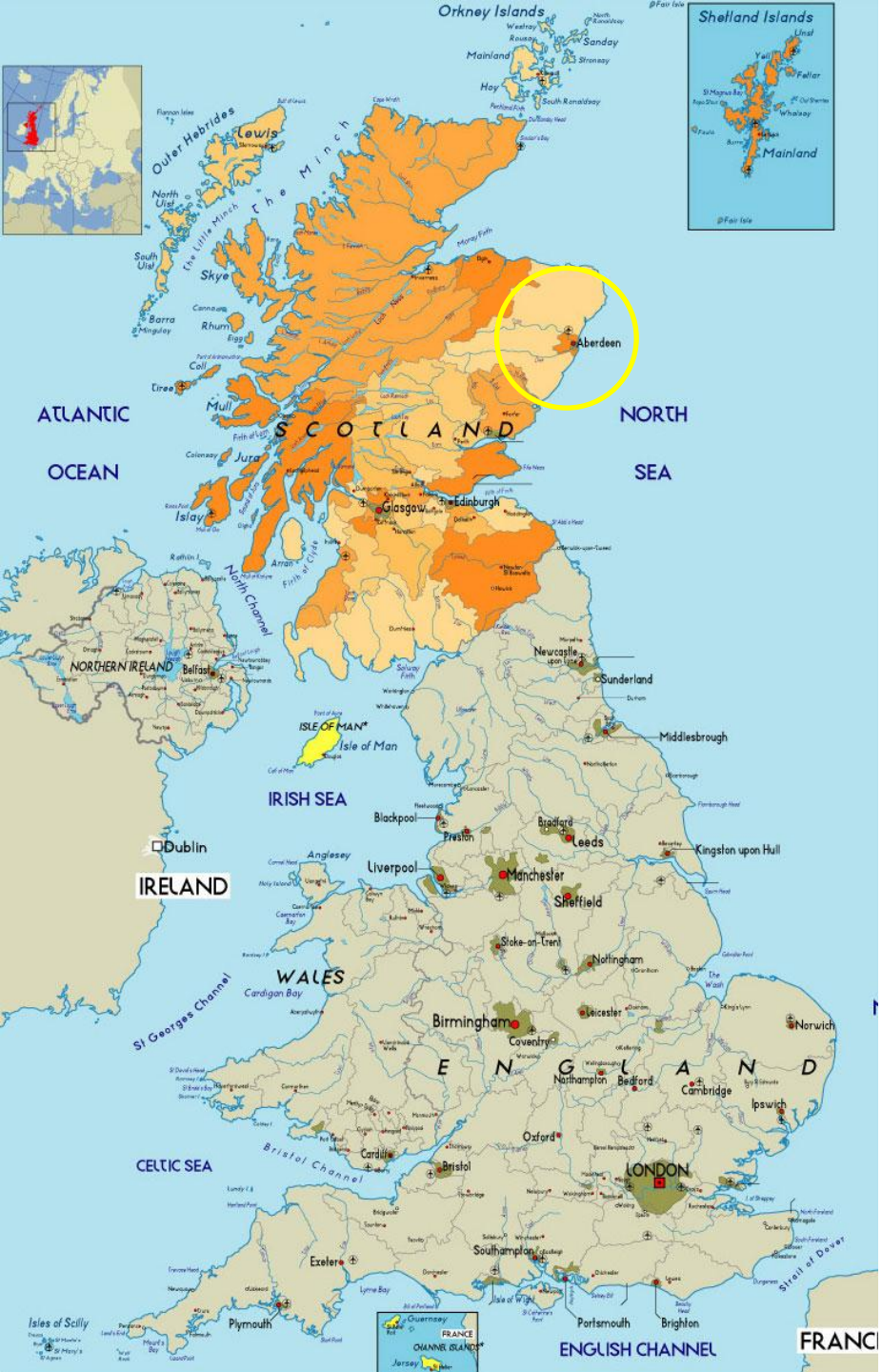


The ruminal microbiome and animal health

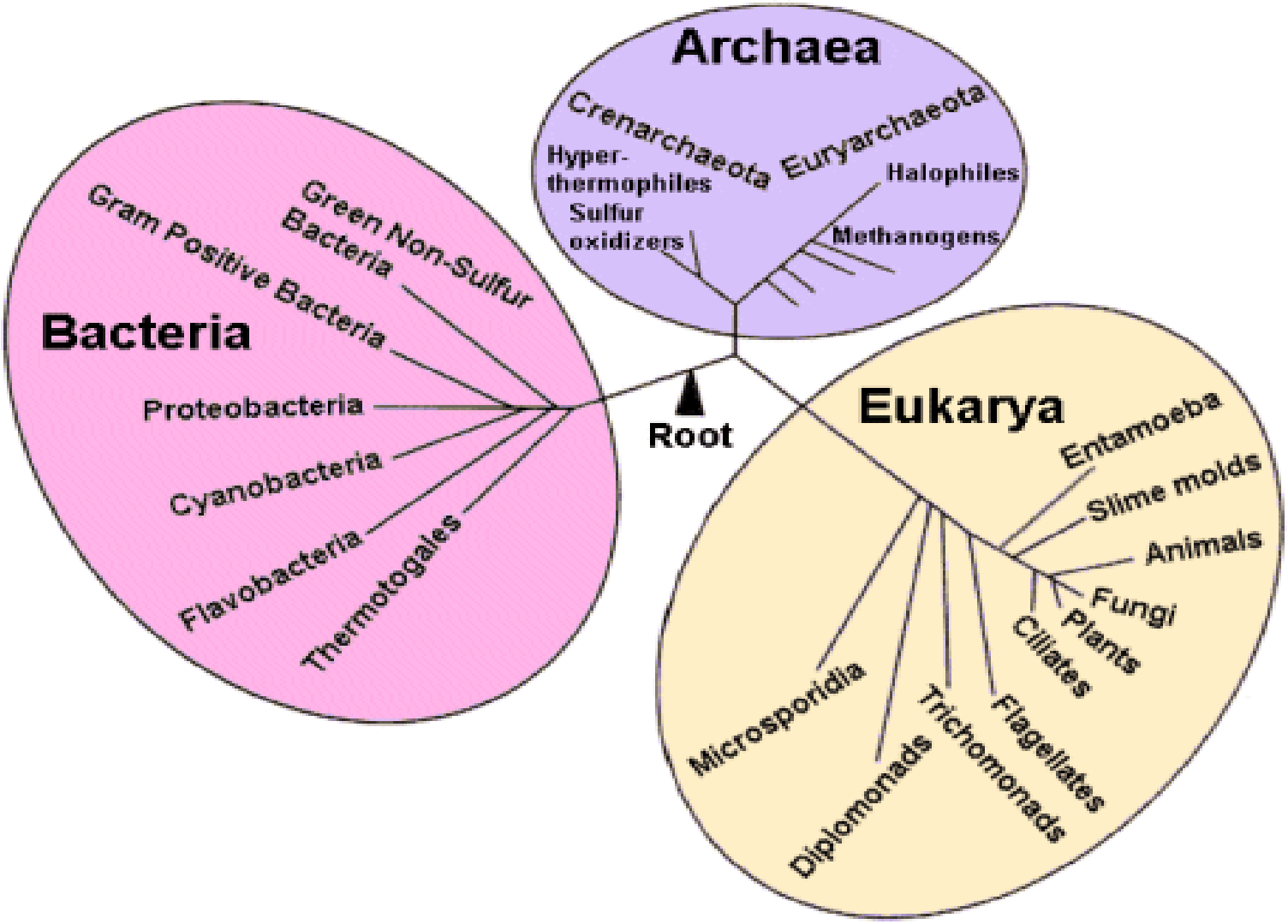
R. John Wallace

Rowett Institute of Nutrition and Health
University of Aberdeen

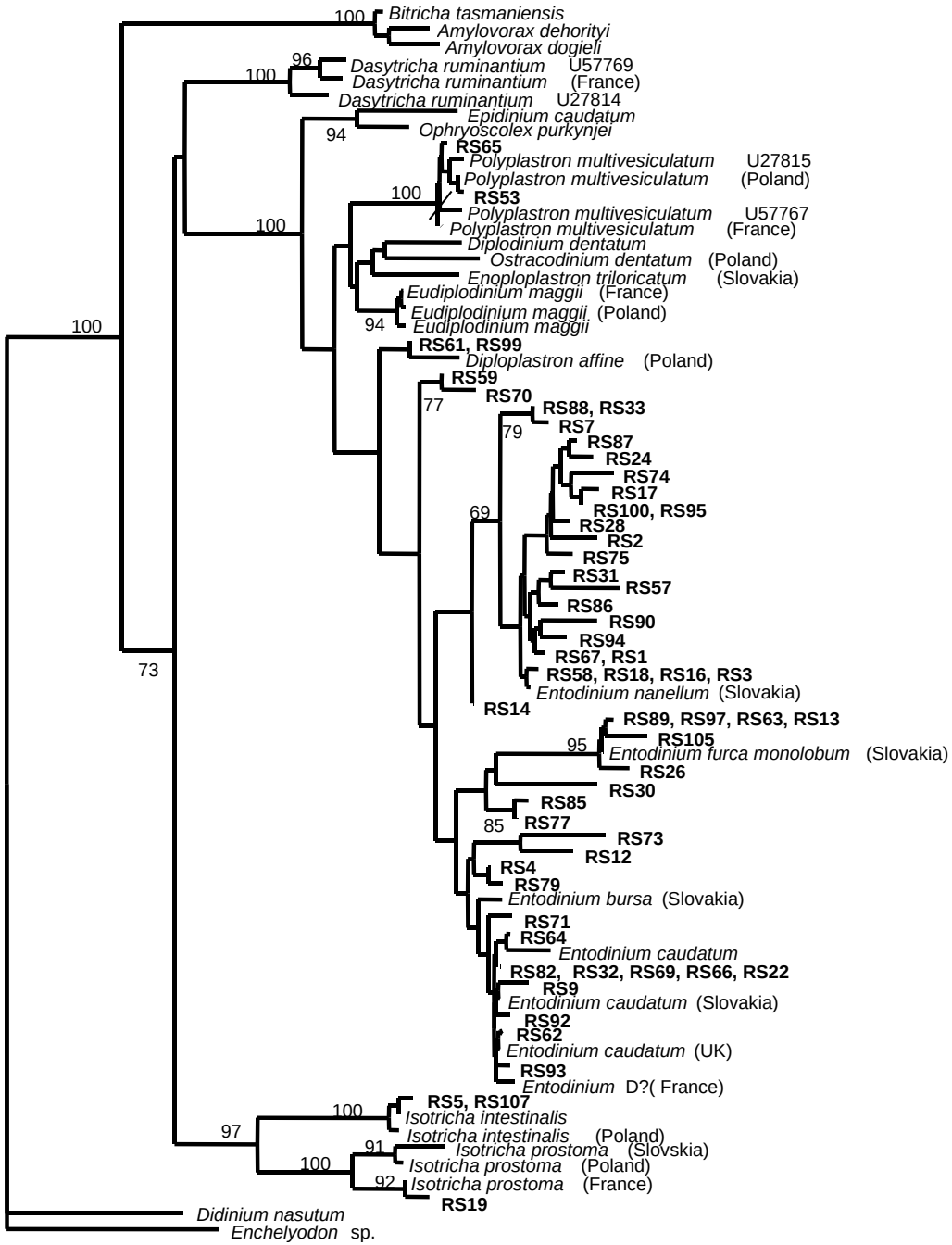
The ruminal microbiome and animal health

