



Technische  
Universität  
Braunschweig



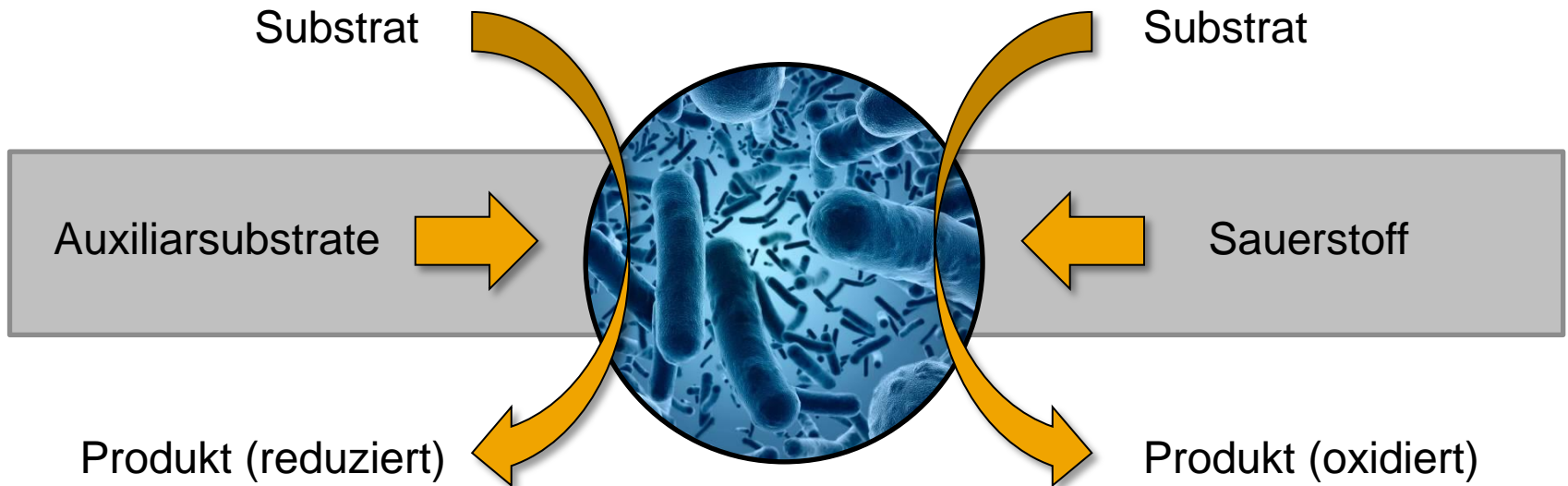
## **Elektrifizierte Mikrobiologie – Bakterien mit Potential!**

Uwe Schröder, Institut für Ökologische und Nachhaltige Chemie, Technische Universität Braunschweig

