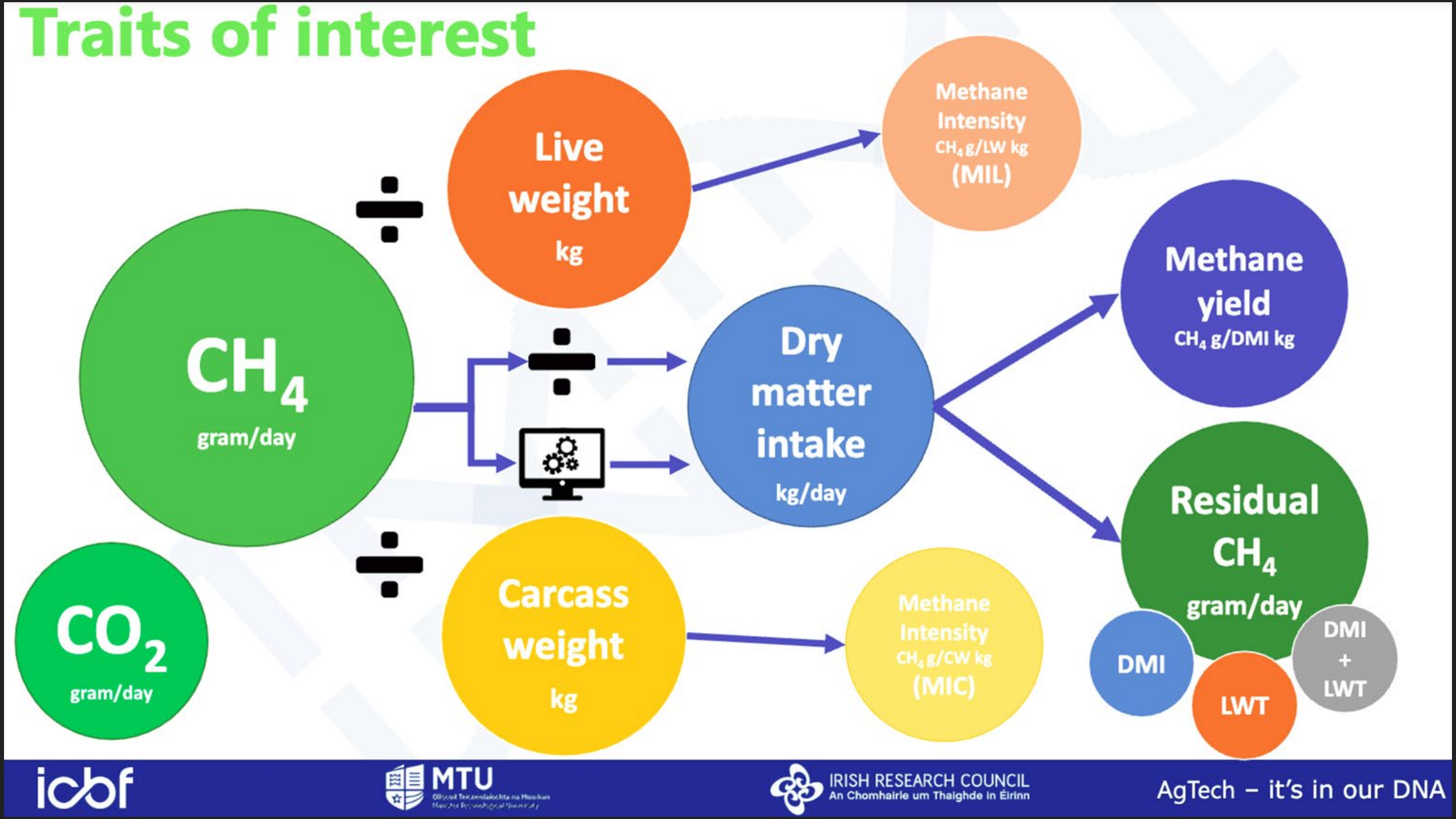
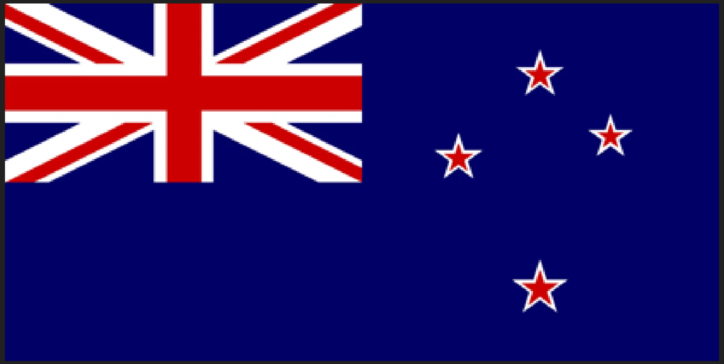
