A core-microbiome approach to identify key microbes and interactions in bioanode microbial communities

Elie Desmond-Le Quéméner, Jean-Clément Flayac, Eric Trably, Nicolas Bernet

4th EU-ISMET, 2018
Newcastle upon Tyne

INRA
SCIENCE & IMPACT

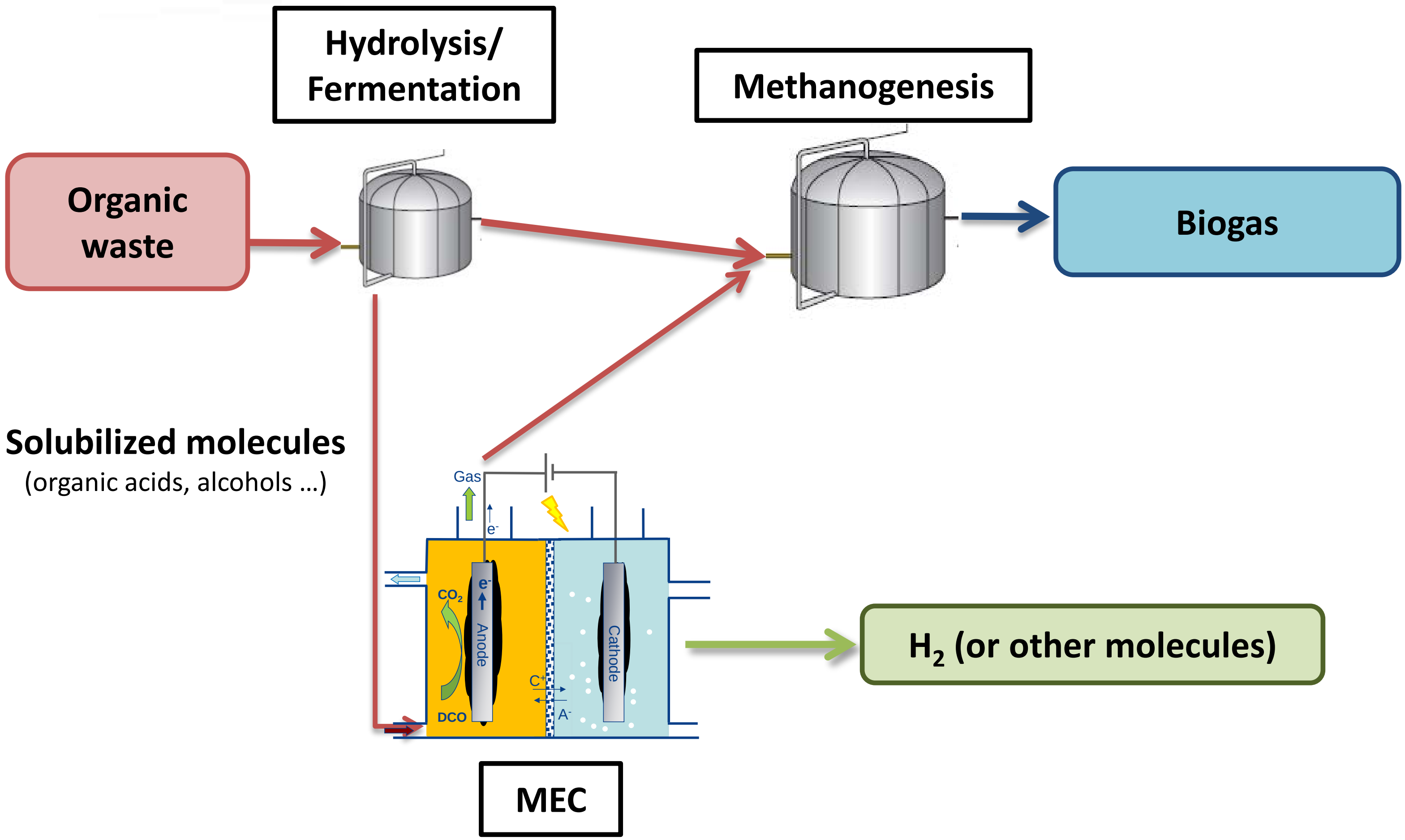
A core-microbiome approach to identify key microbes and interactions in mixed microbial bioanodes

Elie Desmond-Le Quéméner, Clément Flayac, Eric Trably, Nicolas Bernet

elie.lequemener@inra.fr
Laboratoire de Biotechnologie de l'Environnement
INRA - LBE UR050, Narbonne

Context: BES for waste treatment?

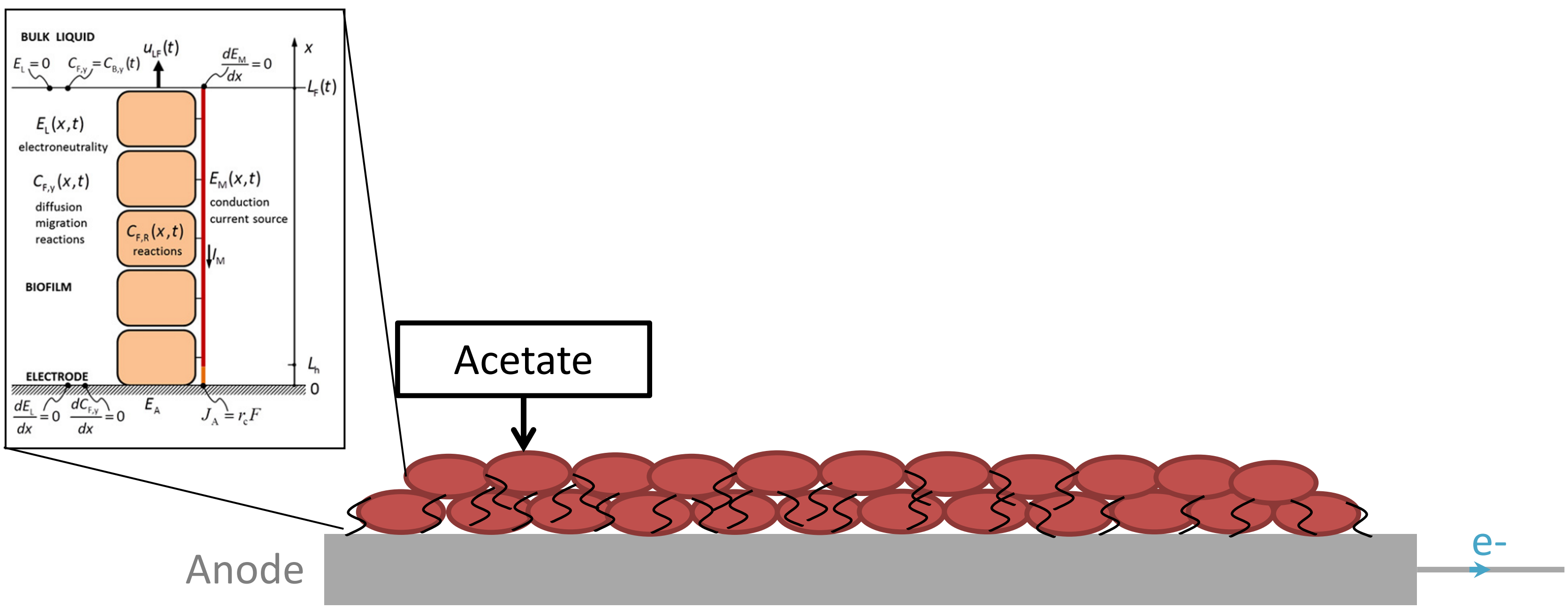
Feeding MEC with organic acids



Context: behavior of a BES fed with various organic acids?

