Reductions in Livestock Emissions: Achievements and Ongoing Research

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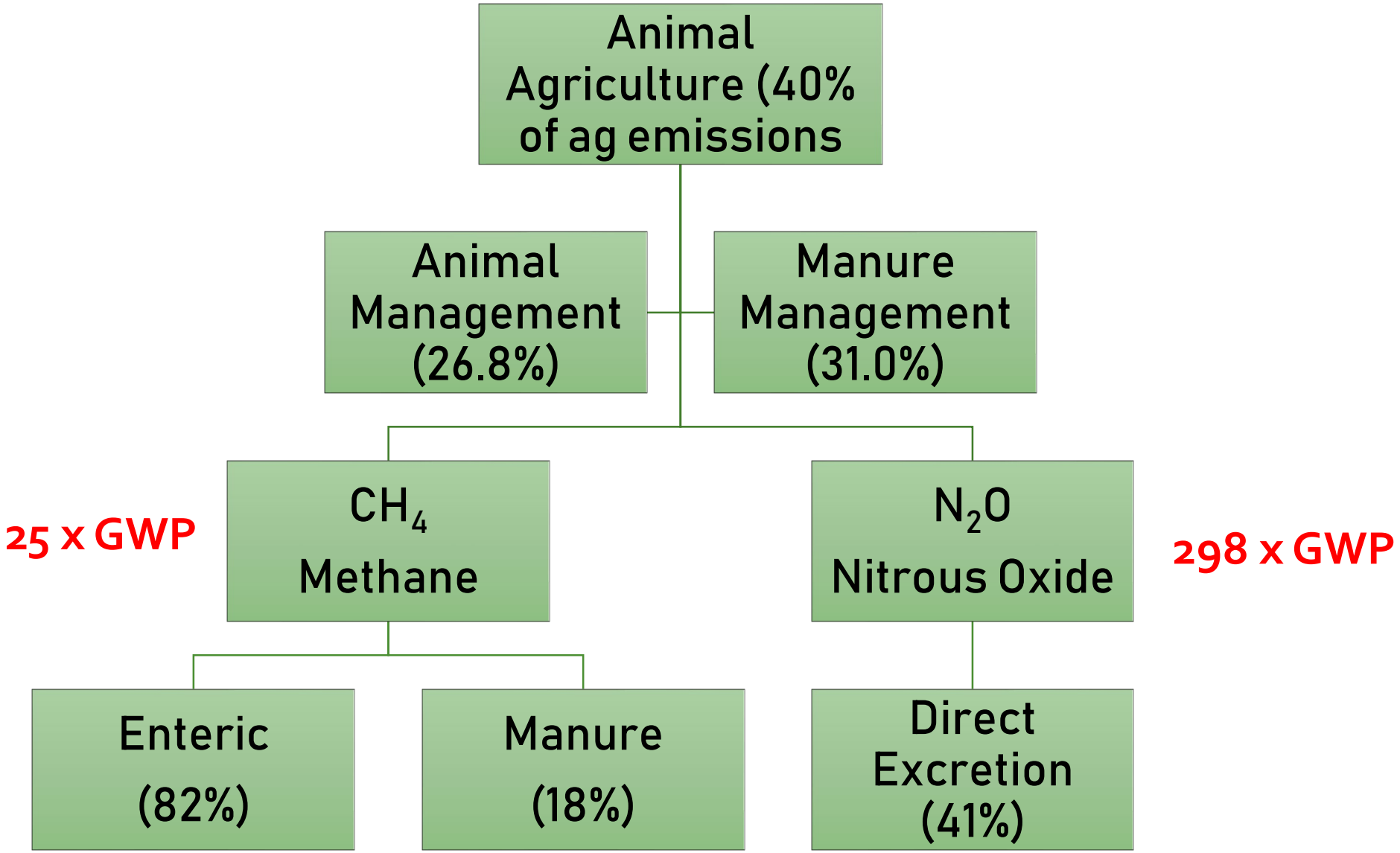
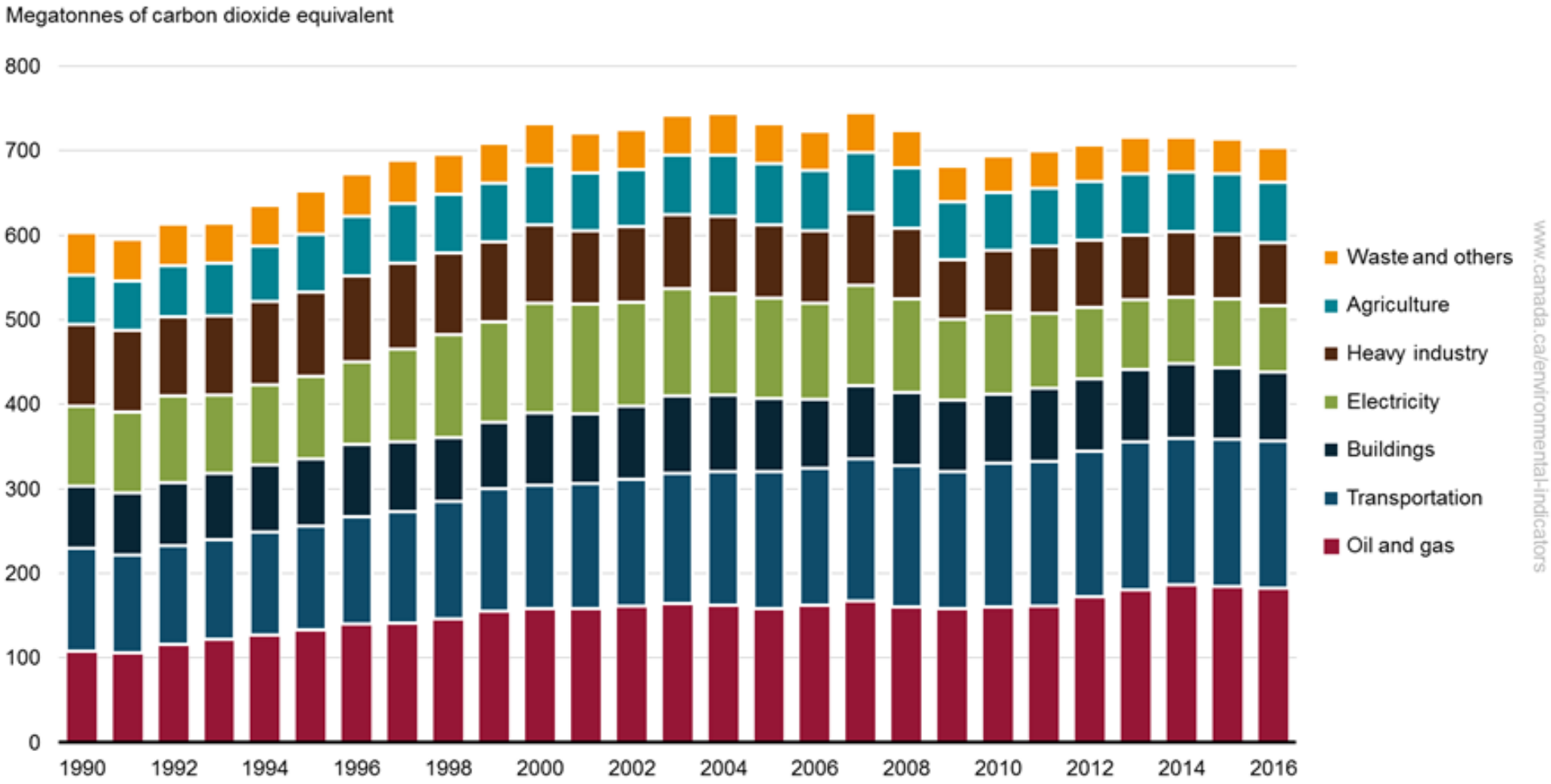
Canada