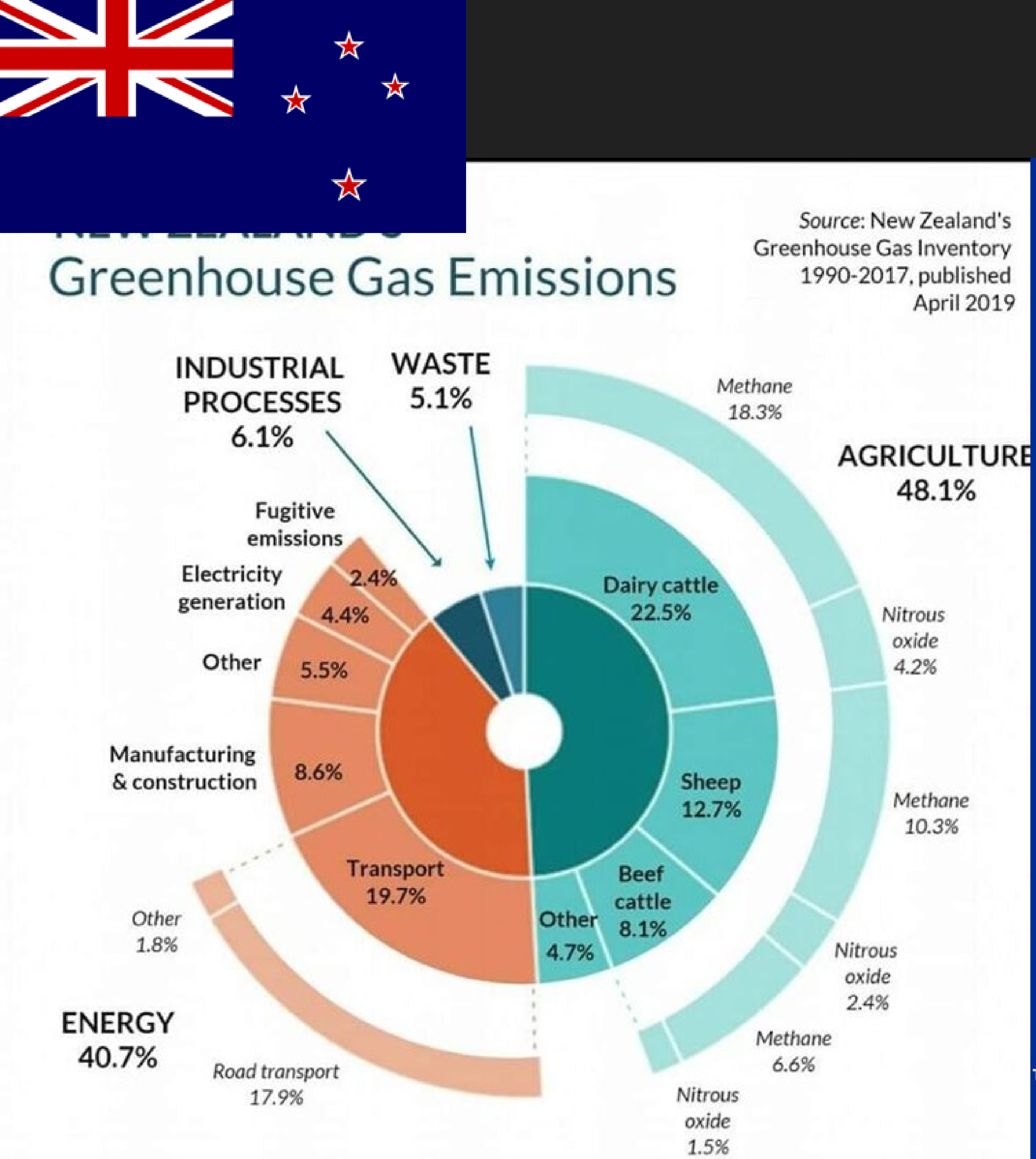
What do we measure??