- Ruminal microbiota
- Ruminal function and dysfunction
- The ban of GPA and its consequences
- The microbiome and rumen function
- The microbiome and animal health: SARA
- Conclusions

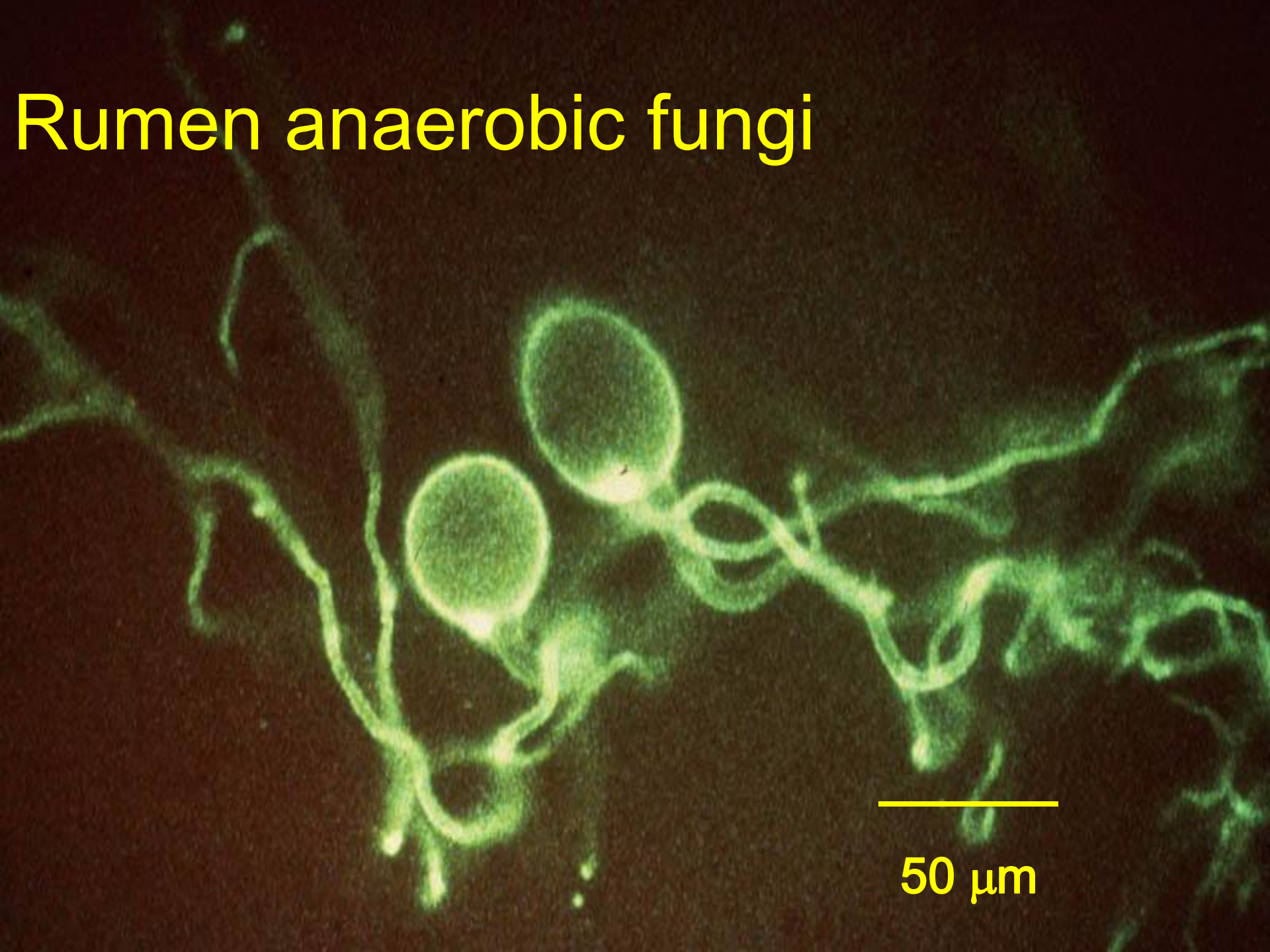
The three domains of life

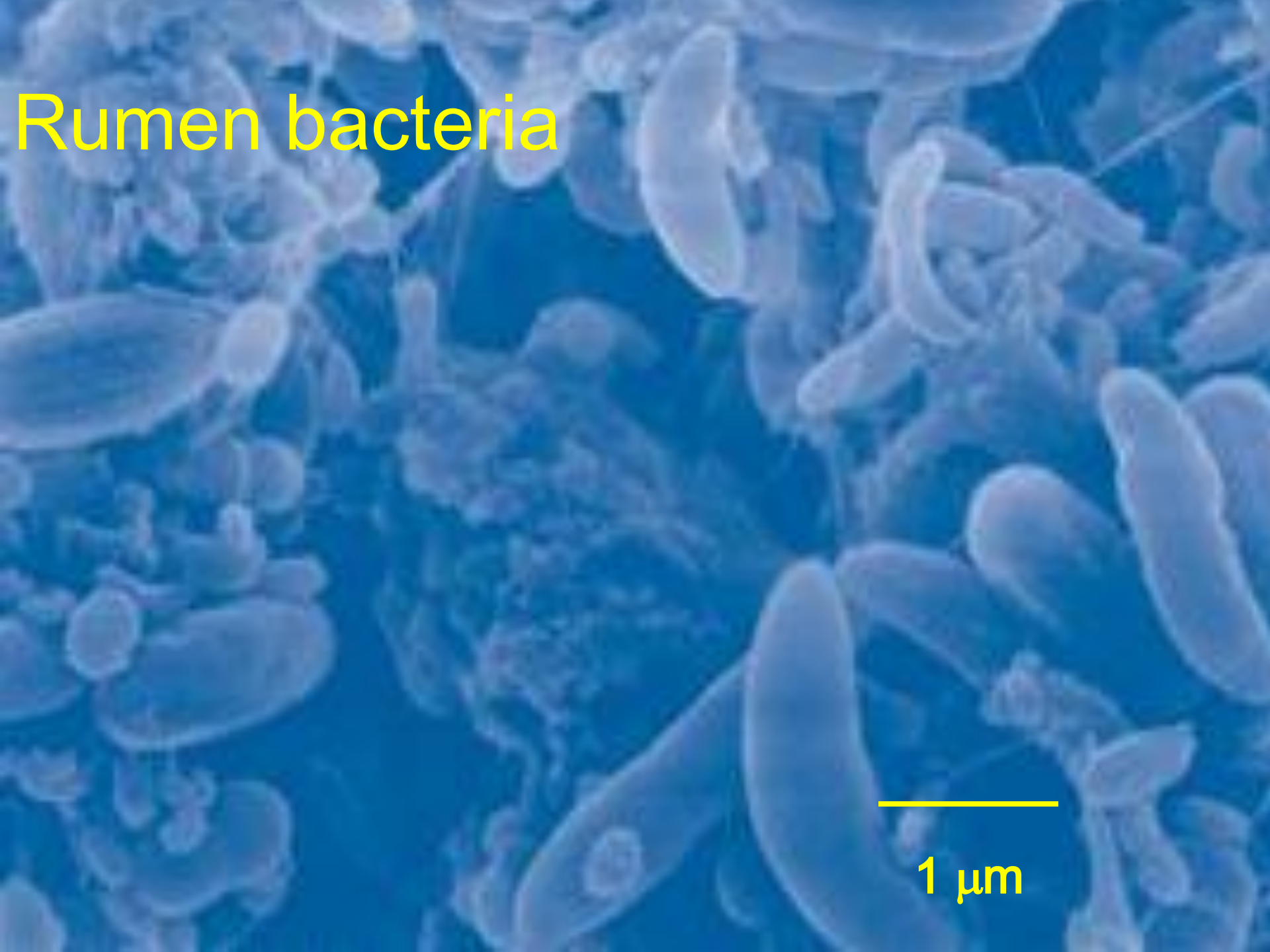


Unexpected protozoal diversity



Rumen anaerobic fungi




Rumen bacteria
1 μm

Proteobacteria

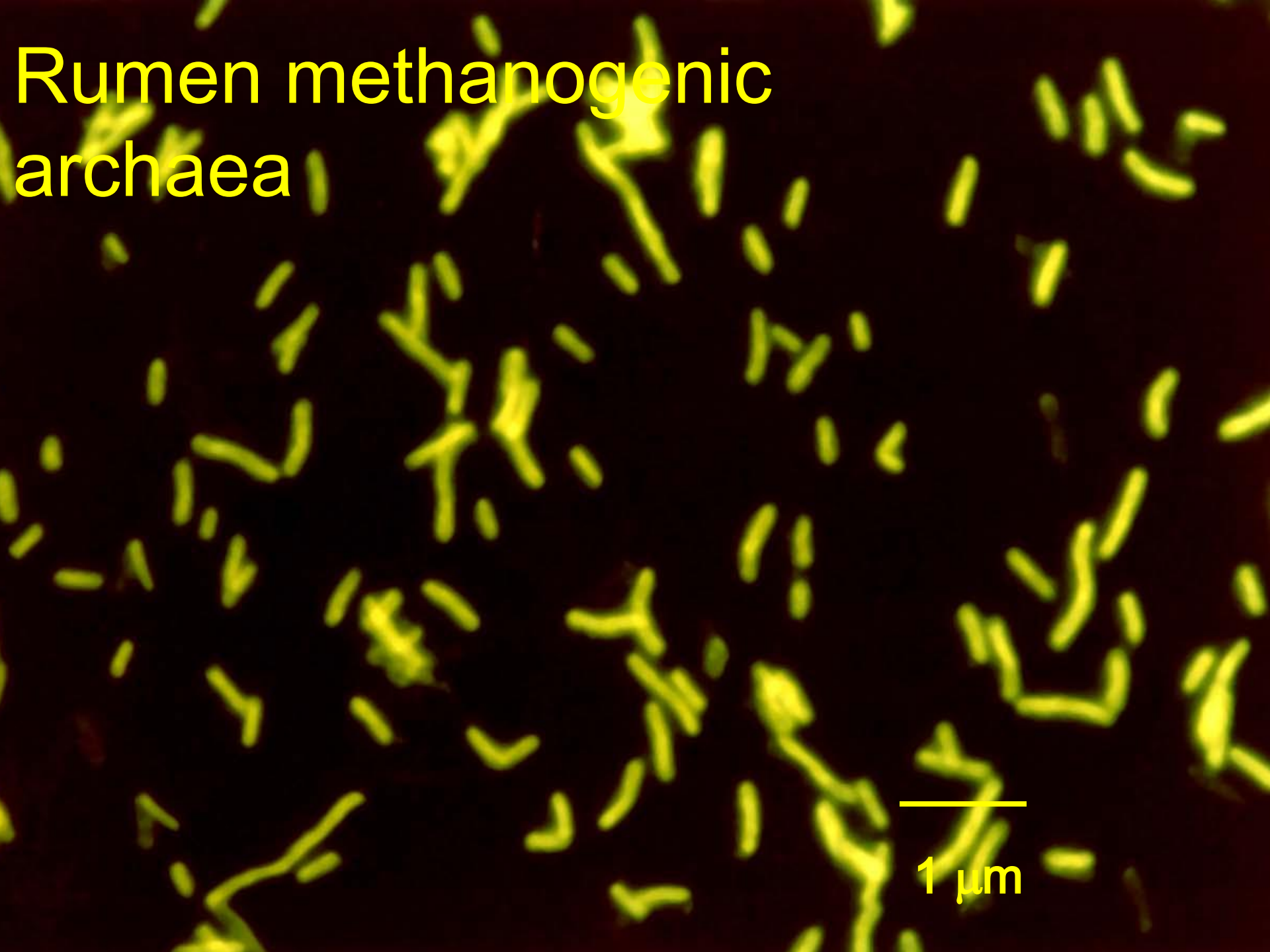
Bacteroidetes

~350 bacterial species
Narrow diversity

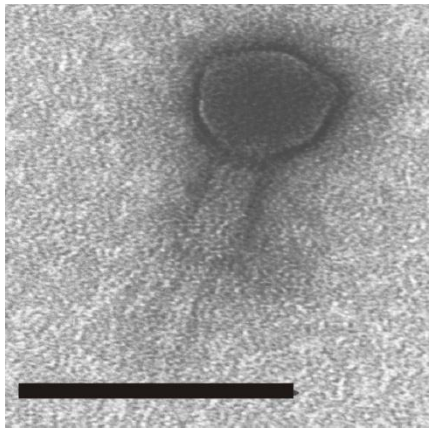
