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

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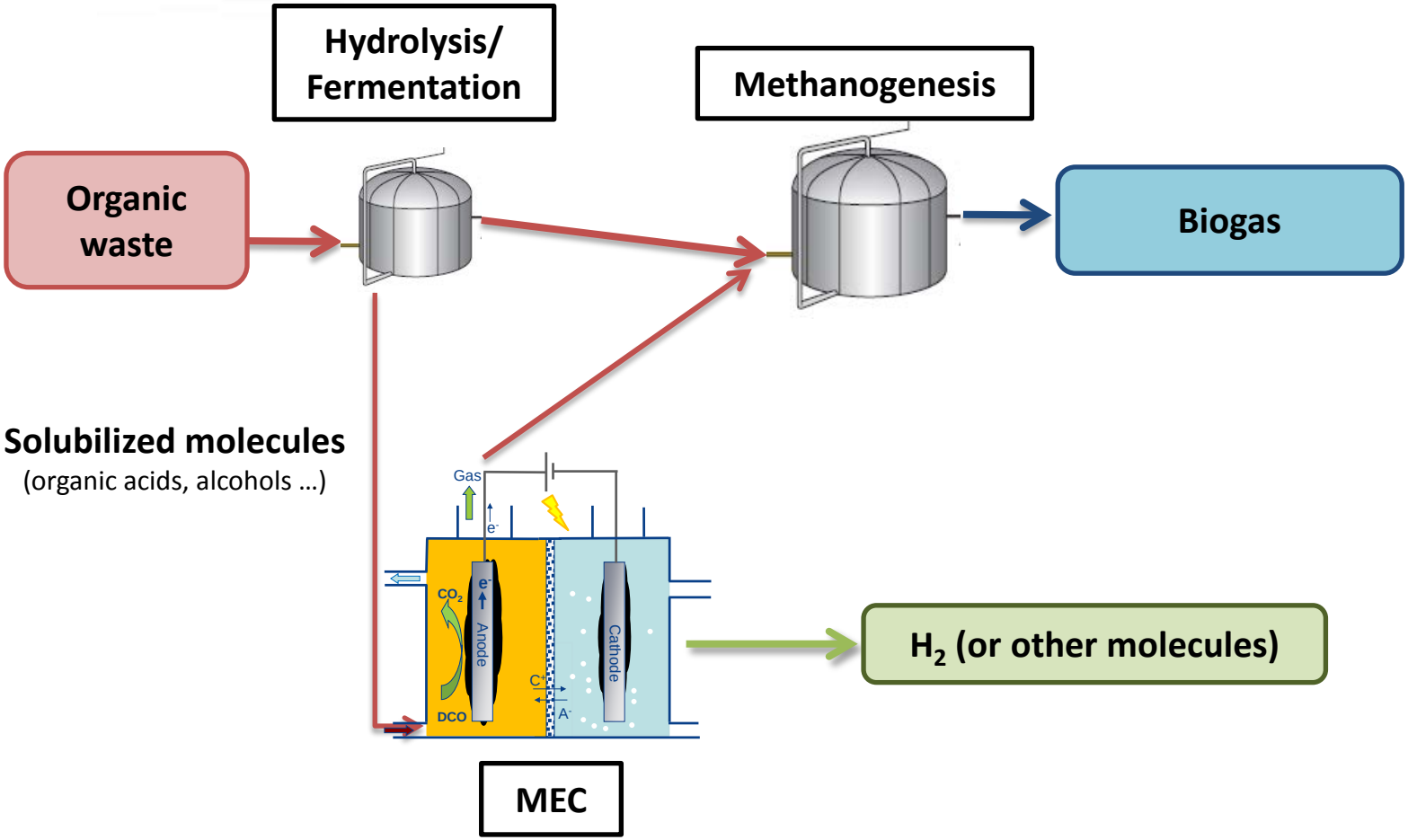
Version postprint

Context: BES for waste treatment?

Feeding MEC with organic acids



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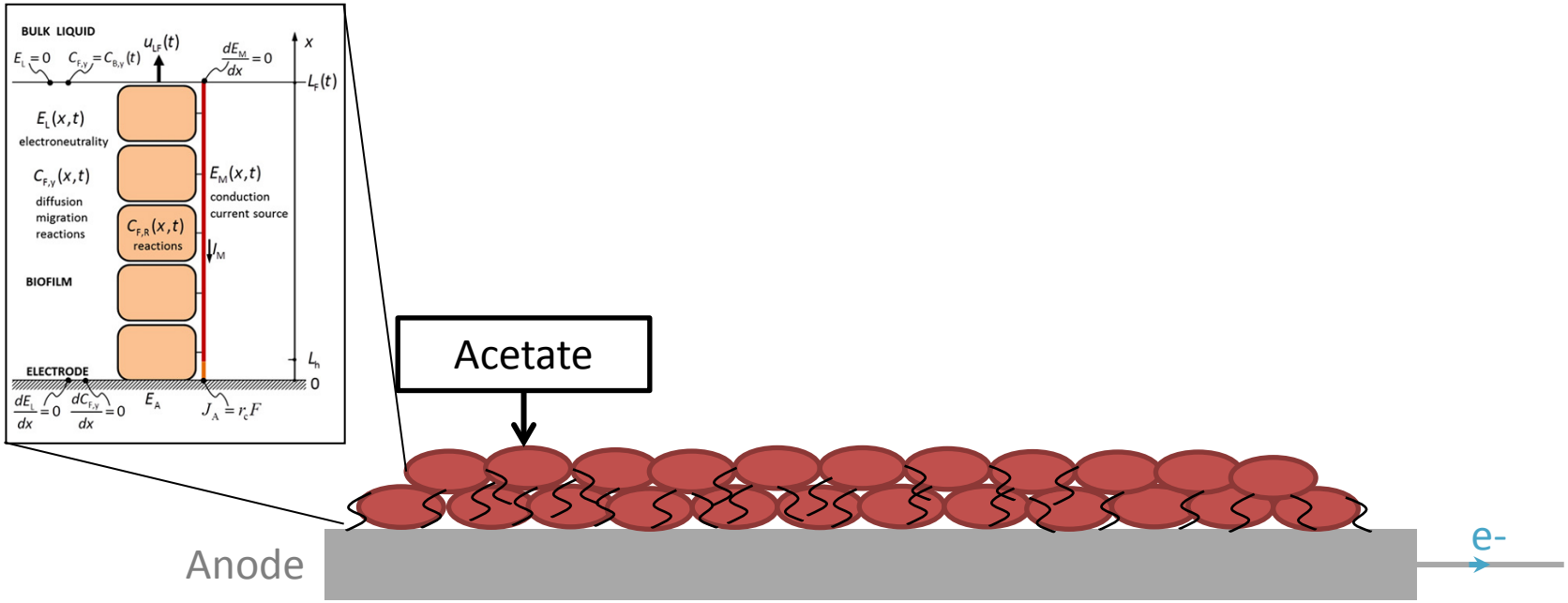
Context: behavior of a BES fed with various organic acids?