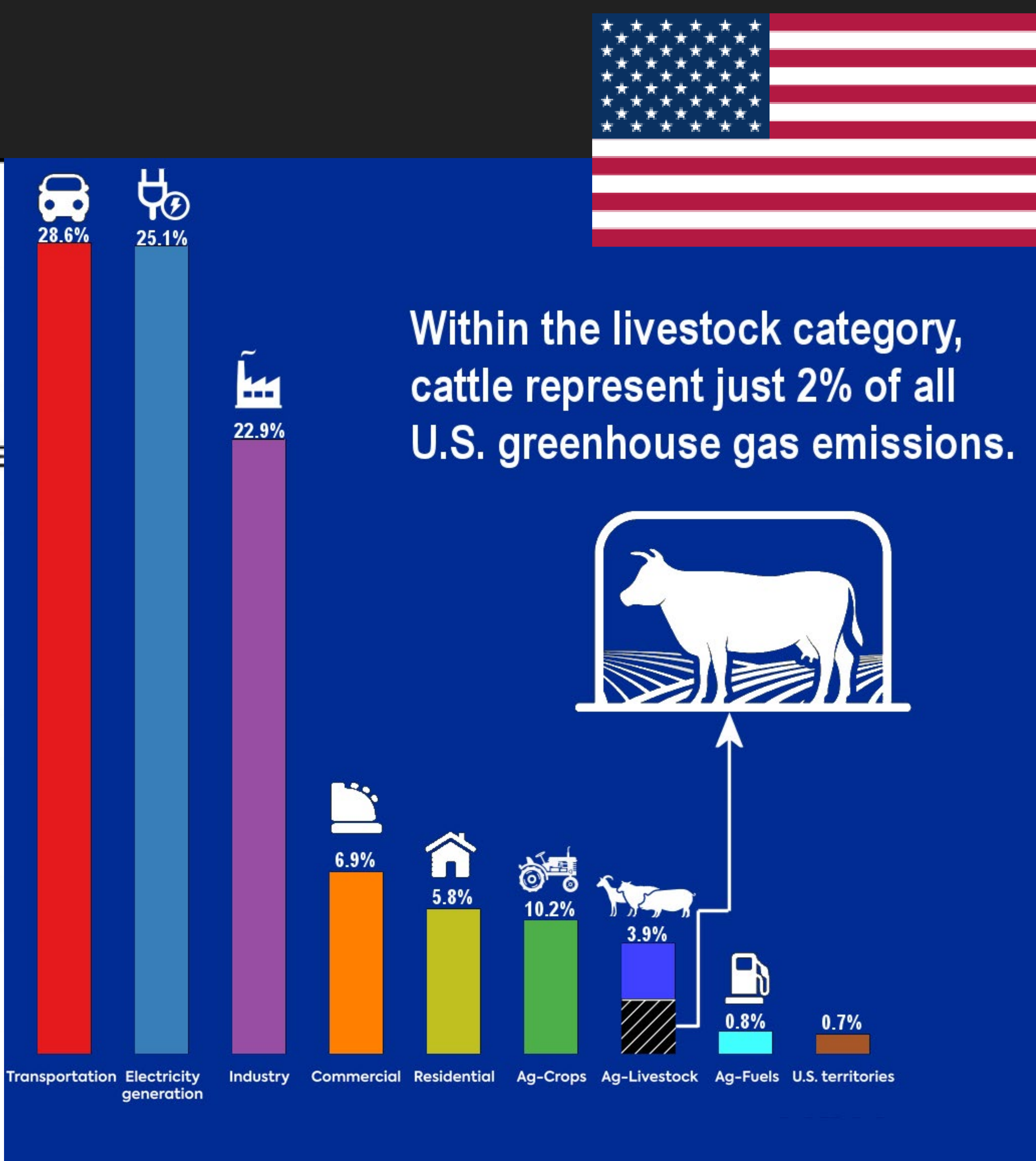


C.V. Ryan et al. 2022 – WCGALP



Why have other countries been leading efforts in enteric GHG emission research?


Greenhouse Gas Emissions
Source: New Zealand's Greenhouse Gas Inventory 1990-2017, published April 2019
INDUSTRIAL PROCESSES 6.1%
WASTE 5.1%
AGRICULTURE 48.1%
Methane 18.3%
Nitrous oxide 4.2%
Methane 10.3%
Nitrous oxide 2.4%
Methane 6.6%
Nitrous oxide 1.5%
Dairy cattle 22.5%
Sheep 12.7%
Beef cattle 8.1%
Other 4.7%
Fugitive emissions 2.4%
Electricity generation 4.4%
Other 5.5%
Manufacturing & construction 8.6%
Transport 19.7%
Other 1.8%
Road transport 17.9%
ENERGY 40.7%


Within the livestock category, cattle represent just 2% of all U.S. greenhouse gas emissions.
28.6%
25.1%
22.9%
6.9%
5.8%
10.2%
3.9%
0.8%
0.7%
Transportation
Electricity generation
Industry
Commercial
Residential
Ag-Crops
Ag-Livestock
Ag-Fuels
U.S. territories

How are other species & countries performing genetic evaluations for methane emissions?

New Zealand Sheep Genetic Evaluations

- Brute force phenotyping using portable accumulation chambers
- Targeted phenotyping initiative
- Phenotyping is a “one-and-done” endeavor for producers

What will methane selection do to other traits?

- Long-term selection experiment in NZ sheep population
- Lamb and ewe CH_4 emission is highly correlated [Jonker et al. 2018]
- Methane emission phenotypes are most important in pasture settings
  - Not correlated with fertility traits in sheep [Hickey et al. 2022]
- No negative impacts on feed efficiency or productivity [Rowe et al. 2022]
- No negative impacts on meat quality or carcass traits

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Breeding values for methane emission

What do we do when methane phenotypes remain too expensive/ difficult to measure at scale?

Canadian dairy cows among first in world bred to belch less methane

New genetics could help reduce one of the biggest sources of potent greenhouse gas

Rod Nickel · Thomson Reuters · Posted: Aug 08, 2023 1:30 PM EDT | Last Updated: August 8

A Holstein cow stands in a pasture at a dairy farm near Calgary in this file photograph. Livestock account for 14.5 per cent of the world's greenhouse gas emissions. (Jeff McIntosh/The Canadian Press)

Measure an indicator phenotype!

