

# Bio Electrical Engineering (BEE) Workshop

30-30 May 2018, University of Warwick



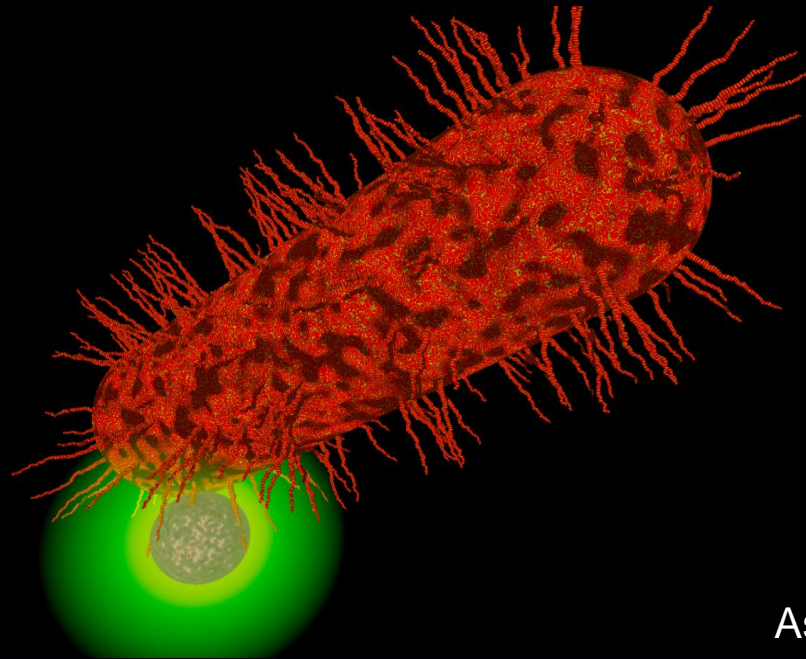
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## Electrochemical investigation of taxis and extracellular electron transfer of *Shewanella oneidensis* MR-1

Lars Jeuken

School of Biomedical Sciences

School of Physics and Astronomy



Astbury Centre

# Shewanella oneidensis MR-1



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## Shewanella oneidensis MR-1:

A model organisms for extracellular electron transfer (EET) in microbial electrochemical systems and bioremediation