Geobacter biofilms fed with acetate

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



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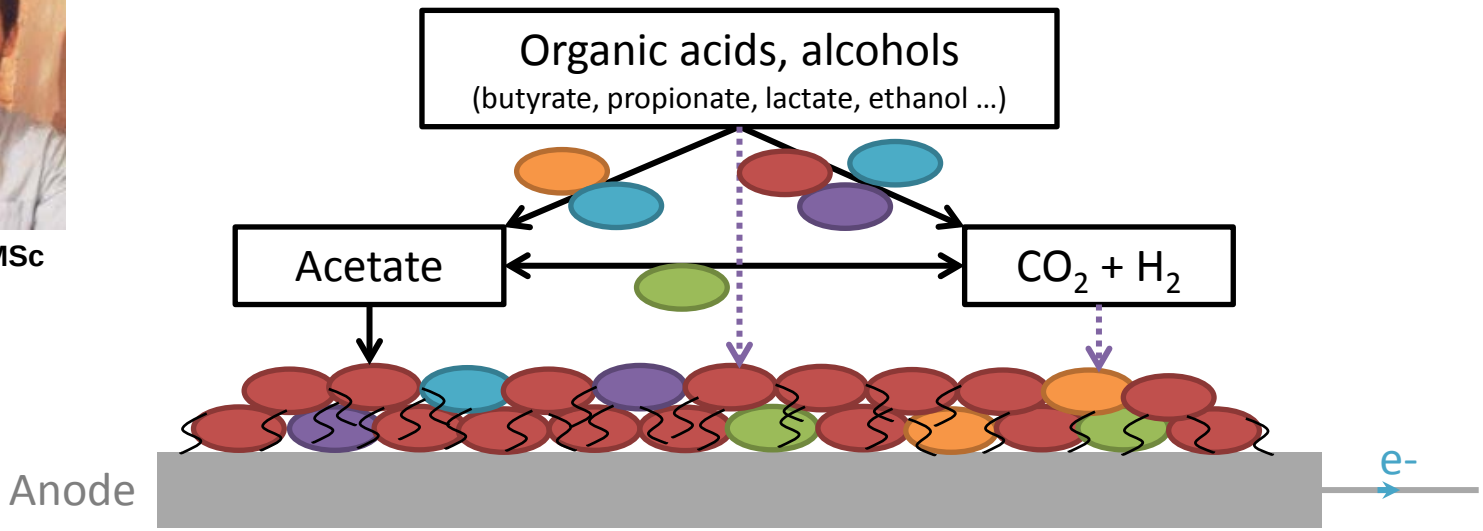
Context: behavior of a BES fed with various organic acids?