Global contribution of Animal Agriculture to GHG



Canada GHG



Environment and Climate Change Canada (2018) National Inventory Report 1990-2016: Greenhouse Gas Sources and Sinks in Canada.

Canadian Agriculture 2016:
Beef Production– 2.4% total GHG/ 23.4Mt

30% of national CH_4 emissions
77% of national N_2O emissions

41% from enteric

THE CONTRIBUTORS TO CANADA'S GREENHOUSE GAS EMISSIONS ARE:[1,6]

delivery of fossil fuels

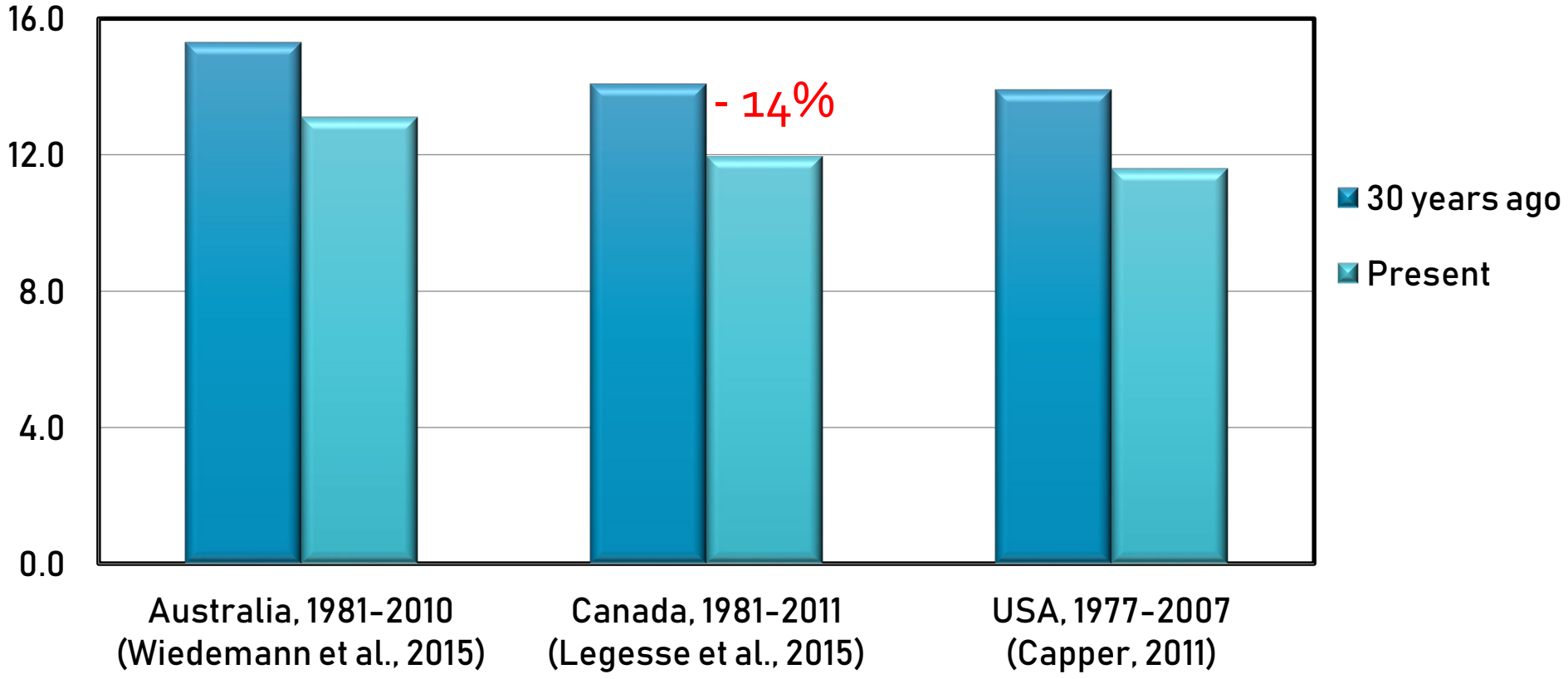
**Mining, smelting, refining and production industrial goods