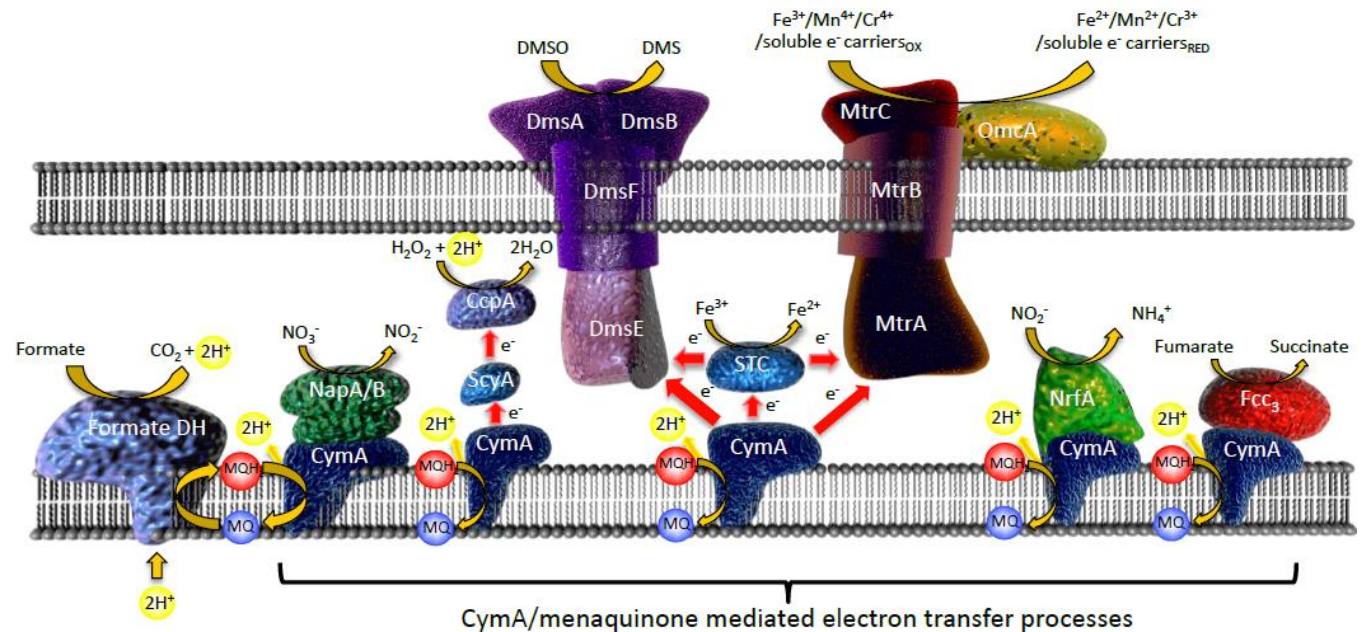


Photo from Oak Ridge National Laboratory

# Thanks



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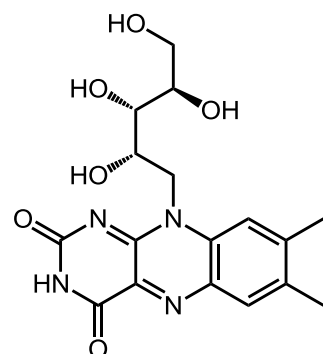
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**Jeff Gralnick**

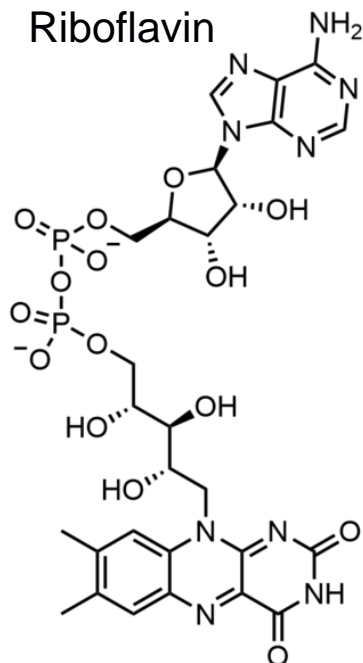
# Extracellular electron transfer (EET)



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Riboflavin



Flavin adenine dinucleotide (FAD)

## Extracellular electron transfer (EET) *Shewanella oneidensis* MR-1

Three EET mechanisms

- Mediator → Flavin (via MtrCAB)
- Direct → via MtrCAB (heme proteins)
- Nanowires → Membrane appendages

### Which mechanism dominates in microbial electrochemistry?

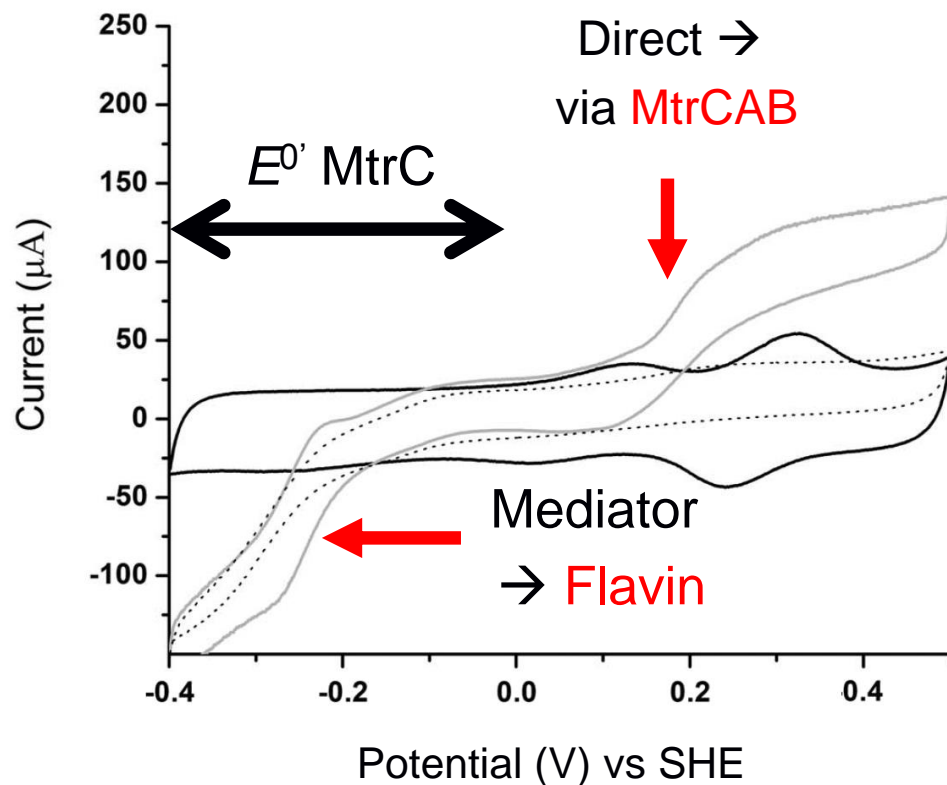
**Problem:** different growth conditions and different electrode materials.