Low G+C Gram positive

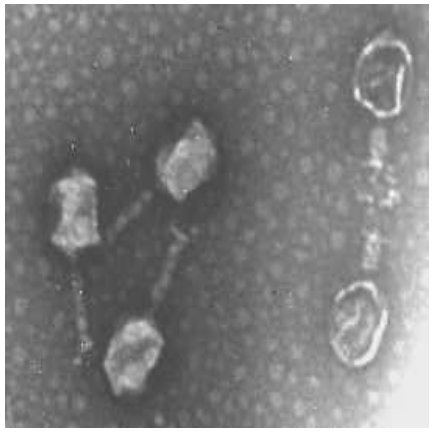
High G+C Gram positive, *Fibrobacter*, *Spirochaetes*, etc

Rumen methanogenic archaea



The ruminal virome

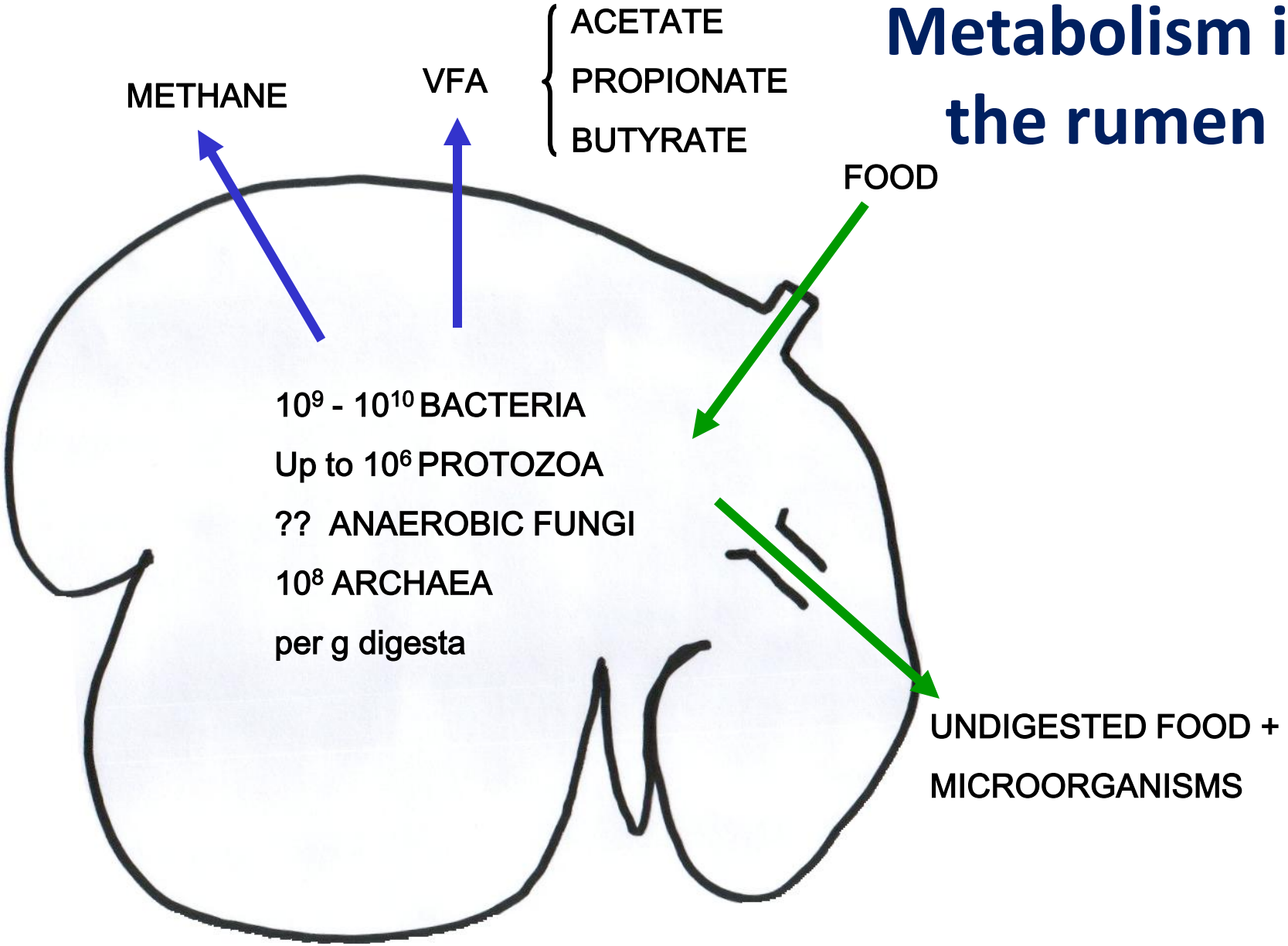




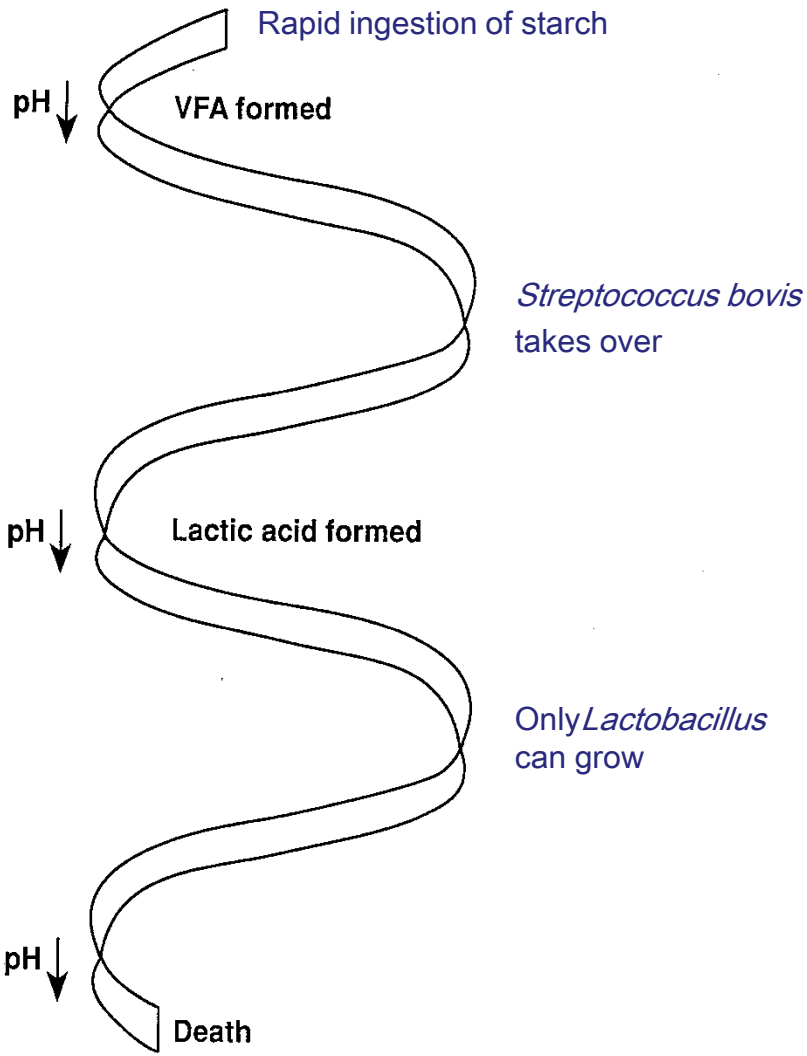
We undertook random pyrosequencing of virus-enriched metagenomes (viromes) isolated from bovine rumen fluid and analysed the resulting data using comparative metagenomics. A high level of diversity was observed with up to 28 000 different viral genotypes obtained from each environment.