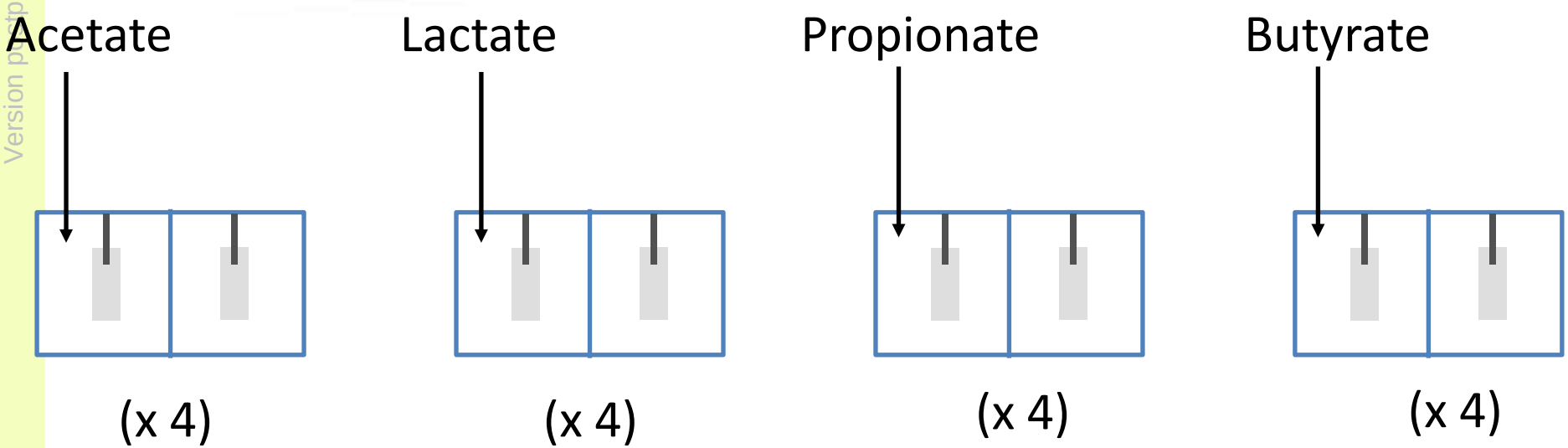
Performances and microbial community

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-

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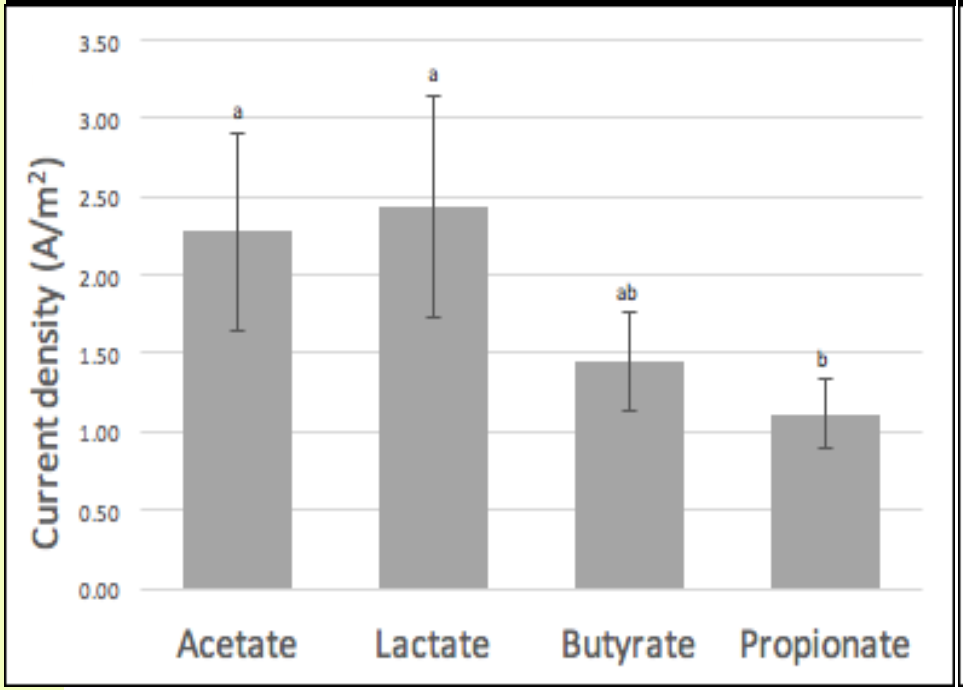
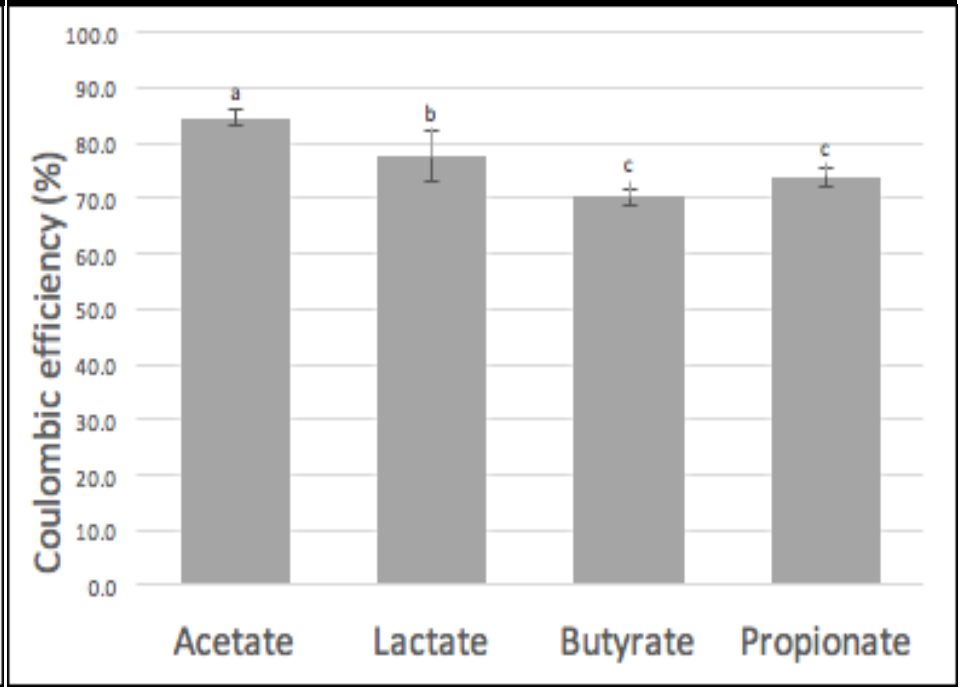
Performances

Current densities (A/m²)



Coulombic efficiencies (%)



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

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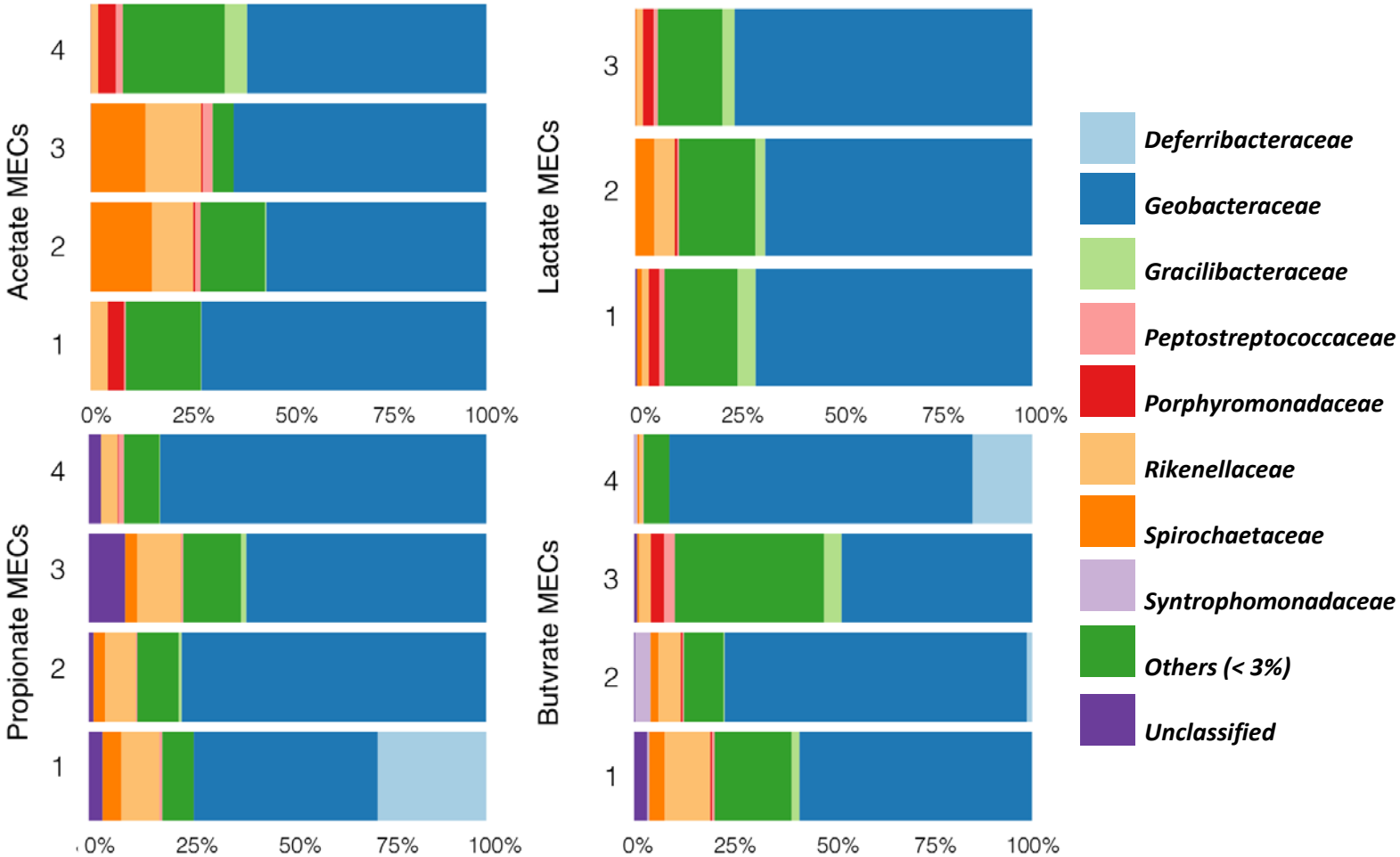
Microbial diversity in biofilms