Geobacter biofilms fed with acetate

B. Korth et al.,
Bioelectrochemistry 106
(2015) 194–206

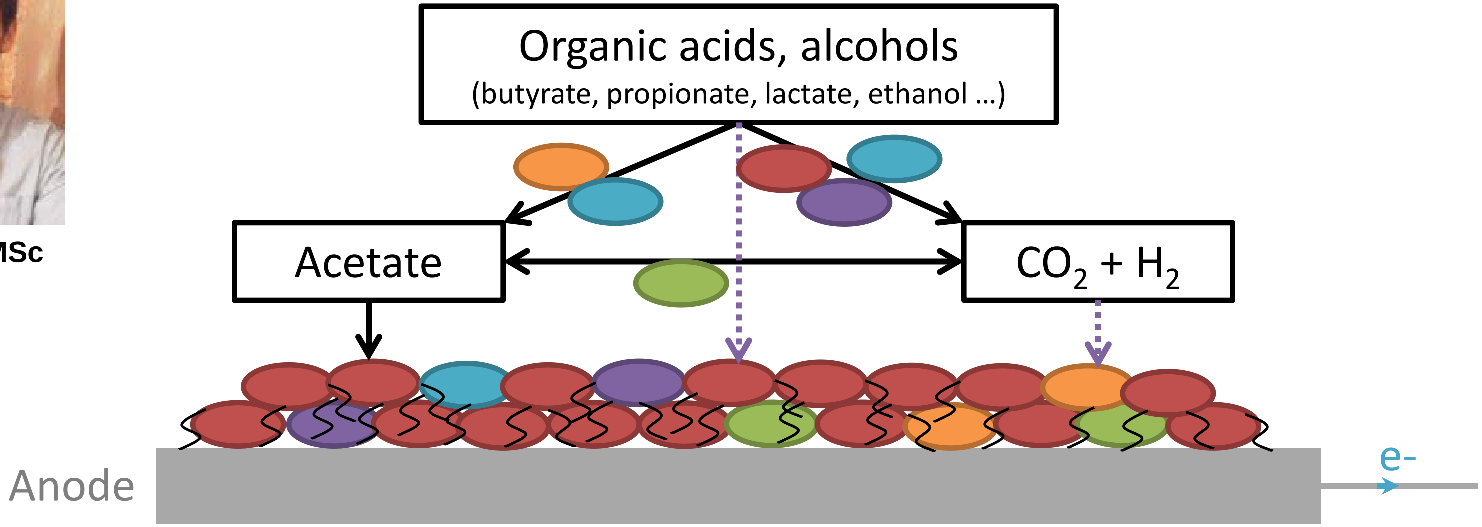


Version postprint

Context: behavior of a BES fed with various organic acids?

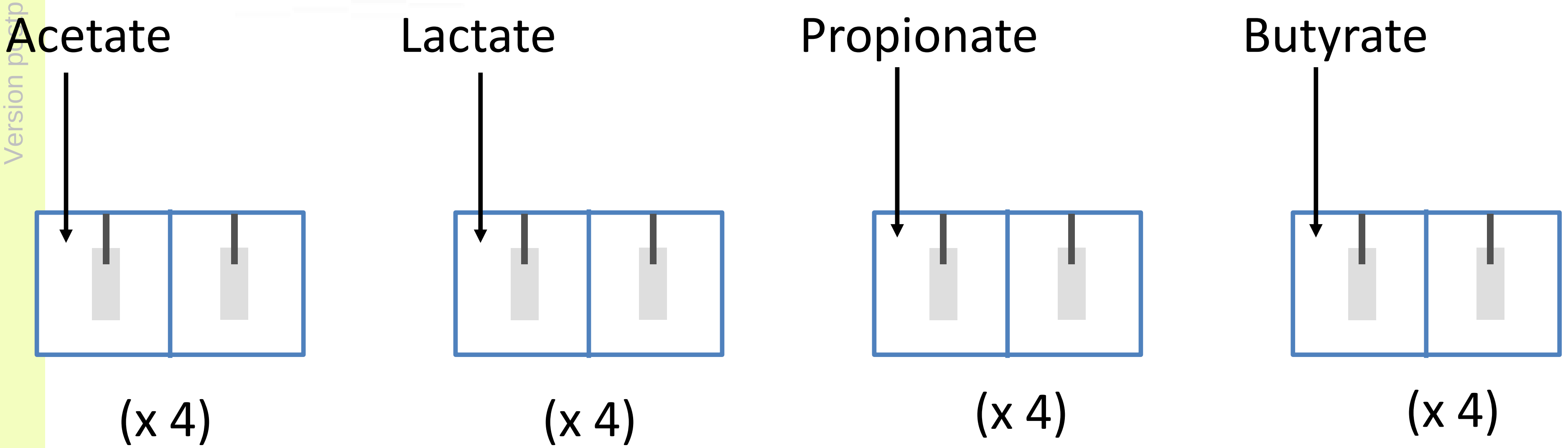
Performances and microbial community

C. Flayac, MSc



Material and methods

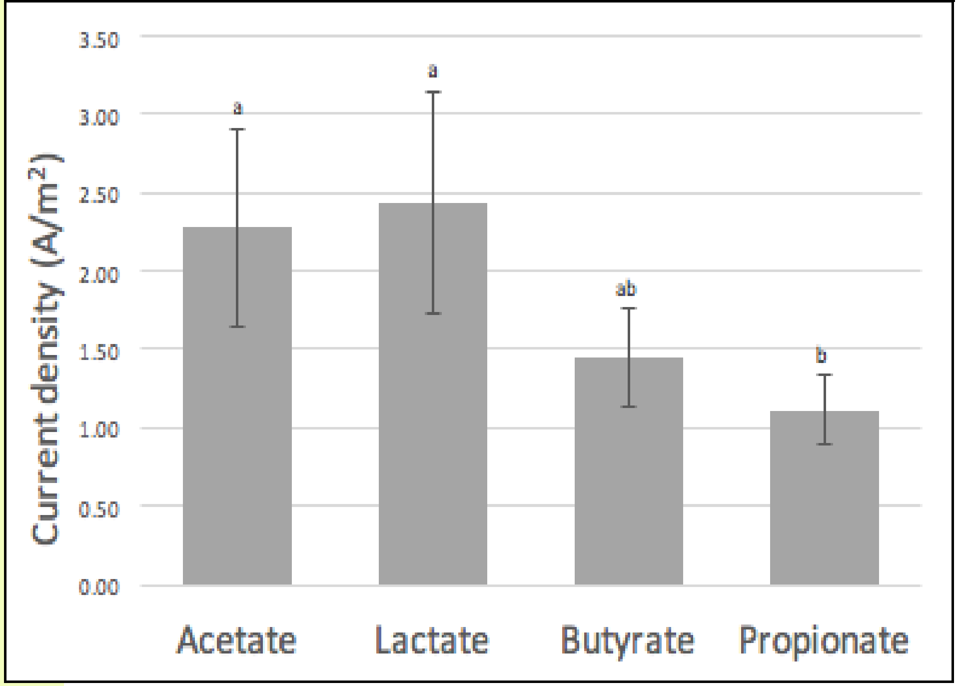
4 substrates with reactors in quadruplicates



