

Optimising Microbial Electricity Generation for Powering Specks

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The Darwin Trust
of Edinburgh

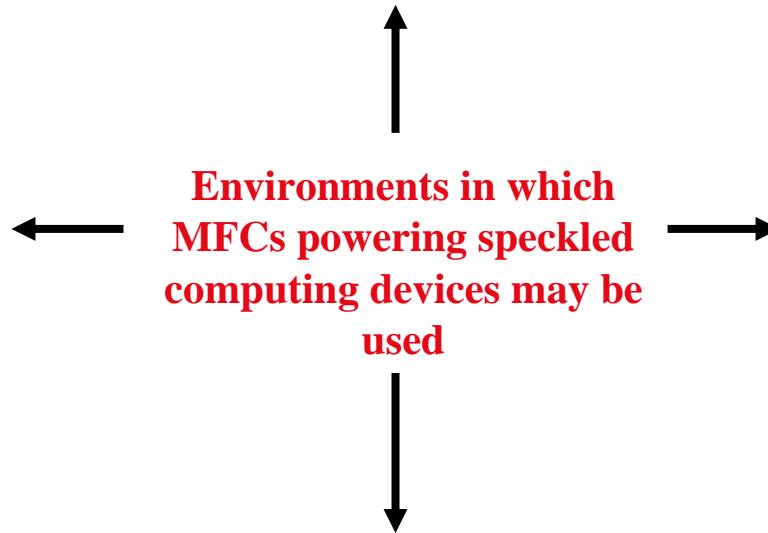




Tree/Forest:
use sap



Pelagic: use
dissolved nutrients



Coastal Sediment



Freshwater
Sediment

- Therefore speck-associated MFCs must be able to work on a variety of substrates in a number of different environments - a CHALLENGE
 - we need a rapid optimisation system for different feedstocks
- Also, the supply of nutrients to these fuel cells will vary, in particular with the season
 - some sort of storage battery will be required

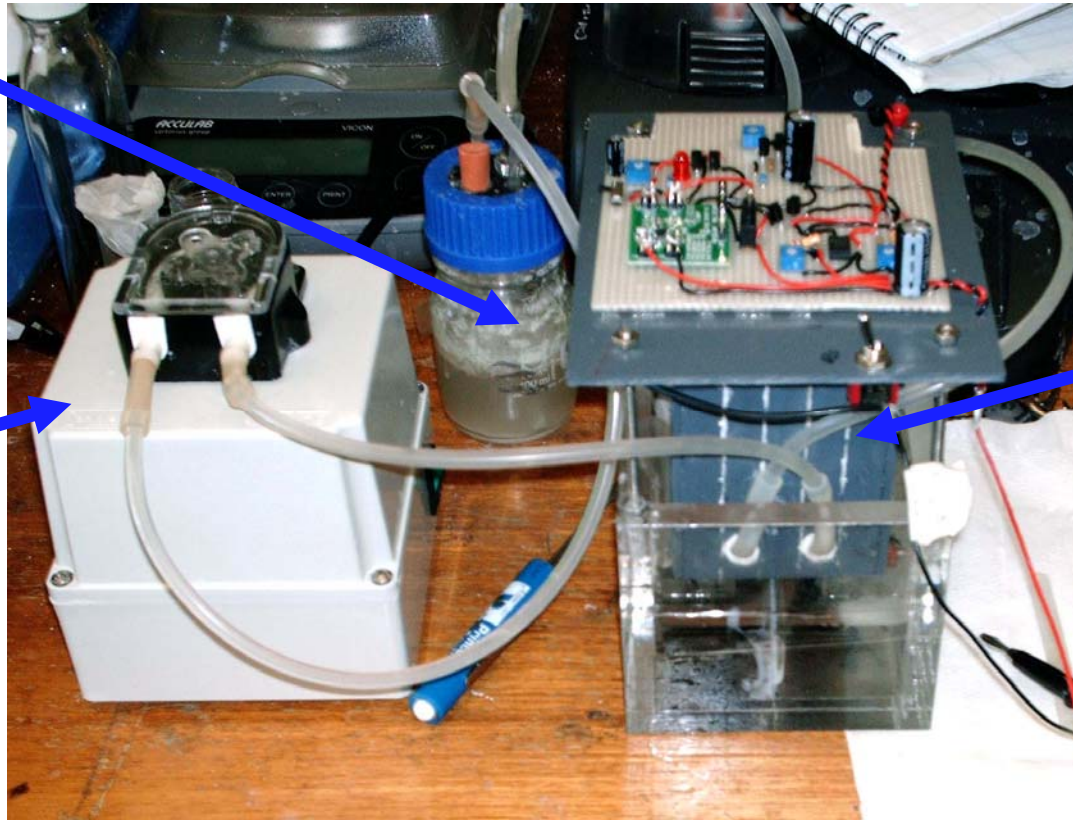


Initial microbial community came from tidal sediments at Cramond, Edinburgh.