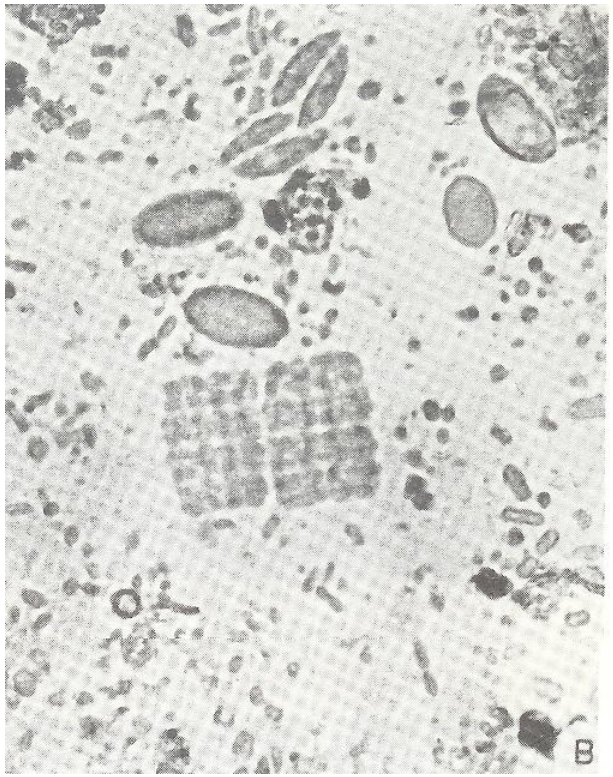
Berg Miller et al. (2012) Environ Microbiol 14, 207

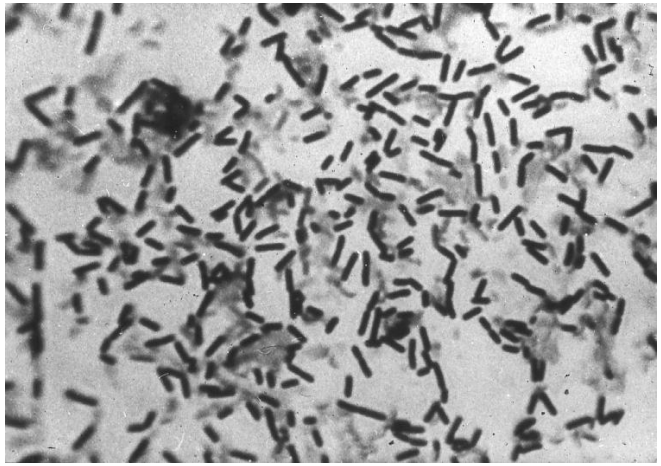
Metabolism in the rumen



Digestive disorders: lactic acidosis spiral







Digestive disorders: subacute ruminal acidosis

- 5.1 < pH < 5.8
- No lactic acid
- VFA absorption compromised
- Inappetance, liver abscesses, laminitis
- Very common when high grain fed
- Difficult to detect except *post mortem*

Digestive disorders: bloat

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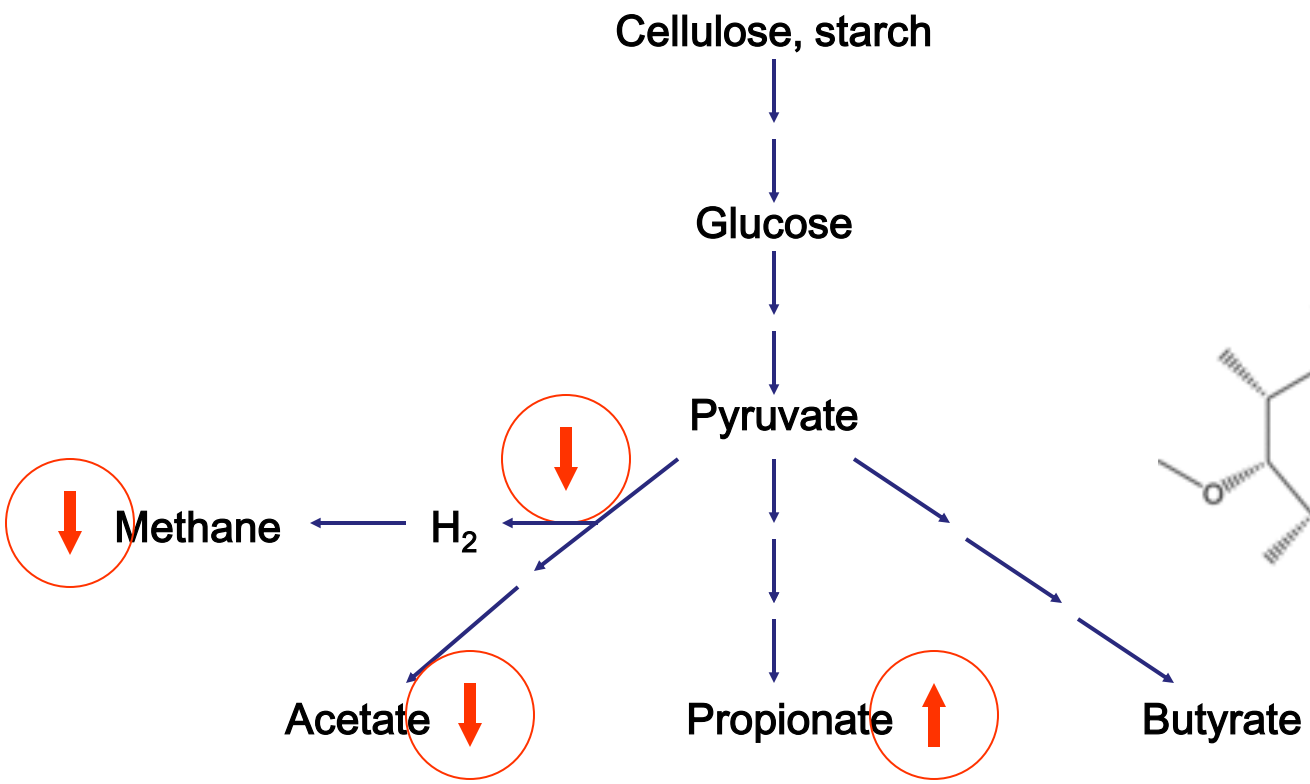
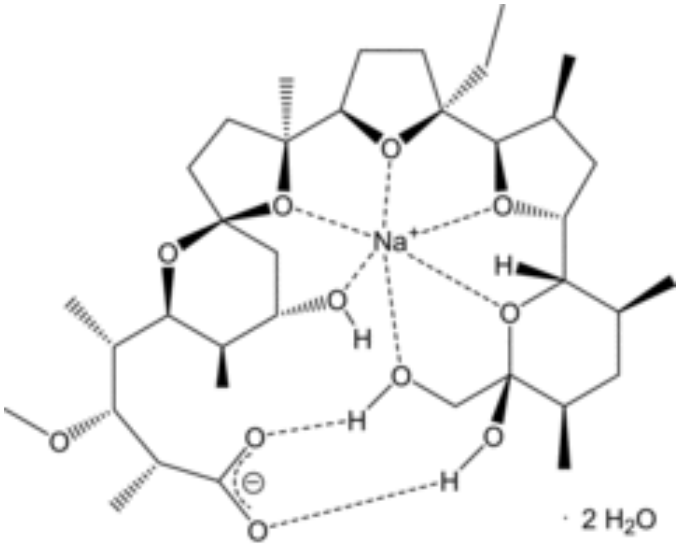
Regulations controlling use of antimicrobial growth promoters

Concern: antibiotic resistance in animal gut bacteria will be transmitted to human pathogens, making therapy ineffective

Sweden	Complete ban, 1986
European Union	Complete ban, 2006
Australasia	Case-by-case
North America	Case-by-case
FAO/WHO	Monitor, risk assessment

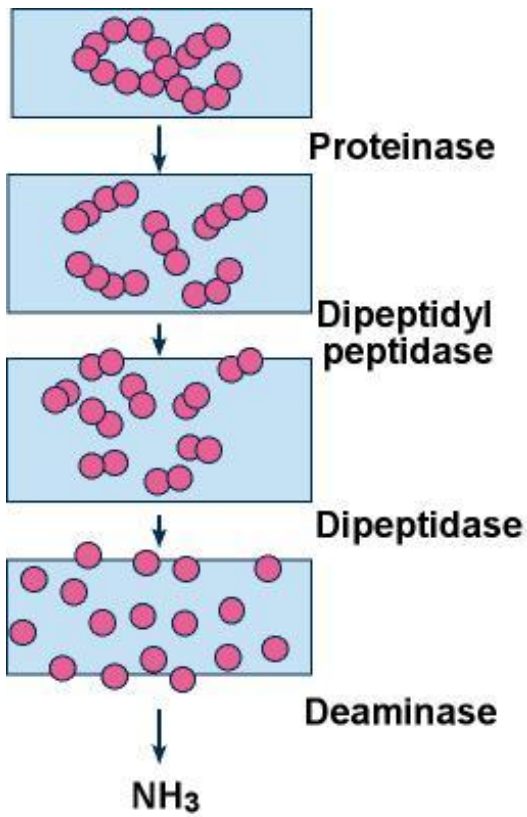
Mode of action of monensin: energy metabolism





(I)