**Workshop "Mikrobielle Brennstoff- und Elektrolysezellen"**

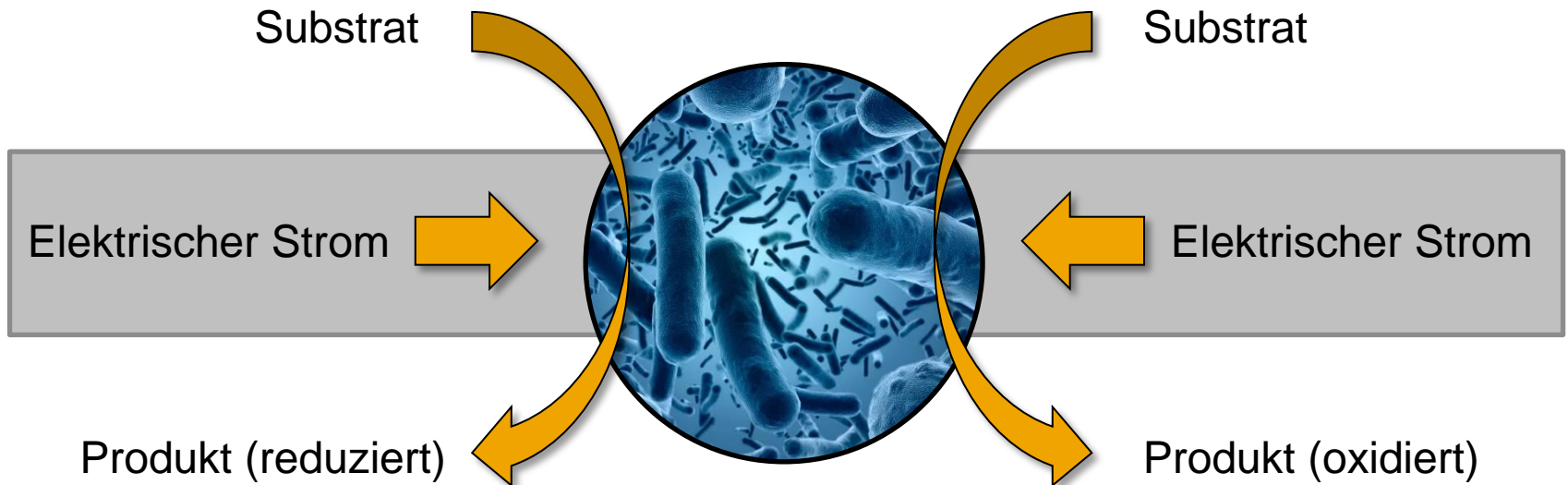
**Reduktion**

**Oxidation**



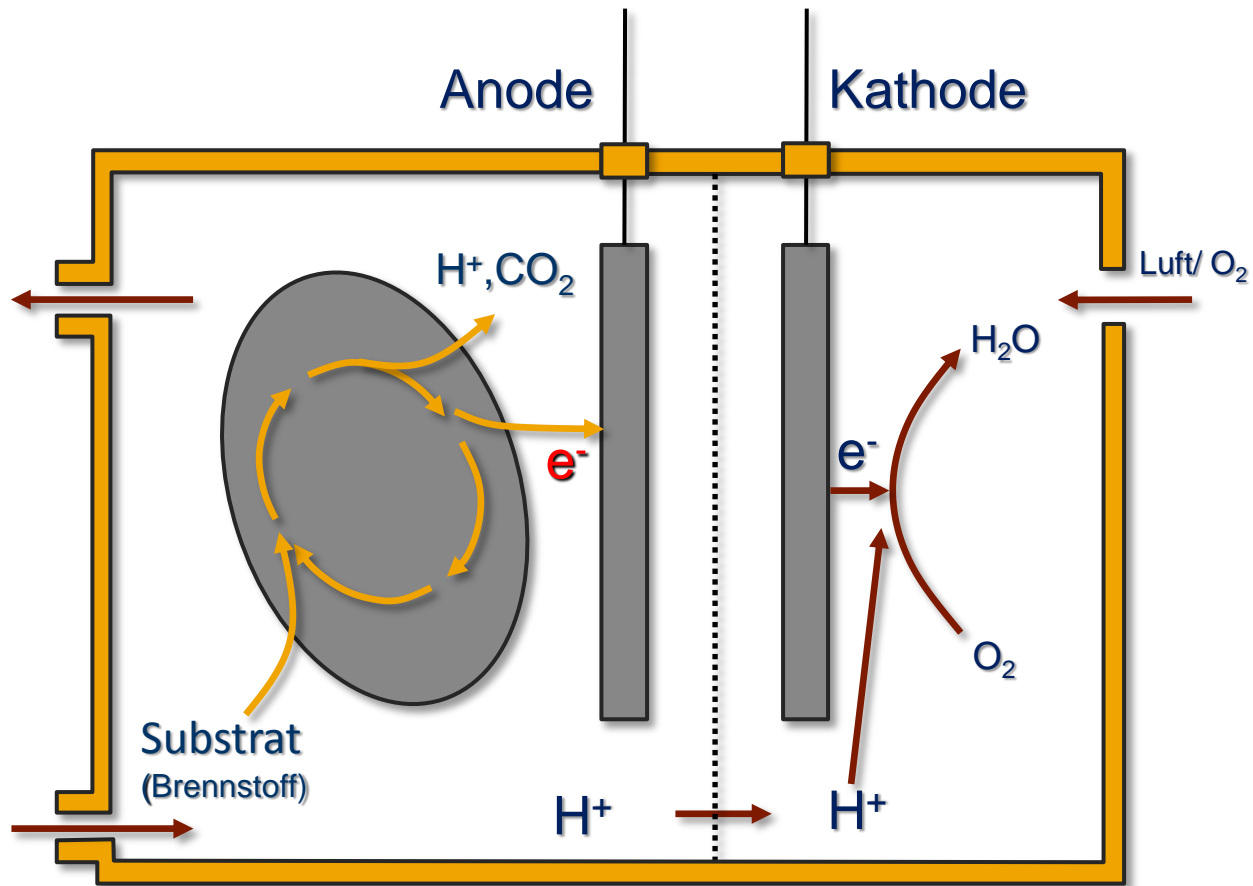
**Reduktion**

**Oxidation**



Mikrobiologie + Elektrochemie = mikrobielle Elektrochemie  
→ Elektrobiotechnologie

# Archetypus *Mikrobielle Brennstoffzelle*

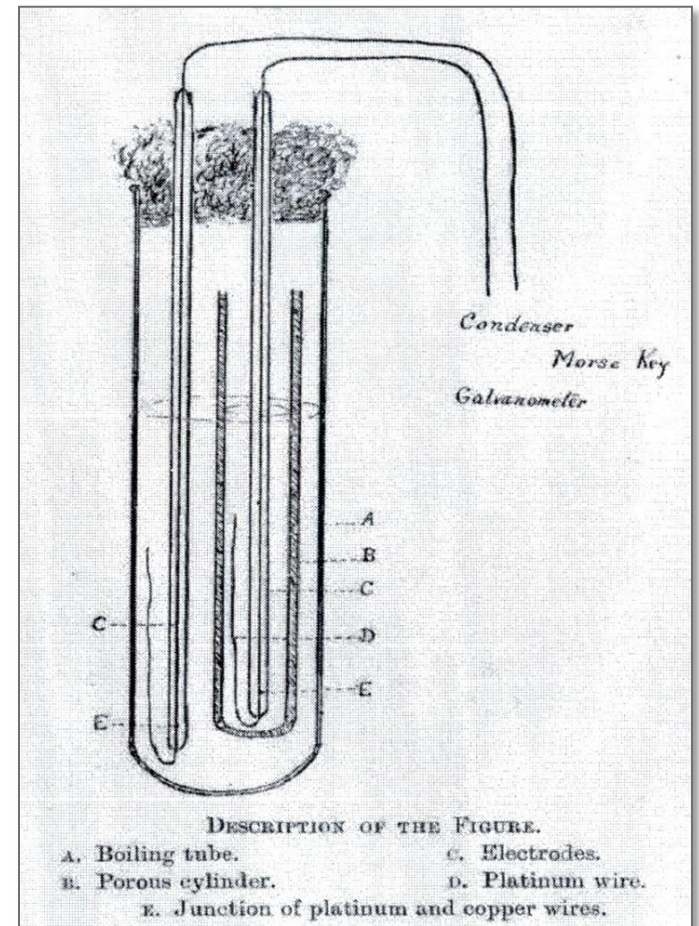


# Vor 100 Jahren

Es wird entdeckt, dass Mikroorganismen Stoffe abbauen und durch Zusatz von Hilfsstoffen dabei elektrischen Strom produzieren können. Das ist die Geburtsstunde „mikrobieller Brennstoffzellen“.

## Electrical Effects Accompanying the Decomposition of Organic Compounds

Potter, Proc. Roy. Soc. London (B)  
(1911) 84, 260-276



# Vor 50 Jahren

Die NASA untersucht den Einsatz der mikrobiellen Brennstoffzellen in der Raumfahrt.