Liquid reservoir

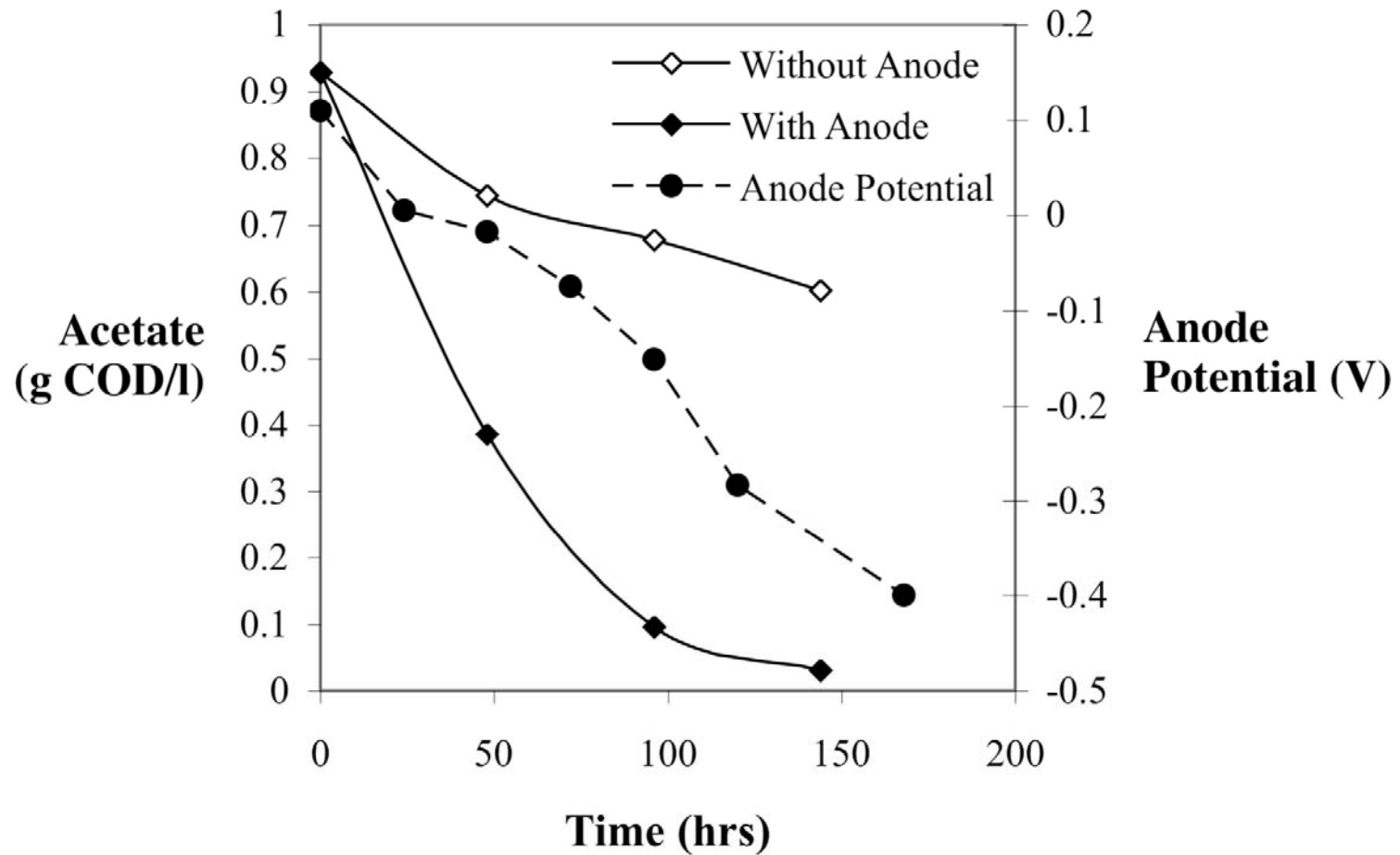
Pump

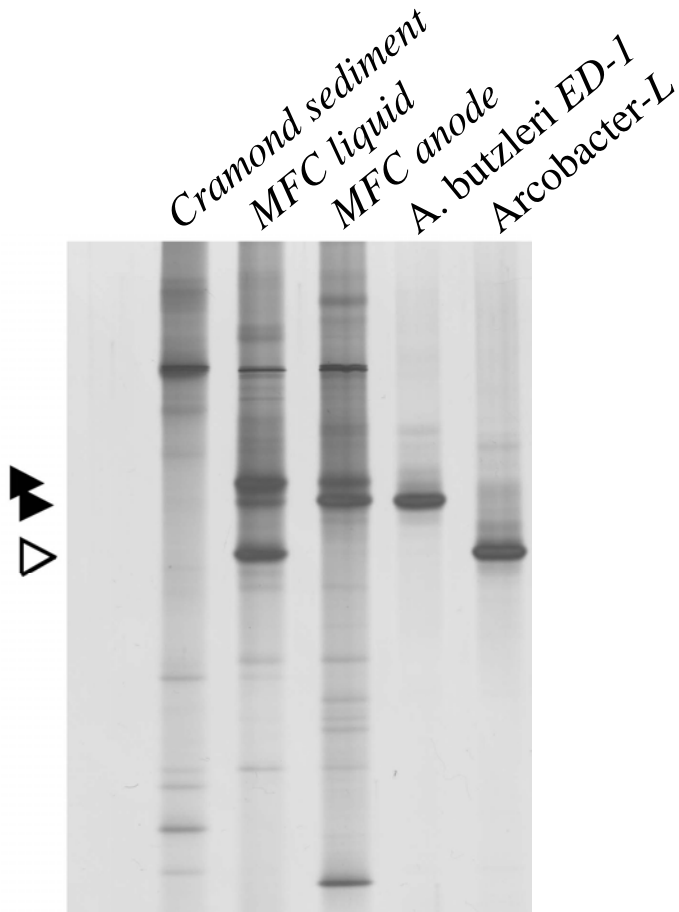
MFC



Sediment inoculum incubated in acetate-fed, recirculating MFC for 3 months