2.4%	4%	5.6%	7%	8%	28%	45%
Agriculture: Beef Cattle	Waste	Agriculture: All Other	Industry**	Energy: Fugitive Sources*	Energy: Transport	Energy: Combustion

– Putting – BEEF *in perspective*

CANADIAN BEEF PRODUCTION ACCOUNTS FOR *only* **0.04%** OF GLOBAL GHG EMISSIONS[1,6]

Change in GHG emissions per kg of live weight from Australian, Canadian and USA beef sectors over the past three decades



- -14% GHG emissions intensity from beef
- Produced the same amount of beef

So Canada has improved its animal related emissions by improving productivity

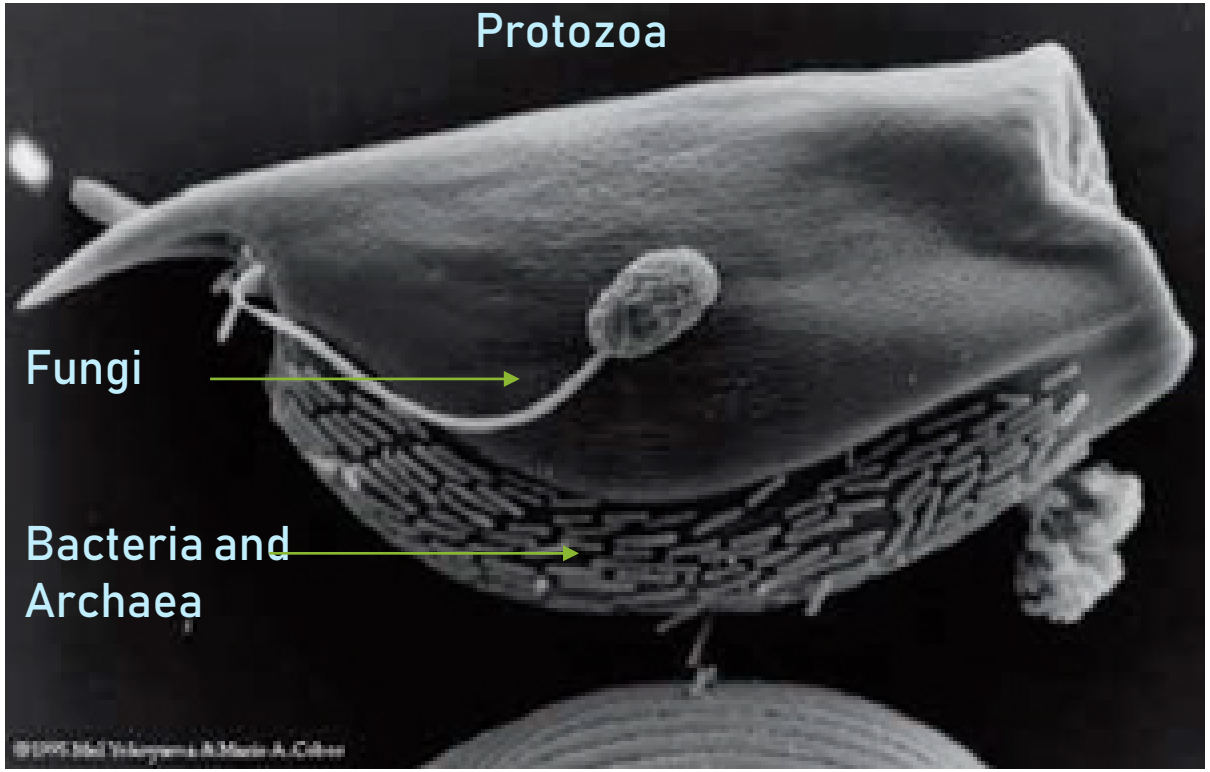
However there is still a way to go

World cattle population is estimated to double by 2050

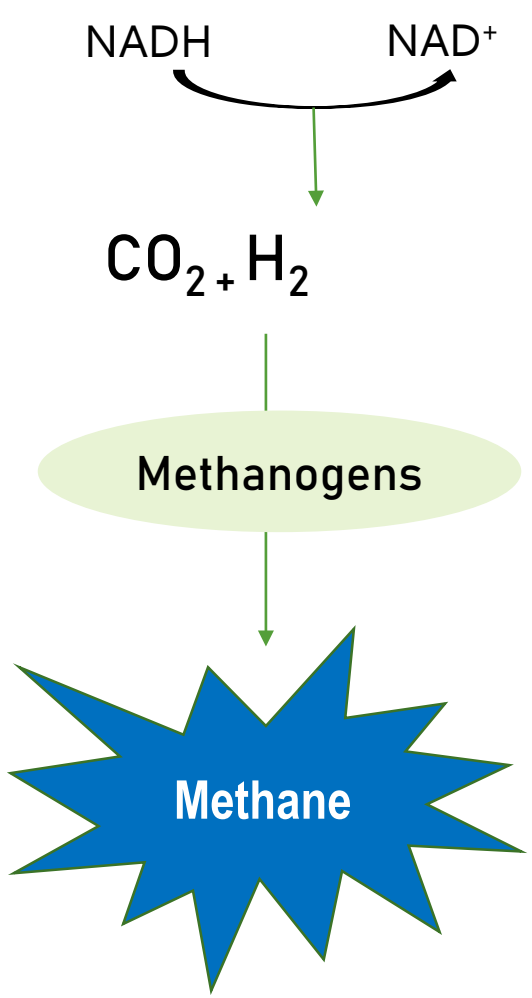
Whilst domestically demand may remain stable, North America will play a vital role in exporting beef for the global increasing population

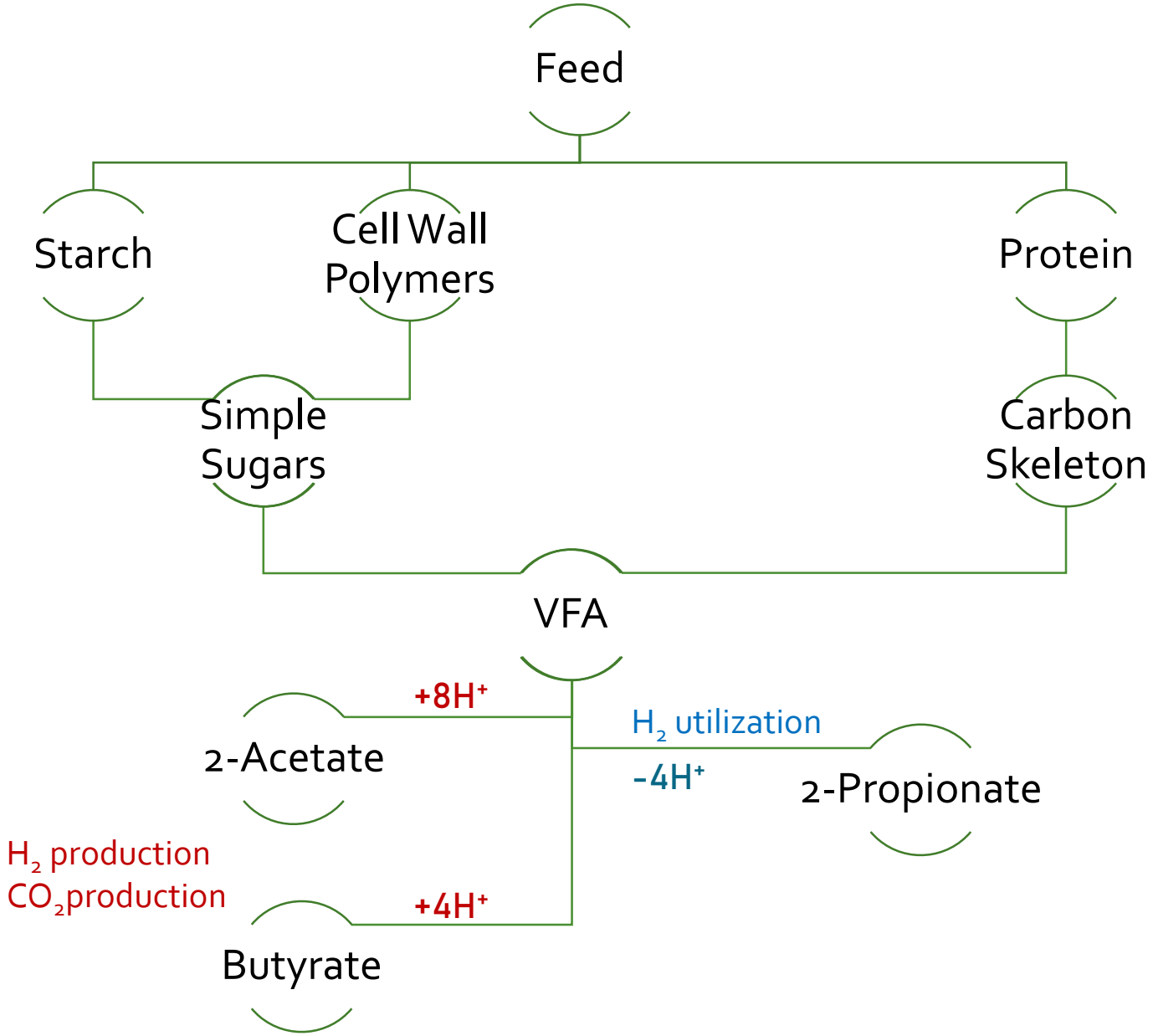
How is methane produced?