Mode of action of monensin: protein breakdown



PROTEIN

↓ Proteinase

OLIGOPEPTIDES

↓ Dipeptidyl peptidase

- Adaptation in *Prevotella* spp. leading to slower peptide uptake

DIPEPTIDES

↓ Dipeptidase

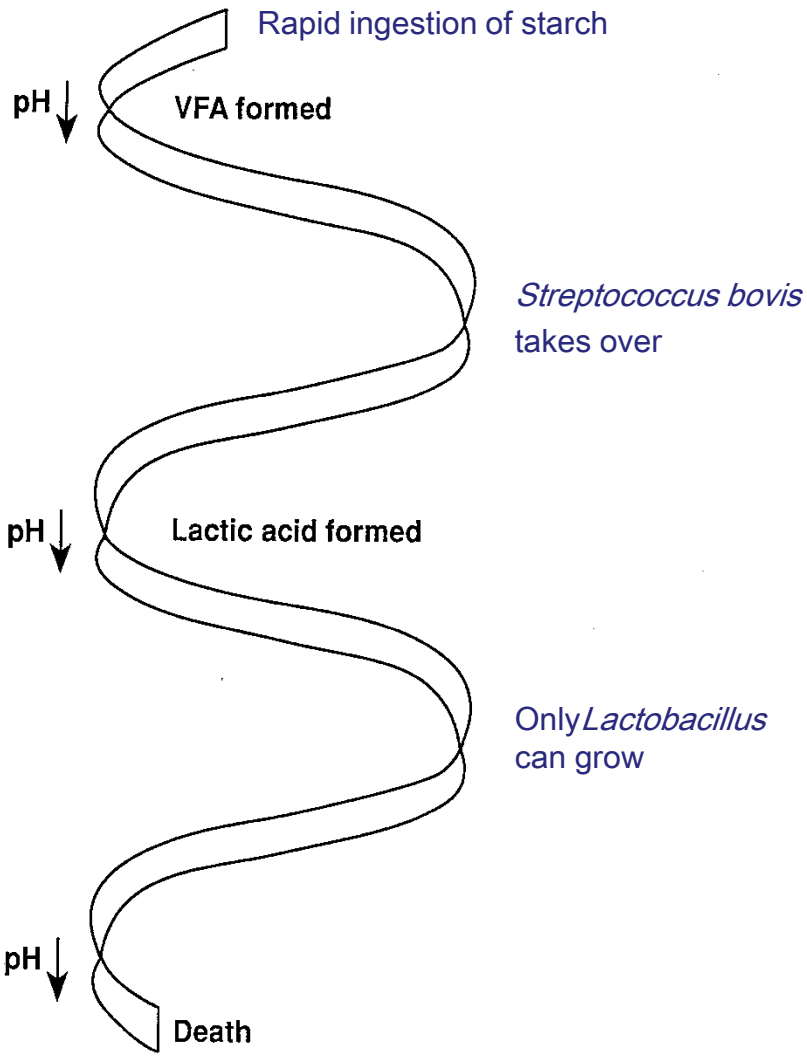
AMINO ACIDS

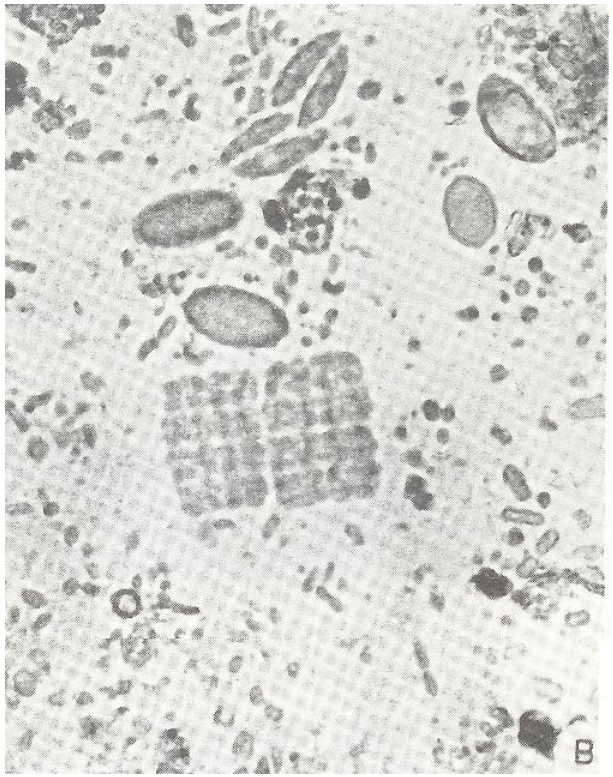
↓ Deaminase

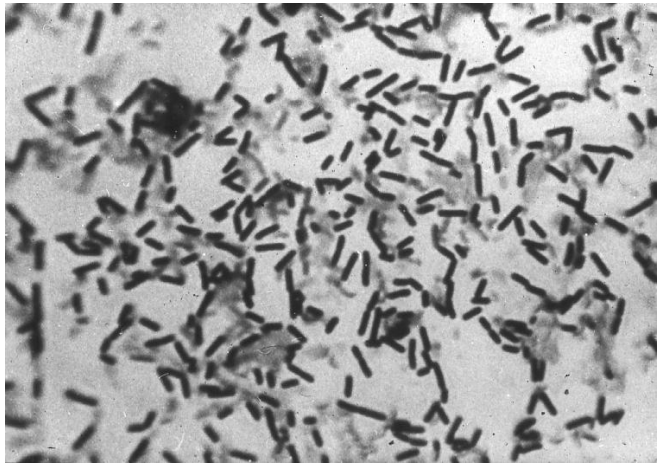
- Inhibits ‘hyper-ammonia producing’ bacteria (HAP)

AMMONIA

Digestive disorders: lactic acidosis spiral





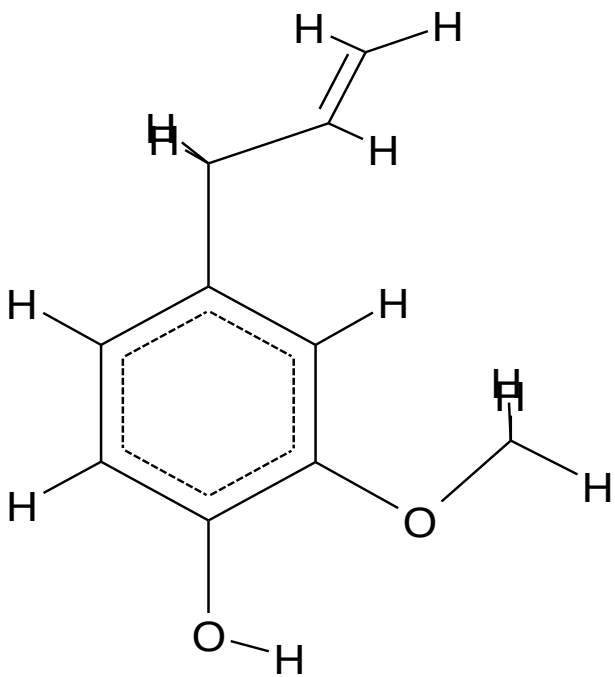


Alternatives to AGP

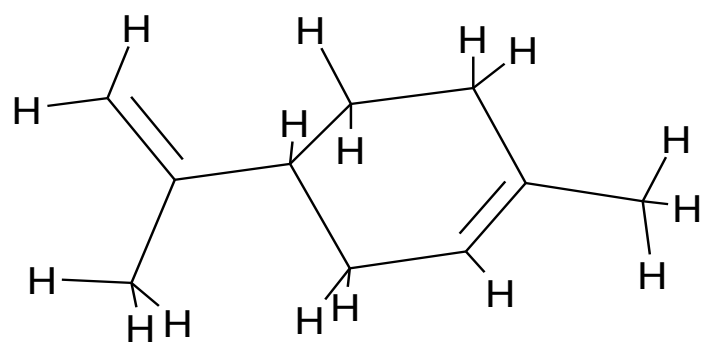
- Alternative feed additives
  - Plant extracts
  - Direct-fed microbials
  - Bacteriocins
- Bacteriophages
- Immunization
  - Methane
  - Acidosis
- Genetic control of the microbiome

Essential oils

Essential oils are steam-volatile or organic-solvent extracts of plants, proven to have antimicrobial and insecticidal properties. They comprise mainly cyclic hydrocarbons and their alcohol, aldehyde or ester derivatives.