Consumption of Acetate by the MFC Bacterial Community

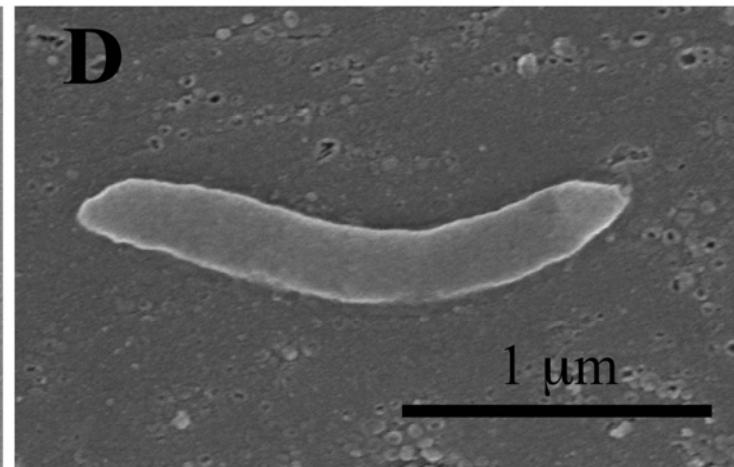
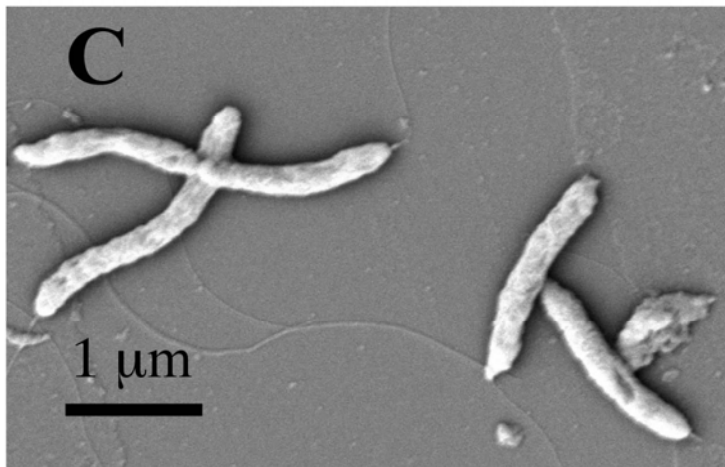
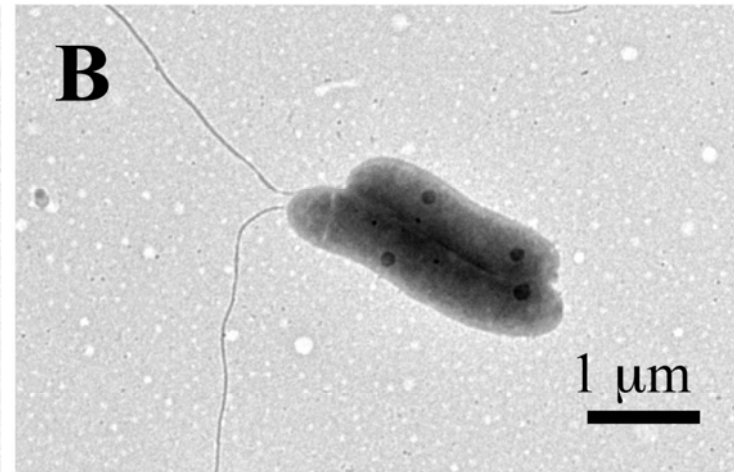
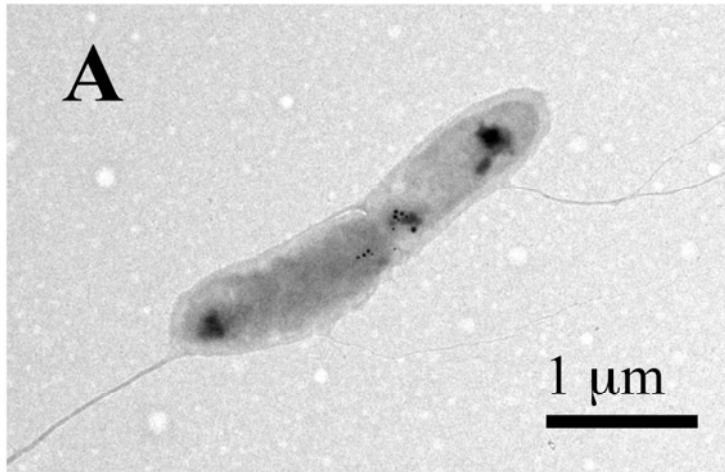