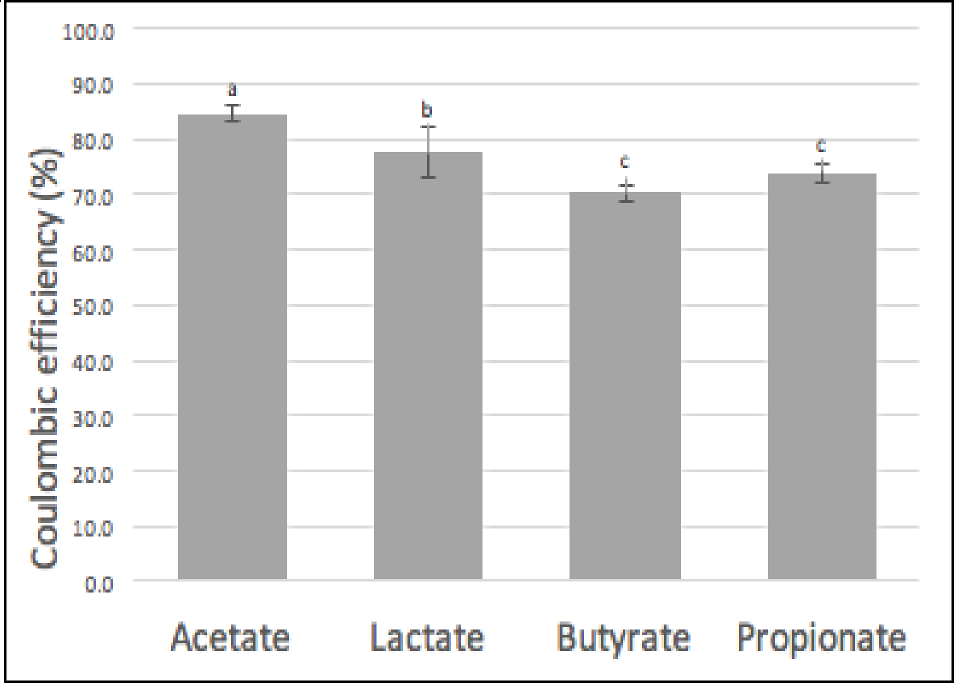
- Electrode: carbon plate
- Three-electrode setup with E_{anode} = +450 vs HNE
- pH=7
- Inoculum = Aerobic sludge
- [Metabolite]: 80 mM eq e-

Performances

Current densities (A/m²)

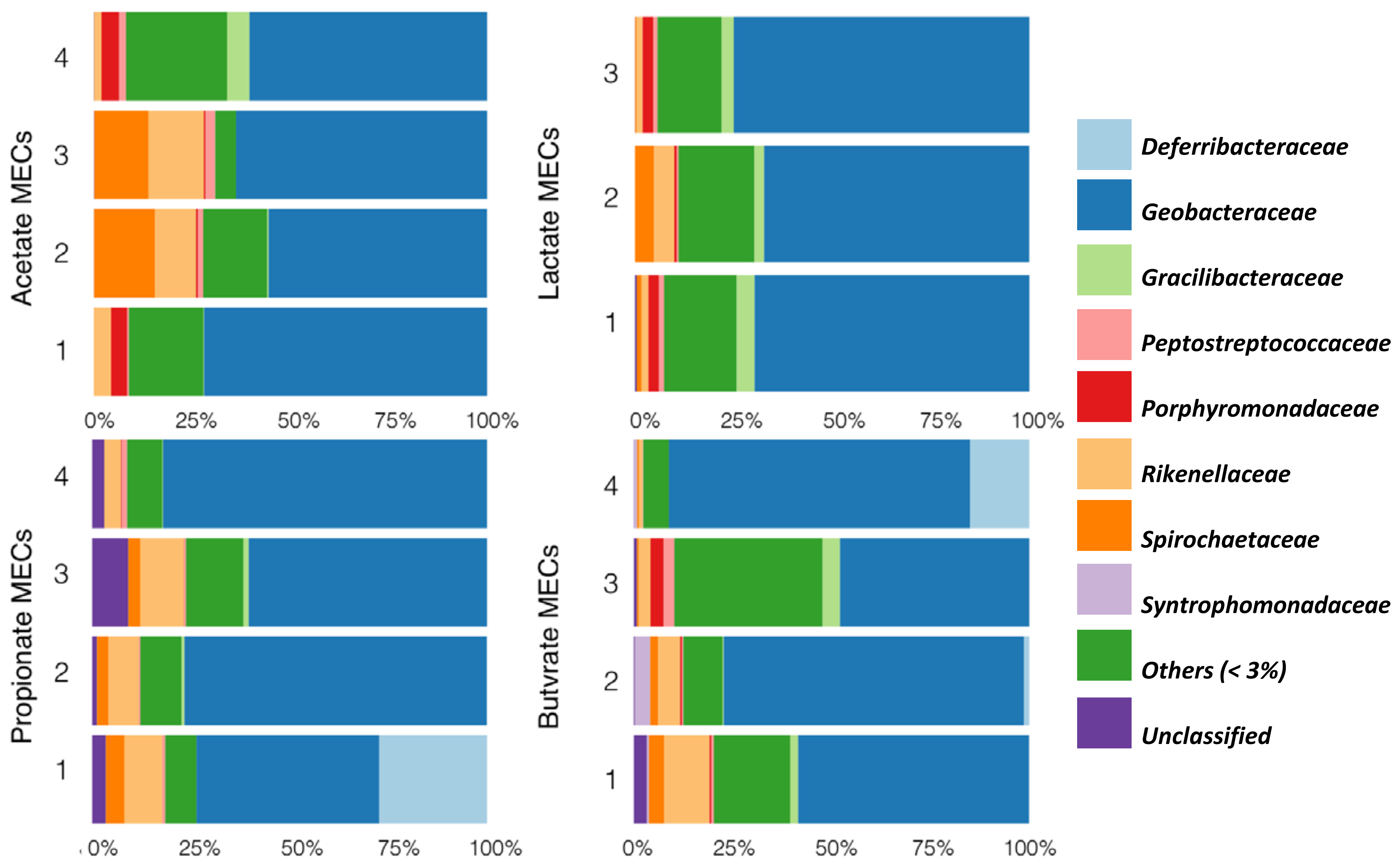


Coulombic efficiencies (%)



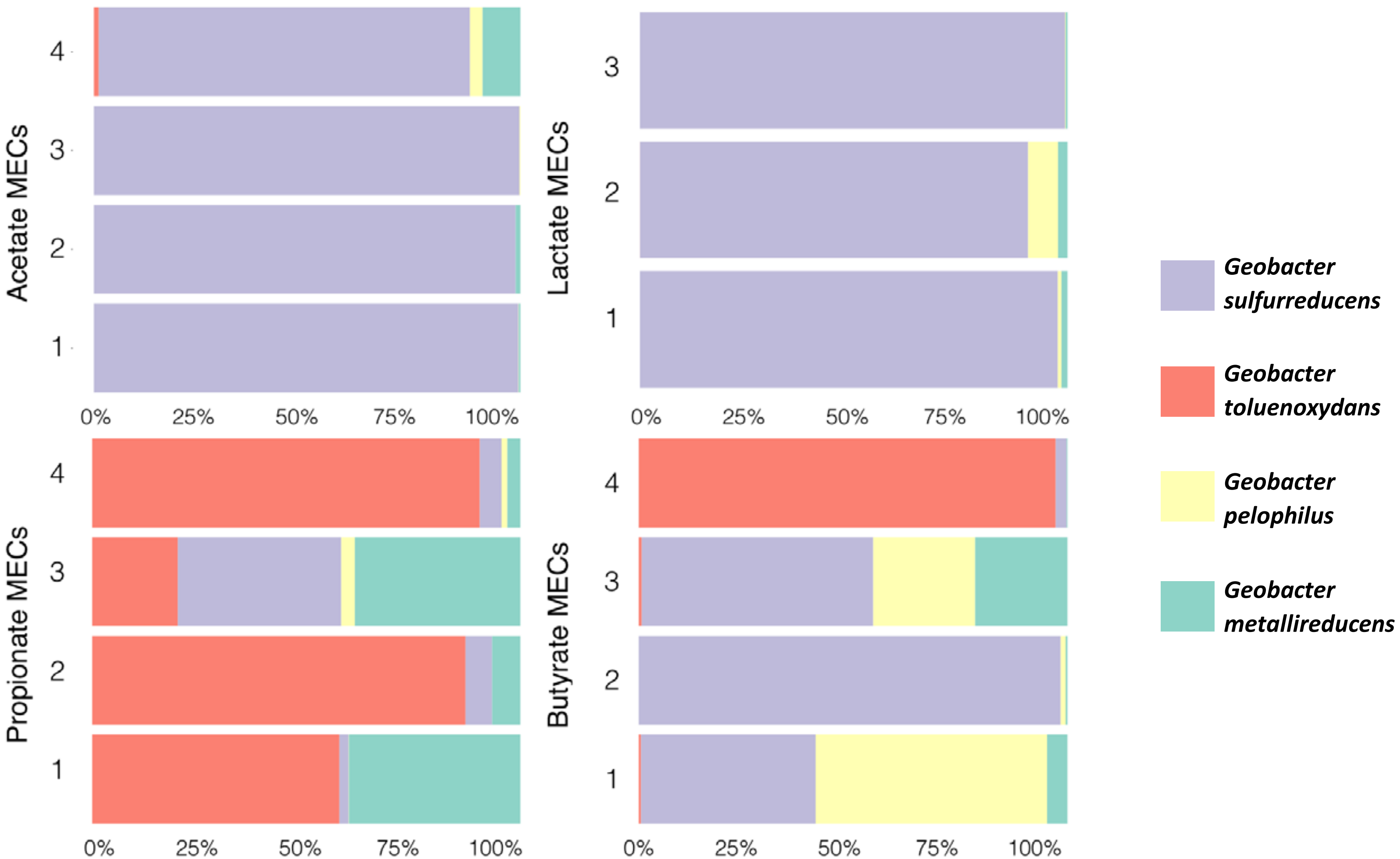
- **Lactate- and Acetate-MECs had best performances**

