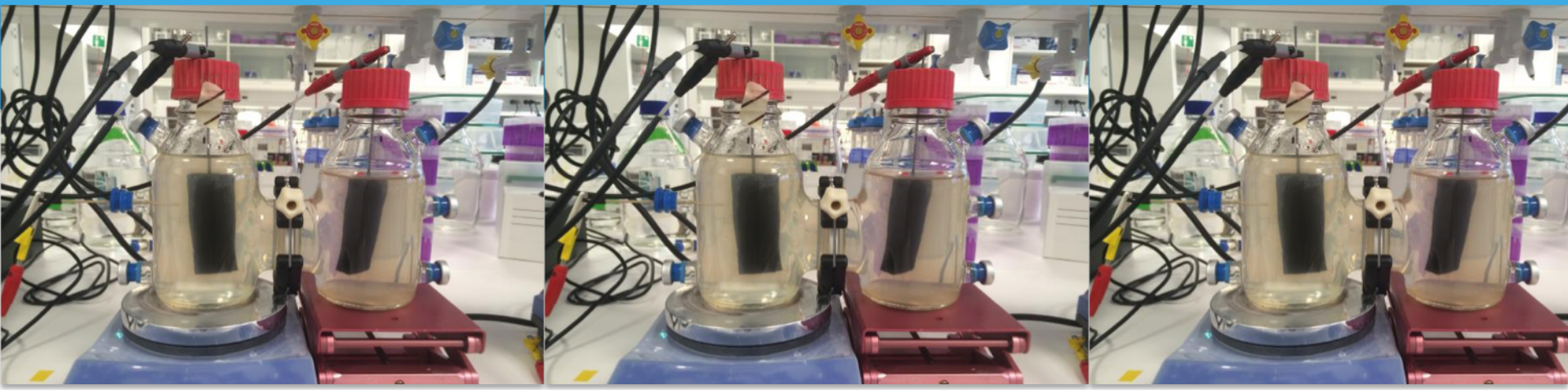
Electromethanogenesis for biogas upgrading



People at SDU:

Amelia-Elena Rotaru

Mon Yee Oo

& Bo Thamdrup

Who is an electromethanogen?

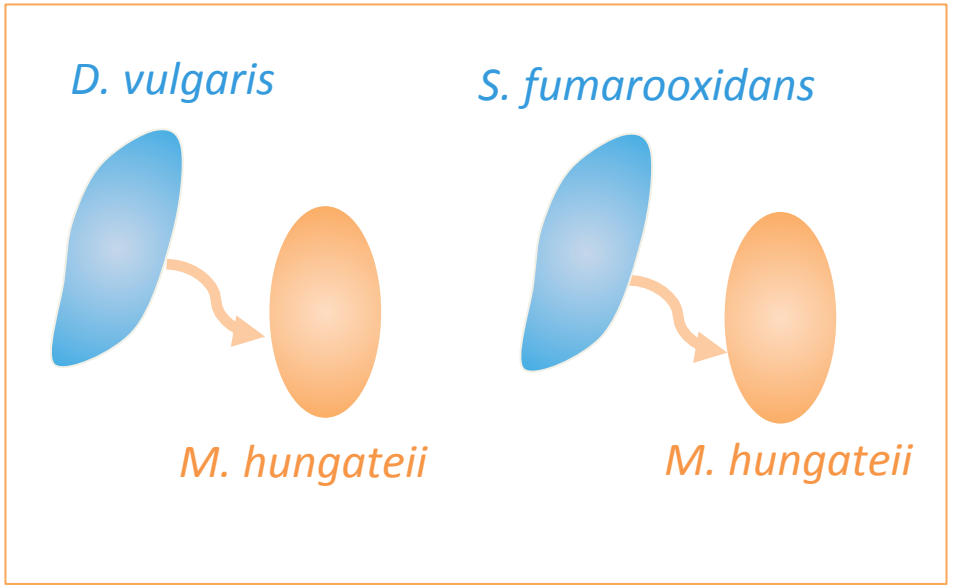
How are they retrieving electrons?

How to use EET to upgrade biogas?

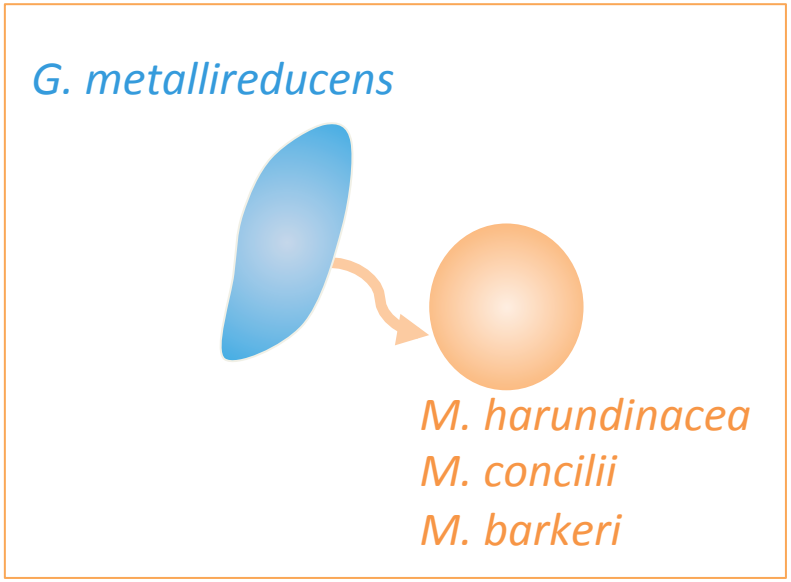
Electron uptake by methanogens

Strategies of electron transfer:

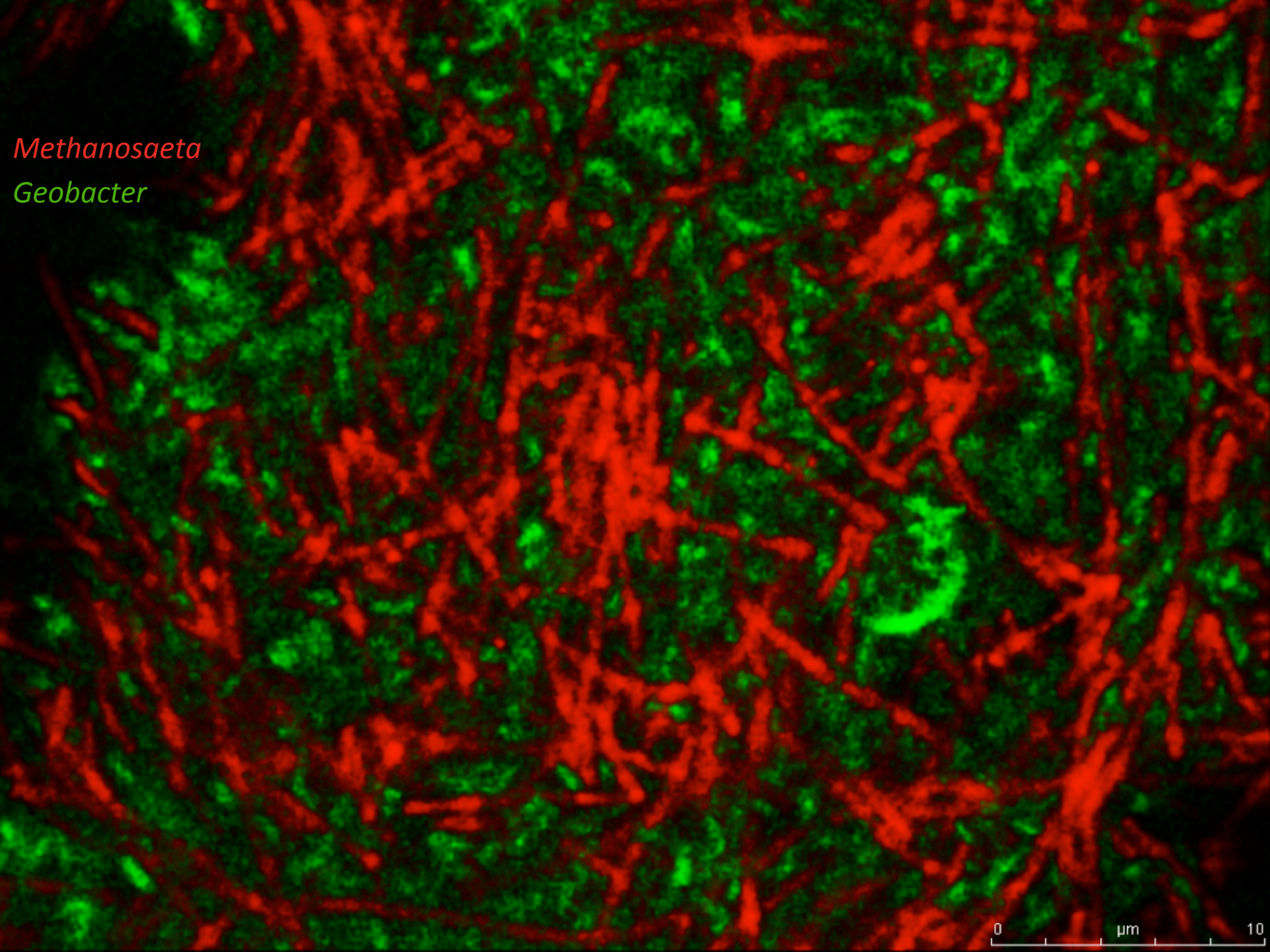
H_2 or formate



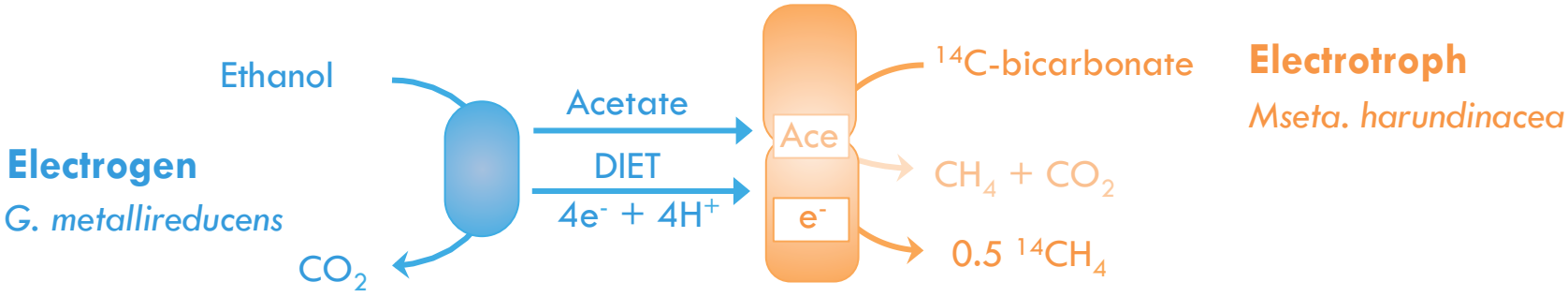
Direct electron transfer

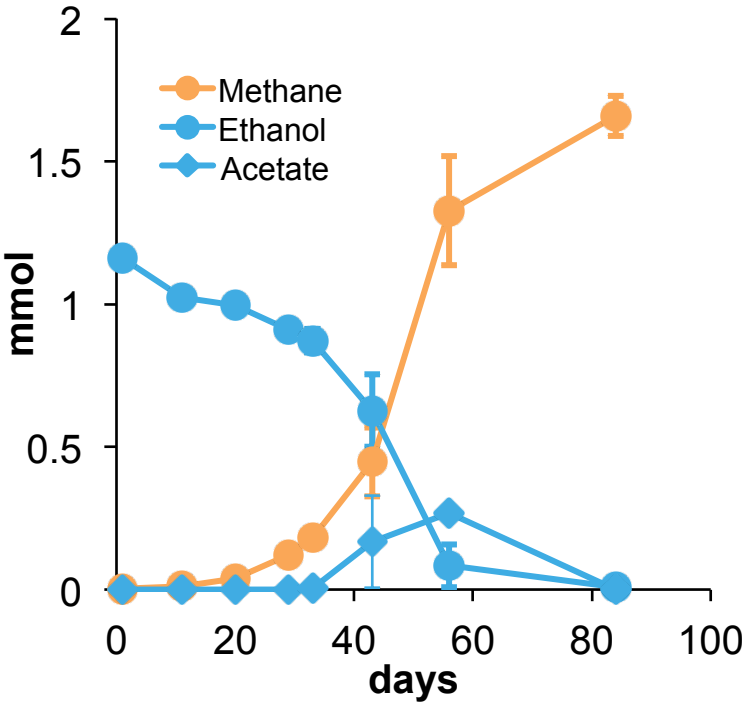


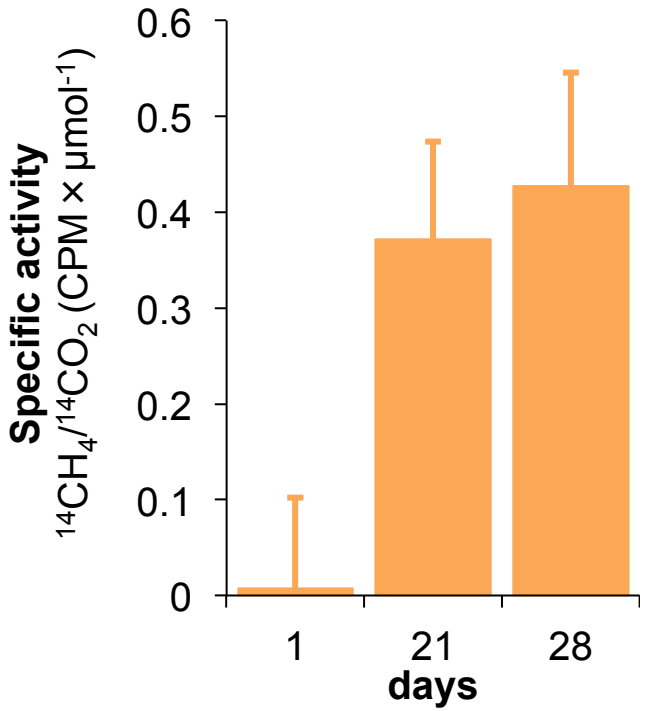
Rotaru 2014a, Rotaru 2014b, Rotaru 2015


Methanosaeta
Geobacter
0
µm
10

A new DIET for Methanosaeta

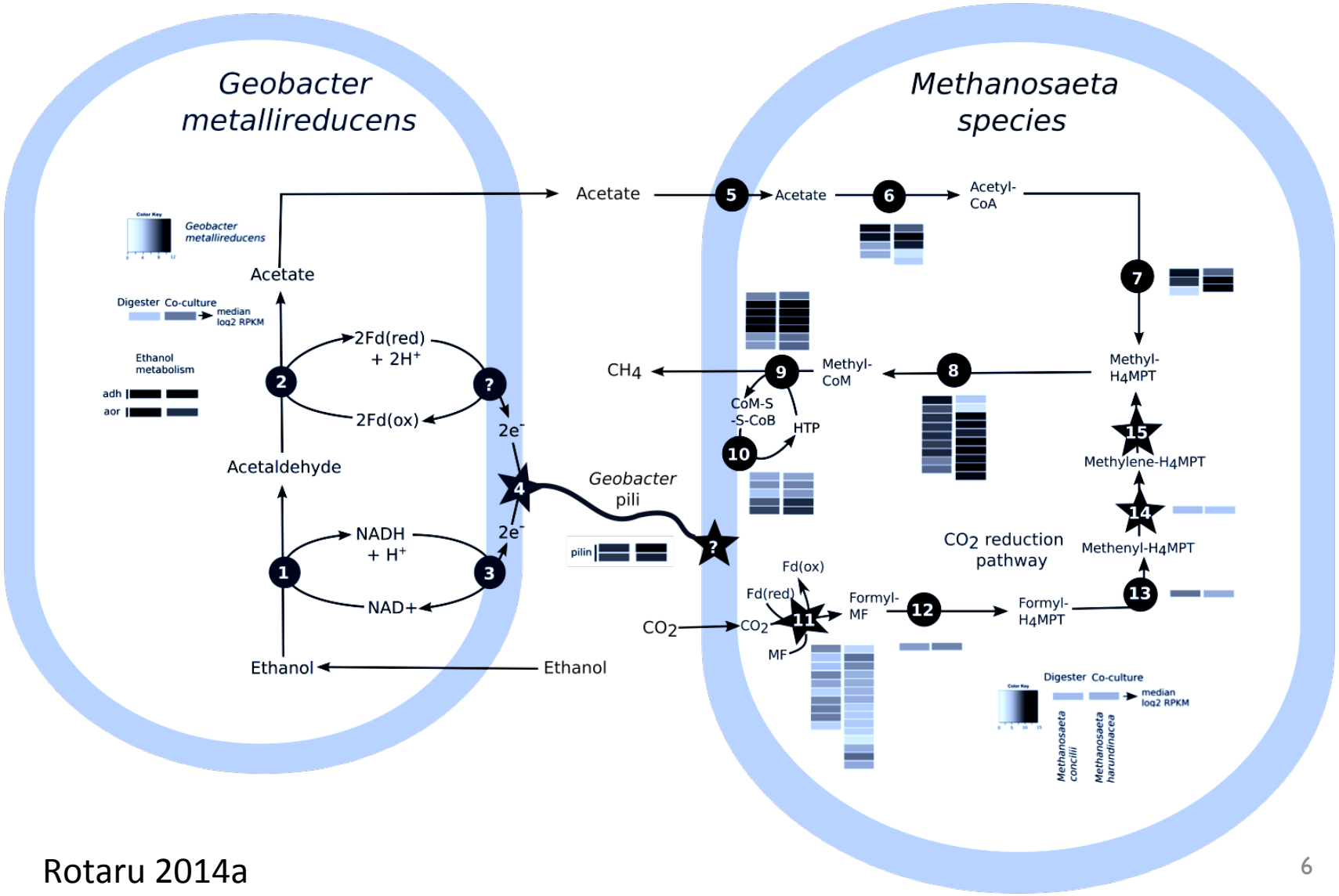






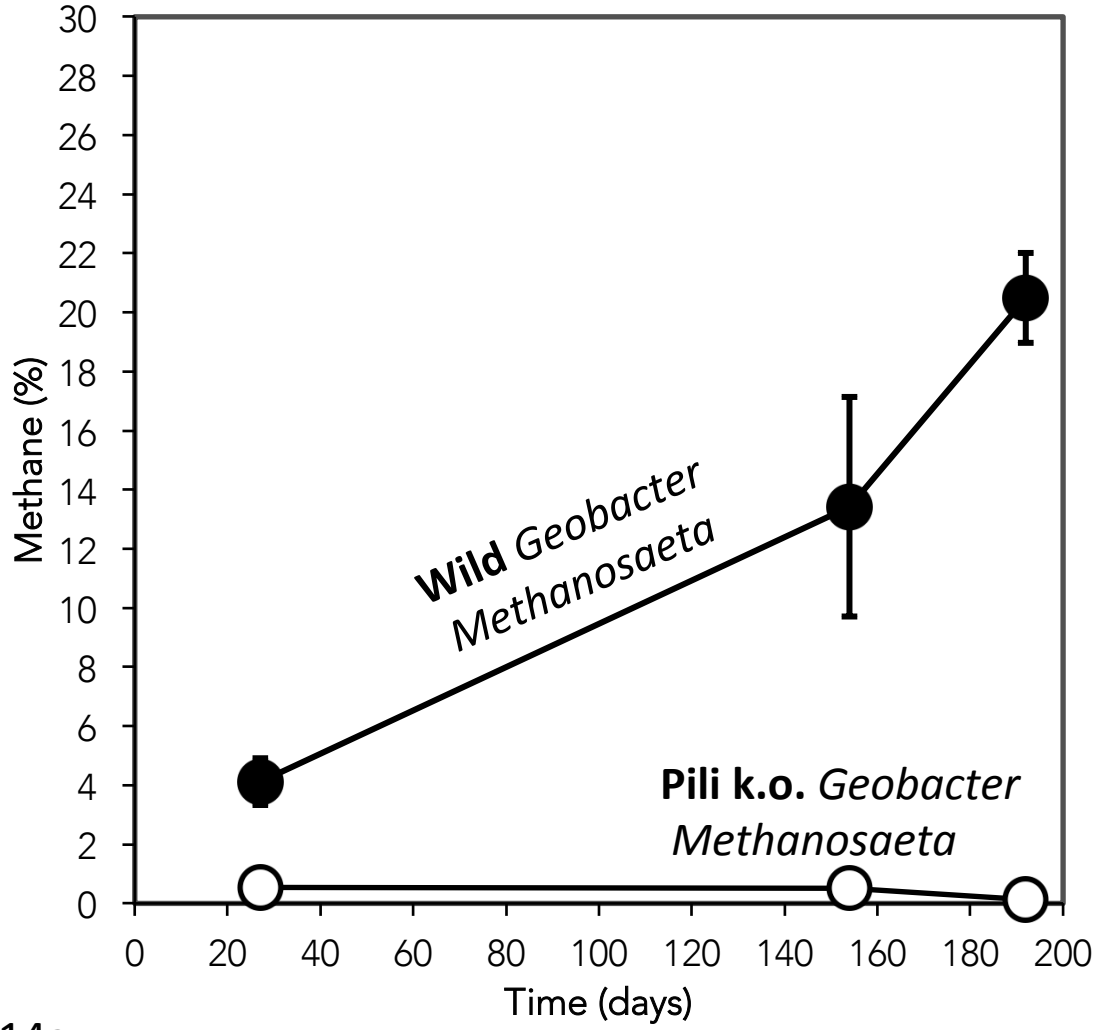
Rotaru 2014a

A new DIET for *Methanosaeta*



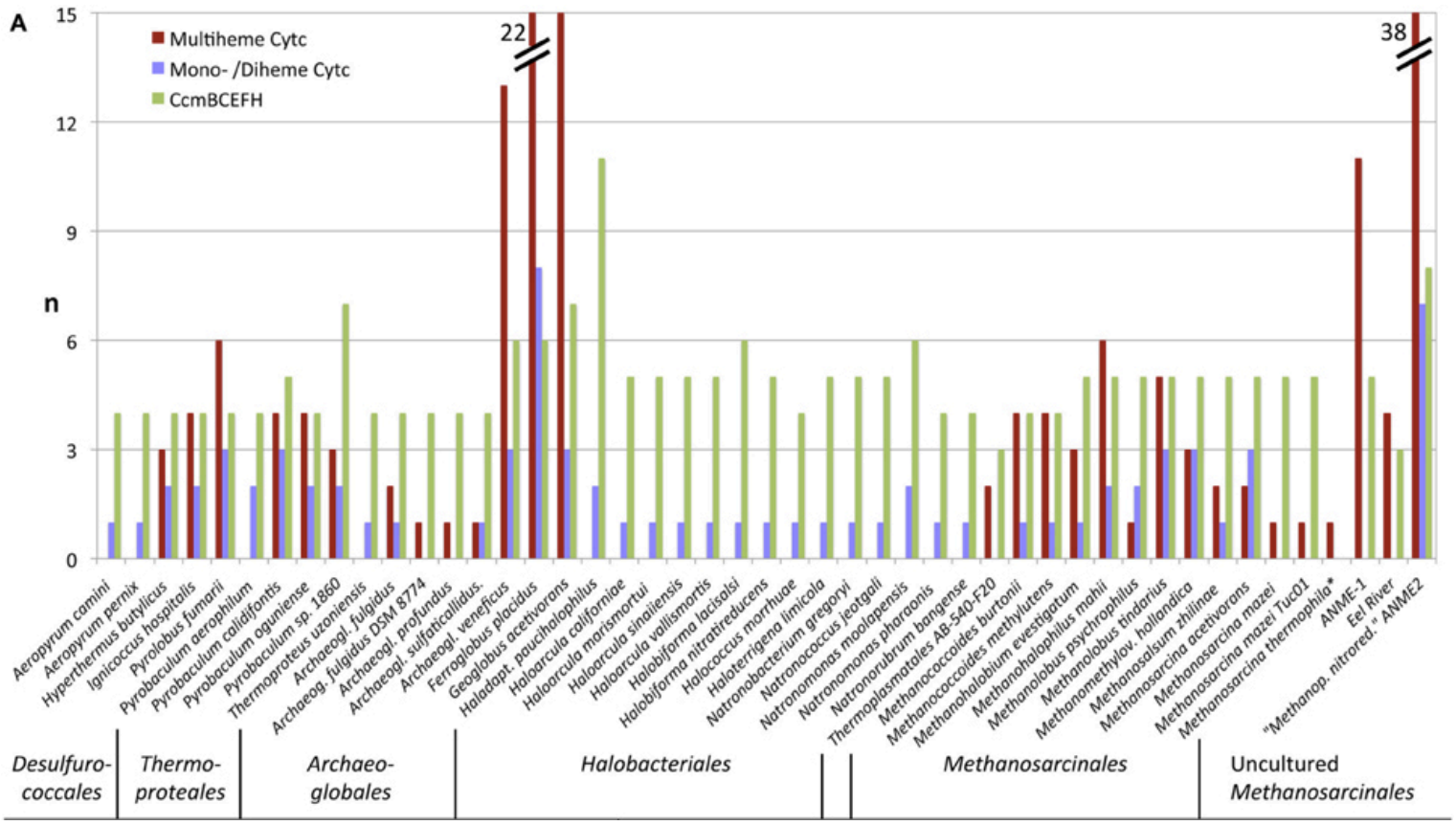
Rotaru 2014a

Conductive pili are required



Rotaru 2014a

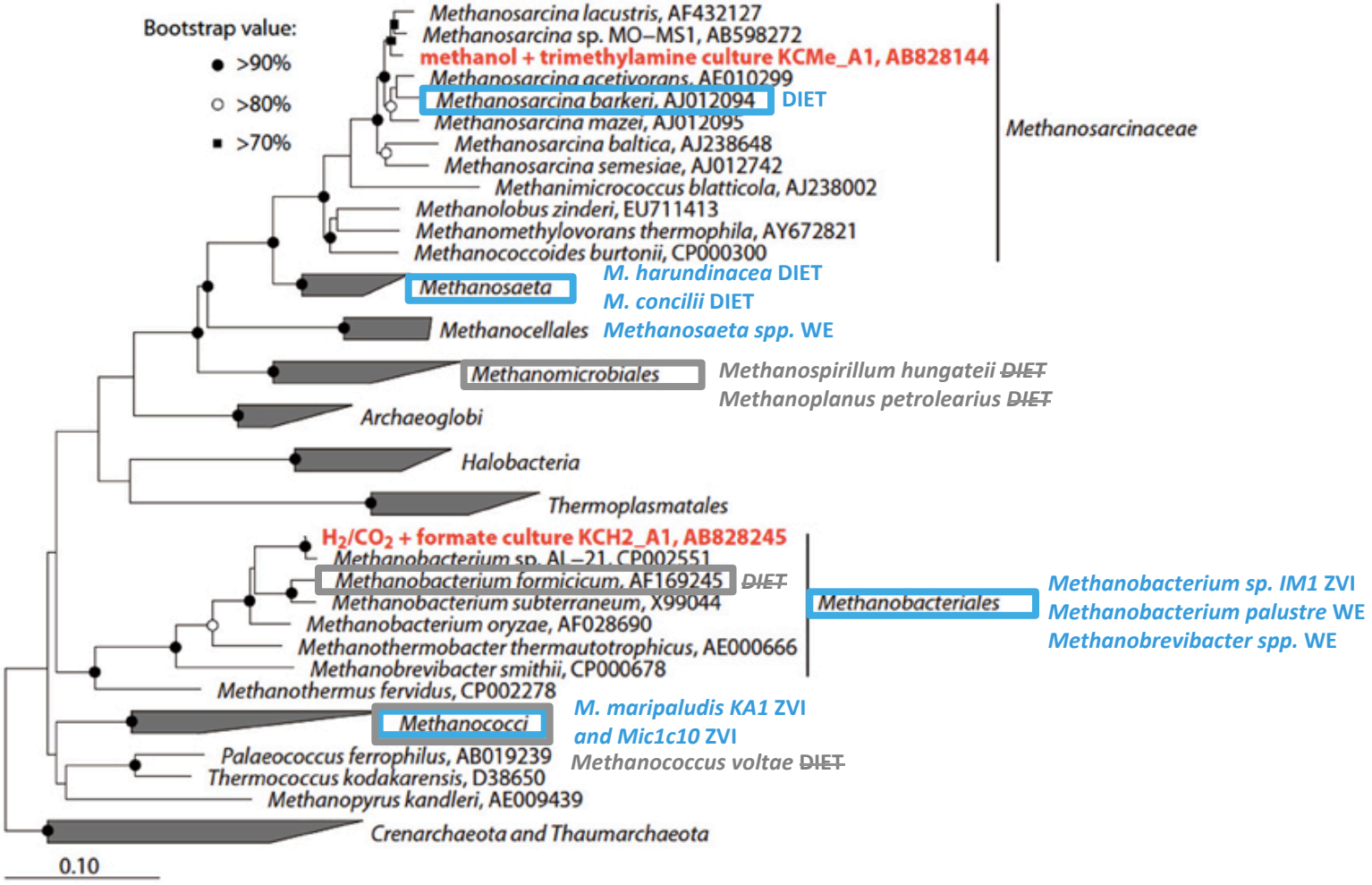
Cytochrome-c containing *Archaea*