Dominance of the *Geobacteraceae* family

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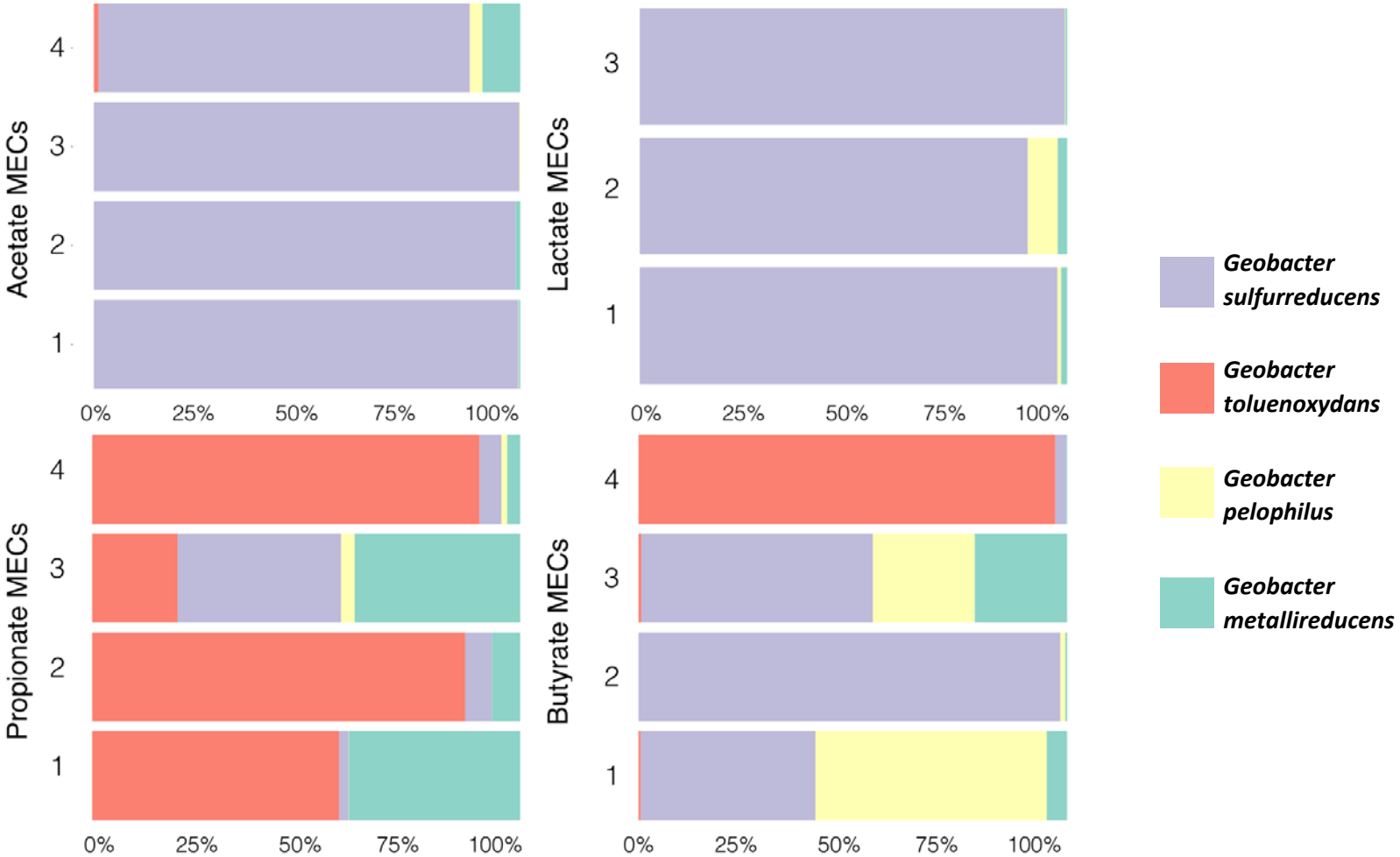
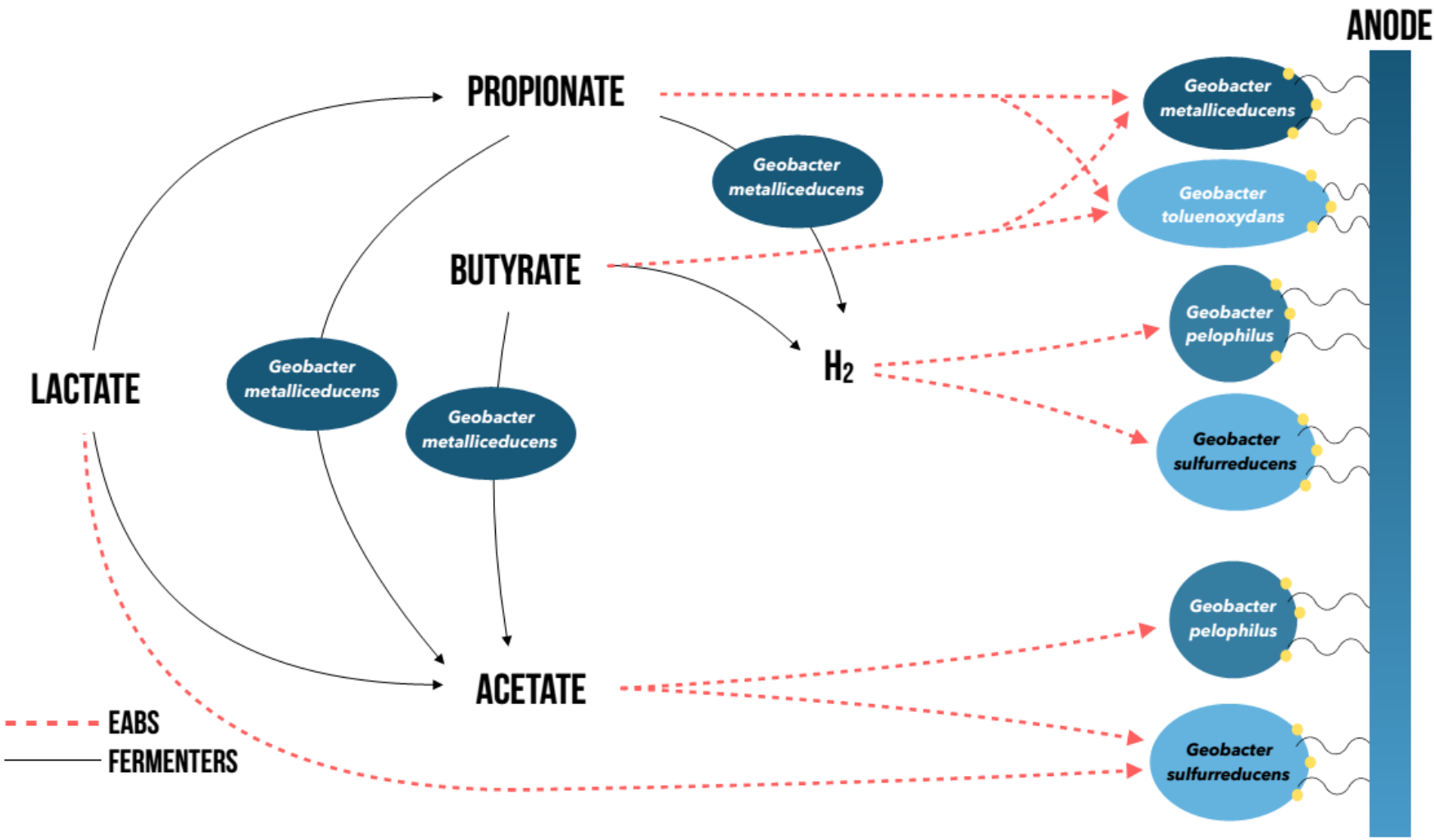
Diversity in the Geobacteraceae family