Microbial diversity in biofilms



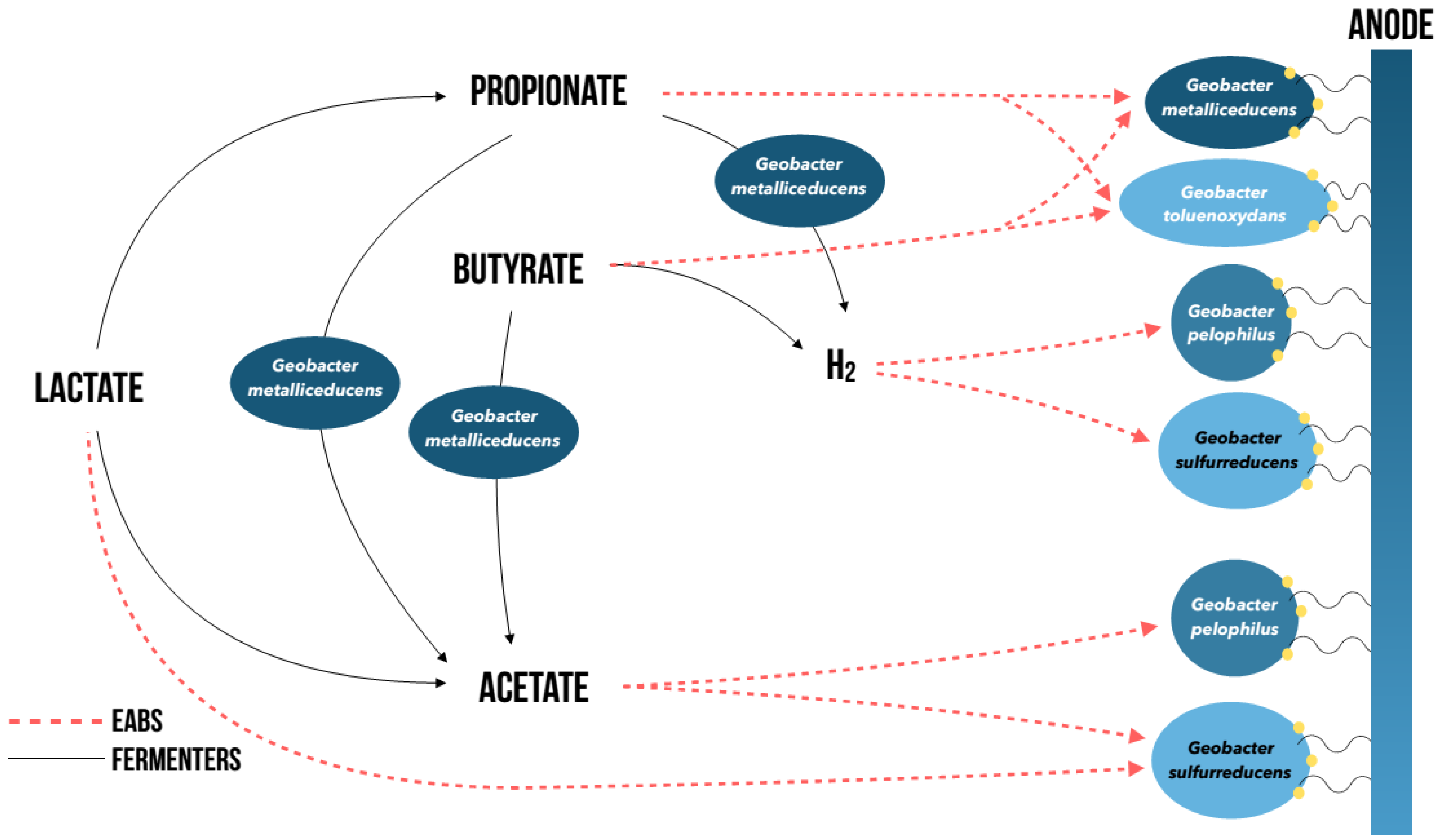
Dominance of the *Geobacteraceae* family

Diversity in the Geobacteraceae family



- **Acetate-MECs: *G.sulfurreducens***
- **Lactate-MECS: *G.sulfurreducens***
- **Propionate- & Butyrate-MECs: Species mix**

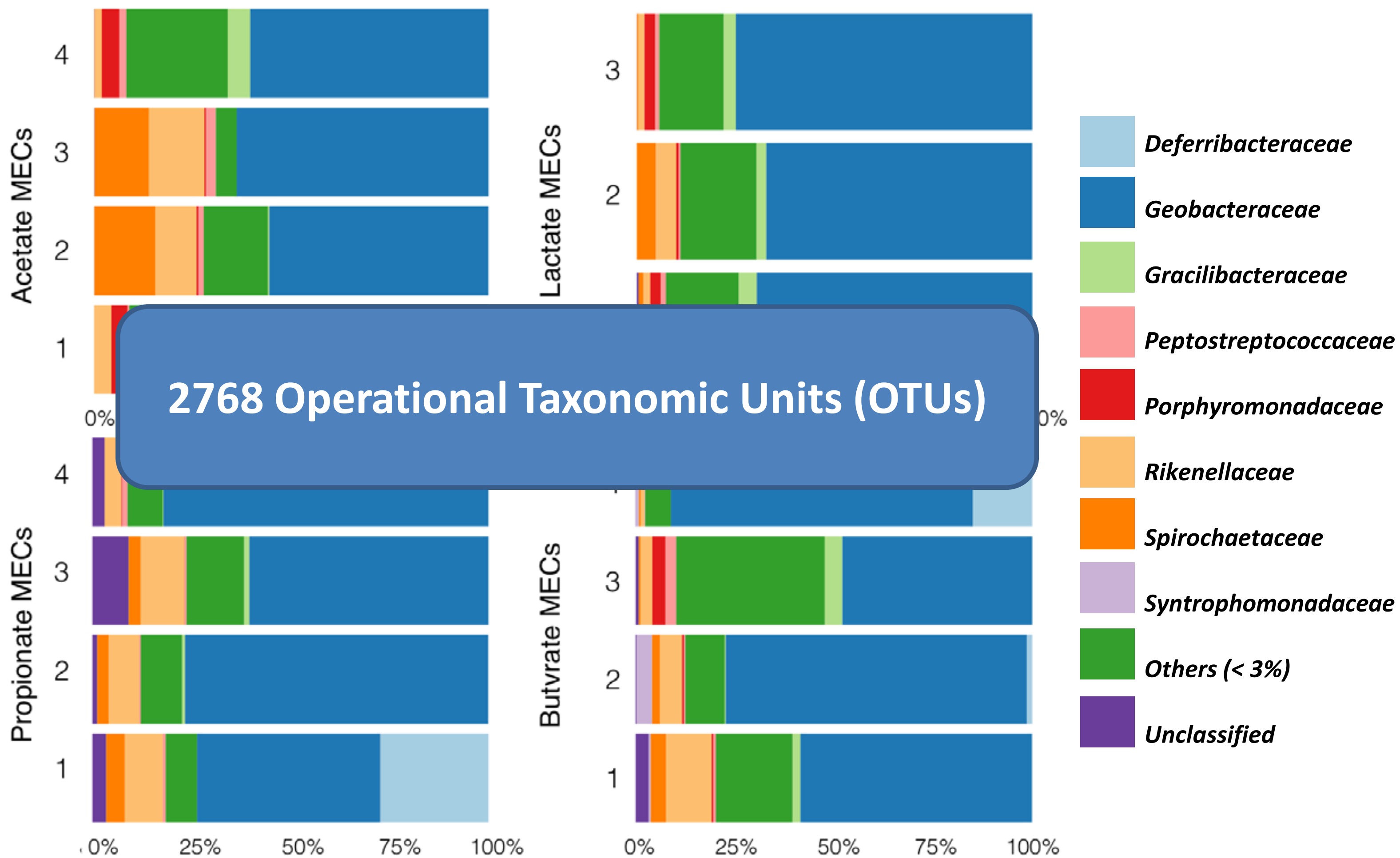
Possible pathways for organic acids oxidation