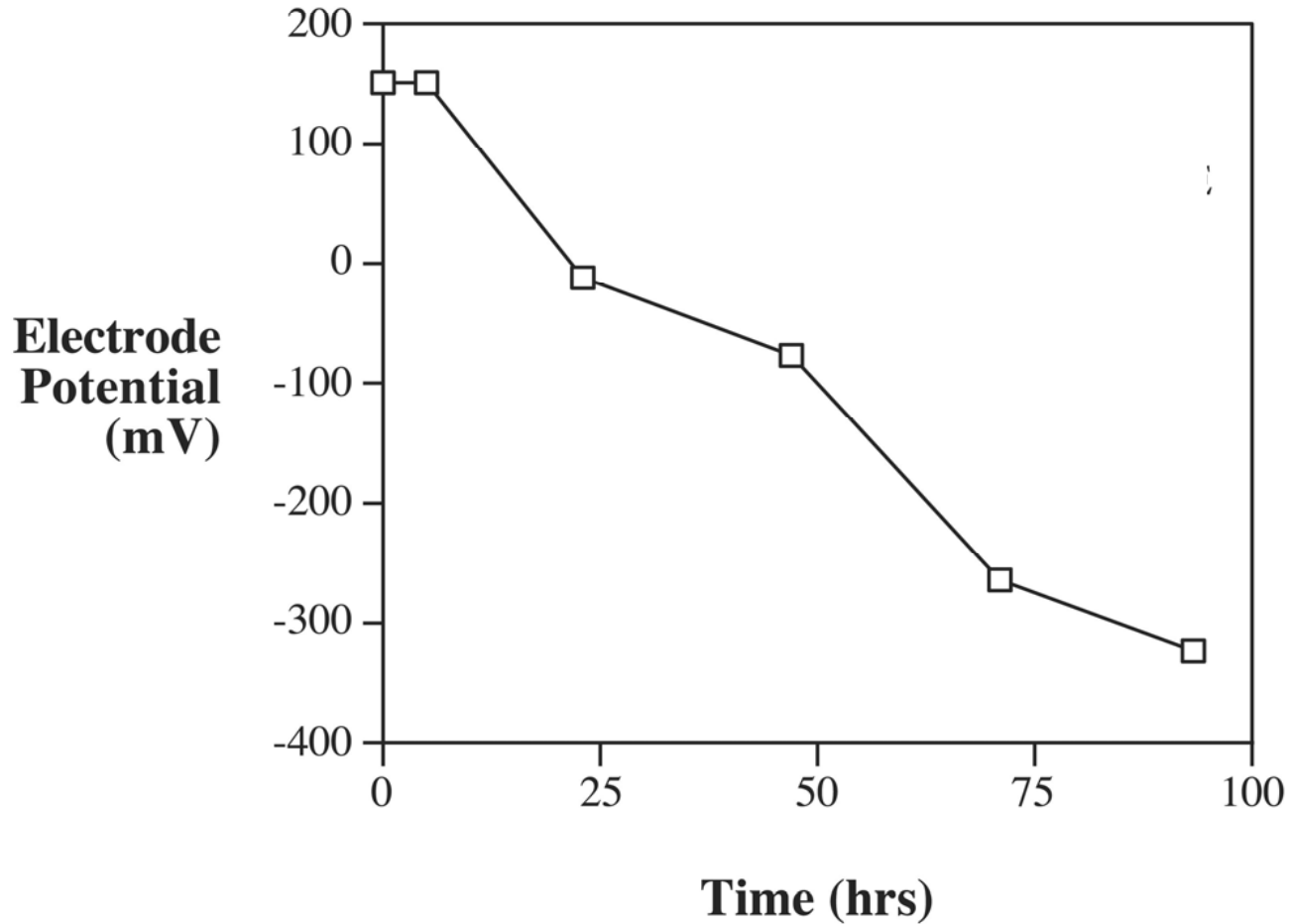
DNA fingerprinting shows two dominant members of the mature MFC community which are selectively enriched in this environment.