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NASA CR-54051  
U-2670  
W.O. 2067

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NASA CR-54051

**FINAL TECHNICAL REPORT**  
**STUDY OF THE FUNDAMENTAL PRINCIPLES**  
**OF BIO-ELECTROCHEMISTRY**

by  
R.C. Bean, Y.H. Inami, P.R. Basford, M.H. Boy  
W.C. Shepherd, E.R. Walwick and R.E. Ke

prepared for  
**NATIONAL AERONAUTICS AND SPACE ADMINISTRATION**  
Washington, D.C.

JUNE 30, 1964

Contract NASw-655  
Reporting Period: March

TECHNICAL  
NASA Lewis Research Center  
Cleveland, Ohio  
Space Power  
Technique  
Mechanics

Especially attractive would be methods for using waste or  
sider obtaining biochemical electricity from their sea and/or  
as garbage, body wastes, or organic matter in fresh or salt wa

**CASE FILE COPY**

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JUN 30 1964  
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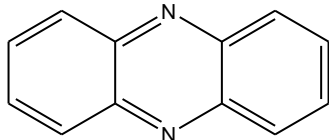
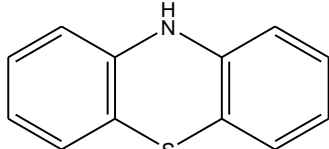
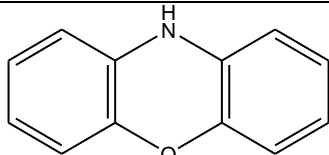
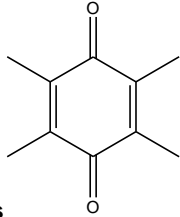
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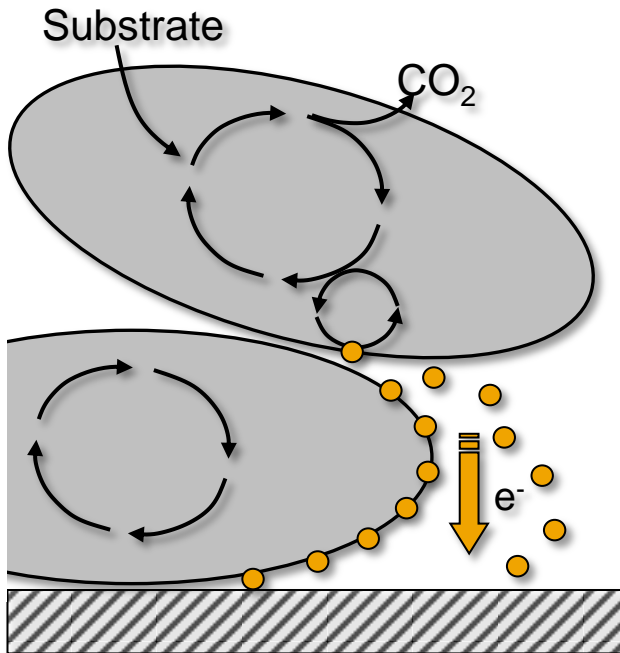
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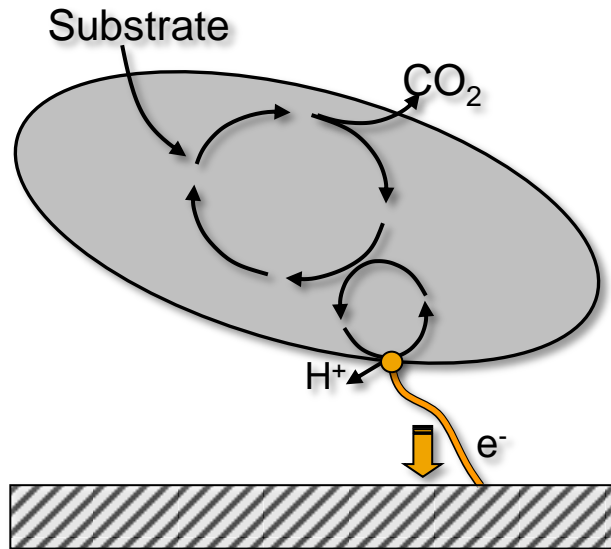
# Problem Mediatoreinsatz

Substance Class	Redox Mediator	Redox Potential $E^{\circ}$ / V
 Phenazines	Neutral Red	- 0.32
	Safranine	- 0.29
	Phenazine ethosulfate	0.06
 Phenothiazines	New Methylene Blue	- 0.02
	Toluidine Blue O	0.03
	Thionine	0.06
	Phenothiazinone	0.13
 Phenoxazines	Resorufin	- 0.05
	Gallocyanine	0.02
 Quinones	2-Hydroxy-1,4-naphthoquinone	n.n.
	Anthraquinone-2,6-disulfonate	n.n.