Kletzin 2015

What other methanogens are implicated in EET?

Methanogens associated with EET



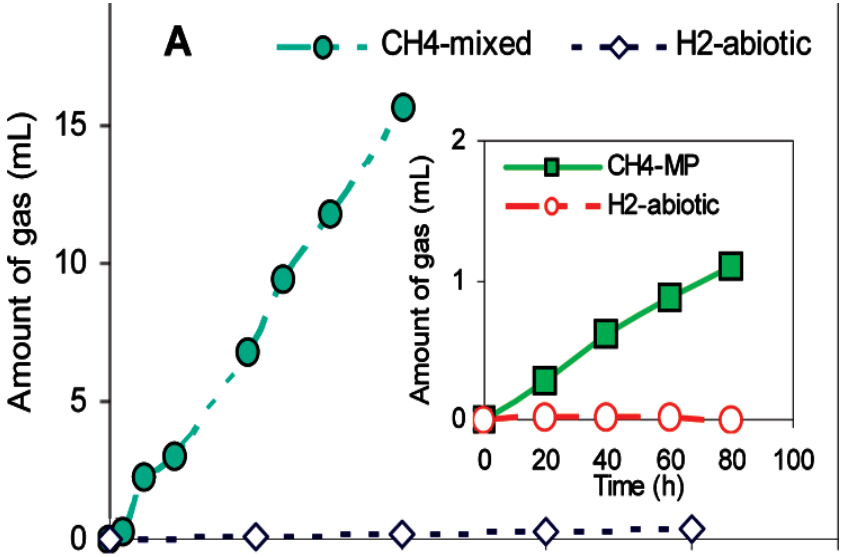
Original tree by Ohtomo 2013

Electromethanogenesis

Environ. Sci. Technol. **2009,** *43,* 3953–395

Direct Biological Conversion of Electrical Current into Methane by Electromethanogenesis

SHAOAN CHENG, DEFENG XING, DOUGLAS F. CALL, AND BRUCE E. LOGAN*



Electromethanogenesis

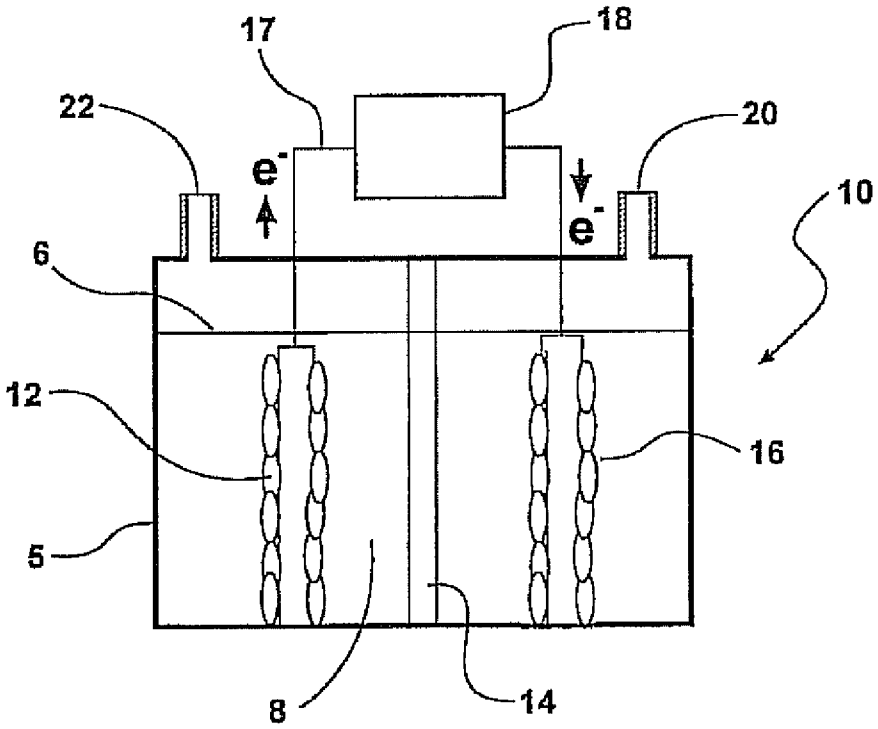
(12) **United States Patent**
Cheng et al.

(10) **Patent No.: US 8,440,438 B2**
(45) **Date of Patent: May 14, 2013**