- **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

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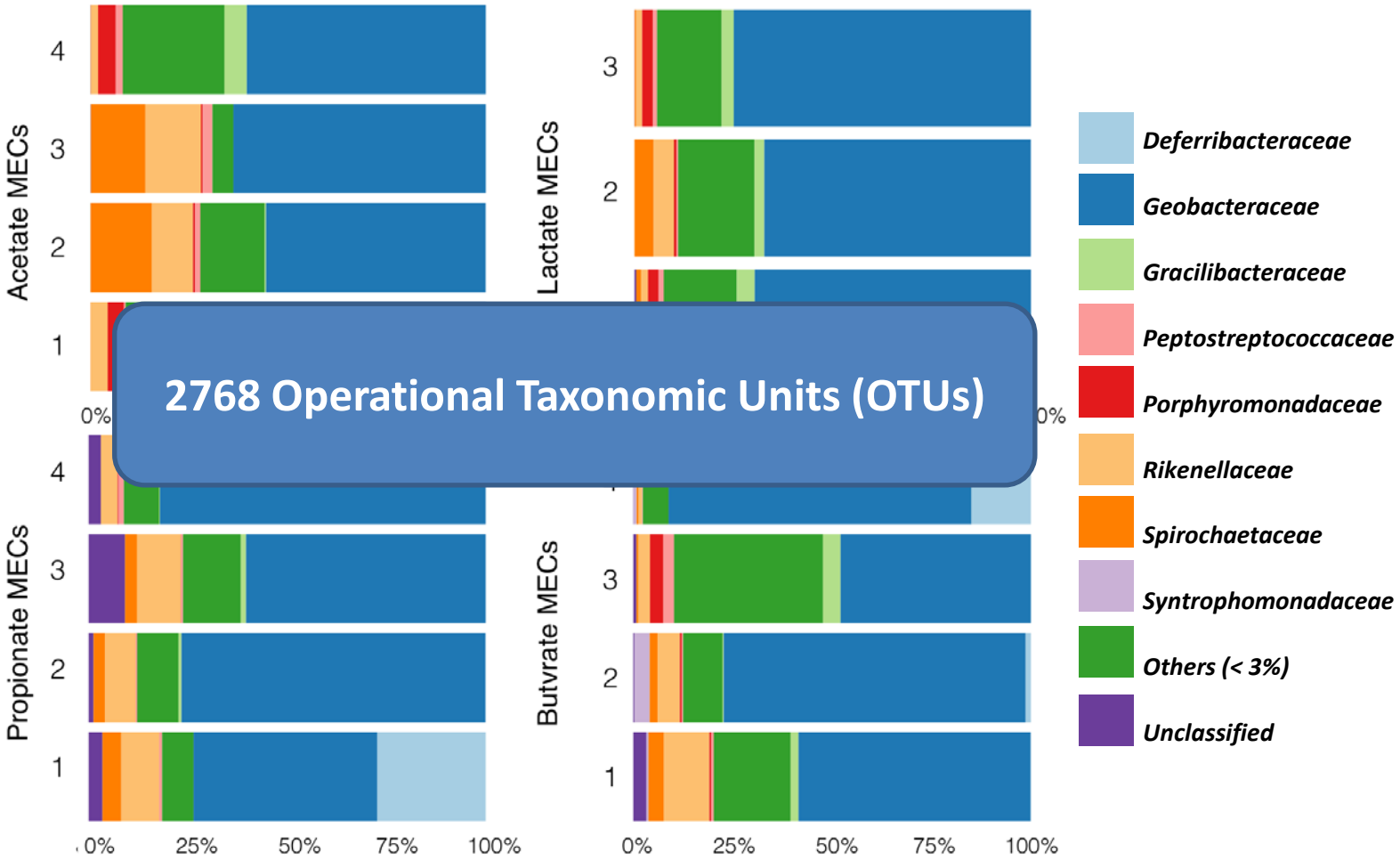
Microbial diversity in biofilms

Interaction network beyond the Geobacteraceae family?



2768 Operational Taxonomic Units (OTUs)

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Anode Butyrate

Anode Propionate

Core microbiome

Anode Acetate

Anode Lactate

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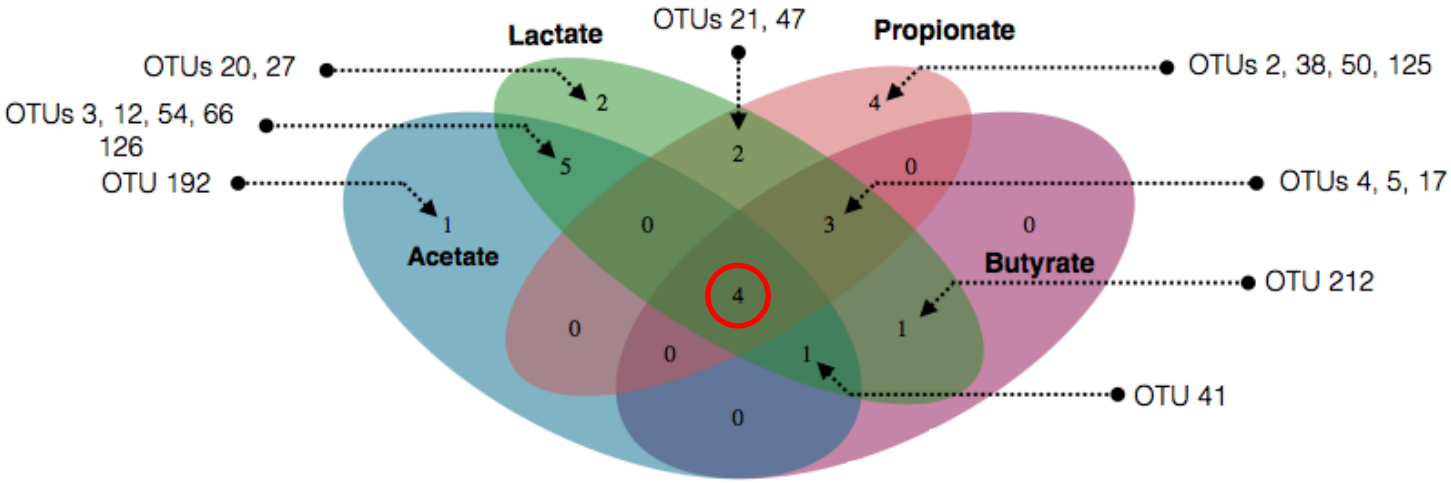
Biofilm core-OTUs