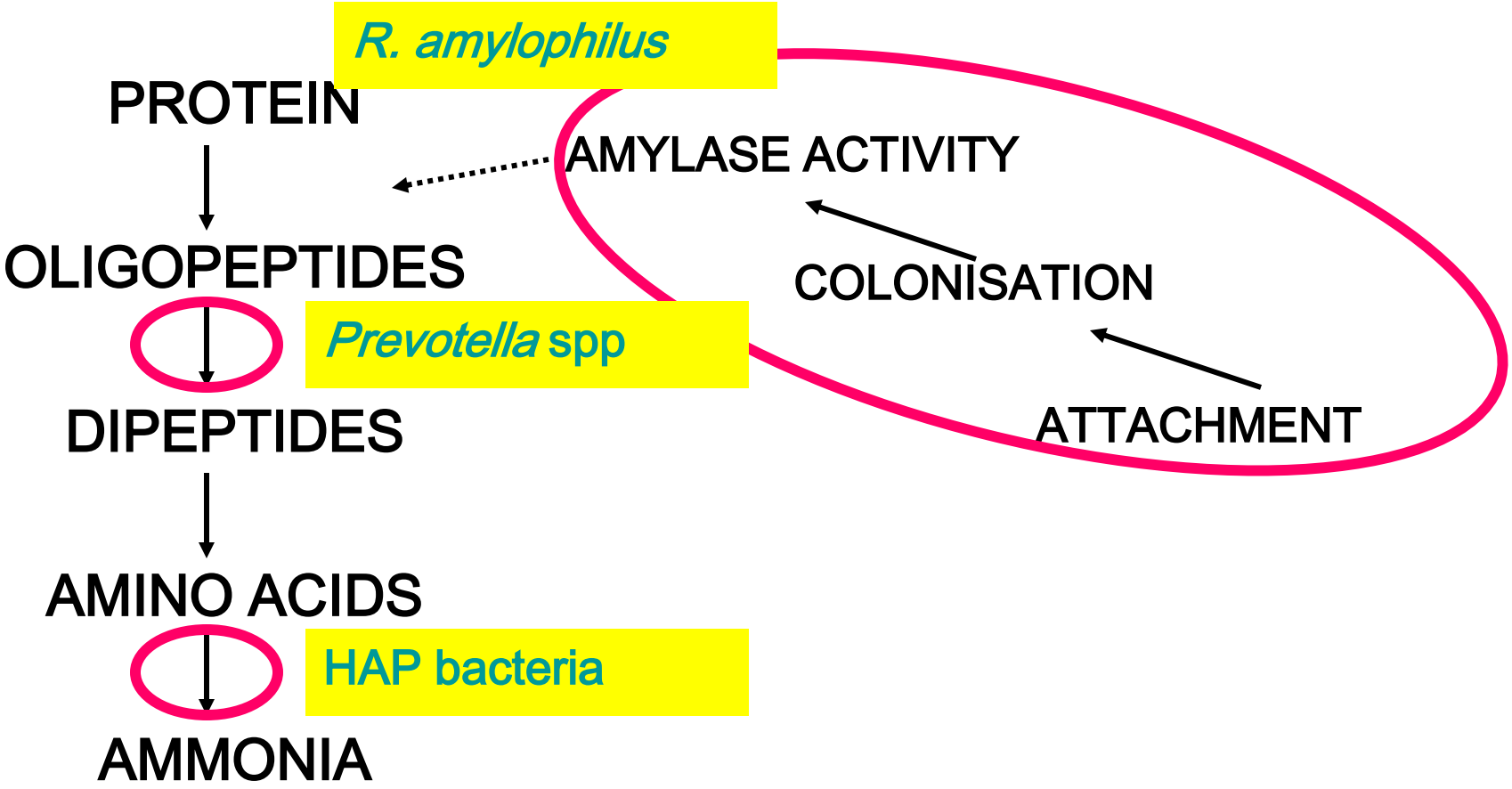


Eugenol

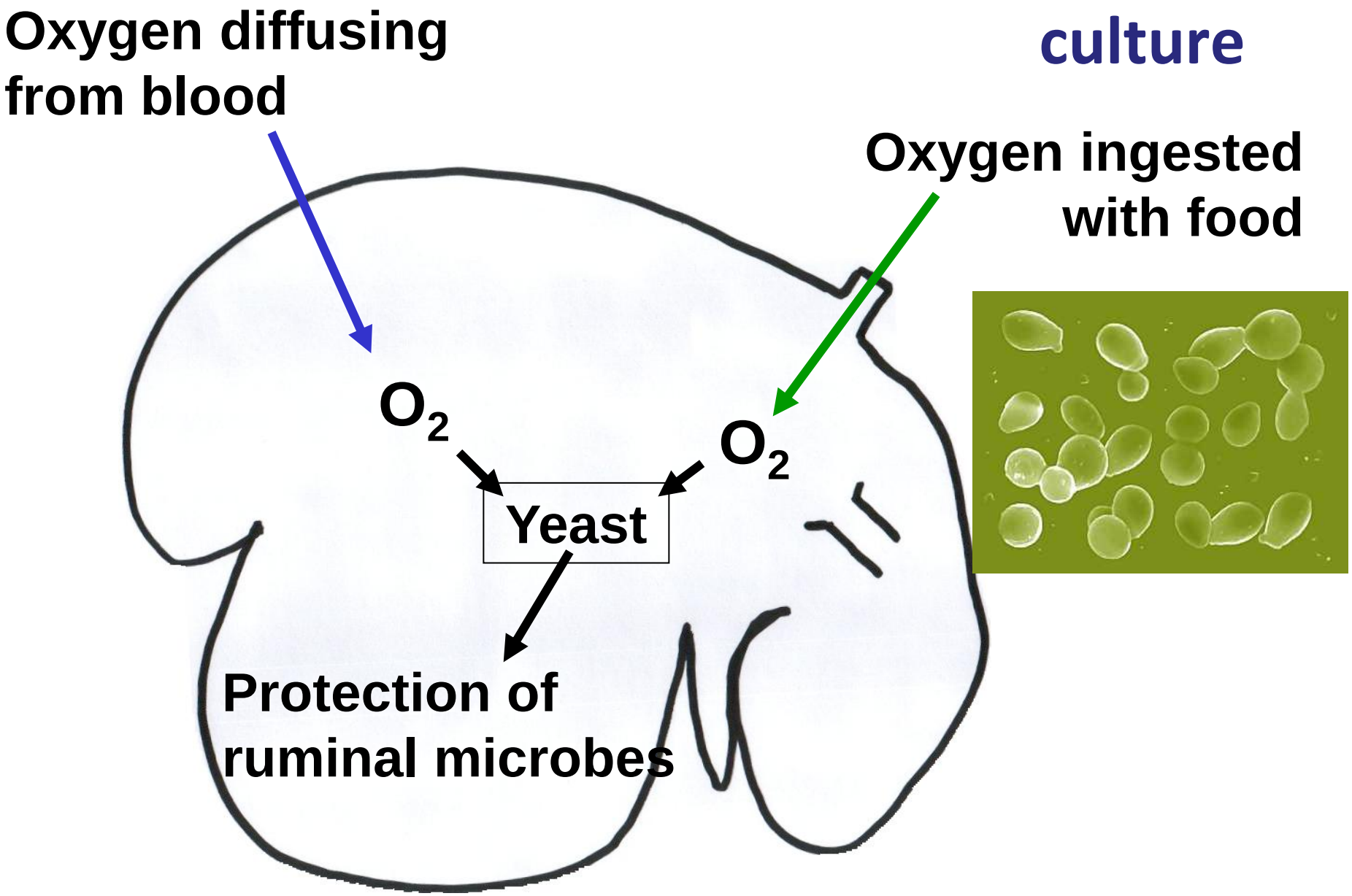


Limonene

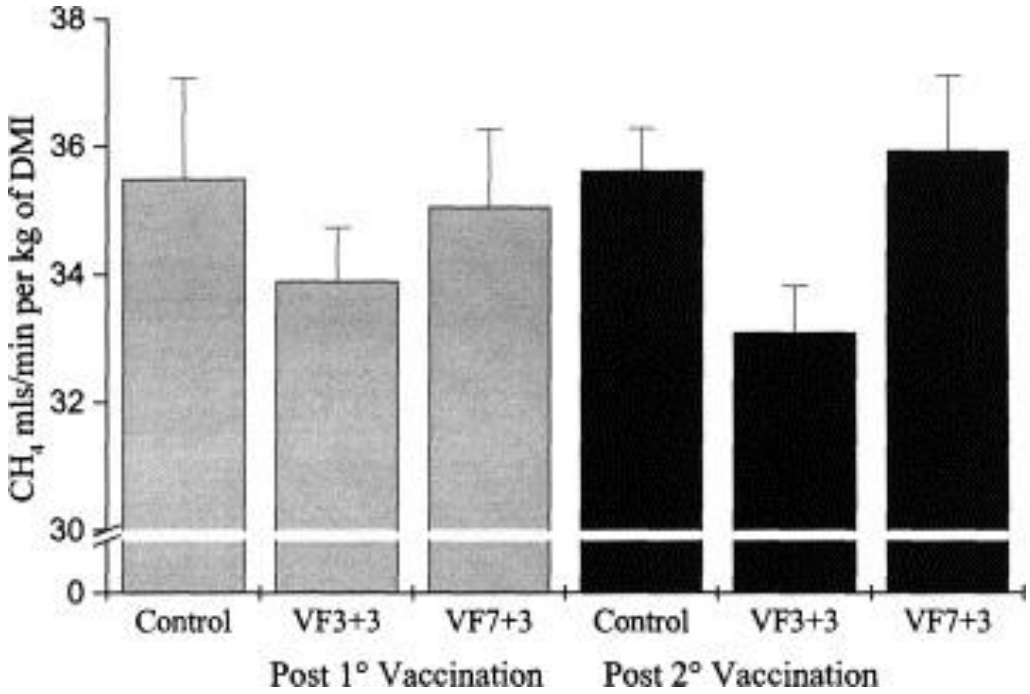
Influence of essential oils on rumen fermentation