These correspond to two members of the ϵ -Proteobacteria: *Arcobacter butzleri* ED-1 and *Arcobacter* sp. (liquid phase).

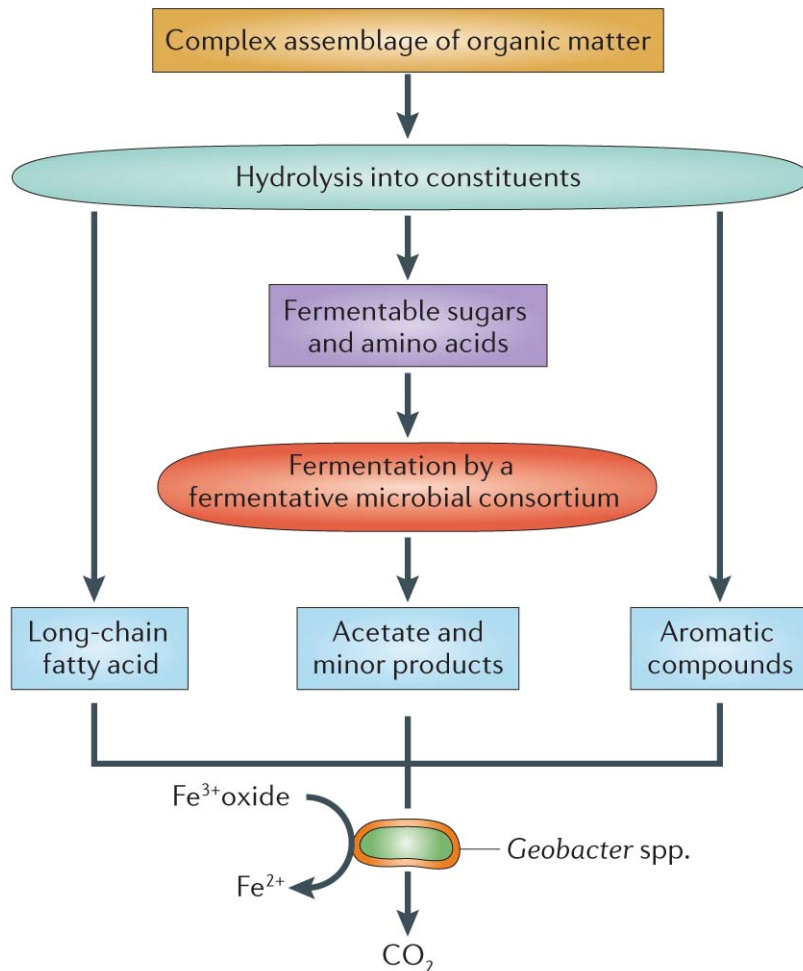
Arcobacter spp. Isolated from the Fuel Cell