(54) **ELECTROMETHANOGENIC REACTOR AND PROCESSES FOR METHANE PRODUCTION**

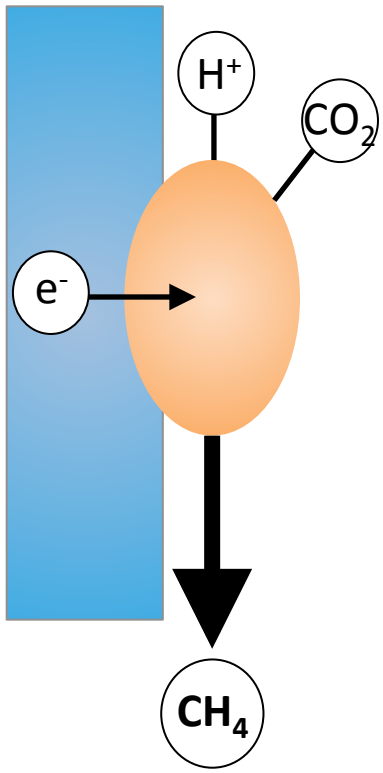
(75) Inventors: **Shaoan Cheng**, State College, PA (US); **Bruce Logan**, State College, PA (US)

rRNA sequence analyses. International Journal of Systematic Bacteriology. 1993. 43(2): 278-286.*
Wolin, EA et al. Formation of methane by bacterial extracts. Journal of Biological Chemistry. 1963. 238(8): 2882-2886.*
Bond, et al., Electrode-Reducing Microorganisms That Harvest Energy from Marine Sediments, *Science*, 295: 483-485, 2002.
Bond, et al. Electricity Production by *Geobacter sulfurreducens*