Direct-fed microbials: yeast culture

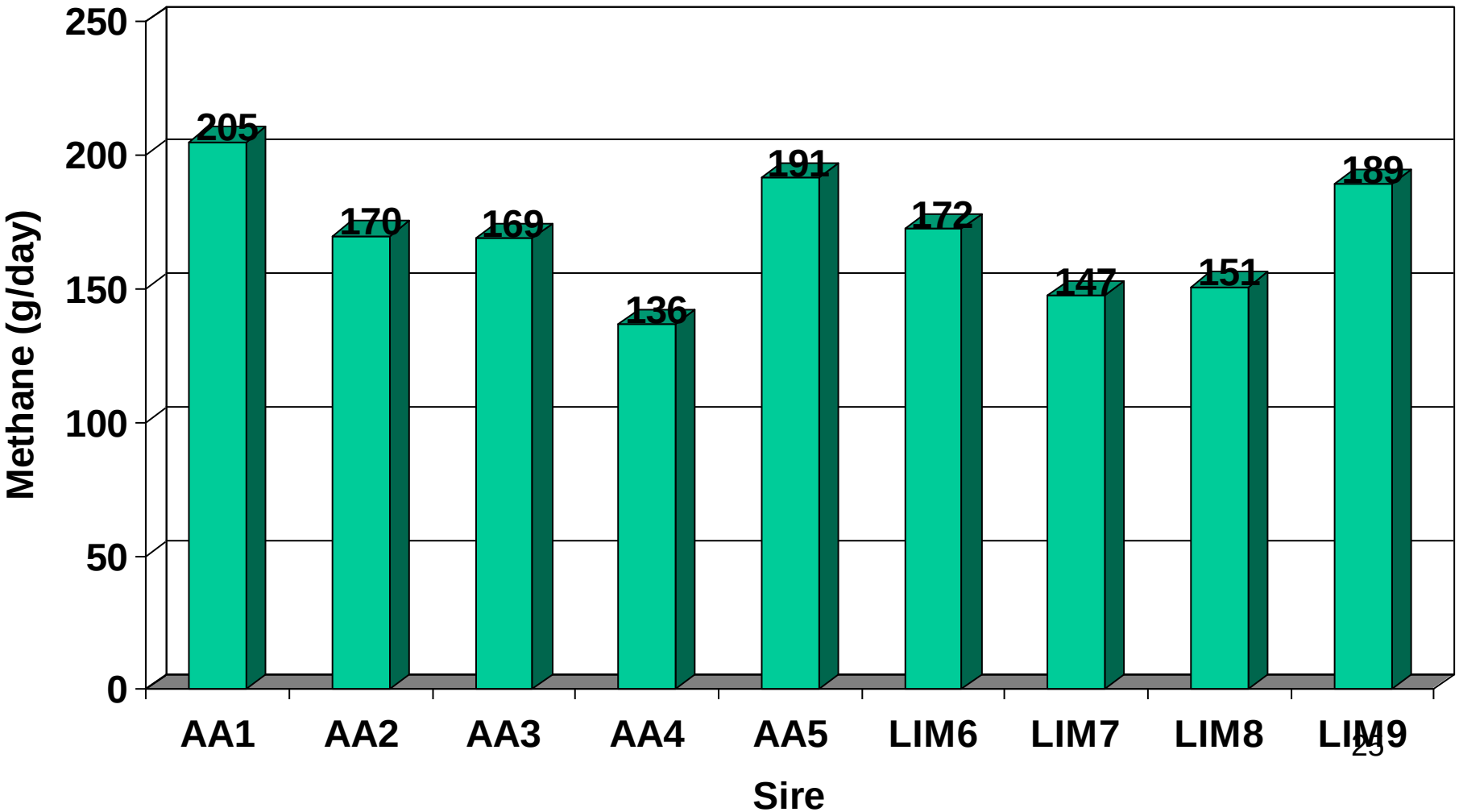


Reducing methane emissions in sheep by immunization against rumen methanogens



Wright et al. (2004) Vaccine 22, 3976

Significant differences among sires of 72 tested steers for methane emissions



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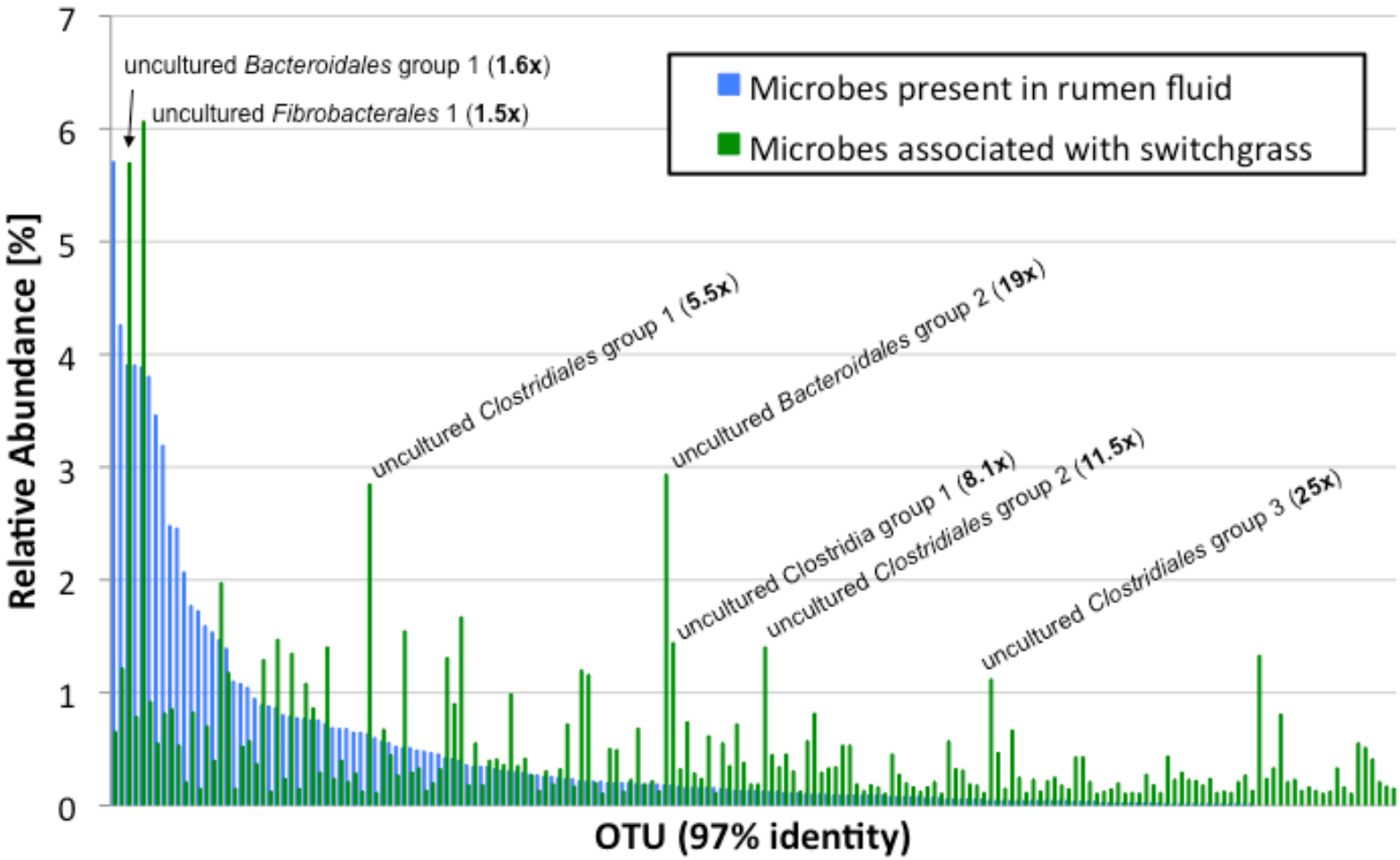
Metagenomic Discovery of Biomass-Degrading Genes and Genomes from Cow Rumen