Electrode Potential Generated by *A. butzleri* ED-1 Fed with Acetate



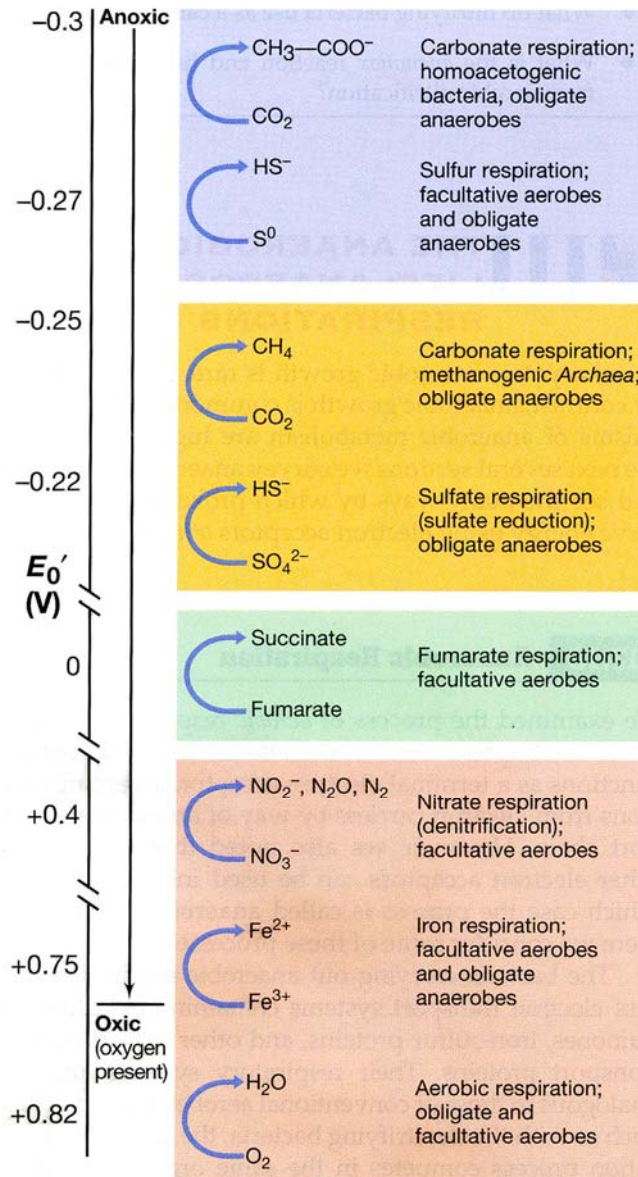
- *A. butzleri* ED-1 can efficiently use acetate to generate an electronegative potential at a carbon anode under anaerobic conditions, but cannot use sugars or more complex organic compounds such as cellulose.
- How can we use this bacterium to generate the power necessary for speckled computing devices operating in the natural environment?
- We need to consider the natural pathways of decomposition by anaerobic microbial communities....



Complex consortium of microbial species converts a variety of organic matter into acetate and other compounds which can be oxidised by a species such as *Geobacter* to CO₂, using iron (III) oxide (or an anode in a fuel cell) as the terminal electron acceptor.

Lovely, D.R. (2006). *Nature Rev. Microbiol.* 4: 497

Competing Processes in Anoxic Degradation



← Methanogenesis

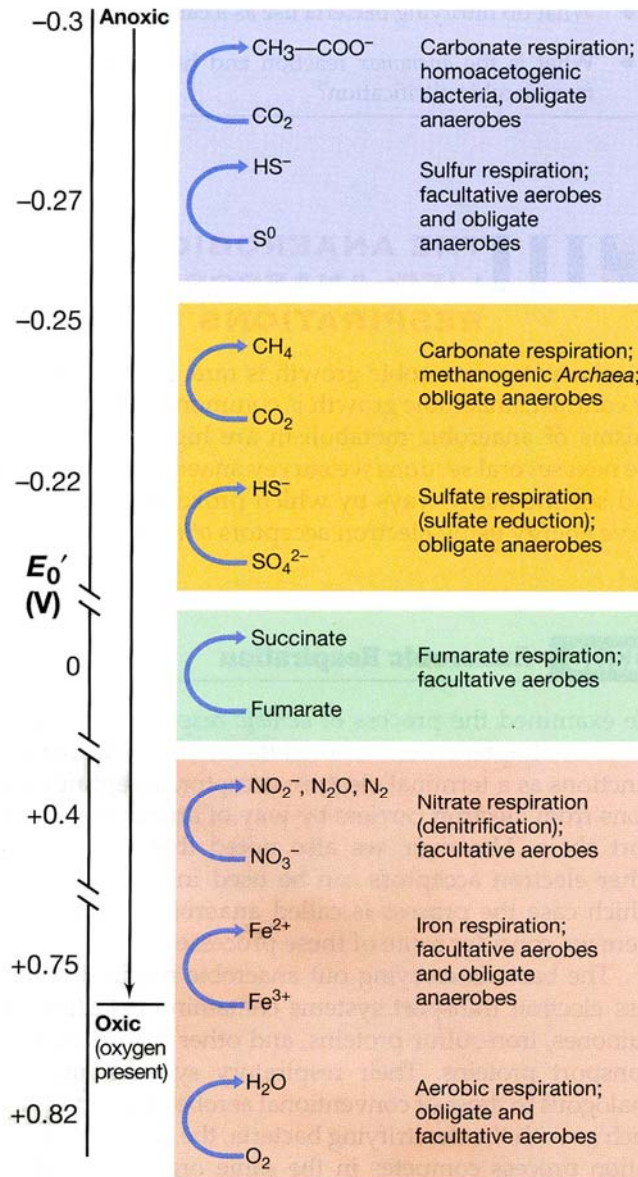
← Sulphate reduction

← Nitrate reduction

← Iron reduction (cf. anode)

O_2

Competing Processes in Anoxic Degradation



← Methanogenesis

← Sulphate reduction

← This can be useful to us!