Only 4 major OTUs are always found with all substrates



Biofilm core-OTUs

Possible functions

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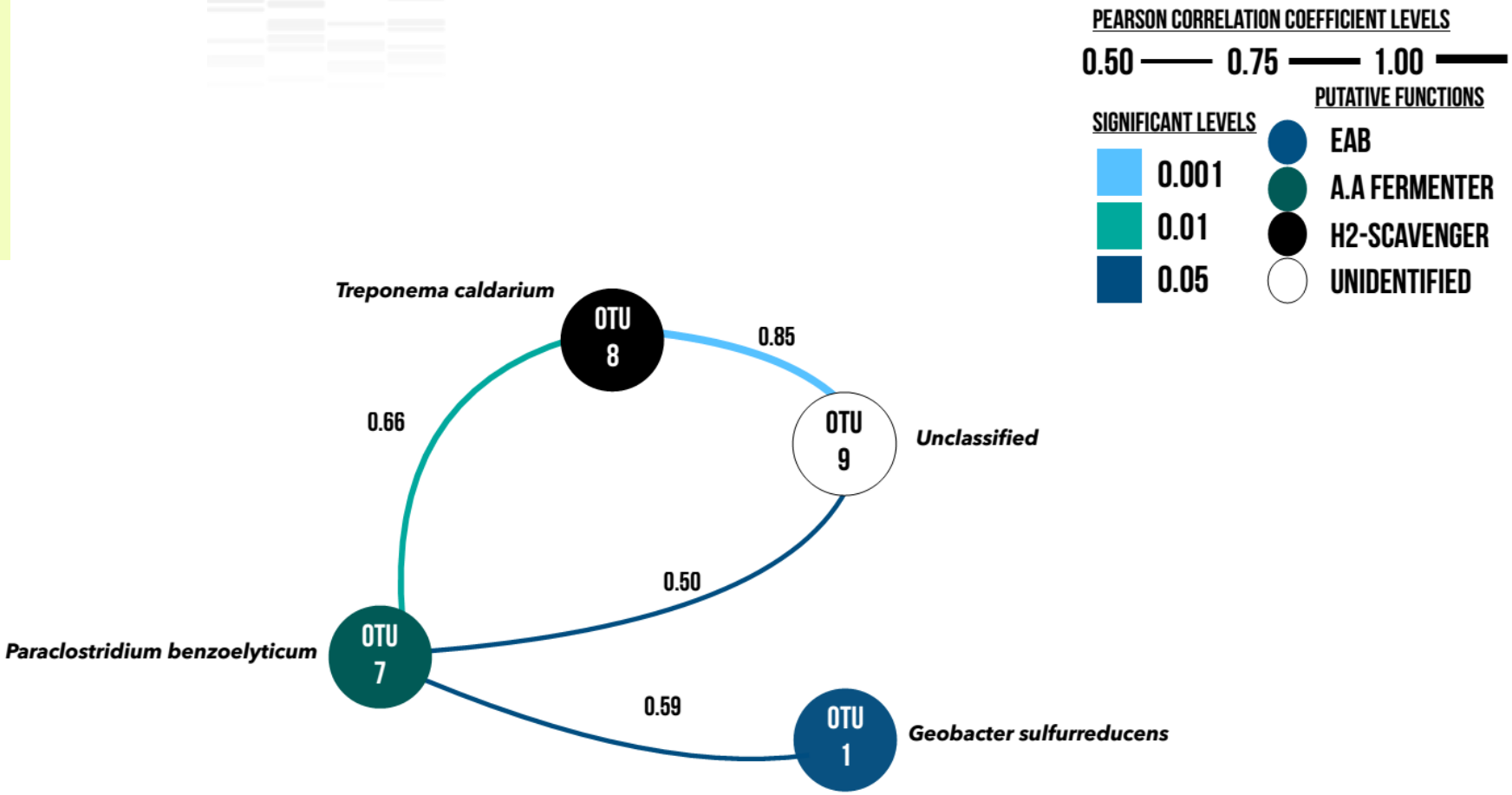
Taxa	OTU n° [%id]	Probable role	Substrat(s)	Product(s)	Ref.
Geobacter sulfurreducens	**1** [100]	Anode respiration	Acetate, Formate, Lactate, H_2	e^-, H_2 ?, CO_2	(Bond and Lovley, 2003)
Paraclostridium benzoelyticum	**7** [100]	Fermentation	Amino acids	H_2, CO_2	(Sasi Jyothsna et al., 2016)
Treponema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



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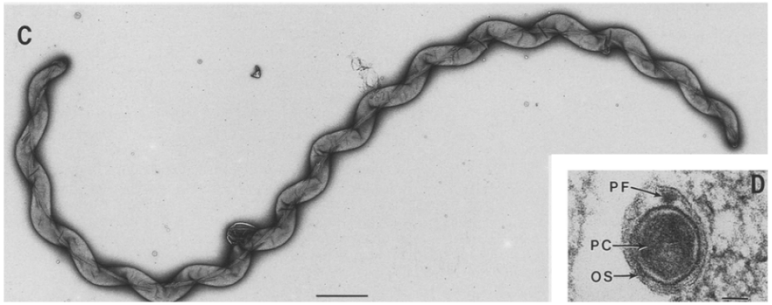
Correlations with performances

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 ?