**AIM:** Can we differentiate between mechanisms by stringently controlling electrode properties.

# Extracellular electron transfer (EET)



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## Graphite Felt Electrode

Grey: One-day old biofilm  
(18 mM lactate, 30 mM fumarate)

Dotted: New medium

Black: Control

Shroff, N. P., Xu, S., Acevedo, J., El-Naggar, M. Y. & Finkel, S. E. A Microenvironment for *Shewanella oneidensis* MR-1 Exists within Graphite Felt Electrodes. *Journal of The Electrochemical Society* **164**, H3103-H3108, doi:10.1149/2.0161703jes (2017).

# Electrochemical study of EET

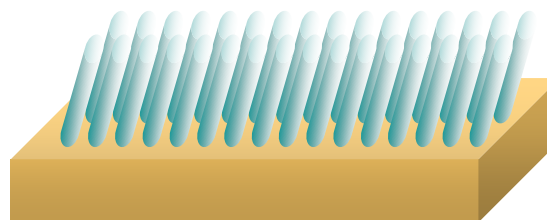


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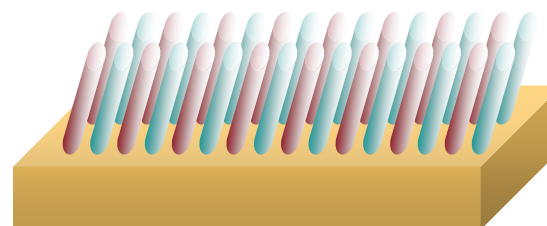
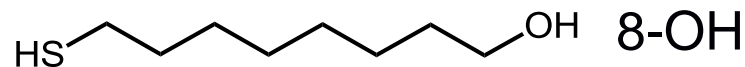
Ultraflat gold



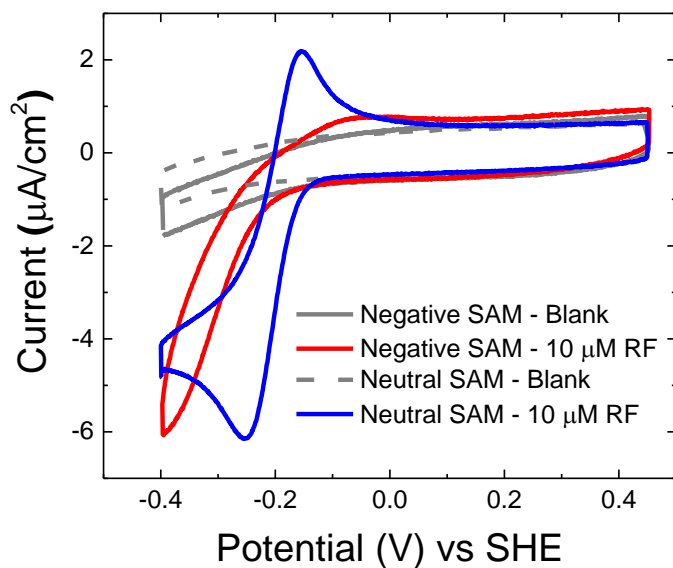
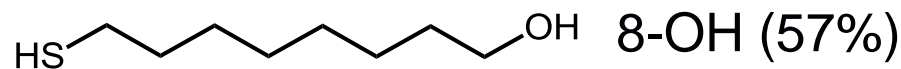
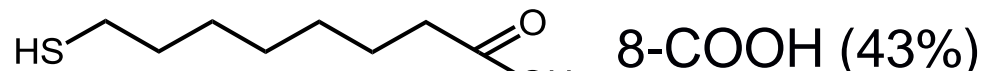
Self-assembled monolayer (SAM)



“Neutral”



“Negative”



Riboflavin (RF)