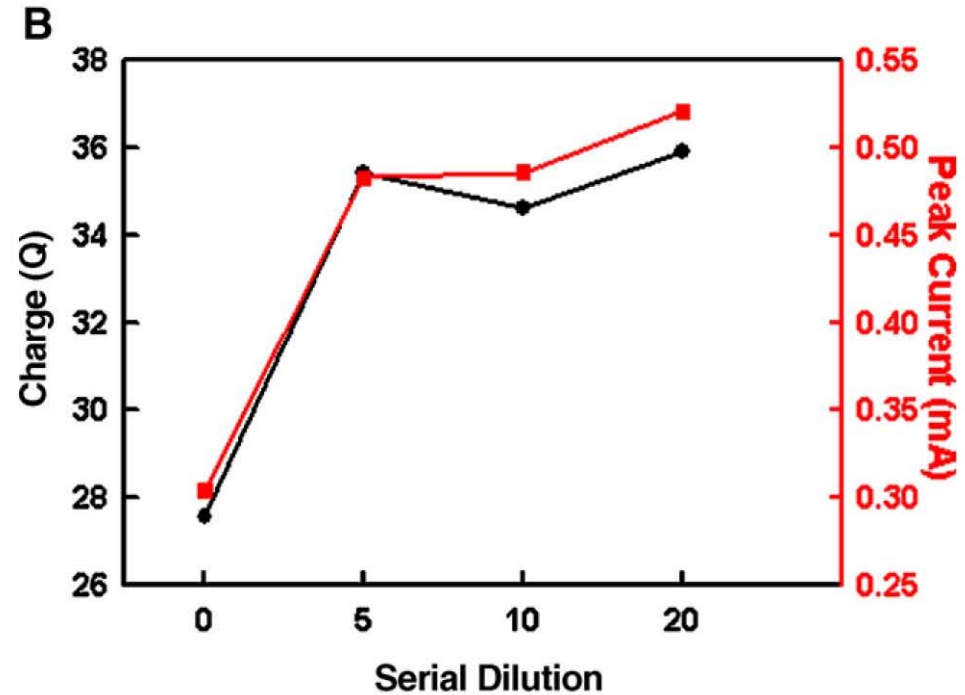
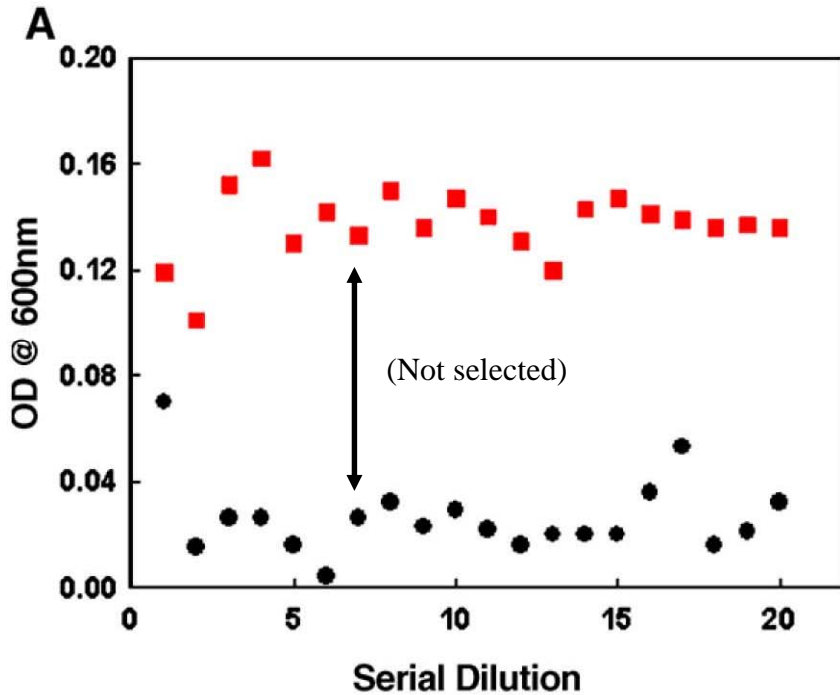
← Nitrate reduction

← Iron reduction (cf. anode)

O_2

- We need to optimise a microbial community for maximal production of electricity from a given feedstock, without the loss of energy to competing pathways.
- We could do this by trying to understand all the links in the chain (reductionist approach, difficult?), or by simply selecting for the “best” microbial ecosystems from a large population (“artificial ecosystem selection”, easier).
- BUT we cannot (yet) build a large number (100s) of MFCs - too costly and time-consuming.