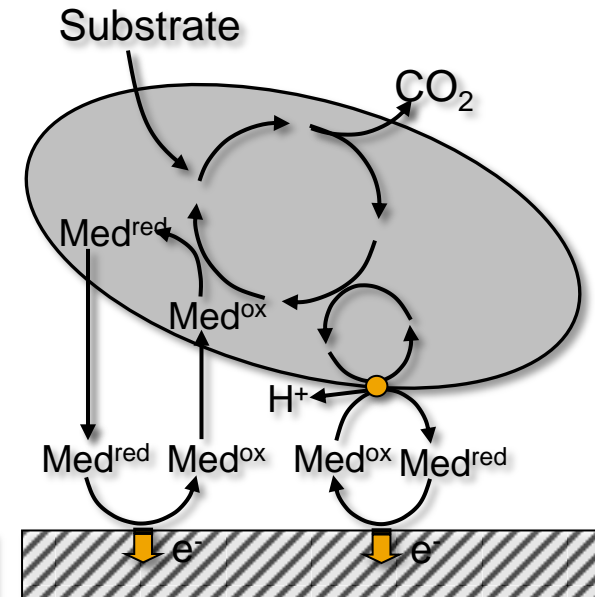
# Schlüsselprozess extrazellulärer Elektronentransfer!