- The rumen harbours a unique population of microbes

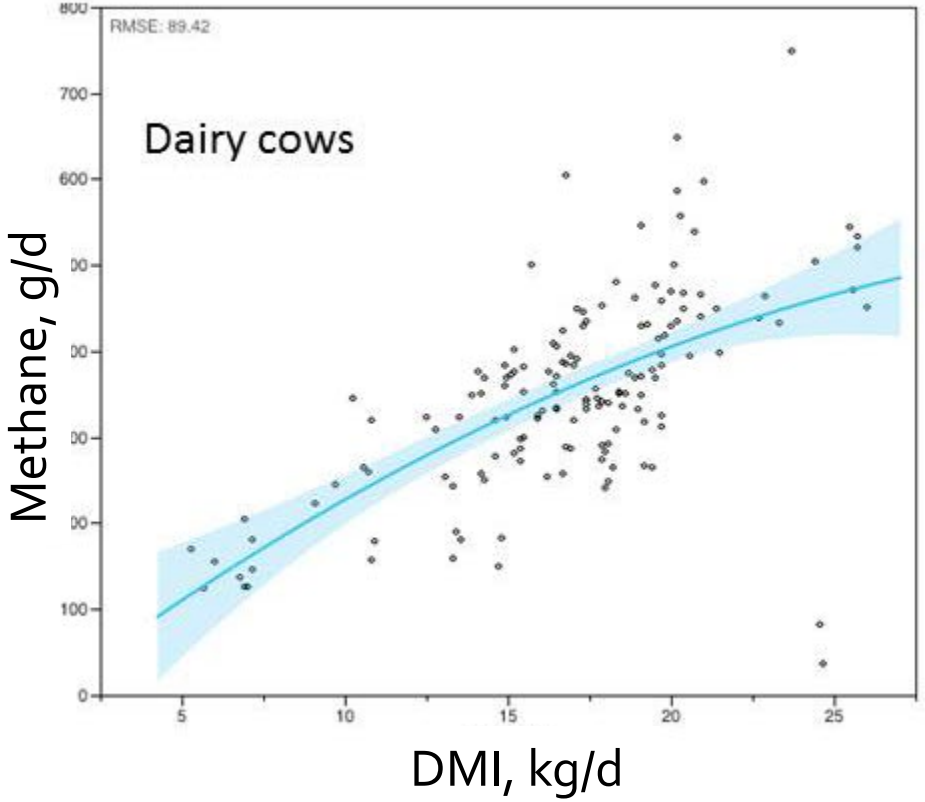


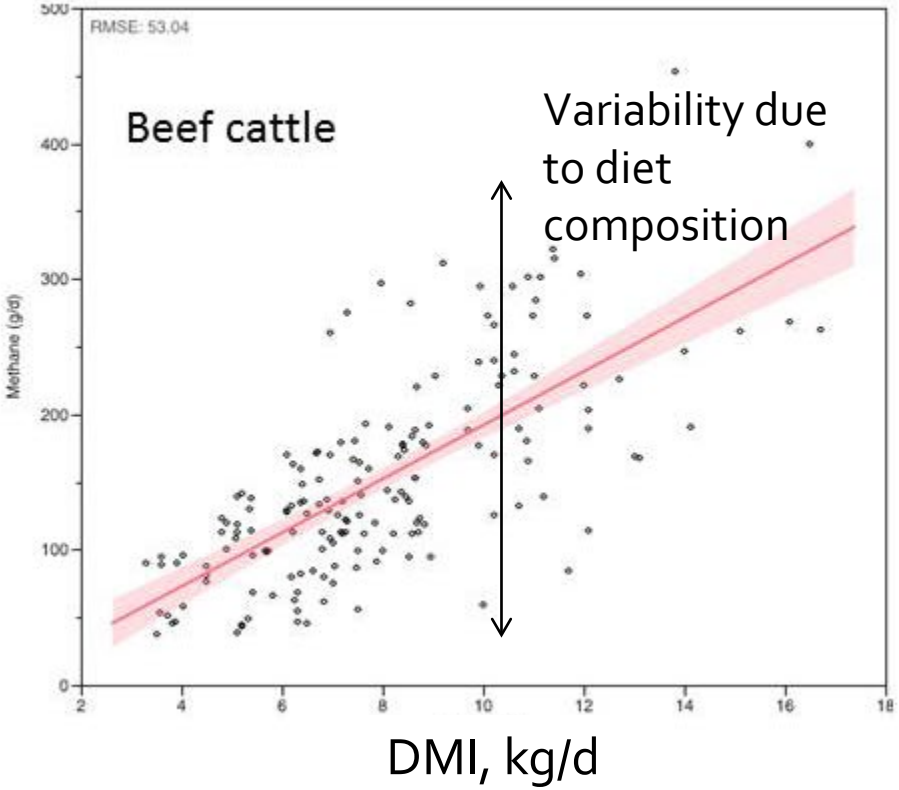
Mel Yokoyama & Mario A. Cobos. USDA publication.


NADH
NAD+
CO2 + H2
Methanogens
Methane


Feed
Starch
Cell Wall Polymers
Protein
Simple Sugars
Carbon Skeleton
VFA
+8H+
2-Acetate
H2 utilization
-4H+
2-Propionate
H2 production
CO2production
+4H+
Butyrate

Factors effecting GHG emissions





(Escobar, Beauchemin and Oba, unpublished)

CH_4

Feed Type

Grains < Forages

Grain Type

Wheat < Barley < Corn

Processing

Cracked < Steam flaked

Starch Content and Degradability

Decrease CH_4 production?