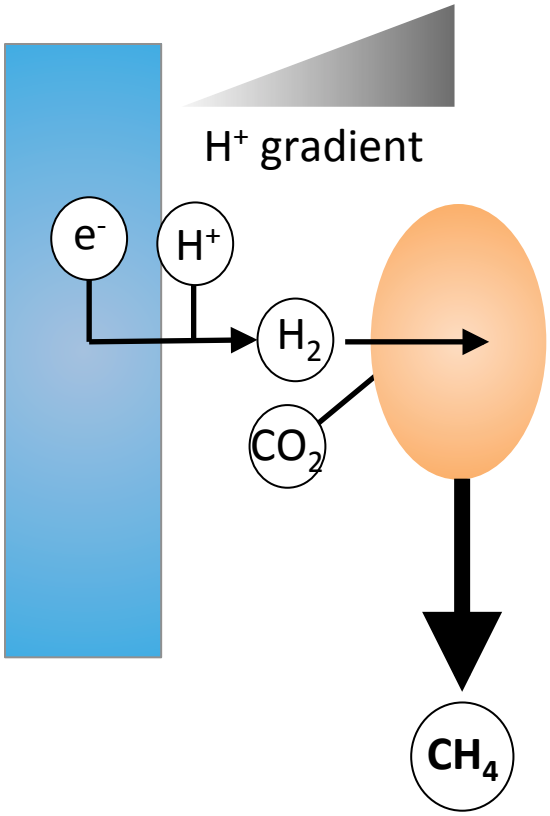


Current-driven methanogenesis

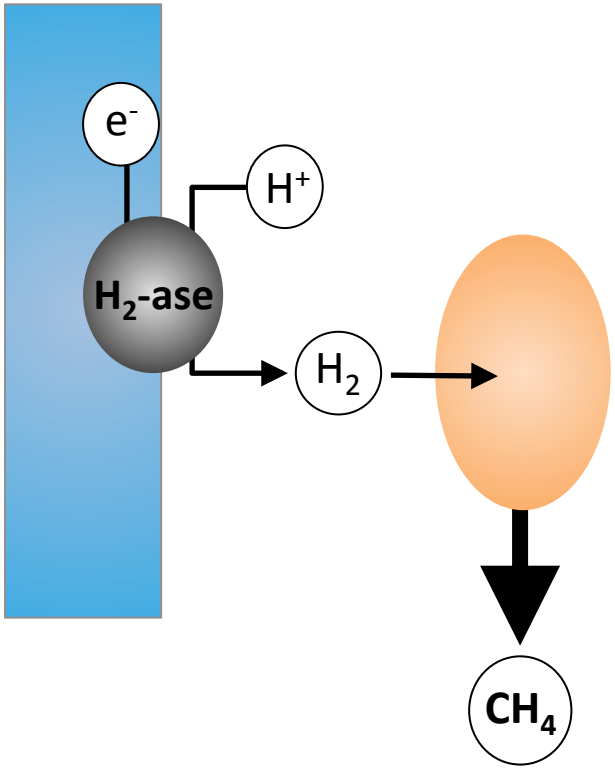
Direct via outermembrane redox proteins



Indirect using electrochemically produced H_2/formate

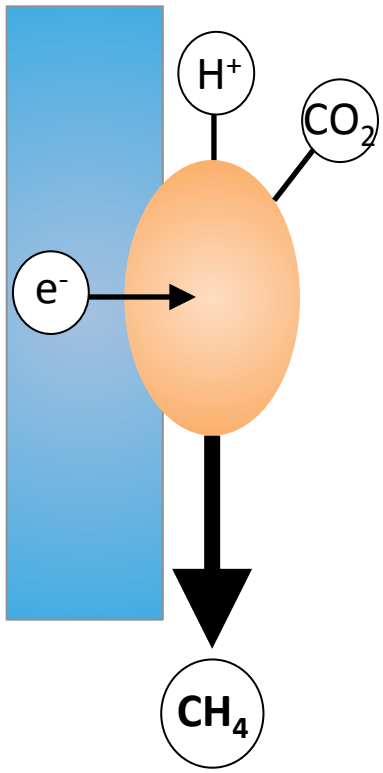


Indirect using H_2 produced enzymatically at the cathode