Adaptation to Anaerobic Growth on Lactate/Fumarate

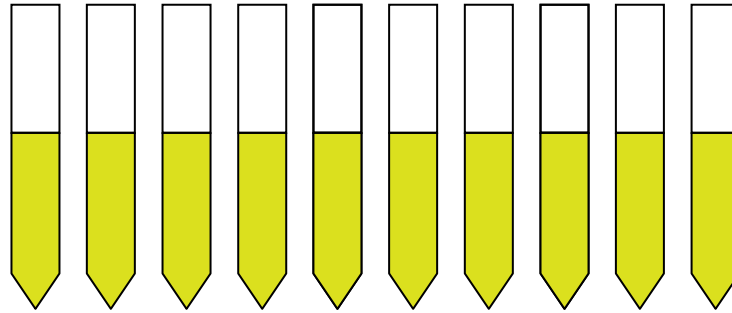
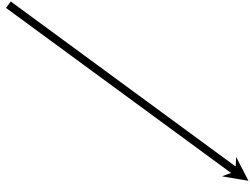


Shewanella oneidensis MR-1 grown for 24 hours on lactate (electron donor) and fumarate (electron acceptor), then serially diluted into fresh medium.

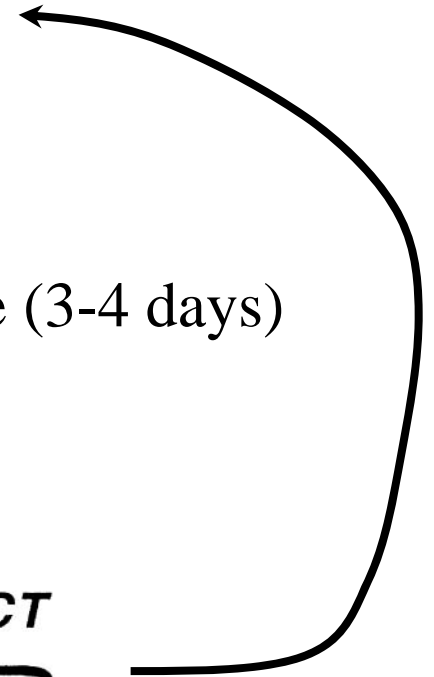
Peak current increases by 65% over 5 generations, but no artificial selection applied.

Cho, E.J. and Ellington, A.D. (2007). *Bioelectrochemistry* **70**: 165

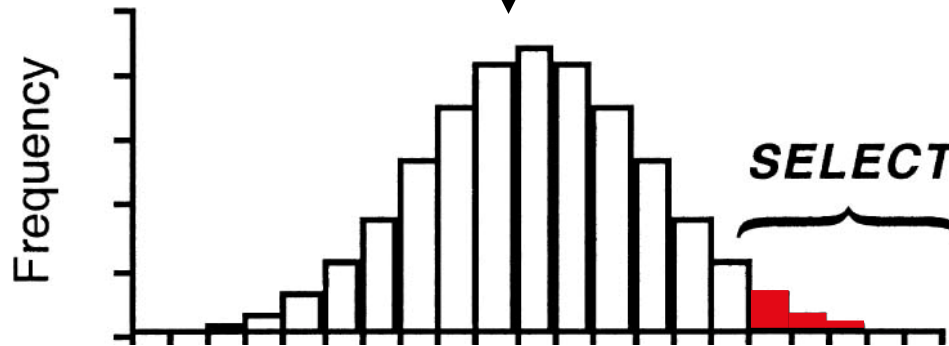
Starting microbial community



Repeat for many (10-20) generations



Anaerobic growth on feedstock of choice (3-4 days)



Increasing Growth
→



Acknowledgements:

Anne-Laure Testou
- *Arcobacter* growth

Matthew Knighton, John Hopkins
- *Arcobacter* characterisation

Eulyn Pagaling (postdoc)
- community analysis

Hongwu Ma, Zi Ler
- metabolic reconstruction

Slava Fedorovich
- Fuel cell construction and operation

Bruce Ward
- *Arcobacter* isolation and initial characterisation

Igor Goryanin
- Project design and implementation

The Darwin Trust of Edinburgh

The Leverhulme Trust

School of Informatics, University of Edinburgh

MRC (Studentship)

Specknet