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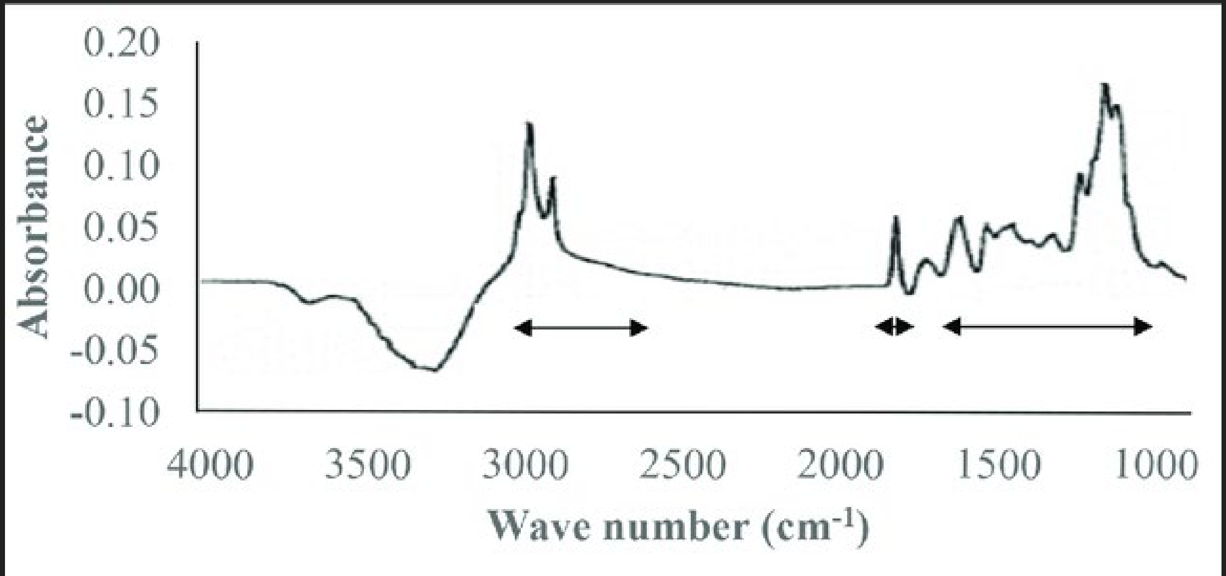
Genetic Evaluations – Canadian Dairy

GreenFeed records on 1000+ animals



Milk spectral data models trained for measured methane

THE Resilient Dairy GENOME PROJECT

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Canadian Dairy Methane Efficiency Evaluation

- MIR predicted CH_4 on first lactation Holsteins between 120 and 185 days in milk
  - 700,000 MIR records being used for predicted CH_4
- ssGBLUP implementation with other Lactanet traits
- Delivered as a relative breeding value (higher value = less CH_4)
  - 5 point increase in RBV = 3 kg/year reduction in CH_4
  - Modelling suggests this could drive a 20-30% reduction in CH_4 is possible by 2050

Lactanet
CANADIAN NETWORK FOR DAIRY EXCELLENCE

Ongoing Developments

Widespread “sniffer” deployment in automatic milking systems (AMS)

Multi-trait modelling with various measurement technologies

Identifying how we handle “incomplete” records?

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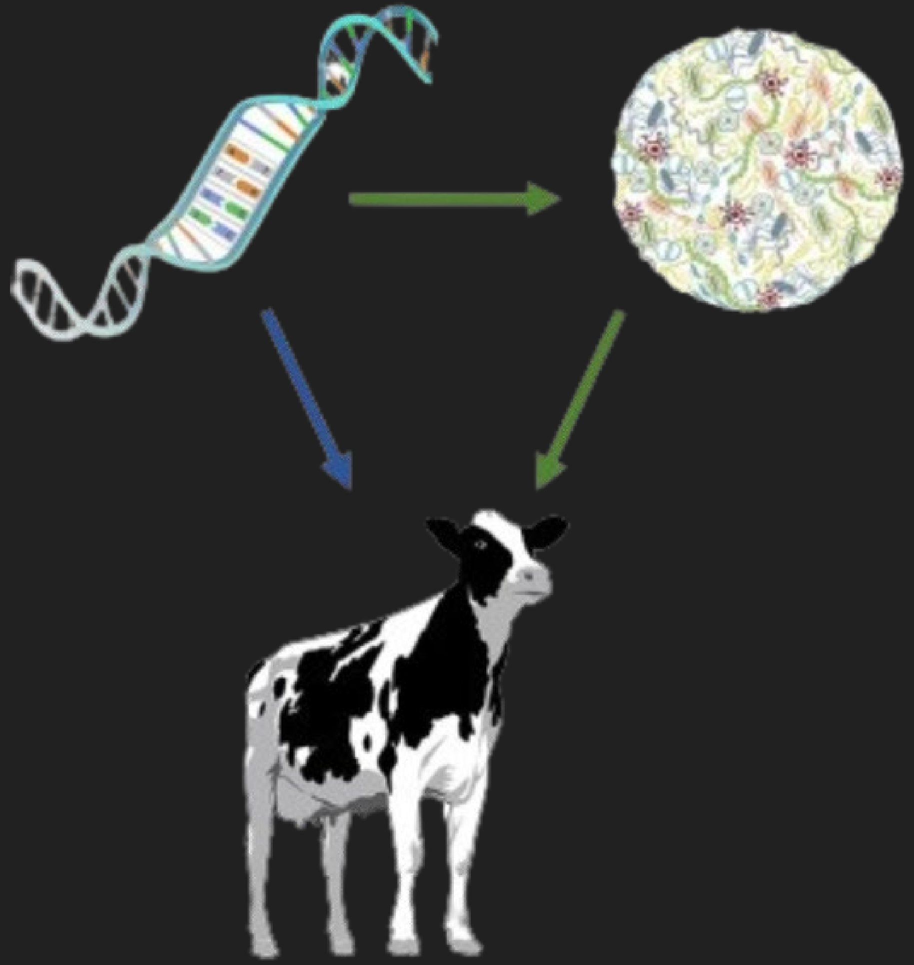
Challenges for the US Beef Industry