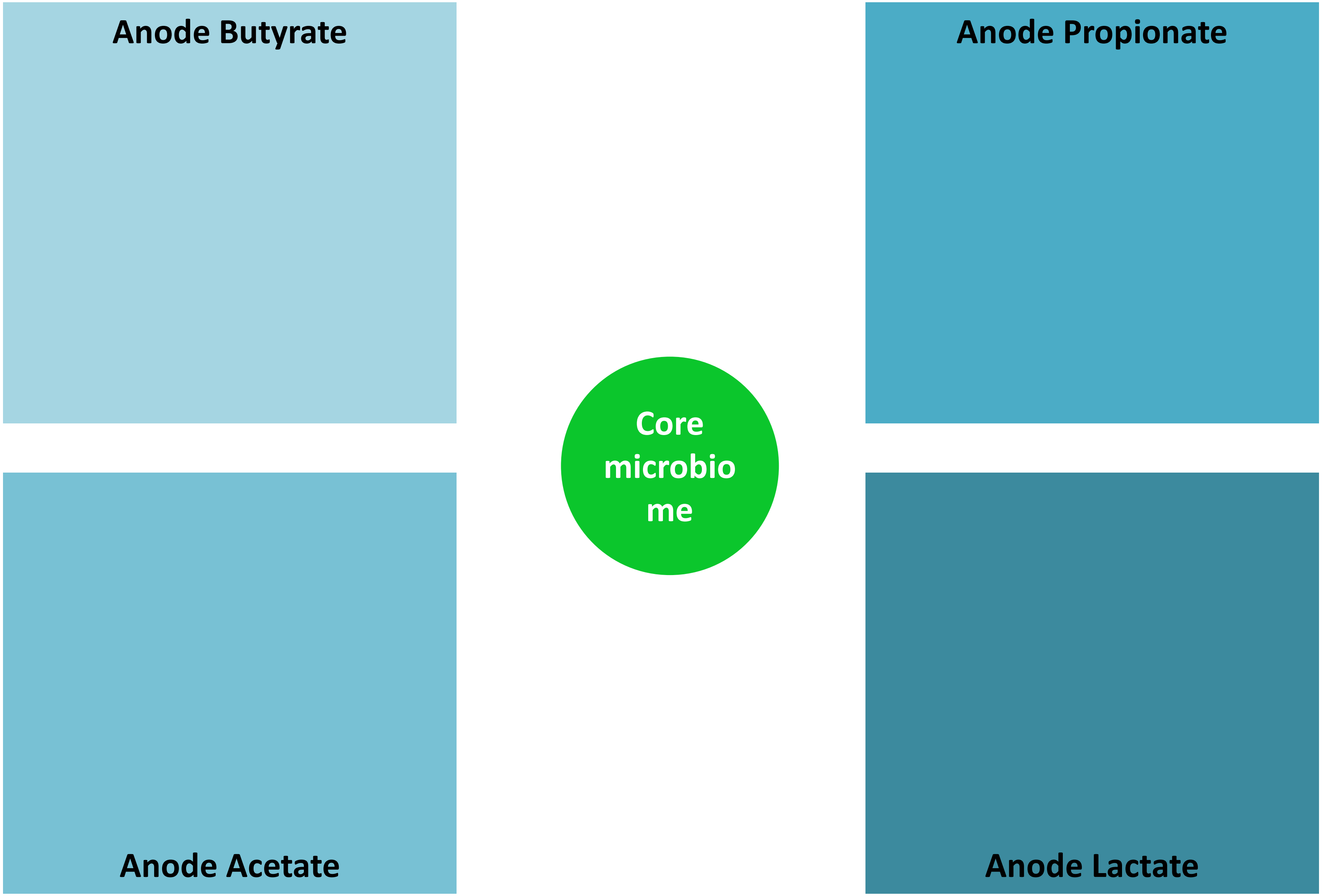
C. Flayac et al., Bioelectrochemistry 123 (2018) 219–226

Microbial diversity in biofilms

Interaction network beyond the Geobacteraceae family?