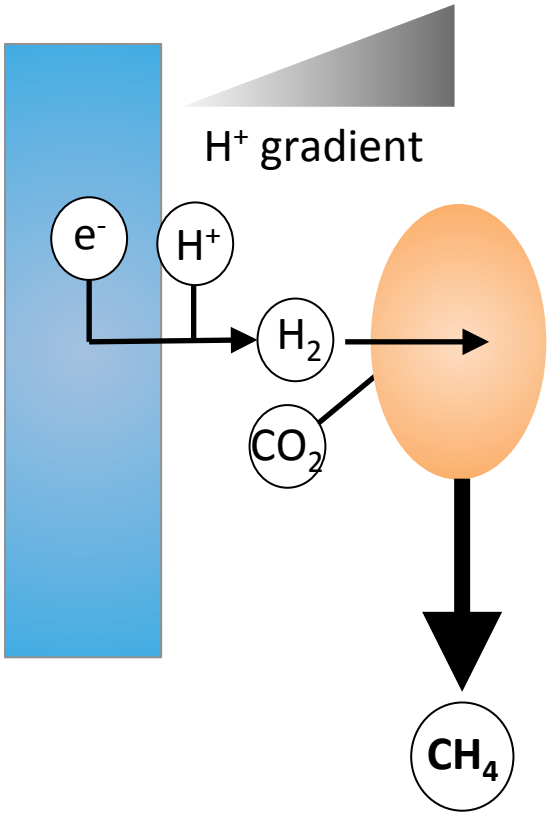


Current-driven methanogenesis

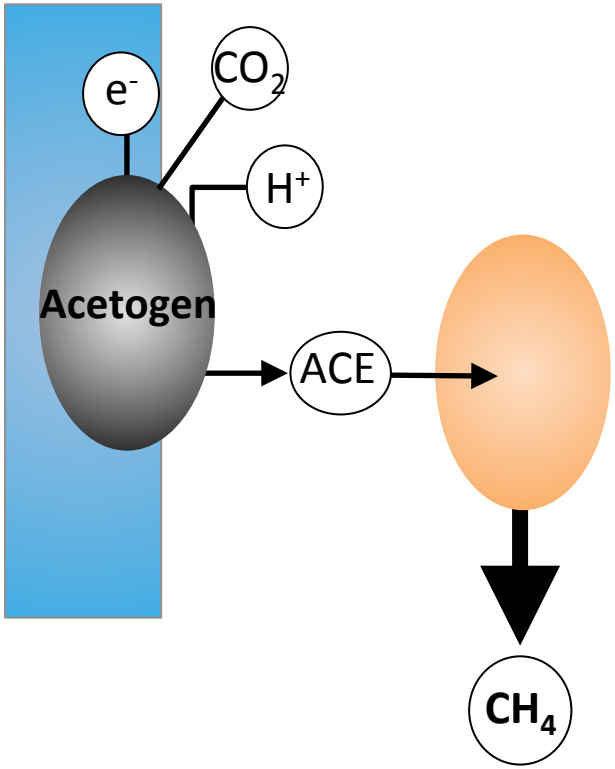
Direct via outermembrane redox proteins

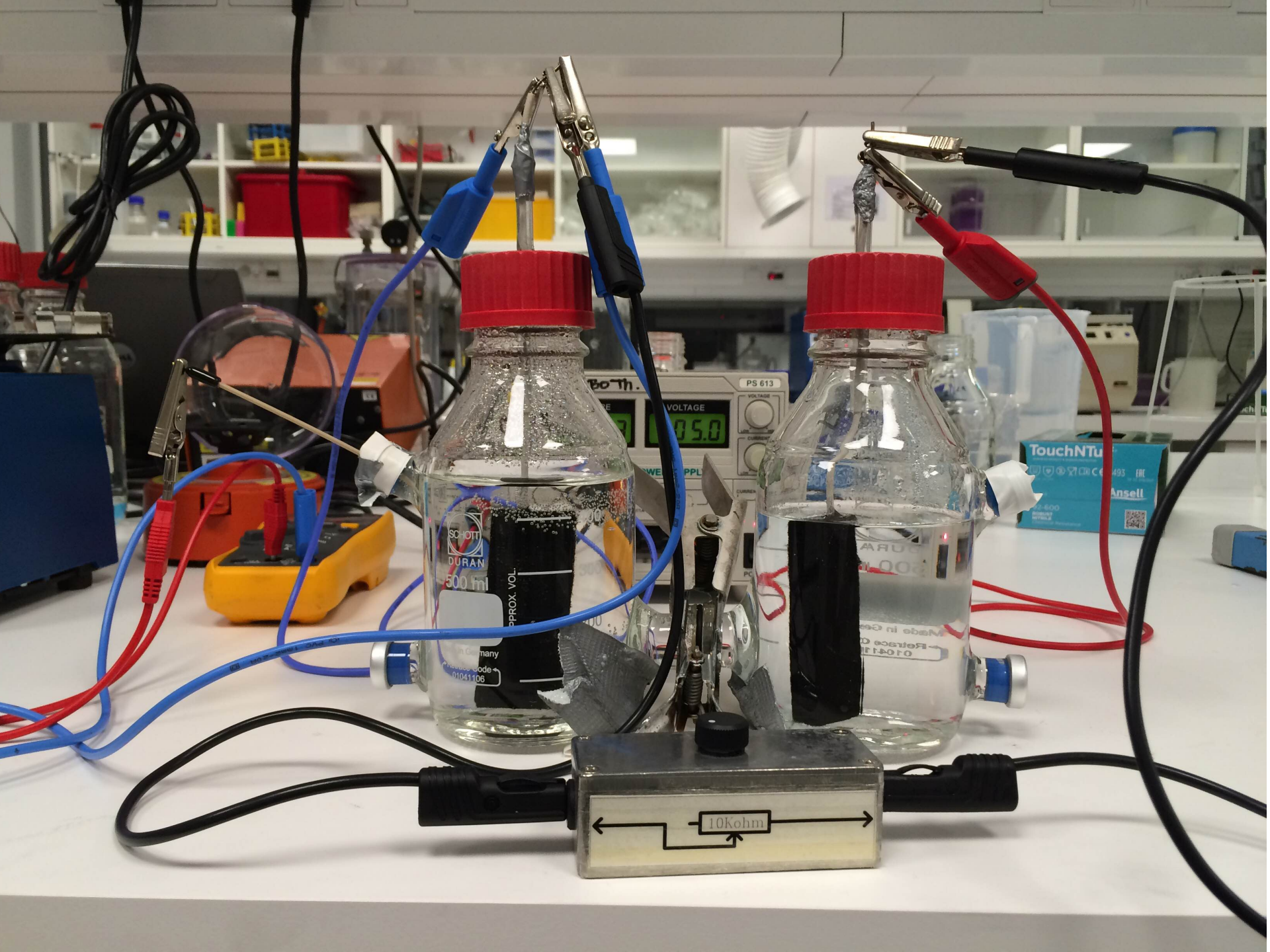


Indirect using electrochemically produced H_2/formate



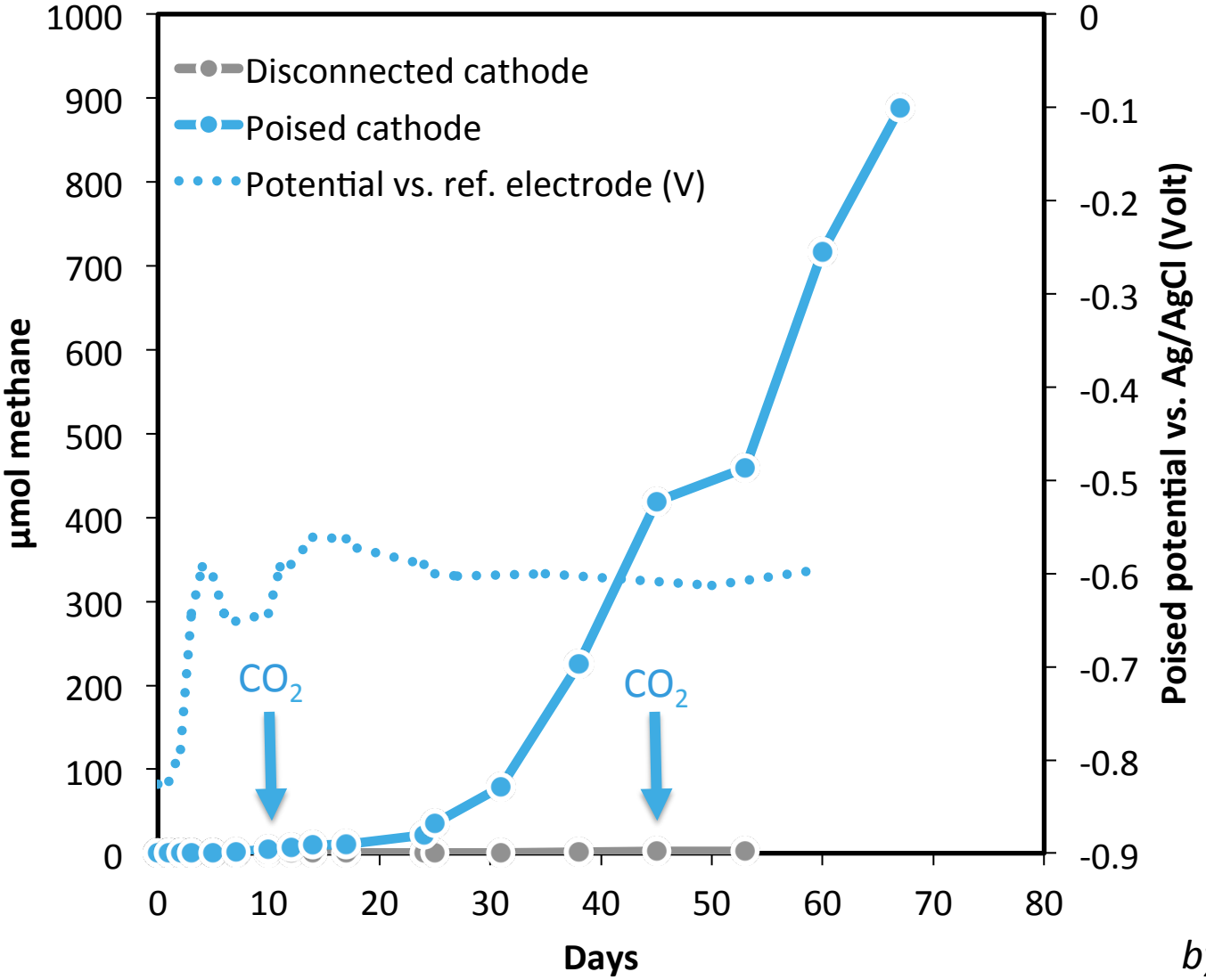
Indirect using acetate produced by acetogens