Hopping



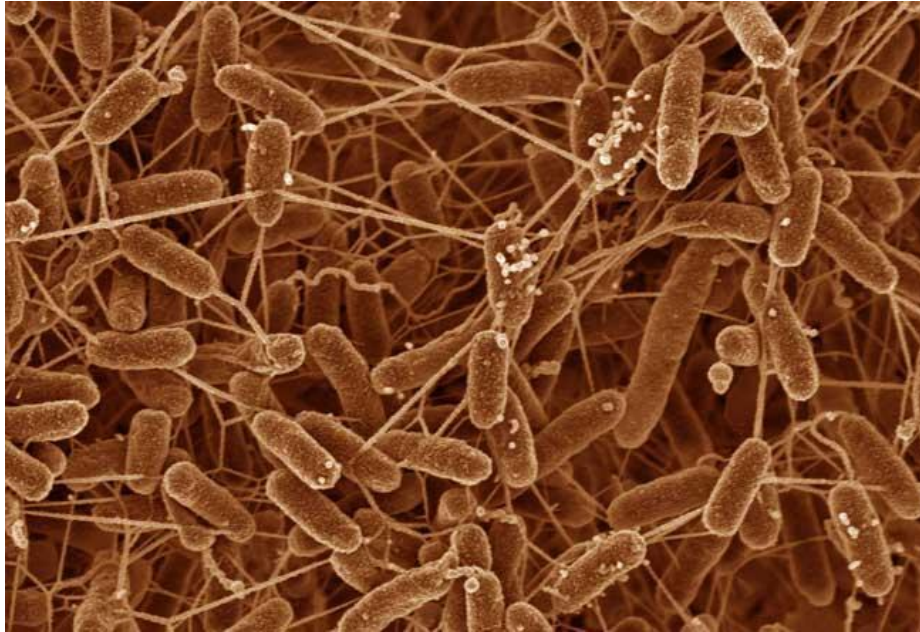
Leitung



Diffusion



# Elektrochemisch aktive Bakterien & Biofilme



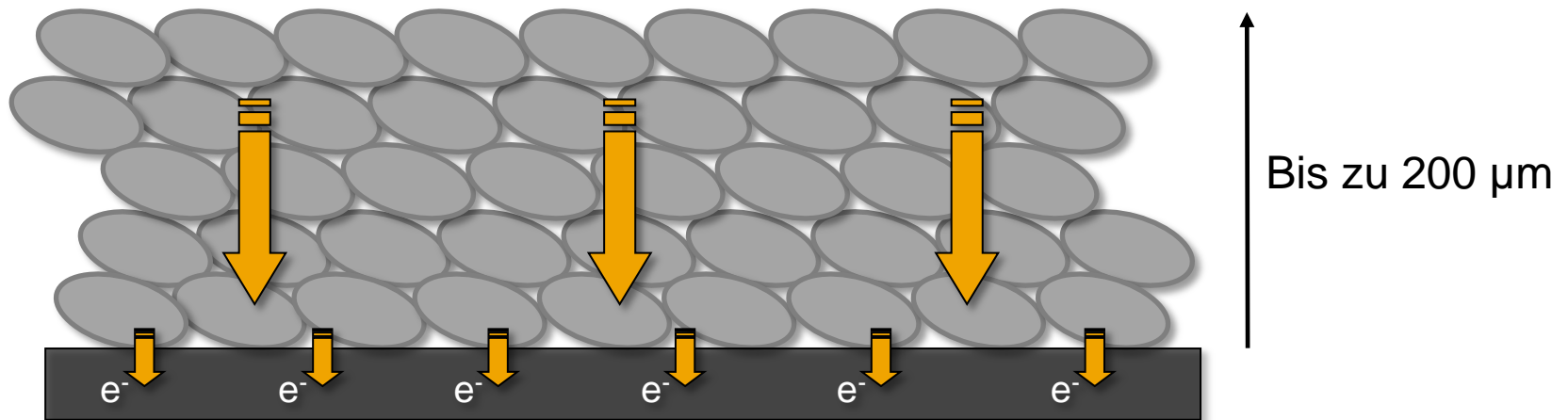
Y. Gorby et al., PNAS, 2006 vol. 103, pp 11358-11363