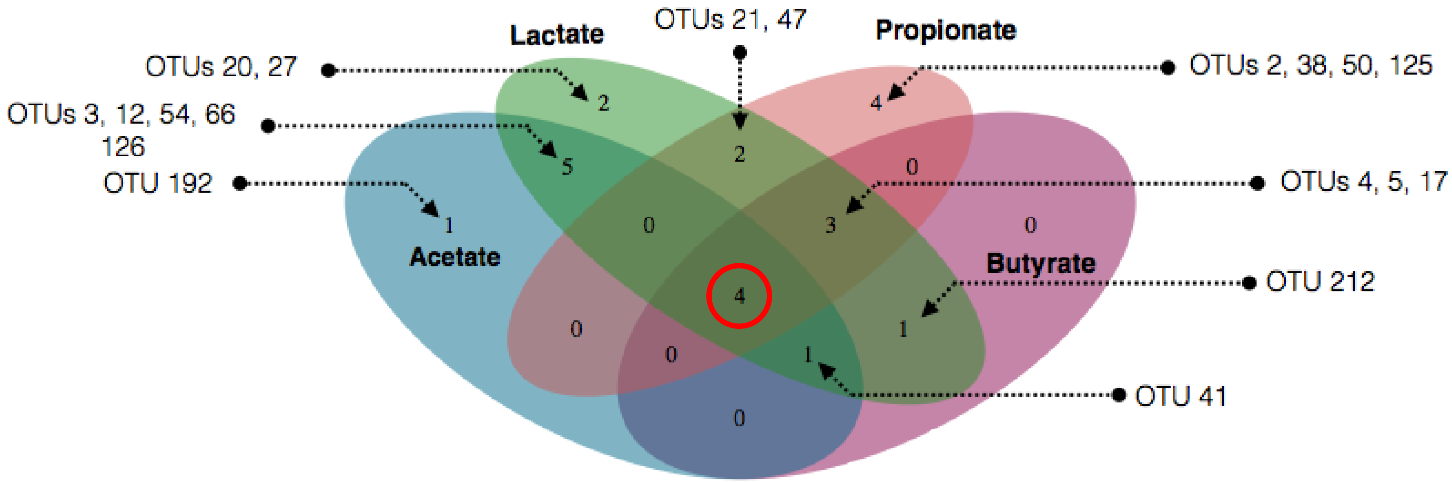


2768 Operational Taxonomic Units (OTUs)


Anode Butyrate
Anode Propionate
Core microbiome
Anode Acetate
Anode Lactate

Biofilm core-OTUs

Only 4 major OTUs are always found with all substrates

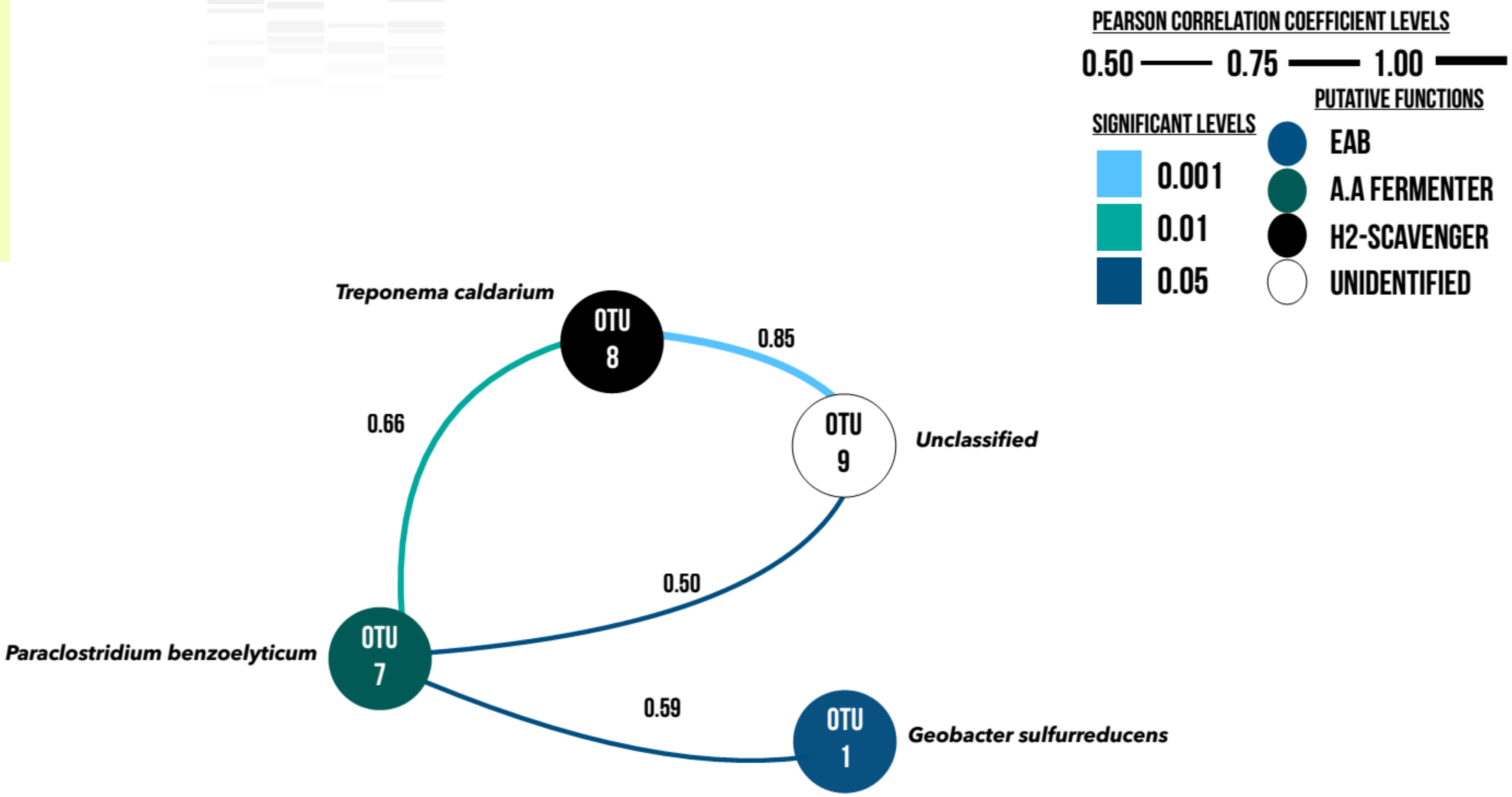


Biofilm core-OTUs

Possible functions

Taxa	OTU n° [%id]	Probable role	Substrat(s)	Product(s)	Ref.
Geobacter sulfurreducens	**1** [100]	Anode respiration	Acetate, Formate, Lactate, H_2	e^-, H_2 ?, CO_2	(Bond and Lovley, 2003)
Paraclostridium benzoelyticum	**7** [100]	Fermentation	Amino acids	H_2, CO_2	(Sasi Jyothsna et al., 2016)
Treponema caldarium	**8** [99]	Fermentation H_2-scavenger?	Glucose H_2, CO_2 ?	H_2, CO_2, Acetate, Lactate	(Pohlschroeder et al., 1994)
unclassified Rikenellaceae	**9**	?	?	?	-

OTUs correlation network

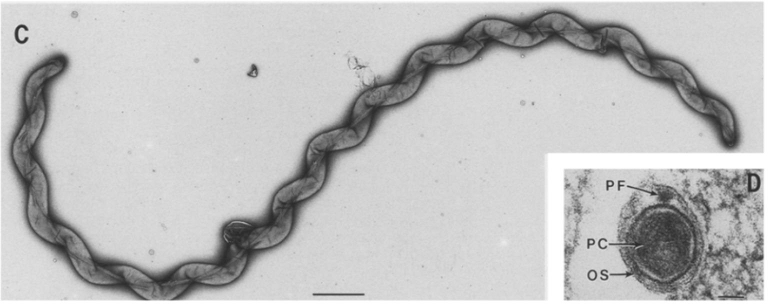


Correlations with performances

Performances indices	OTU 1	OTU 7	OTU 8	OTU 9
Current density ($A.m^{-2}$)	-.32	-.74**	-.95***	-.79***
Coulombic efficiency (%)	.67**	.57*	.49	.19

Abundances of OTUs 8 (*Treponema caldarium)* and 9 (unclassified Rikenellaceae) are anti-correlated with current densities

- Slow oxidation mechanisms ?
- Mechanical disturbance of the biofilm ?
- Interactions ?