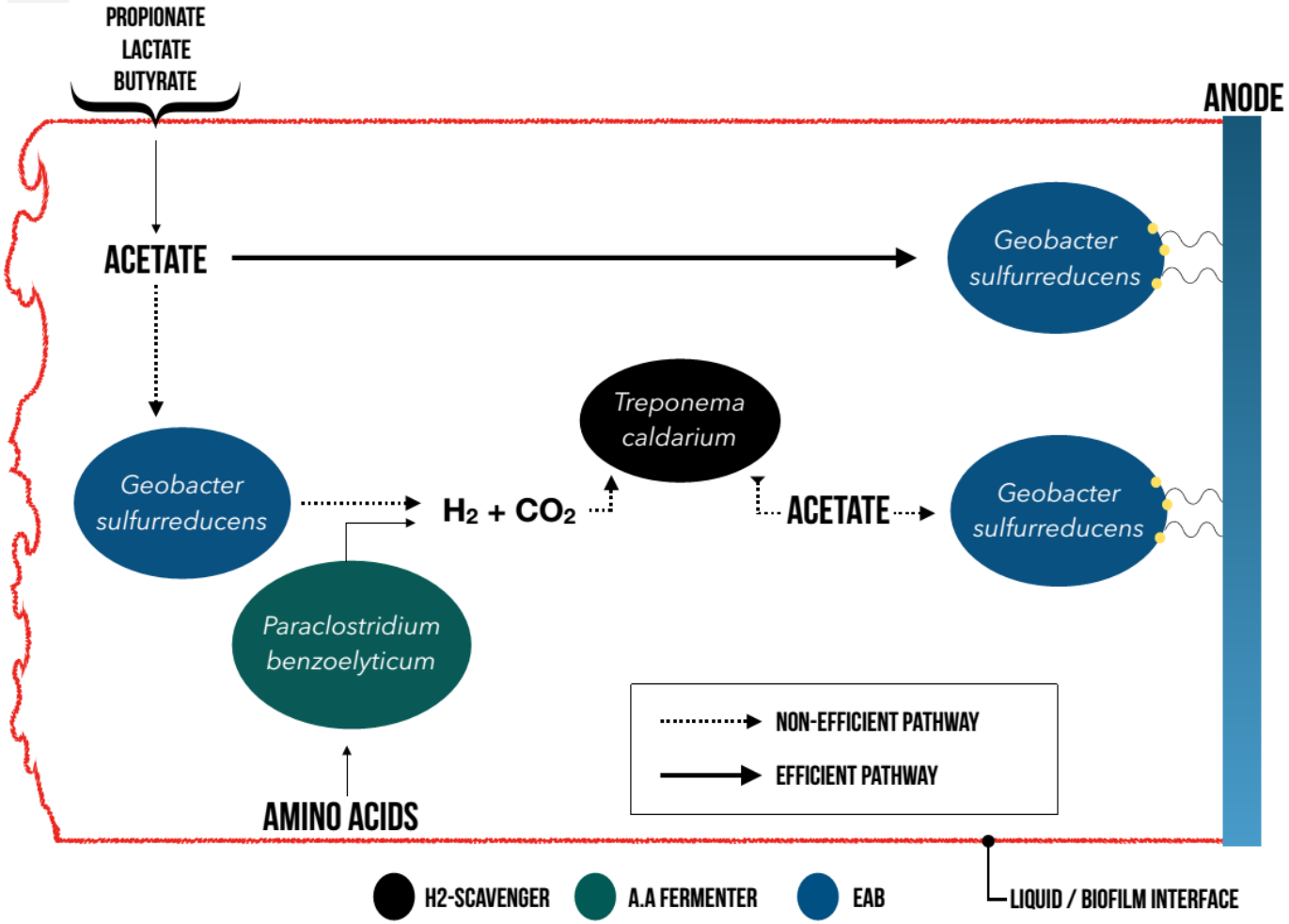
Treponema caldarium

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

Version postprint

Putative biofilm pathways

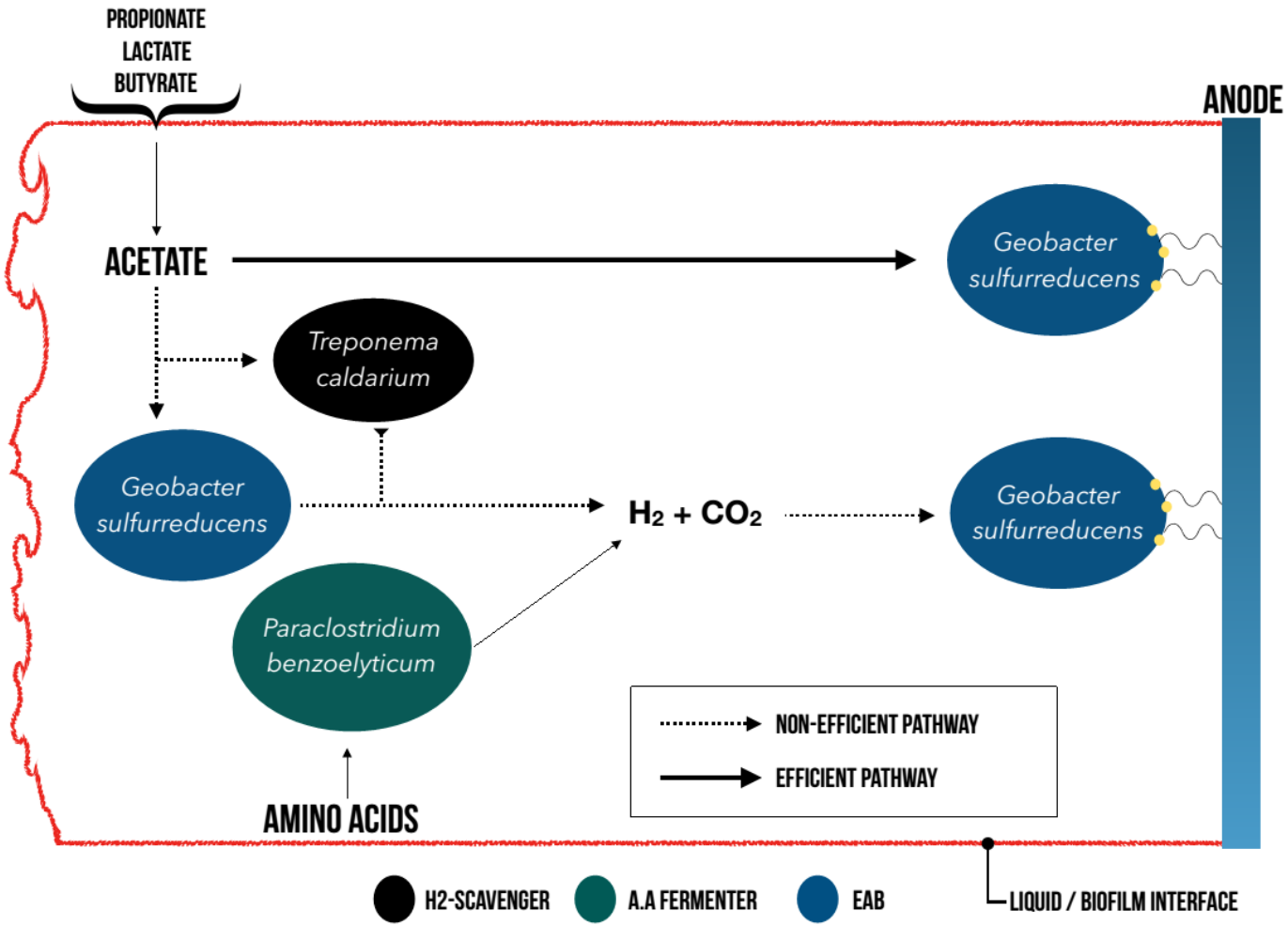
Hydrogenotrophic acetogenesis by Spirochaetes?