- **<u>Phenotyping challenges:</u>**
  - Cost prohibitive to producers
  - Collection in extensive systems
  - Data sharing of limited phenotypes
  - Data heterogeneity/quality
  - Which correlated traits do we fit together?
- Market signals are unclear (how to we fit into an index)

Other Opportunities & Ongoing Research

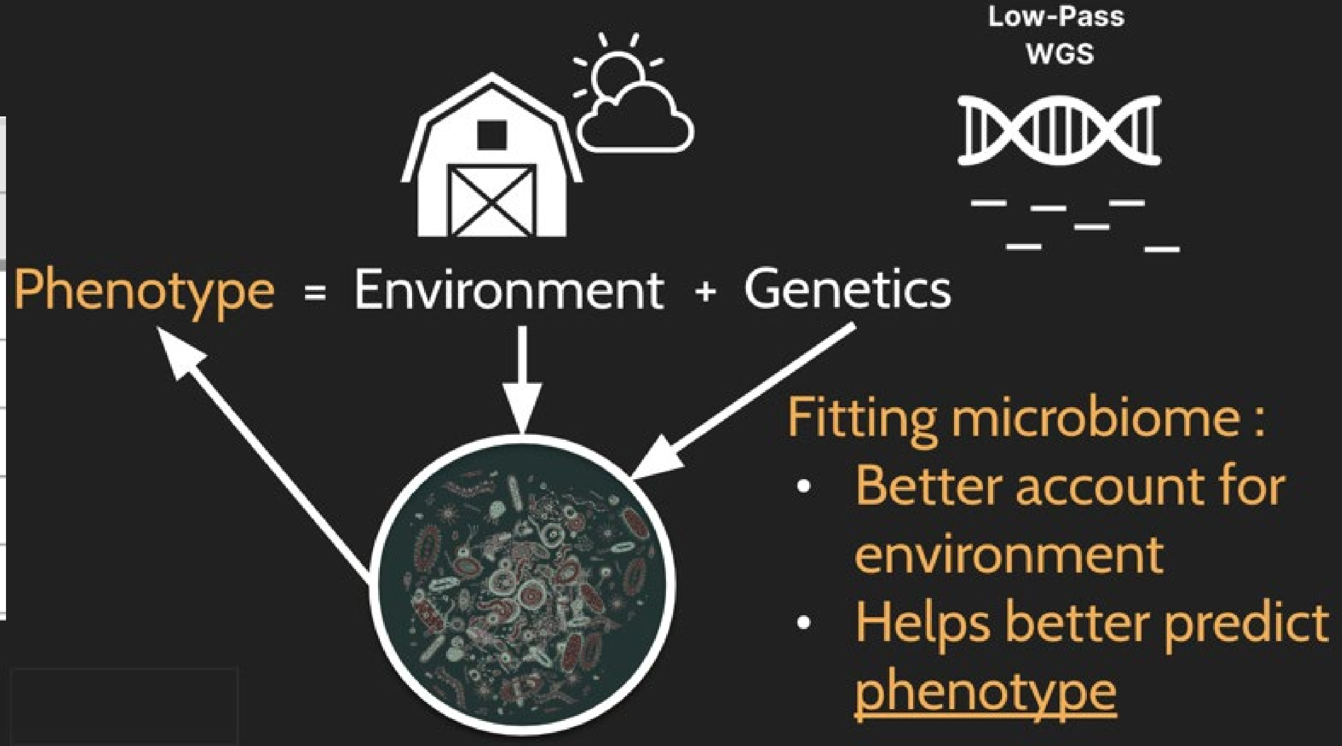


Can we keep ignoring the rumen microbiome?

Modelling the Microbiome

Model[a]	Component[b]	Grass adult	
		PropVar[c]	Accuracy[d]
G	G_G	0.33 ± 0.07	0.18 ± 0.08
M	M_M	0.95 ± 0.20	0.31 ± 0.14
G + M	G_{G+M}	0.25 ± 0.11[f]	0.17 ± 0.08[f]
	M_{G+M}	0.75 ± 0.11[f]	0.31 ± 0.14[f]
	$G + M_{G+M}$	1.00 ± 0.00[f]	0.35 ± 0.12[f]

Hess et al. 2023



How do we make rumen microbiome characterization easier, cheaper, and less invasive?