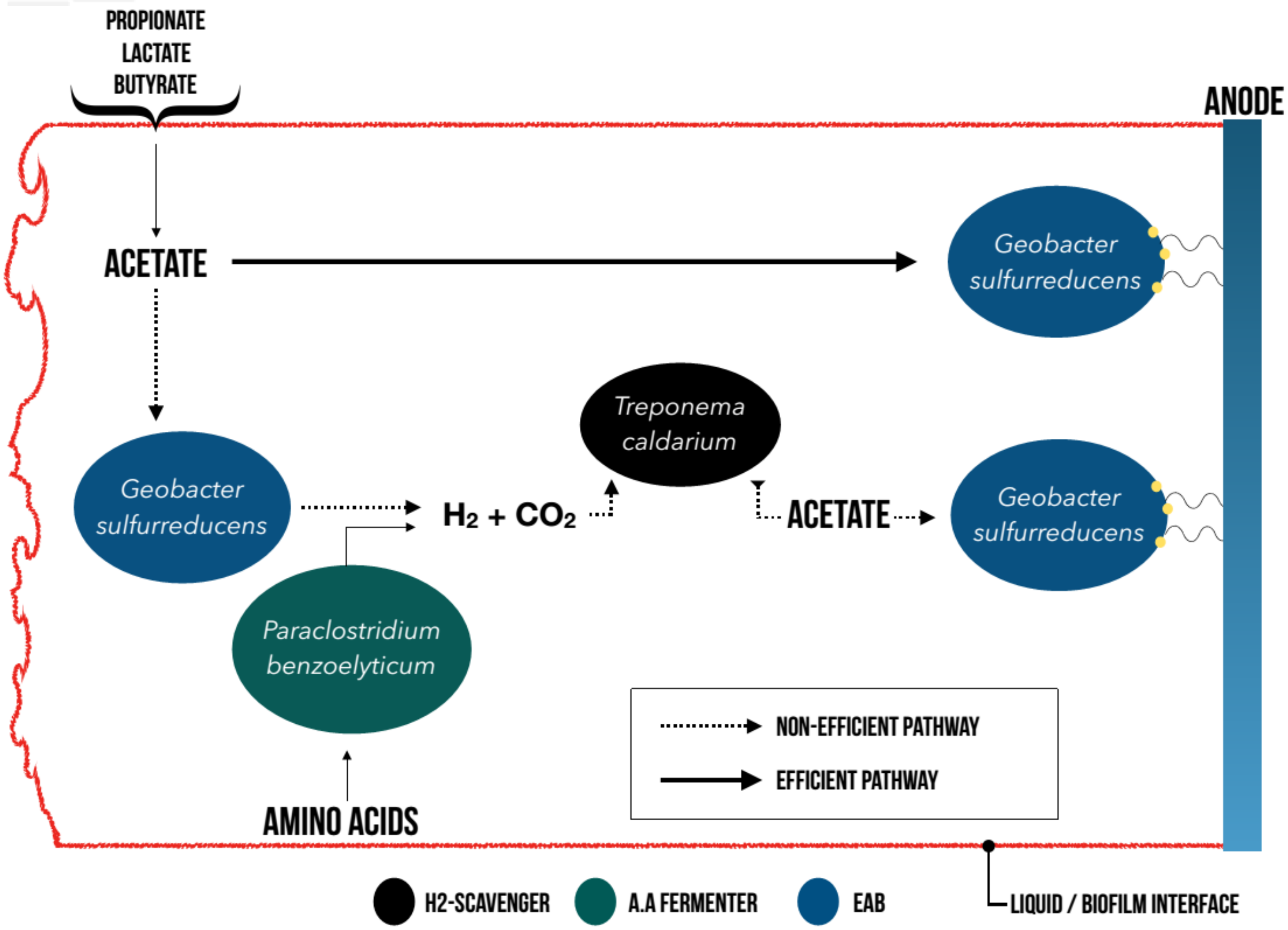


Treponema caldarium

Pohlschroeder et al., Arch Microbiol (1994) 161:17-2

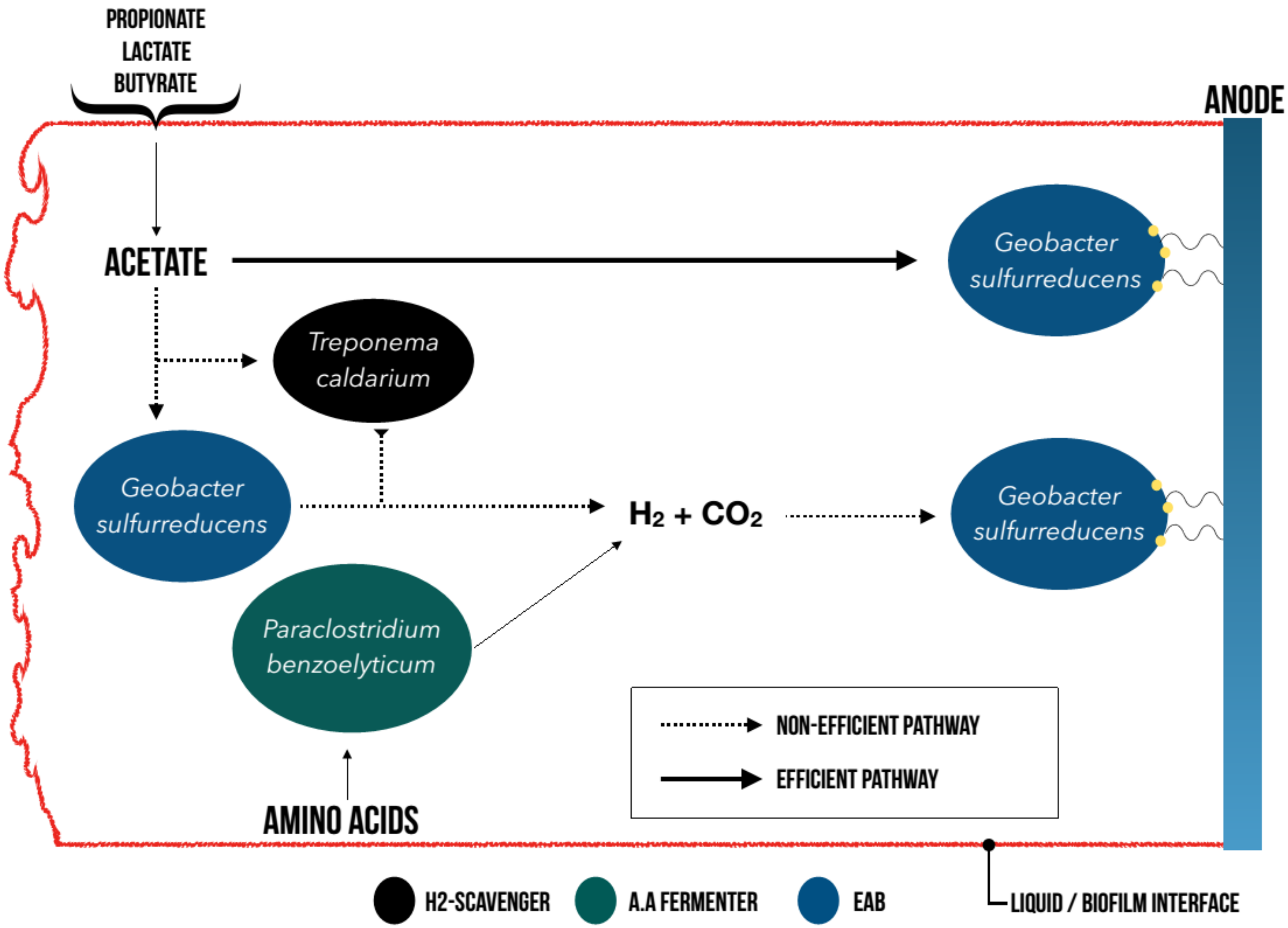
Putative biofilm pathways

Hydrogenotrophic acetogenesis by Spirochaetes?