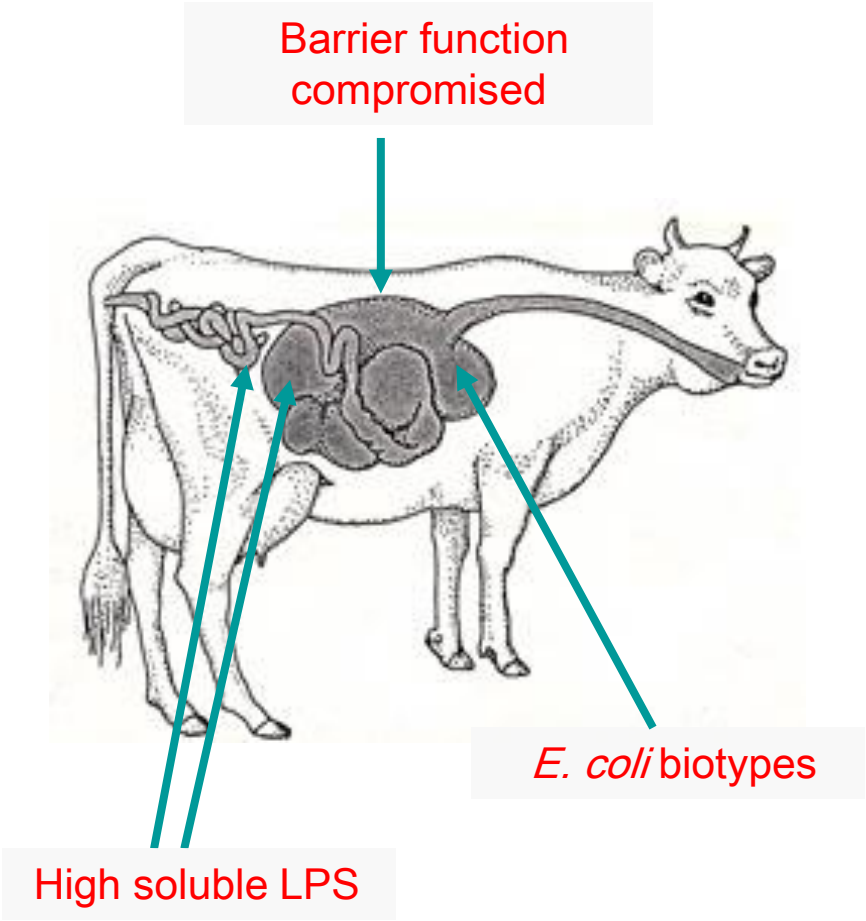
Science 28 Jan 2011

Bacterial communities in the rumen

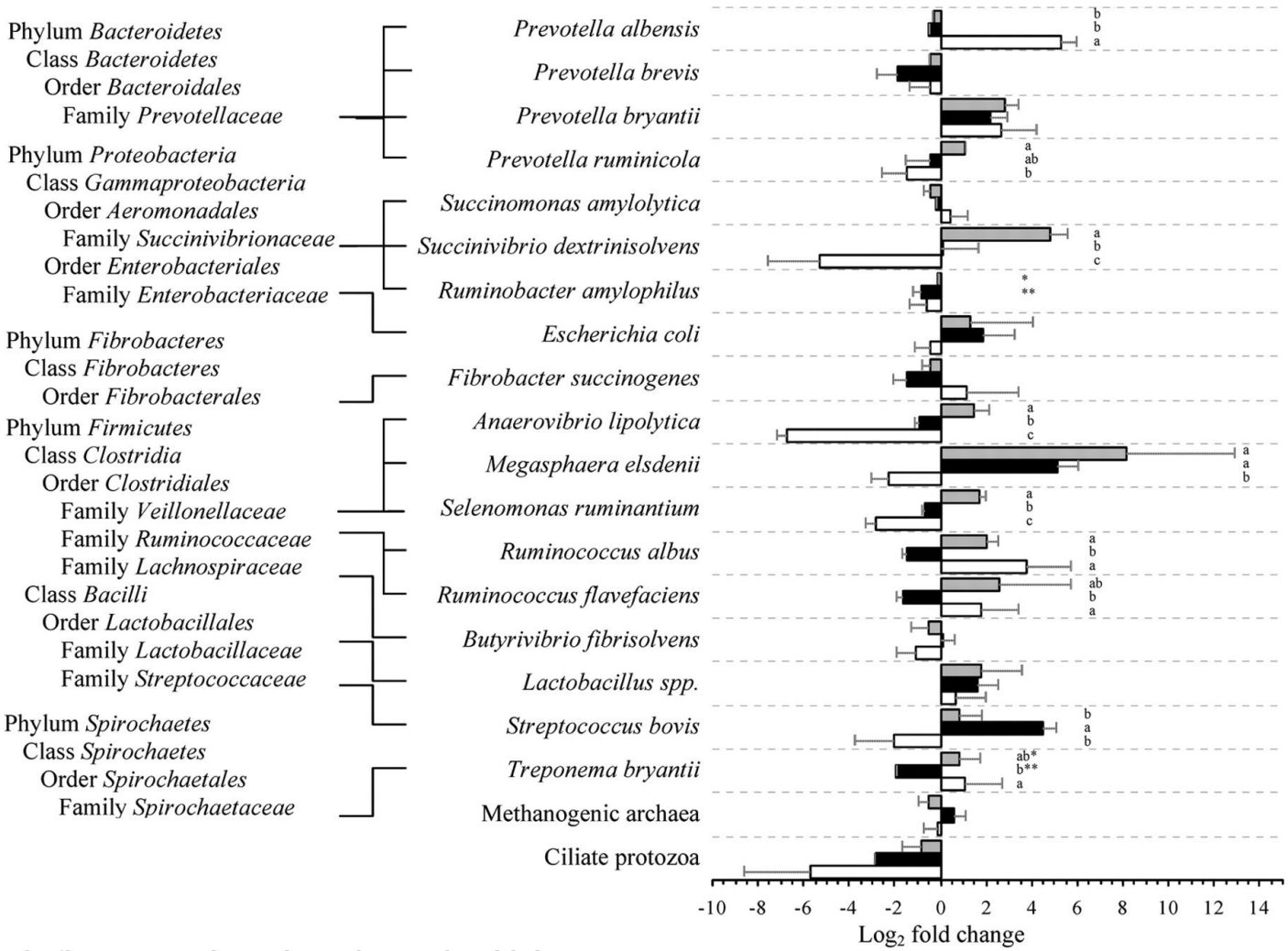


Sub-acute ruminal acidosis

Denis Krause
1965-2011

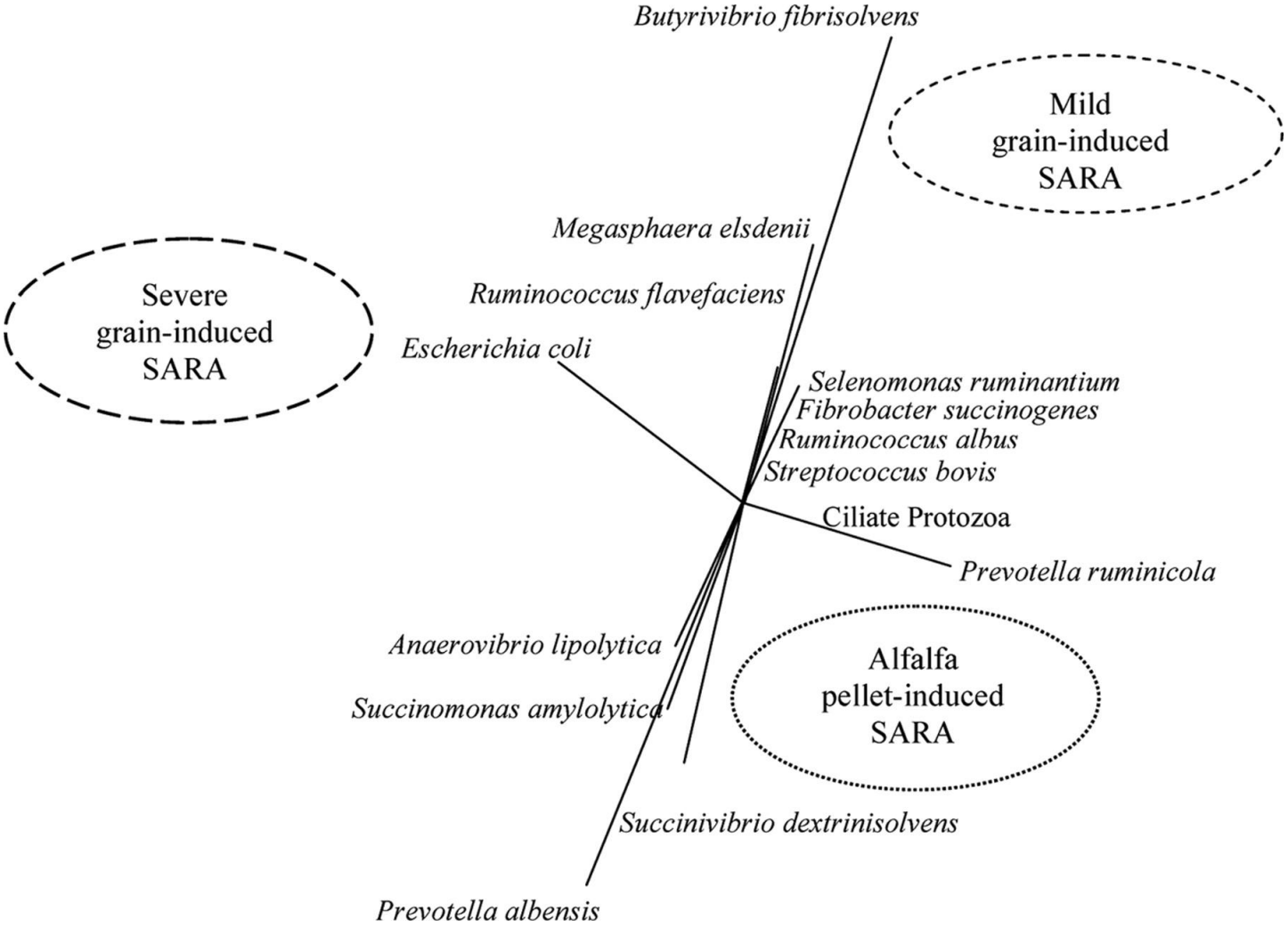


Changes in the microbiome in SARA



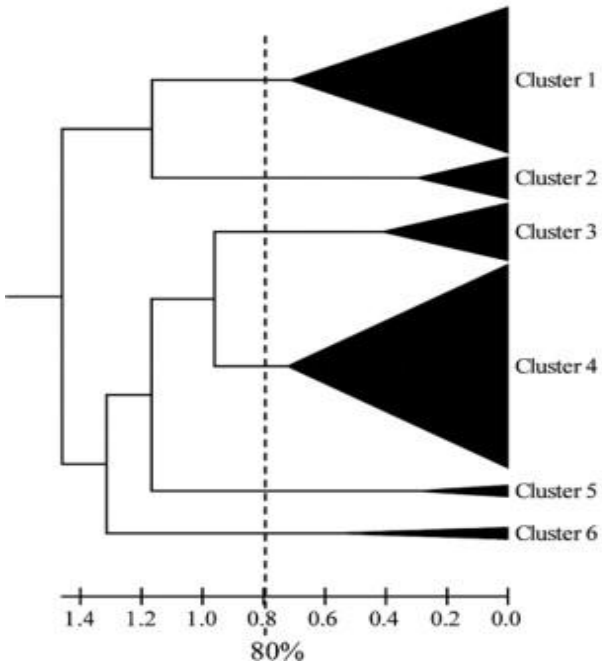
Khafipour E et al. Appl. Environ. Microbiol. 2009;75:7115-7124

Changes in the microbiome in SARA: discriminant analysis

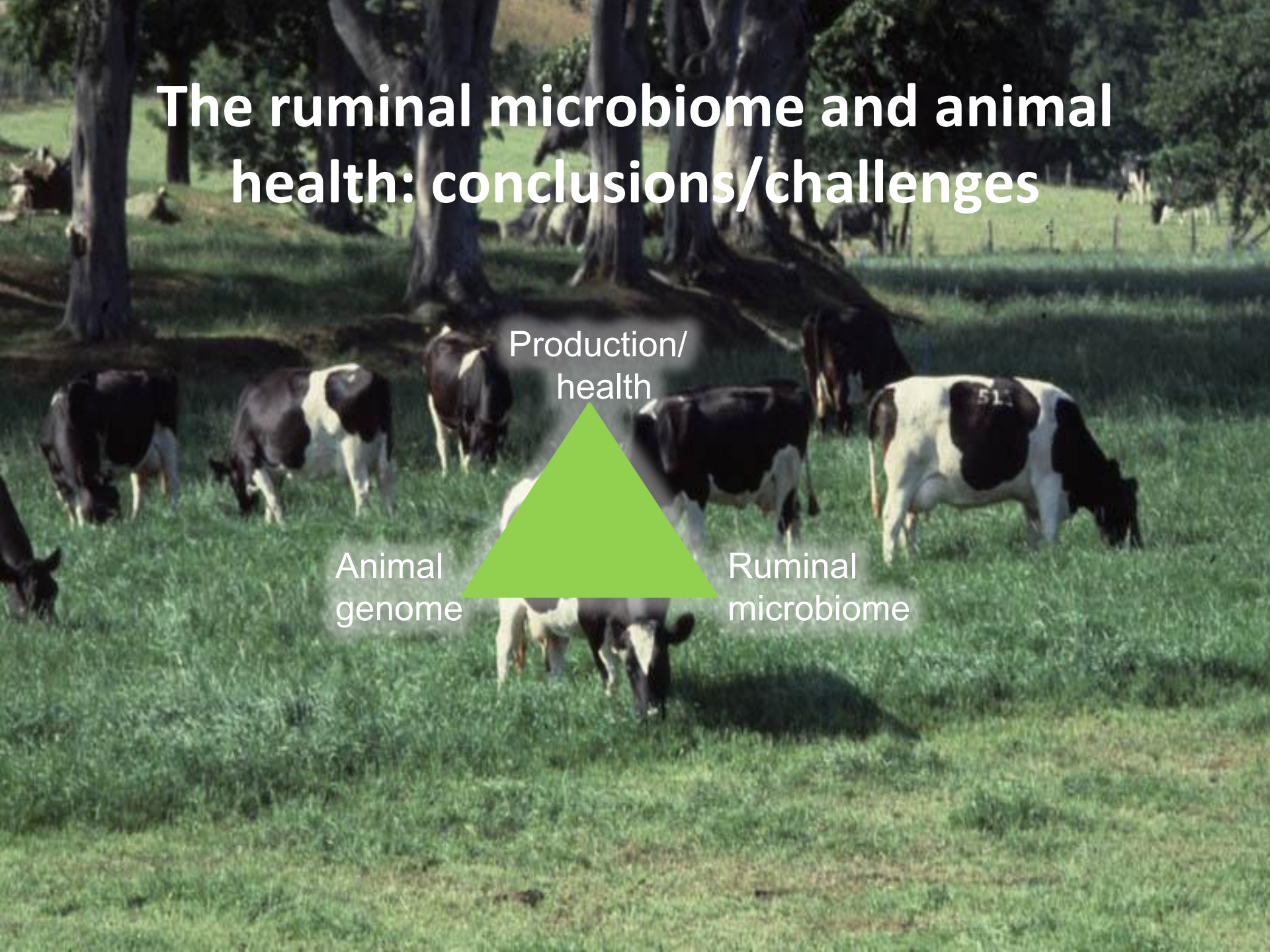


Khafipour E et al. Appl. Environ. Microbiol. 2009;75:7115-7124

Changes in the microbiome in SARA: *E. coli*



	Rep-PCR clustering					ABD system			
	GPI Control	GPI SARA	API Control	API SARA	Total	A	B1	B2+D	Total
Cluster 1	8	20	5	5	38	19	18	1	38
Cluster 2	3	7	1	0	11	7	4	0	11
Cluster 3	8	5	1	1	15	4	8	4	16
Cluster 4	17	5	21	10	53	29	26	3	58
Cluster 5	1	0	1	1	3	1	1	1	3
Cluster 6	0	0	1	2	3	0	1	2	3

Khafipour et al. (2011) Journal of Dairy Science 94, l351 - 360

The ruminal microbiome and animal health: conclusions/challenges