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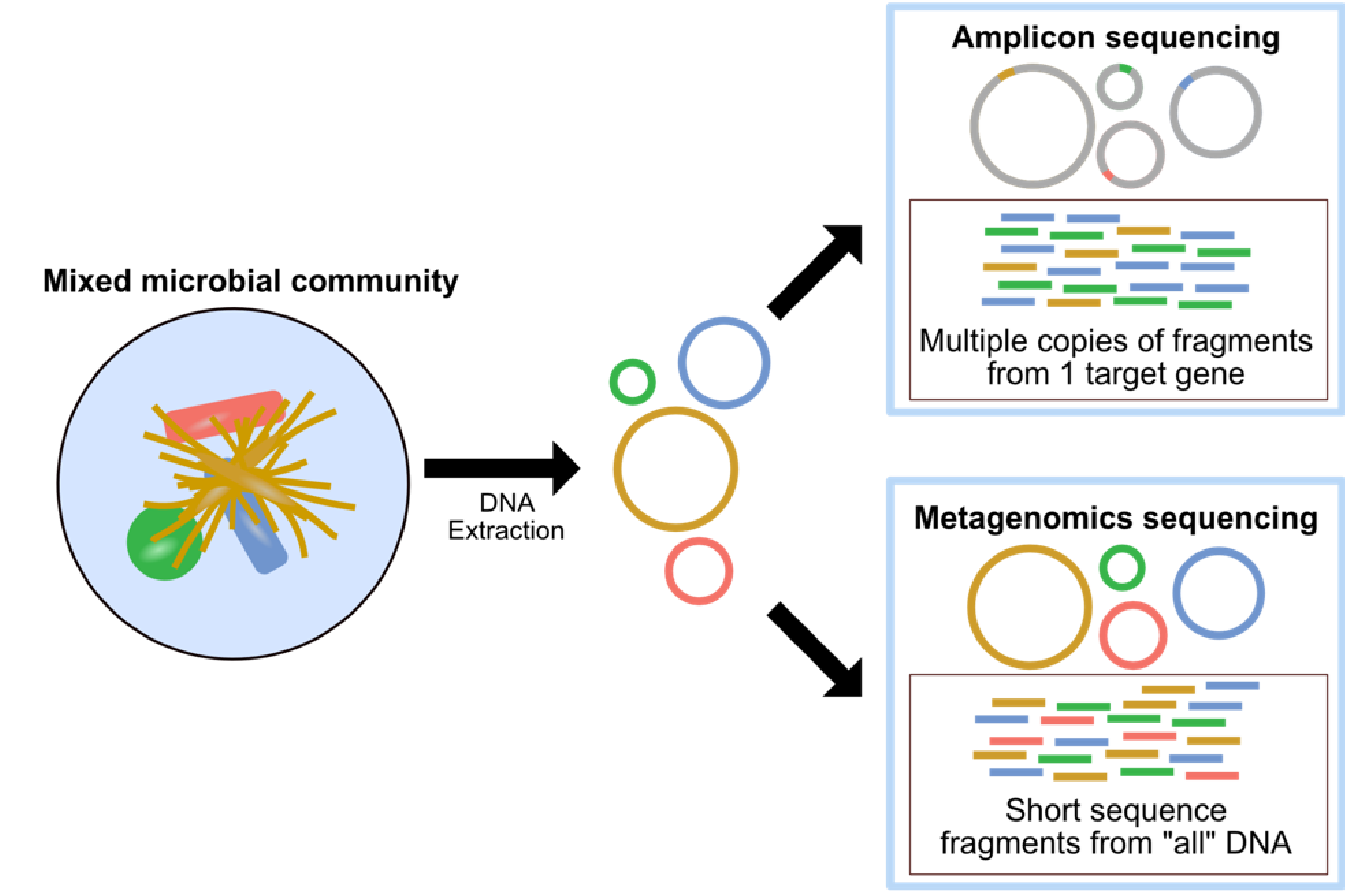
Microbiome Sequencing Approaches