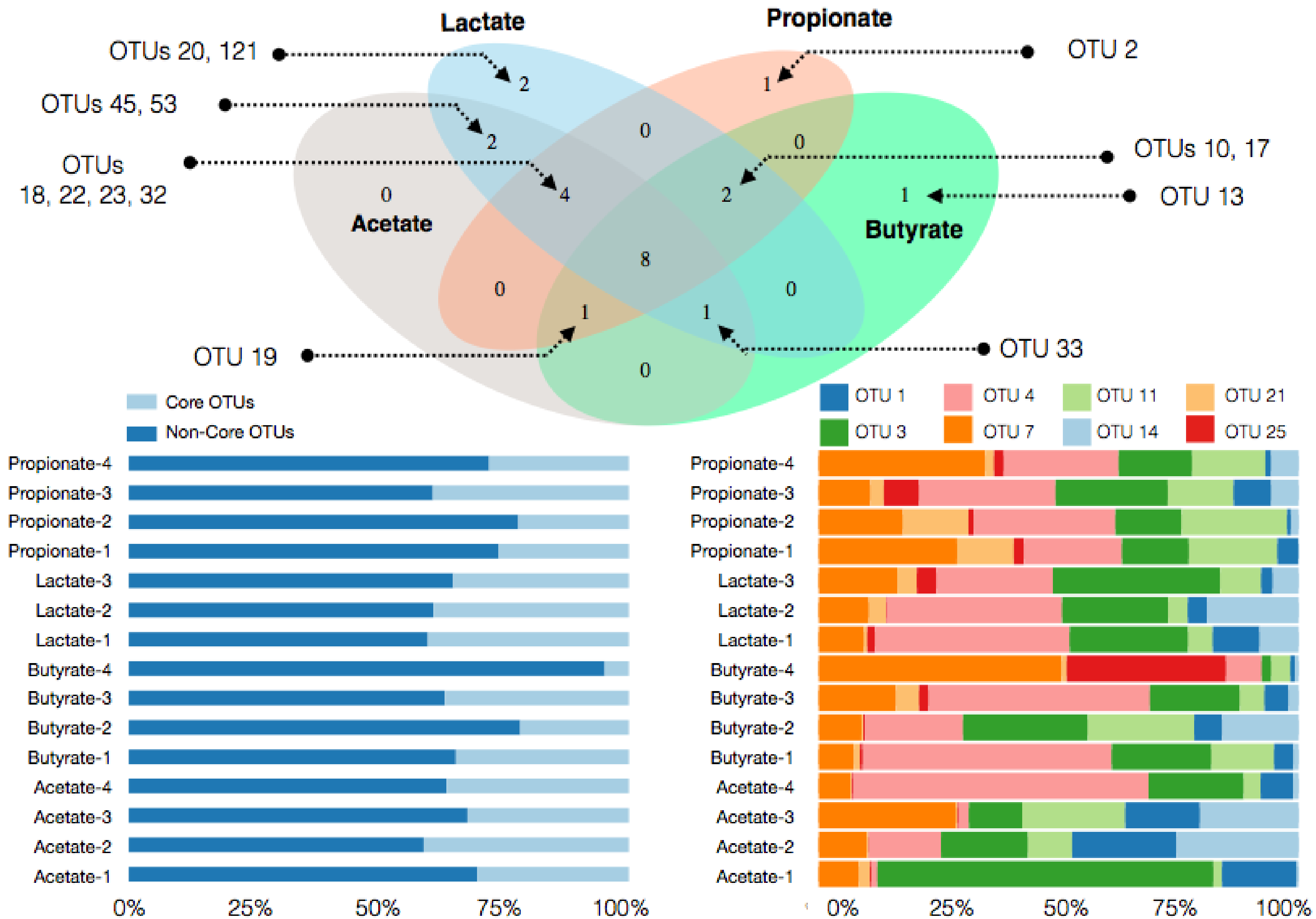
Putative biofilm pathways

Acetate oxidation by Spirochaetes?

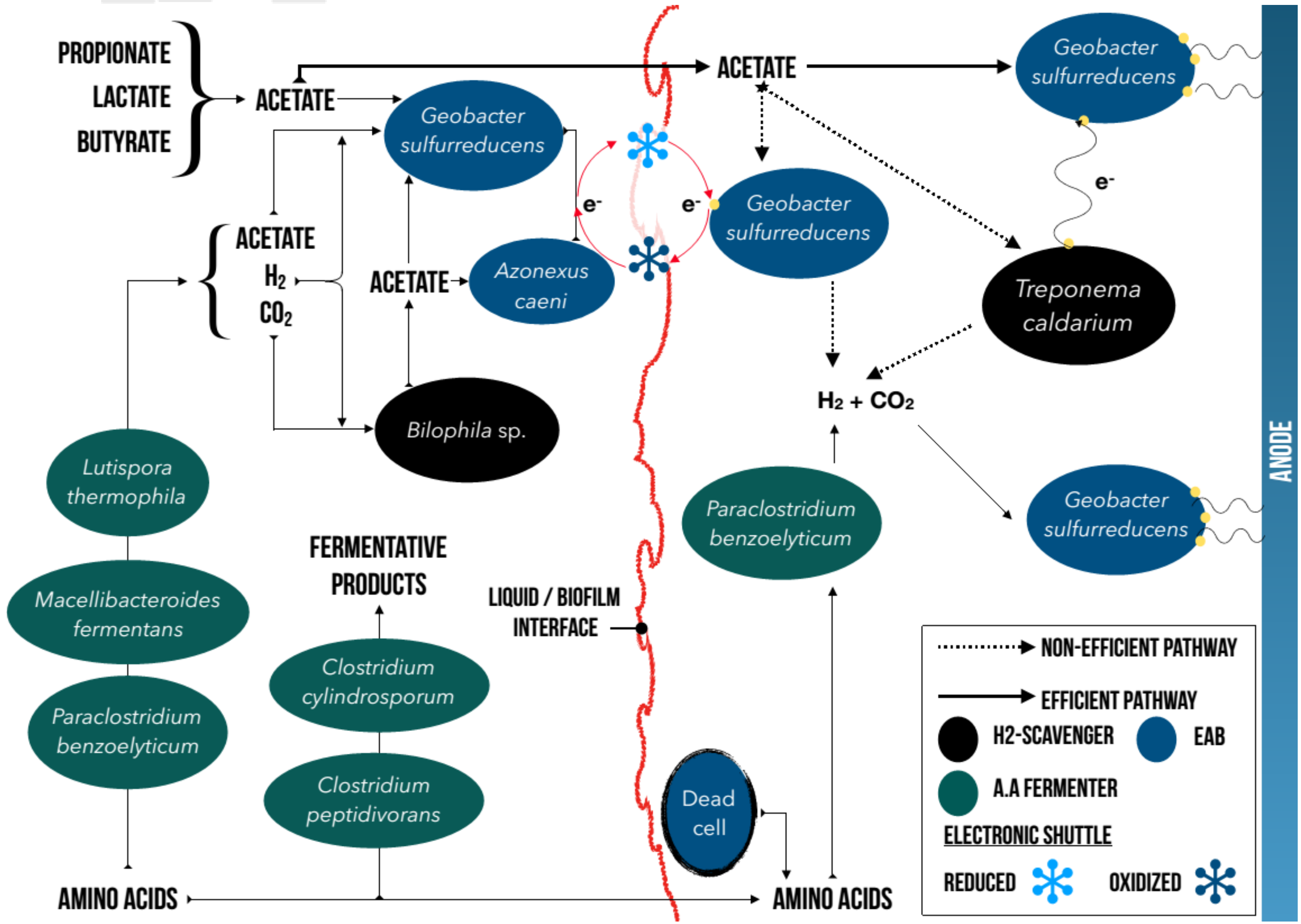


S.-H. Lee et al. (2018) « Evidence of syntrophic acetate oxidation by Spirochaetes during anaerobic methane production ». Bioresource Technology 190 (2015) 543–549

Planktonic core-OTUs



Putative pathways for bulk and biofilm



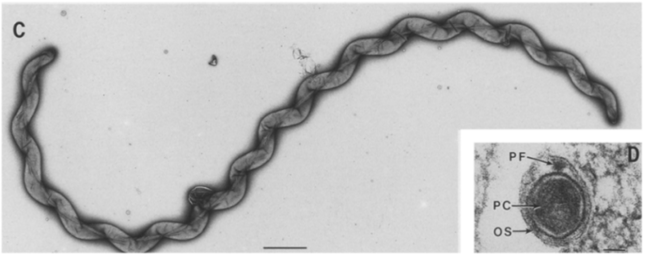
Conclusions/perspectives

- **Statistics with replicated experiments are a power full tool** for exploring microbial diversity in bioprocesses

- **Core OTUs found in bioanodes** fed with various organic acids were: **electroactive bacteria**, **H_2 scavengers**, **acetate oxidizers** and **AA fermenters**

- **Spirochaetes may be a bioindicator of a loss of biofilm electroactivity**
  - Metabolism?
  - Mechanical disturbance of the biofilm?

- Perspective: in depth study of interactions between electroactive bacteria and other bacteria



Treponema caldarium

Pohlschroeder et al., Arch Microbiol (1994) 161:17-2

Thank you for your attention!