PS 613
VOLTAGE
SCHOTT
DURAN
500 ml
10Kohm

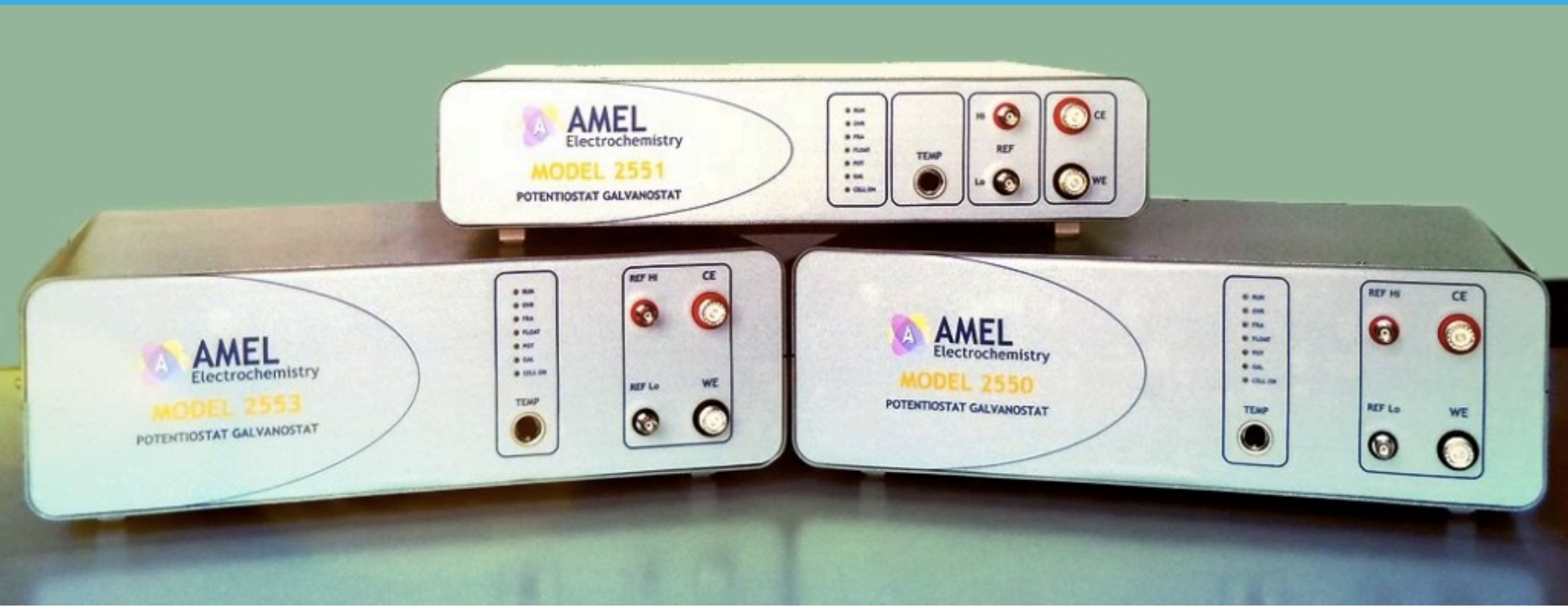
a *Methanosarcina*

- which cannot use H_2 or formate



by Mon Yee Oo

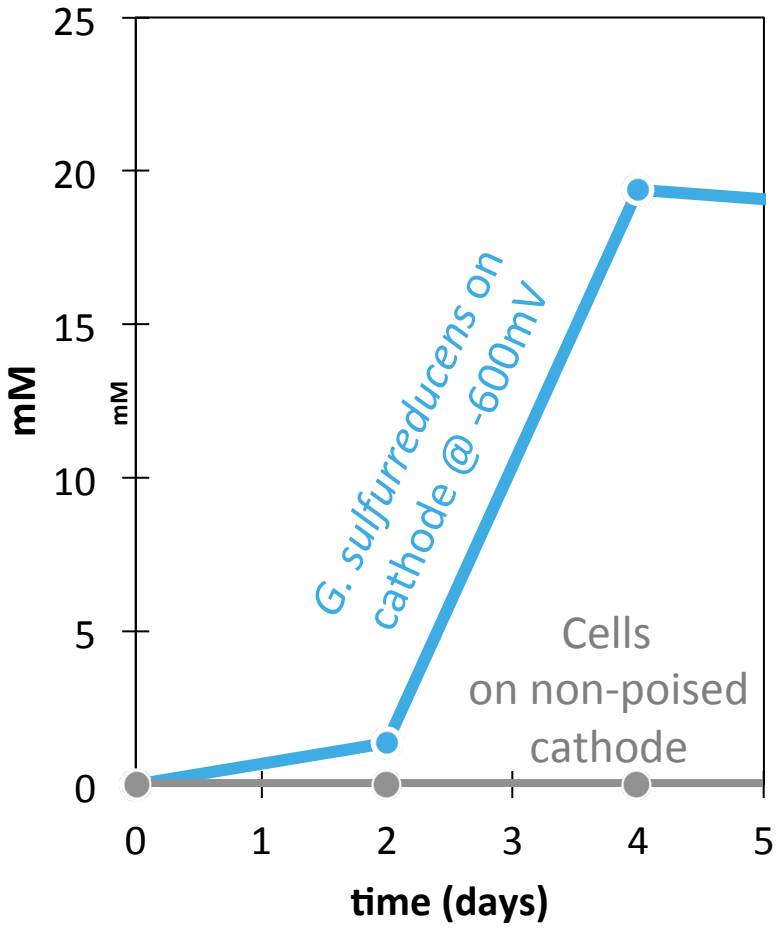
New potentiostats

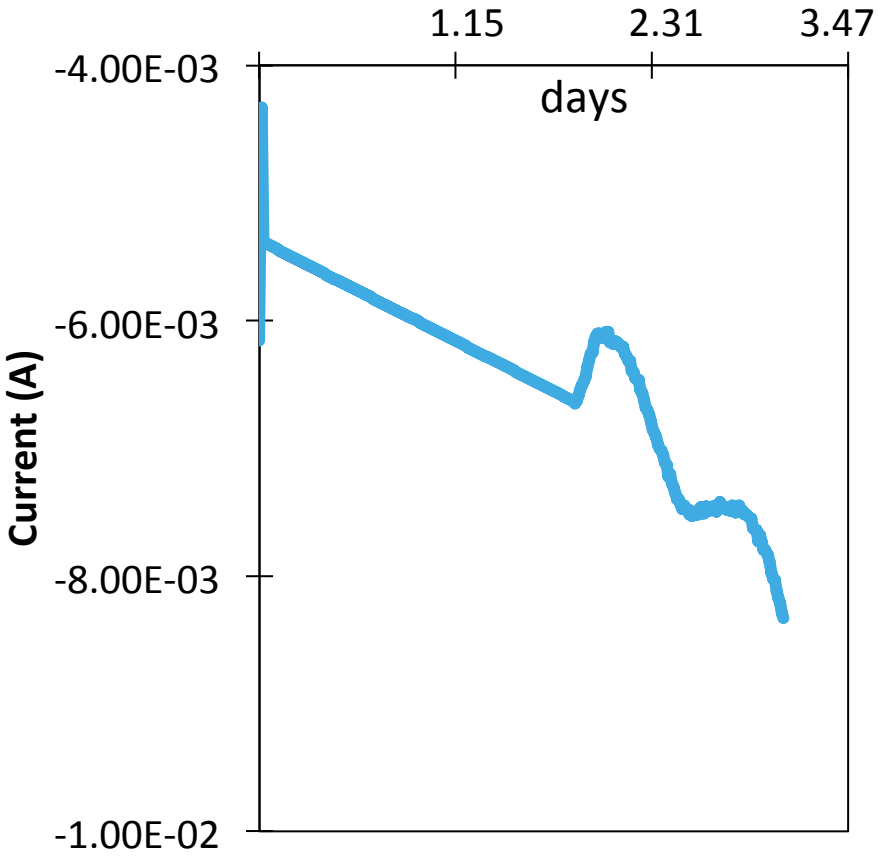


PalmSens
Compact Electrochemical Interfaces


AMEL
Electrochemistry
POTENTIOSTAT GALVANOSTAT
REF HI
CE
TEMP
AMEL
Electrochemistry
POTENTIOSTAT GALVANOSTAT
TEST 2
TEST 2

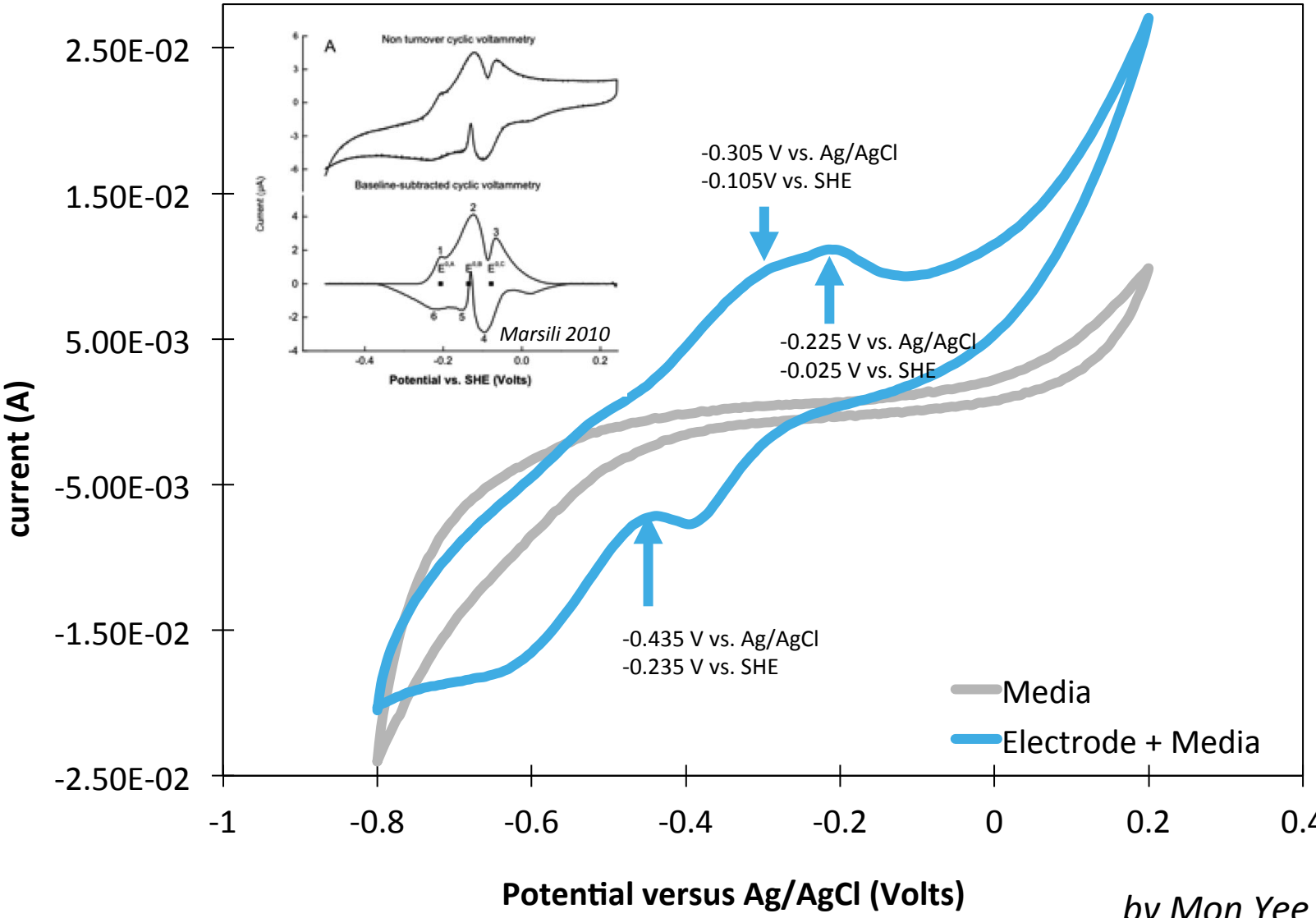
Geobacter sulfurreducens on a cathode polarized at -600mV by AMEL2550