# Electrochemical study of EET

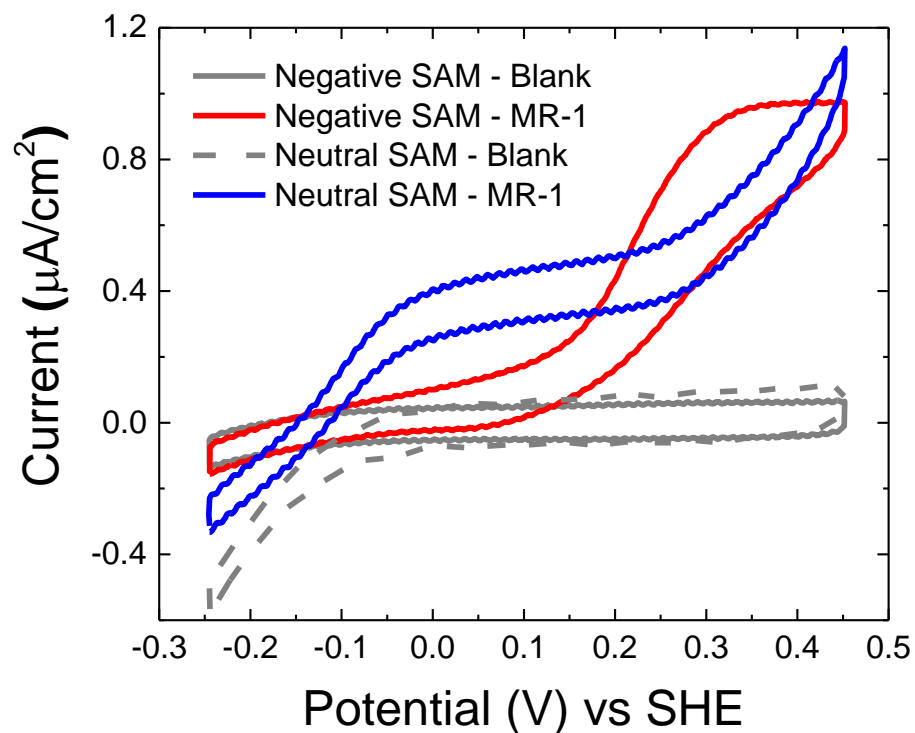


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Special conditions: Biofilm formation at 0.22 V vs SHE in  
*buffer (no metals/minerals) with 10 mM lactate as fuel source*

**Neutral:** flavin (excreted by MR-1)  
functions as electron mediator

**Negative:** is this direct electron  
transfer via MtrCAB?



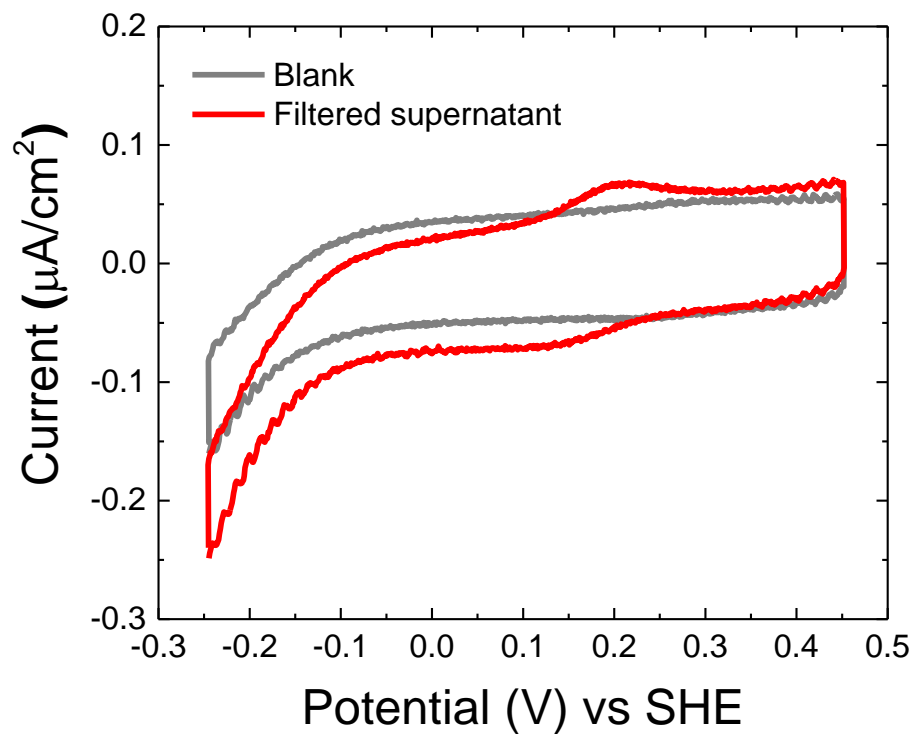
# Electrochemical study of EET



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Remove supernatant and analyse:

- LC-MS
- Filtration (3 kDa cut-off)
- Electrochemistry

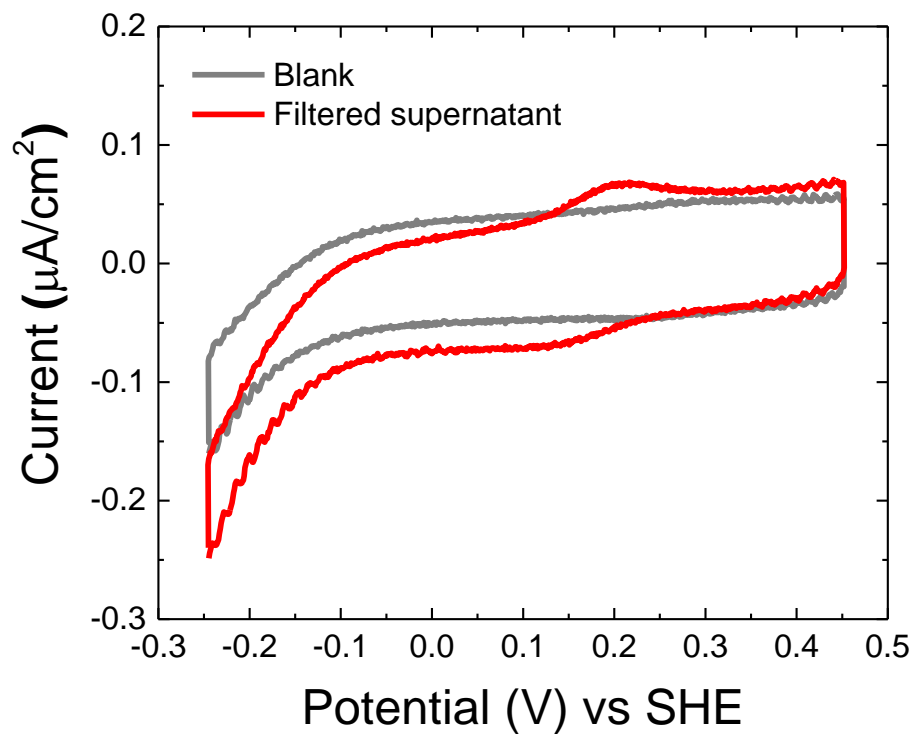
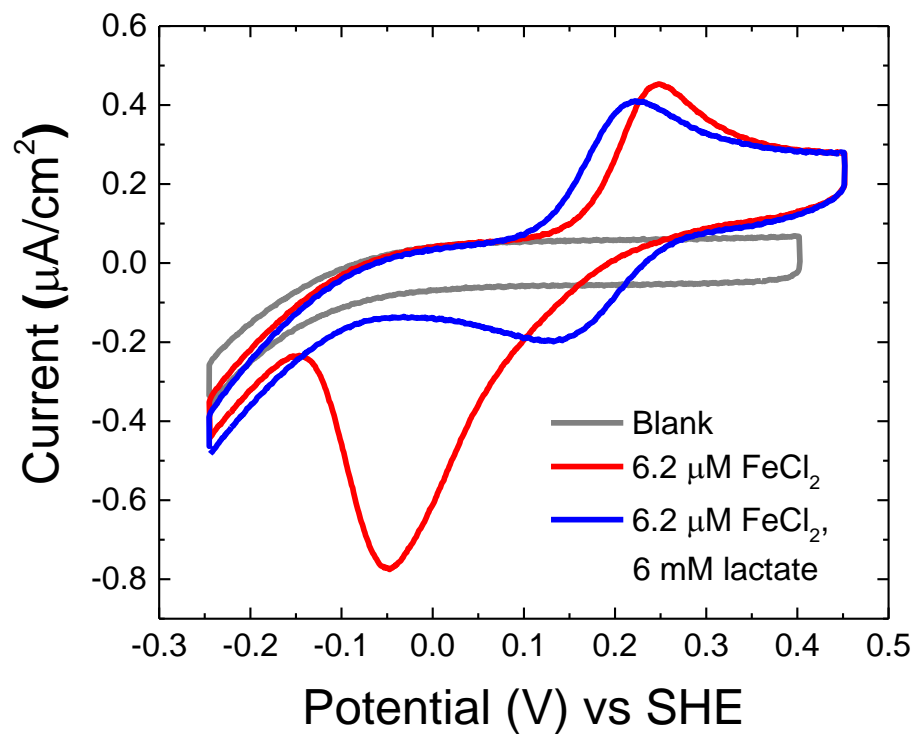