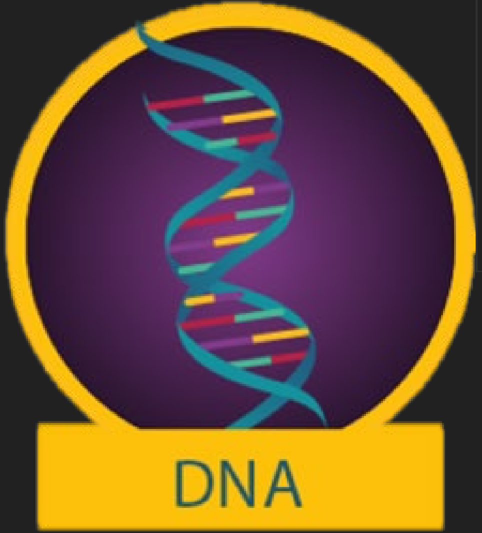


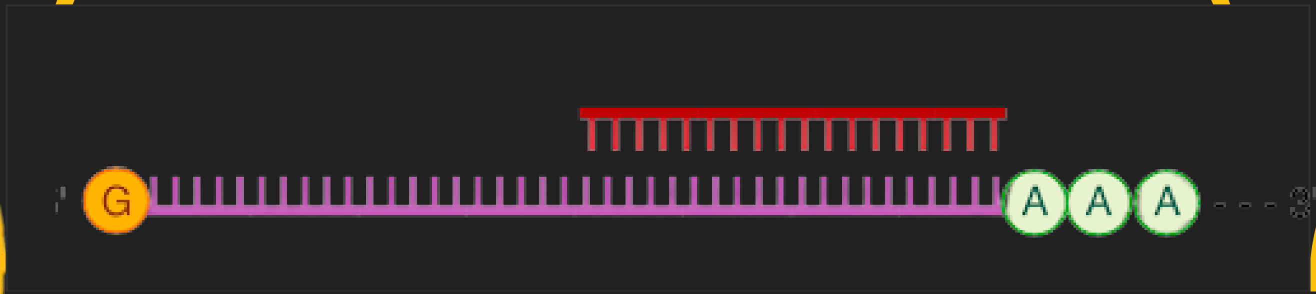
Buccal Swabs: Collect non-invasive microbiome proxy while generating a DNA sample

Sequencing doesn't distinguish between host/microbe DNA!

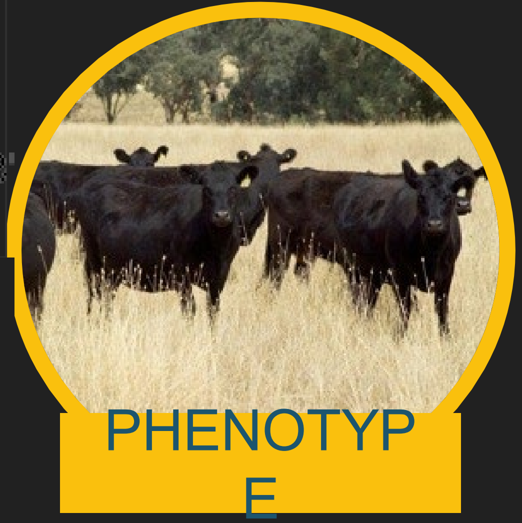
Do proxies for CH_4 emission exist (like MIR for dairy cows) that we could measure in beef animals?

Can we use these as "proxy" phenotypes for hard-to-measure traits?