Lower pH

↓ growth of methanogens

↓ protozoa and fungi – big hydrogen producers

↑ Passage rate

↑ Propionate production

- However, concentrates only reduced CH_4 when given at over 80%
- Supplementation with grains can actually increase CH_4 ↑rumen production however this ↓ GHG intensity

**Increasing diet degradability can result in decreased pH – lead to acidosis – increases GHG intensity

Enteric Methane and Forages

Decreasing NDF content < Methane Emissions

Legumes < Grass

Cereal silages < Grass silages

Condensed tannin containing legumes?

Saponins and Tannins
Native Canadian Legumes

Birdsfoot Trefoil

In dairy cows, ↓ CH_4 by 14%

Also increased milk yield and intake

Doesn't cause bloat

(Woodward et al. 2004)

Tannin containing legumes

Inconsistent methane responses

Sainfoin

Very variable CH_4 responses

Has ↑ DM intake and digestibility

But has also inhibited NDF digestibility → may decrease CH_4

Issues with tannins

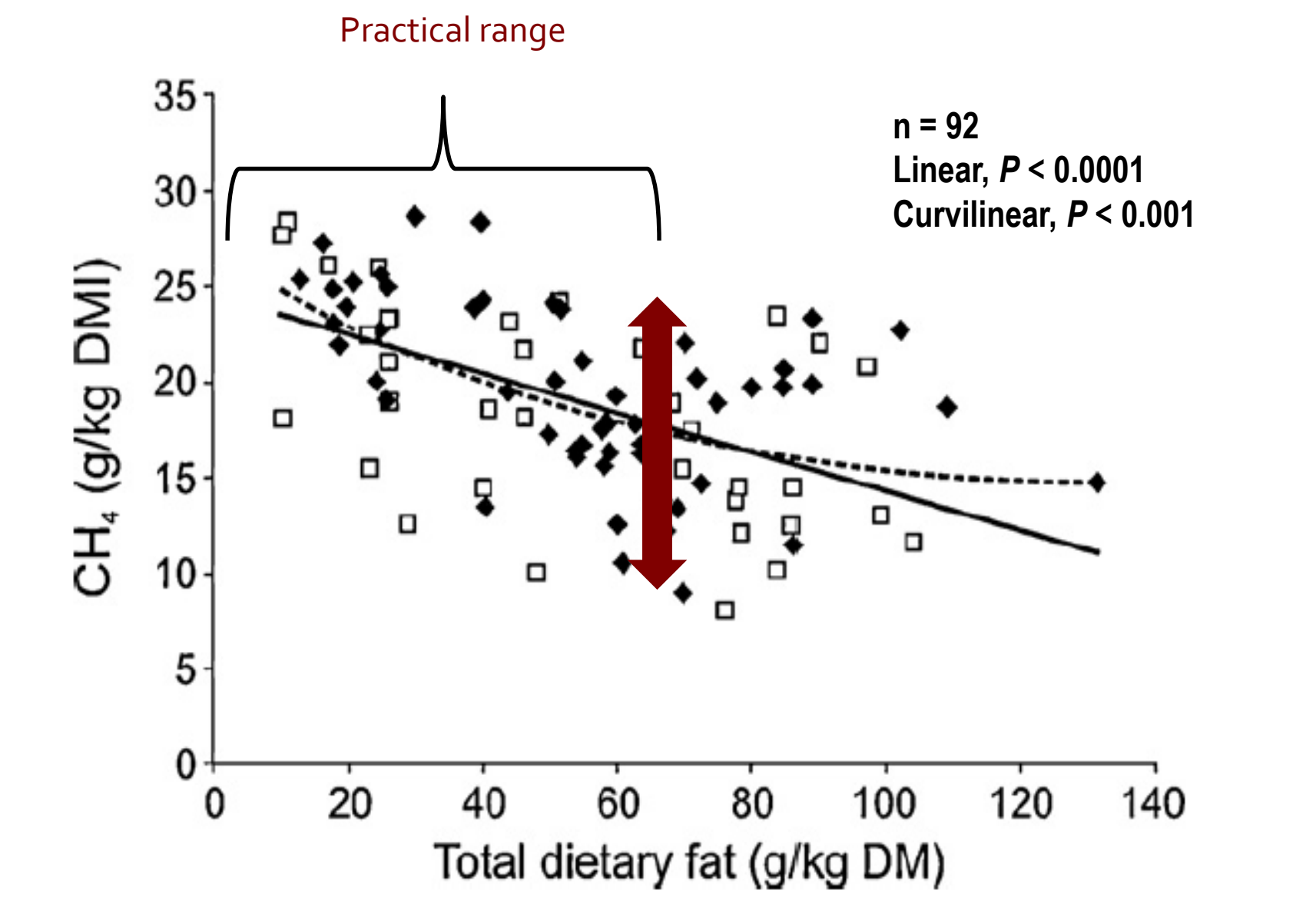
Inconsistent results

- Species variability
- Different tannin types
- Concentration in the diet

May also ↓ CP digestibility – protein binding

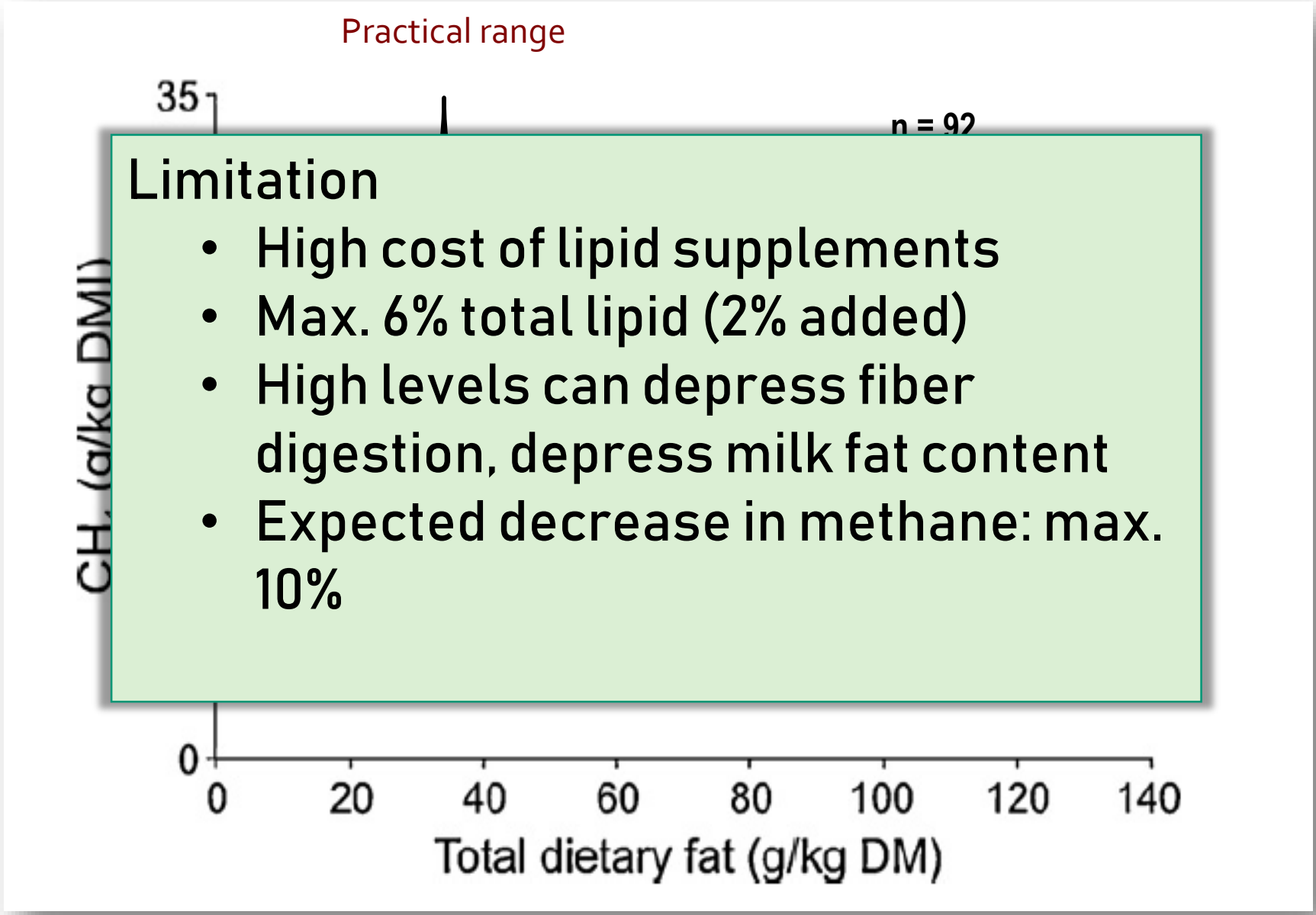
They also increase faecal N and decrease urine N
→ Urine is less stable and has higher N-related emissions

Fat



Grainger and Beauchemin, 2011

Fat



Limitation

- High cost of lipid supplements
- Max. 6% total lipid (2% added)
- High levels can depress fiber digestion, depress milk fat content
- Expected decrease in methane: max. 10%

Grainger and Beauchemin, 2011

Fats

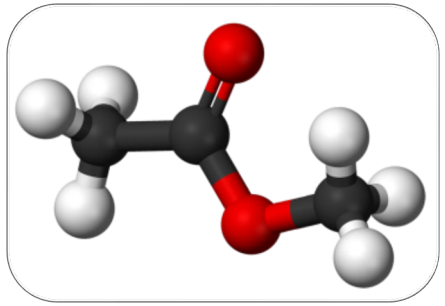
- (i) having a toxic effect on methanogens and protozoa
- (ii) replacing fermentable carbohydrates
- (iii) providing an alternative H_2 sink via biohydrogenation