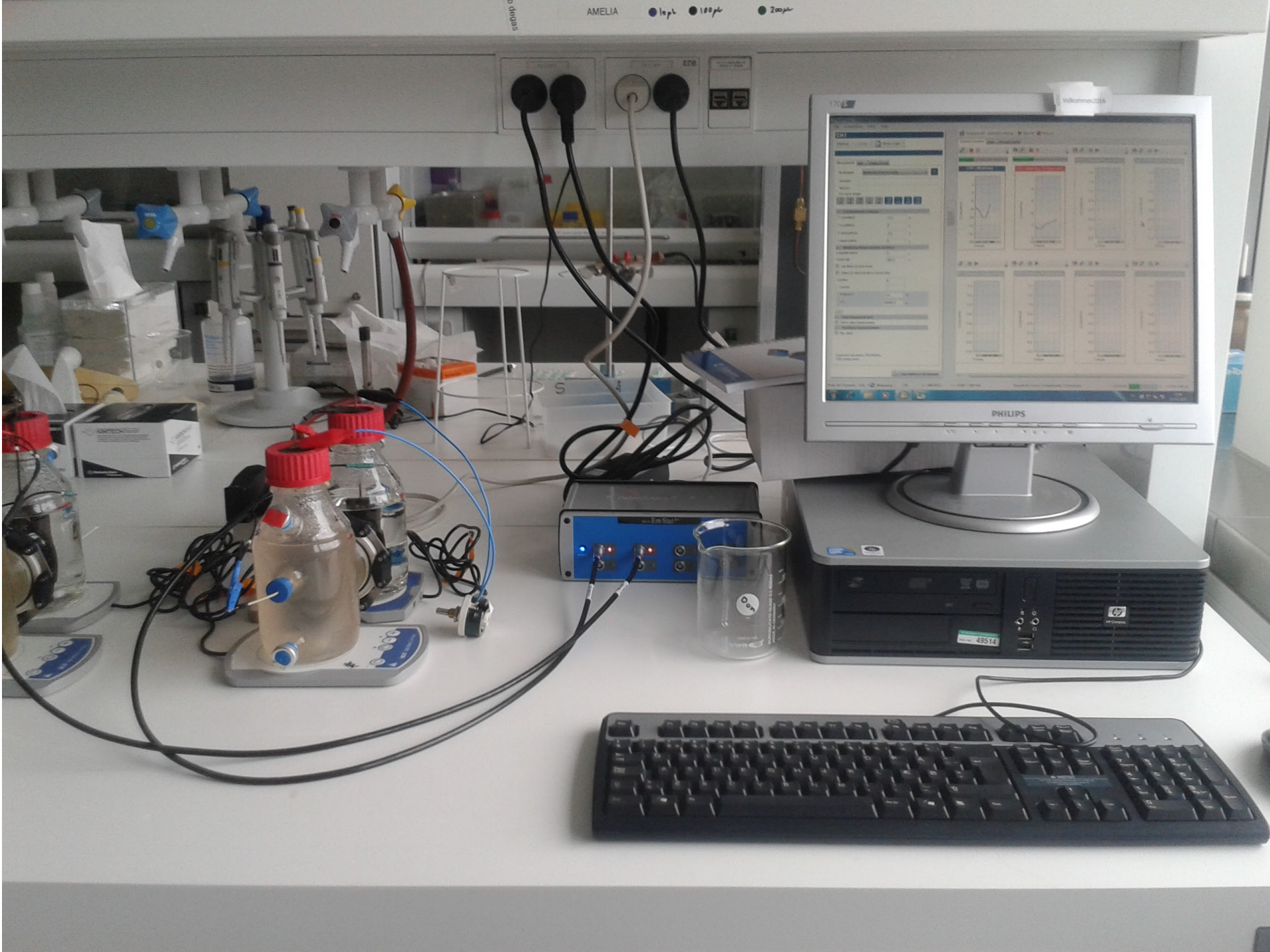


by Mon Yee Oo

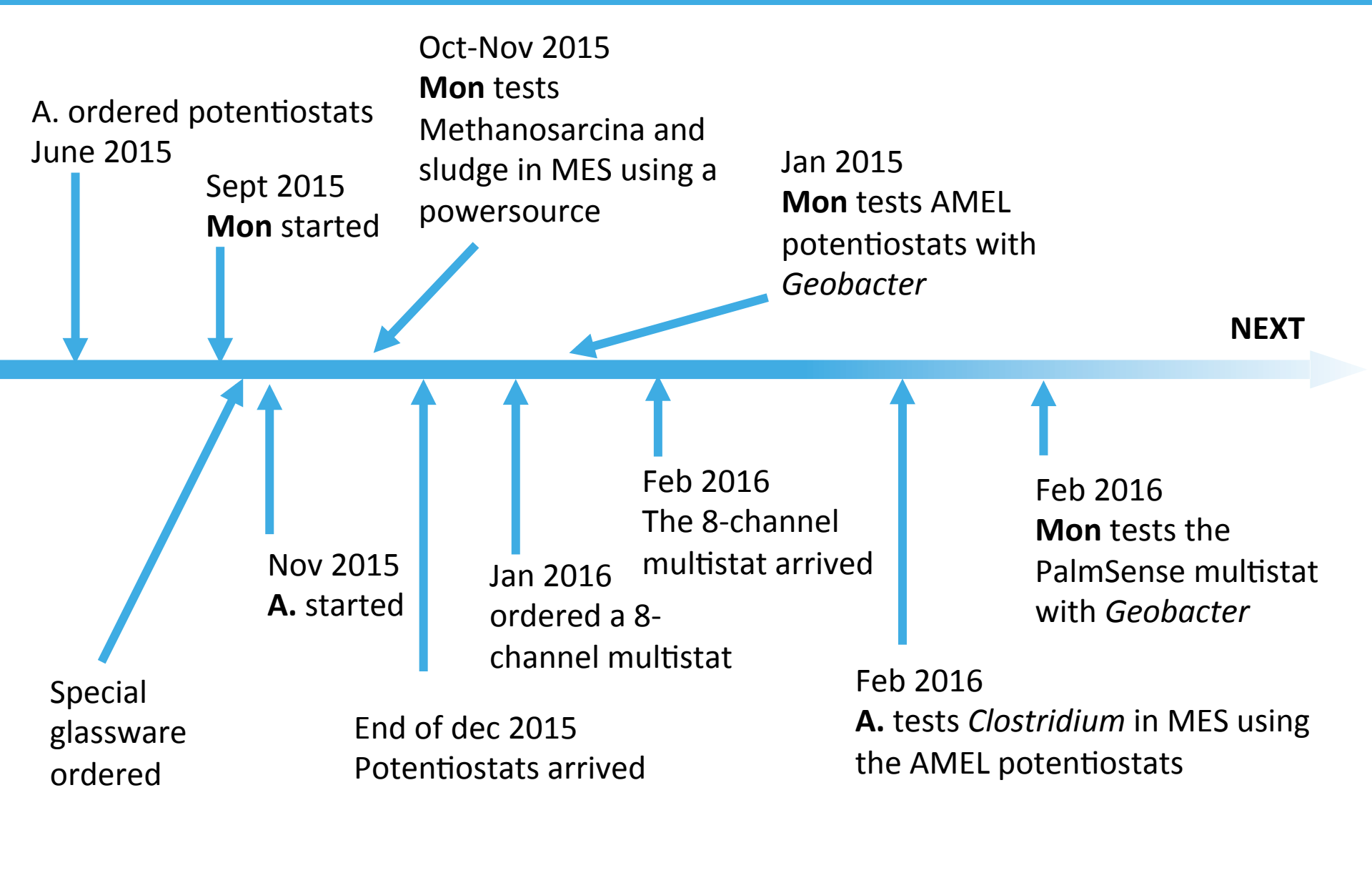
Cyclic voltametry – 3 redox couples



by Mon Yee Oo

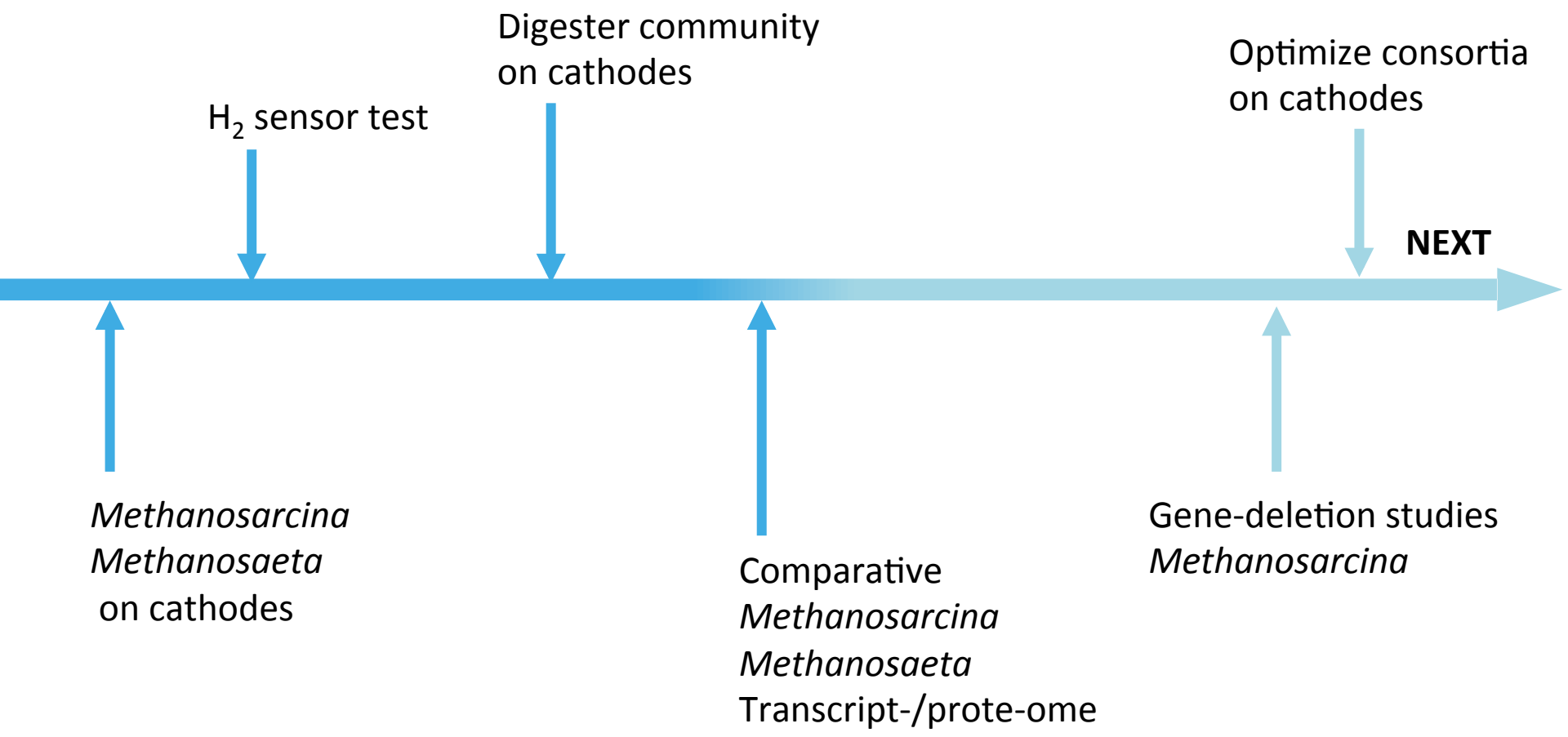

AMELIA
PHILIPS

Time line


A. ordered potentiostats
June 2015
Sept 2015
Mon started
Oct-Nov 2015
Mon tests Methanosarcina and sludge in MES using a powersource
Jan 2015
Mon tests AMEL potentiostats with *Geobacter*
NEXT
Special glassware ordered
Nov 2015
A. started
End of dec 2015
Potentiostats arrived
Jan 2016
ordered a 8-channel multistat
Feb 2016
The 8-channel multistat arrived
Feb 2016
A. tests *Clostridium* in MES using the AMEL potentiostats
Feb 2016
Mon tests the PalmSense multistat with *Geobacter*

What next?

Who? How?



PEOPLE: Mon, Karen, Amelia, Bo, Lars, Lars-Peter, Niels-Peter, Cornelia