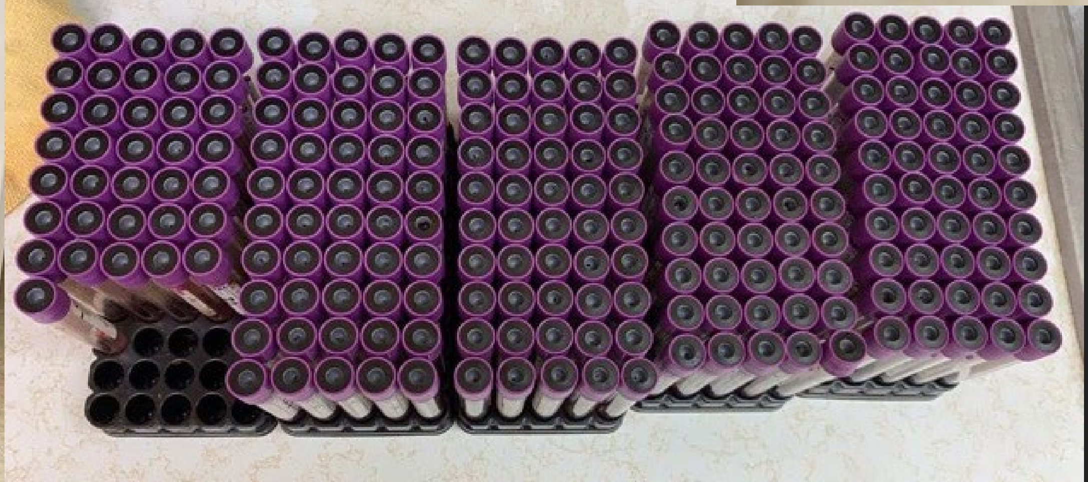


< $10 USD Gene Expression w/ 3' RNA-Seq

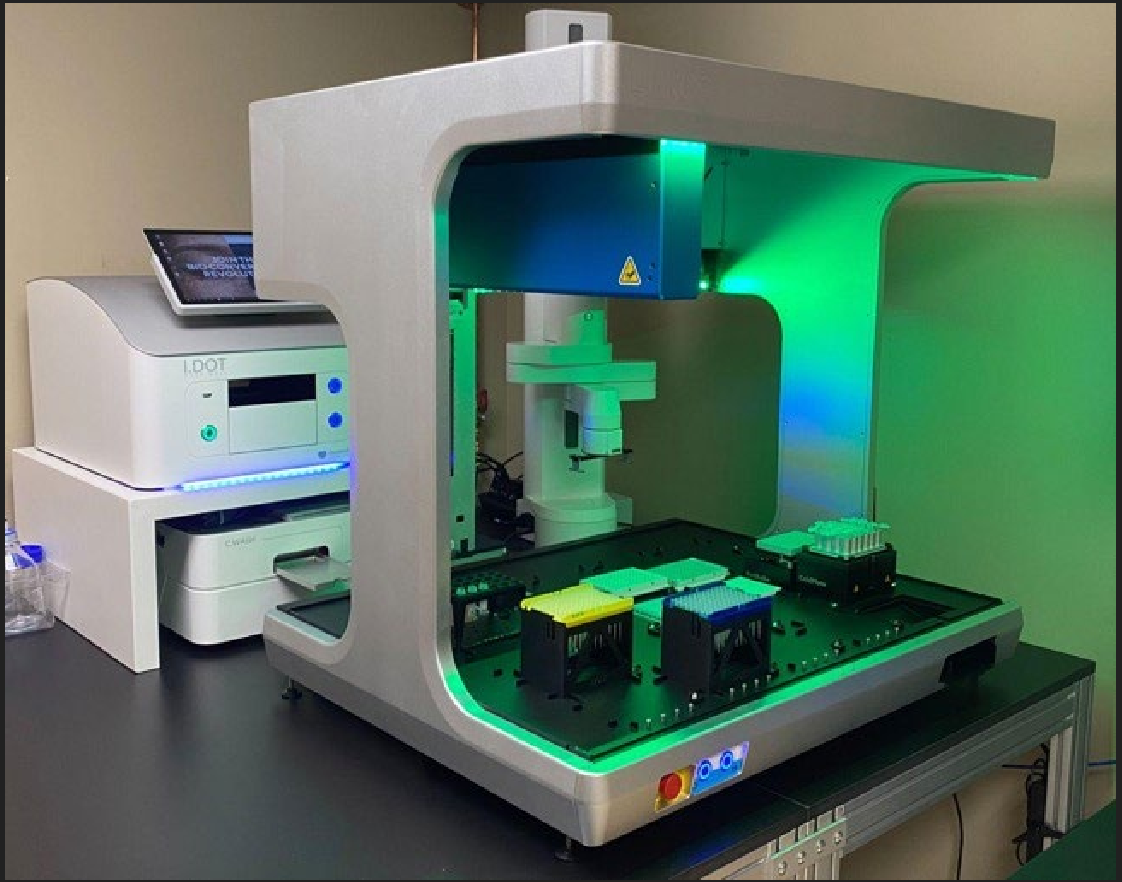


MUST BE COST EFFECTIVE

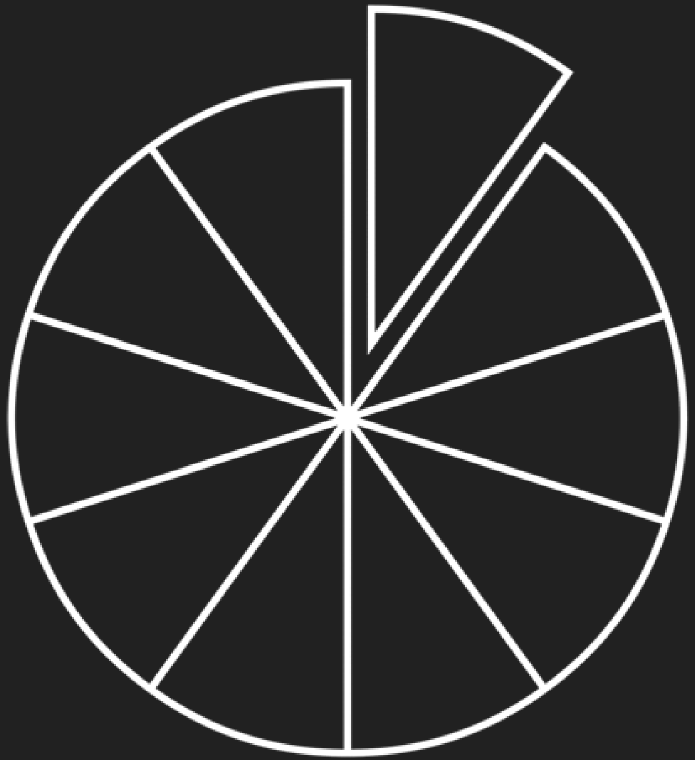
Using gene expression as efficiency indicators



“Wet Lab” Developments



Robotic preparation



Fractional reactions

Genetics is a tractable approach to reducing methane in ruminant production

Canadian dairy and NZ sheep industries have active genetic evaluations for CH_4

Assembling genetic evaluation-sized datasets is a major challenge

Strategies exist for integrating rumen microbiome profiles into predictions

Research presented in this presentation was funded by Foundation for Food and Agricultural Research (FFAR) Grant No. 22-000087

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Reach out with questions!

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