# Electrochemical study of EET



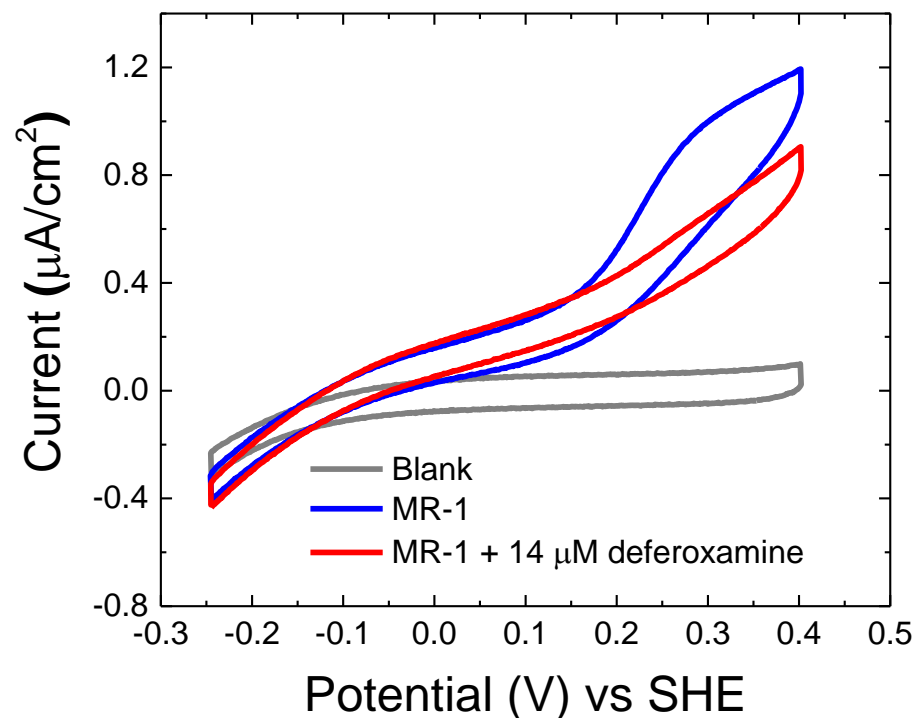
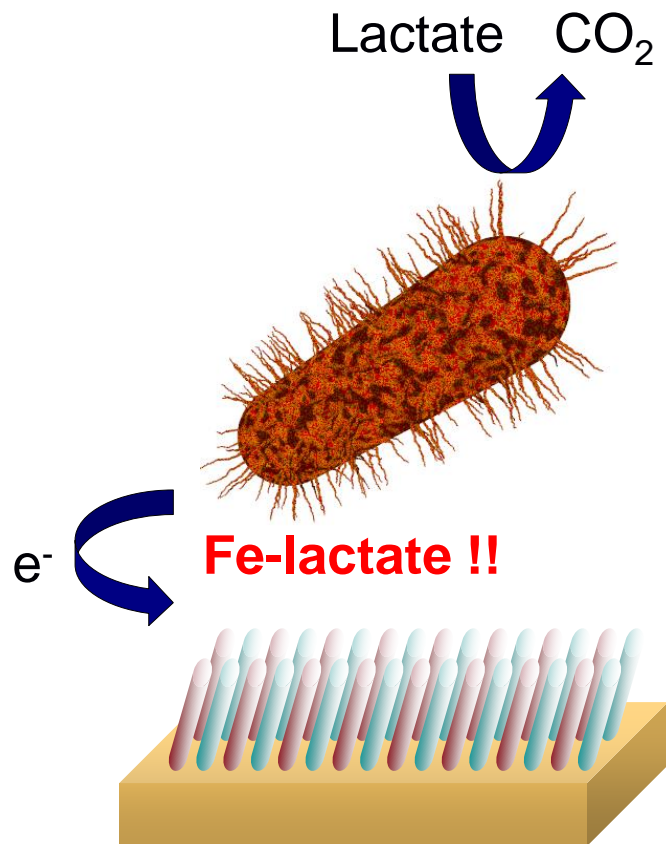
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# Electrochemical study of EET



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Similar results were obtained with ITO and graphite electrode and/or when using minimal medium (instead of buffer/lactate)

# Conclusions & Hypotheses



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- The electrode surface chemistry can determine the EET mechanism in a microbial electrochemical system.
- We have found no evidence for *direct* electron transfer between *S. oneidensis* MR-1 and modified gold, graphite or ITO electrode at potentials  $> 0$  V vs SHE.