Version postprint

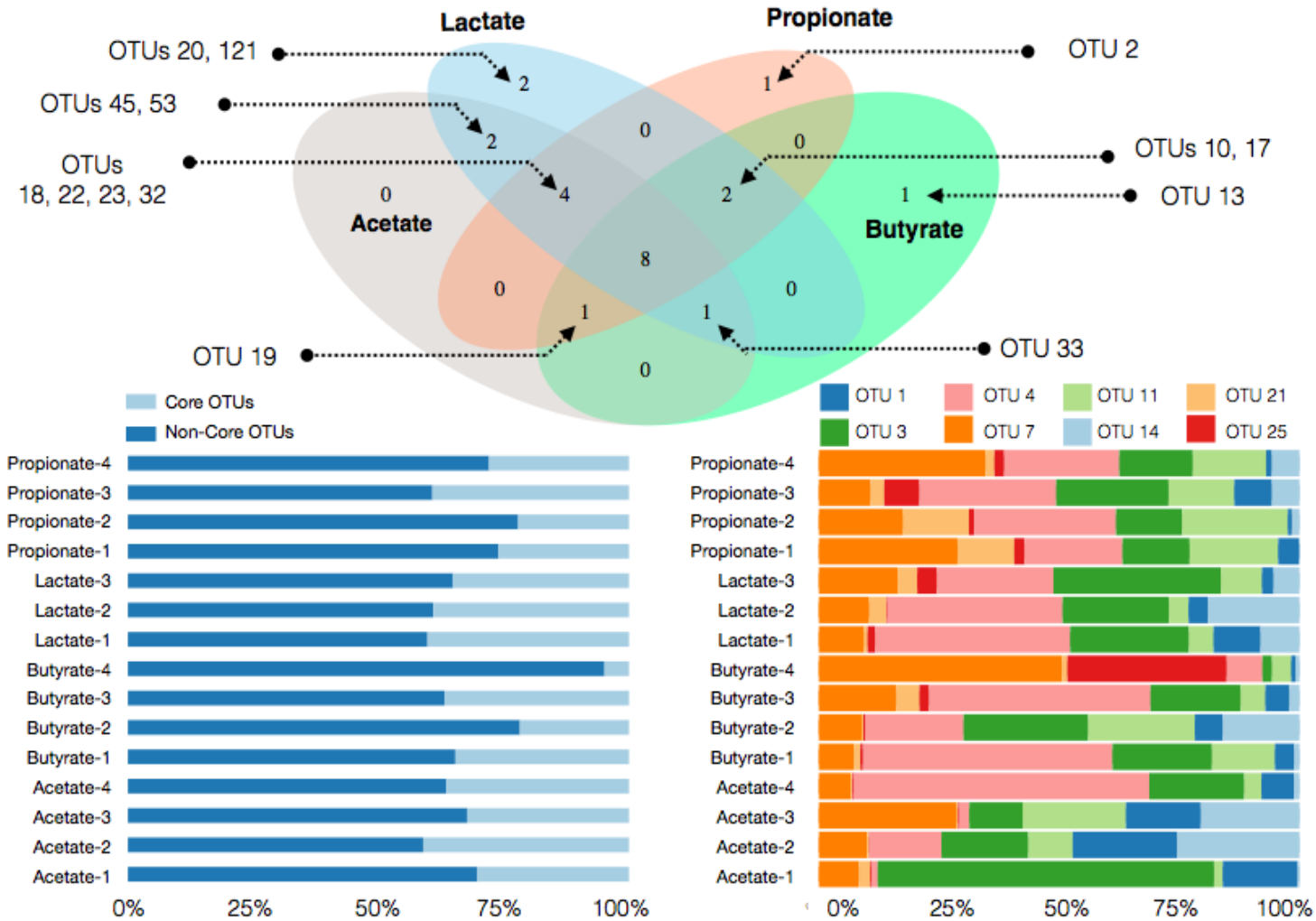
Putative biofilm pathways

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



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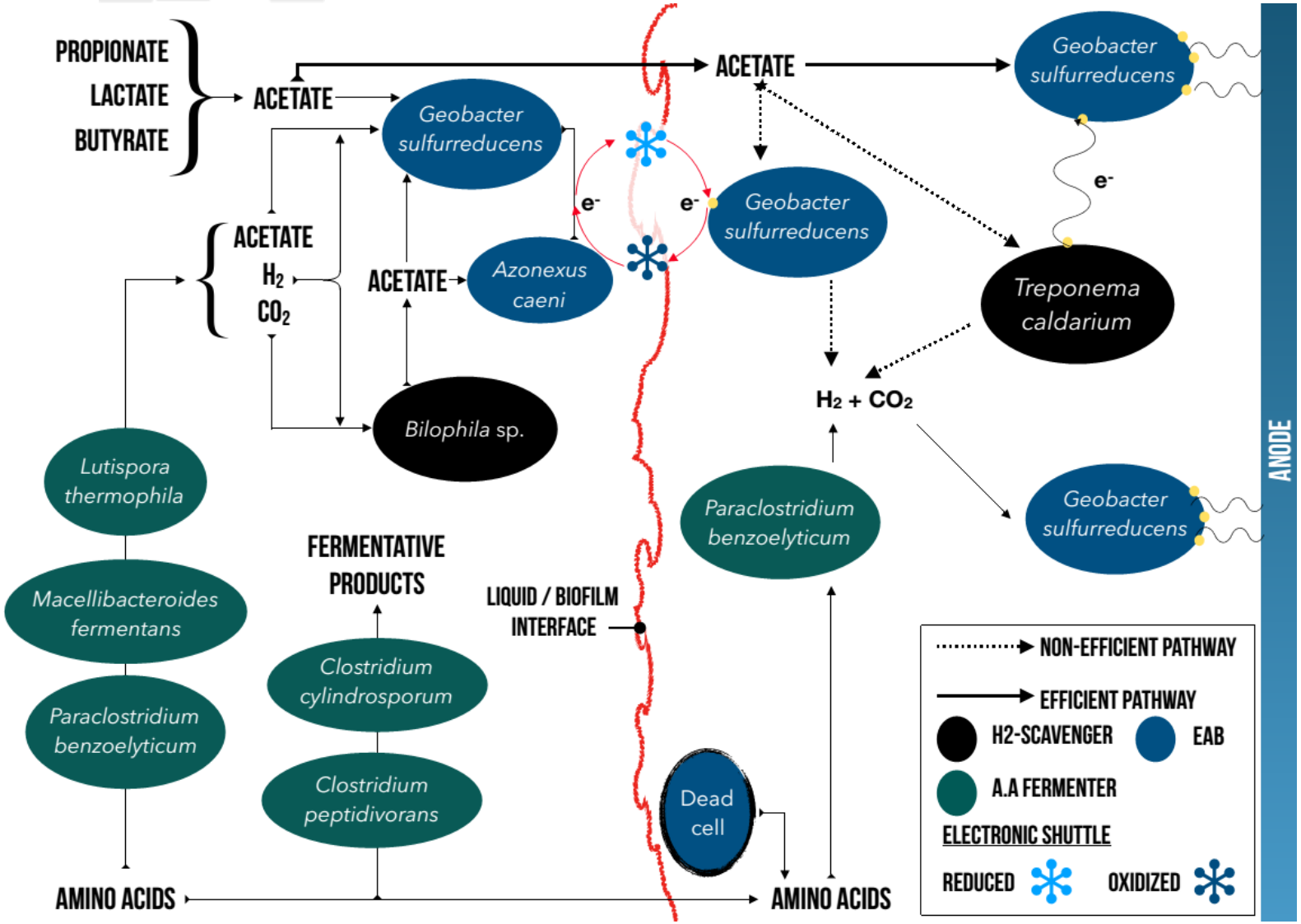
Putative pathways for bulk and biofilm



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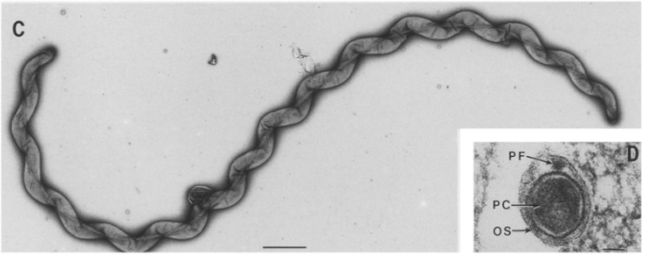
Conclusions/perspectives

- **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

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Thank you for your attention!