Dietary Additives

Tannins, phenolics

Plant bioactives

Essential oils

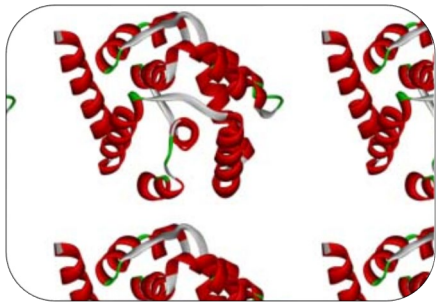


Organic acids

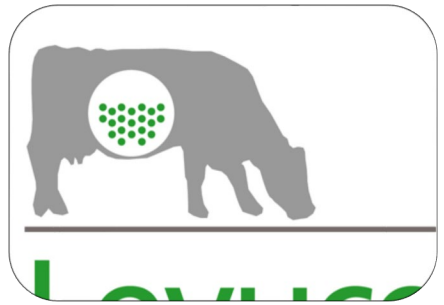
Probiotics

GM microbes

Direct fed microbials



Enzymes



Pre-biotics

Dietary Strategies

Additive	Methane mitigation effect
Inhibitors	
3-nitrooxypropanol	High
Electron receptors	
Nitroethane	Low
Nitrate	High
Ionophores	Low
Plant bioactive compounds	
Tannins (condensed)	Low?
Saponins	Low?
Essential oils	Low?
Bacterial direct fed microbials	Low?
Defaunation	Low
Dietary lipids	Medium
Inclusion of concentrate	Low to medium
Improving forage quality	Low to medium
Grazing management	Low
Feed processing	Low
Mixed rations and feeding frequency	?
Precision (balanced) feeding and feed analysis	Low to medium

3-NOP

- Direct inhibition of archaea enzyme activity
- Was found to decrease methane emissions by up to 80.7%
- Not approved in Canada or US

- Improvements in performance related parameters are variable and most likely do no enhance production

Seaweed

- Preliminary studies indicate that adding seaweed to the diet reduced CH_4 emissions by up to 38%, *in vitro*, without impacting performance
- Seaweed Asparagopsis (red algae) decreased methane production by 99% when included at 2% OM.
- Same seaweed in Australian sheep resulted to a 63% decrease in methane (Li et al. 2018)
- Holstein cows fed 1% DM of seaweed had a 58% reduction in methane production (unpublished, 2019)

Issues

- Reports of decreased DMI
- Decrease in VFA

Reduced methane via:

- Tannins (Phlorotannins)
- Anti-methanogenic?
- Bromoform – safe? Carcinogen?

Future

- Rumen microbes did not adapt
- Haloforms are not deposited in meat
- Long term health effects
- Limited studies – new area of interest

Breeding programs to reduce methane

Table 2 *Heritability (h^2), repeatability estimates (±s.e.) for methane traits and LW at measurement*

Trait	*n* records	Mean	σ_p	$h^2 \pm$ s.e.	Repeatability		
					Consecutive days	Across rounds	Across years
g CH_4/day	5236	24.6	3.18	0.29 ± 0.05	0.94 ± 0.003	0.55 ± 0.02	0.53 ± 0.02
g CH_4/kg DMI	5235	15.7	1.62	0.13 ± 0.03	0.89 ± 0.005	0.26 ± 0.02	0.24 ± 0.02
LW (kg)	4869	48.5	5.12	0.46 ± 0.07	0.93 ± 0.004	0.88 ± 0.01	0.80 ± 0.01

LW = live weight; DMI = dry matter intake.

Potential for selecting a low emissions herd?

Pinares-Patino et al. 2013

Microbial abundance and expression = CH_4 output

Low CH_4 yield rumen – Small Rumen

Heritable trait

smaller rumen = shorter retention time = less exposure to microbes = less methane

larger rumen = longer retention time = more exposure to microbes = more methane

Correlation between: CH_4 yield, retention time, total feed and rumen volume

Low residual feed intake = more feed efficient = lower CH_4 emissions

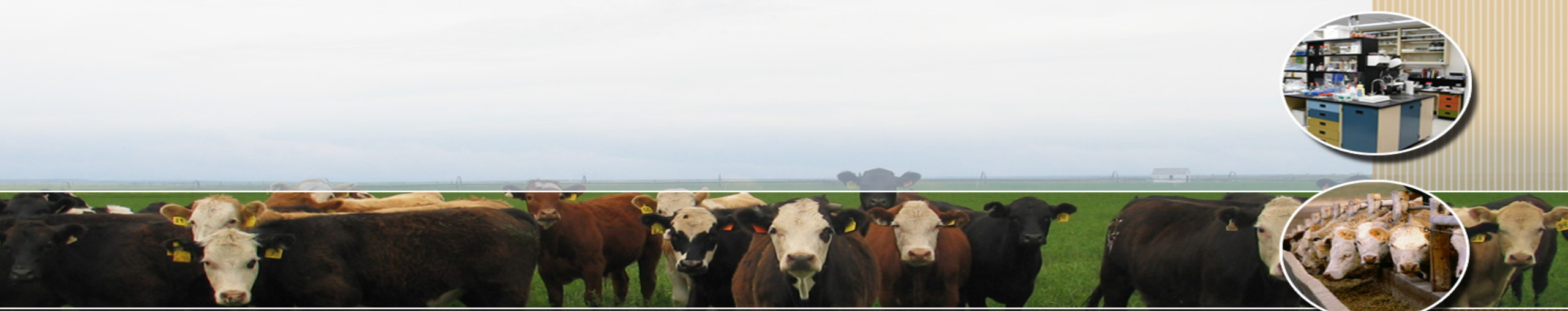
However there is also a correlation between decrease in CH_4 and decrease in diet/fibre digestibility

Best way to decrease CH_4 emissions

- Improve efficiency of production, reduces days until slaughter and reduce the number of animals required to produce the same quantity of beef
- Its about emissions intensity, producing the same amount of meat with less input

- A lot of the recommendations take away from ruminants ability to effectively turn fibrous matter into product

- Complex process
- There isn't an easy fix



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