Quelle: Flickr

# Elektrochemisch aktive Bakterien & Biofilme

1-1.5 mA/cm<sup>2</sup>



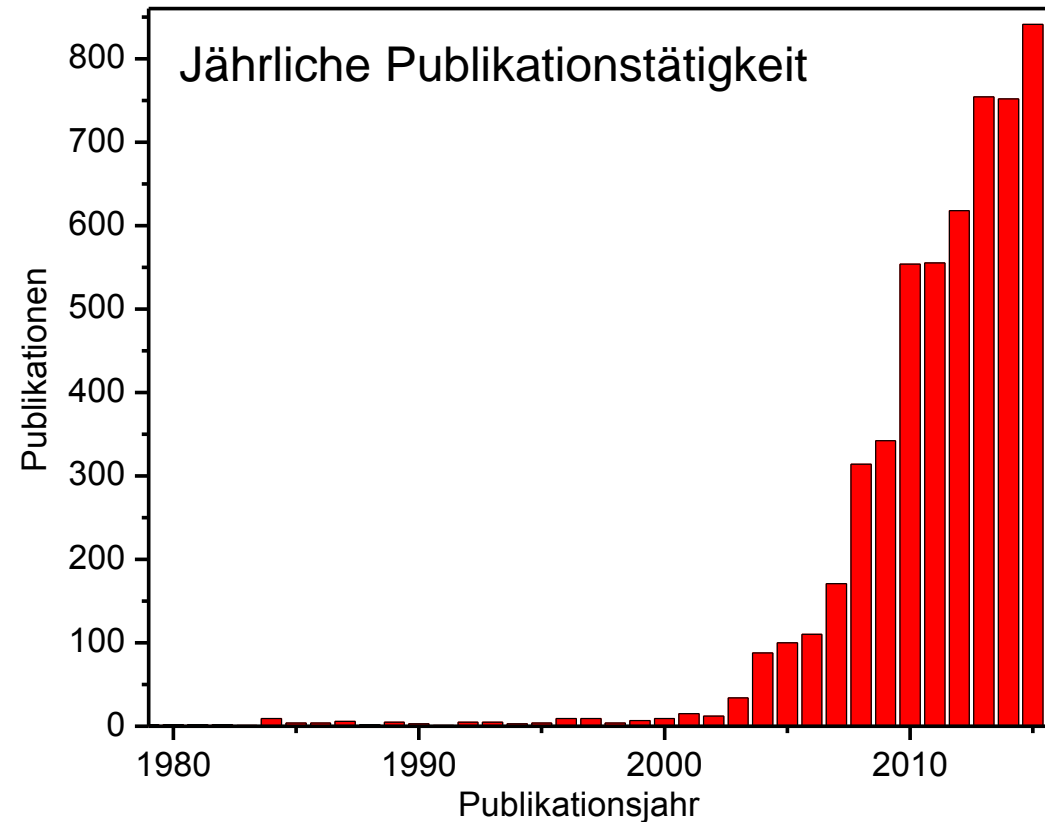
# Killerapplikation Abwasserbehandlung



- Annual amount of municipal wastewater in Germany ca. 10 km<sup>3</sup>\*
- Annual energy consumption of German wastewater treatment plants: 4,4 TWh!\*
- Energy contents in municipal wastewater: ca. 3,3 kWh/m<sup>3</sup>
- Energy contents in municipal wastewater (per year, in Germany): ca. 33 TWh



# Eine wachsende, active Community!



***International Society for  
Microbial Electrochemistry &  
Technology (ISMET)***

***ISMET-Tagungen***

*2008: Pen State, USA*

*...*

*2013: Cairns, Australien*

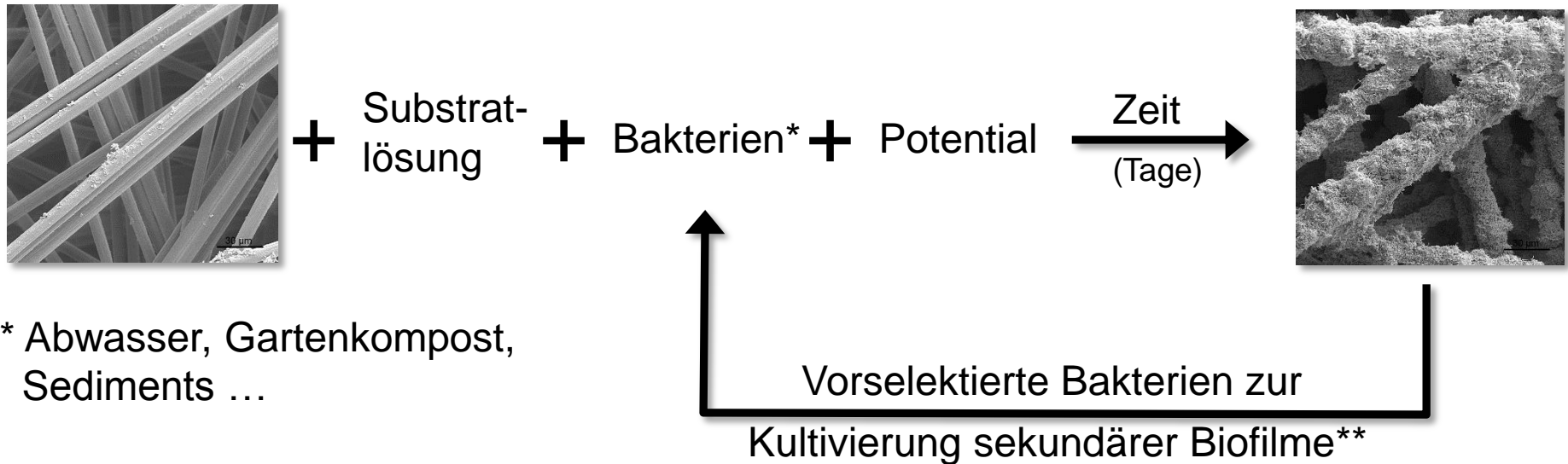
***2015: Arizona, USA***

*2016: EU-, NA- & AP-ISMET Tagungen*

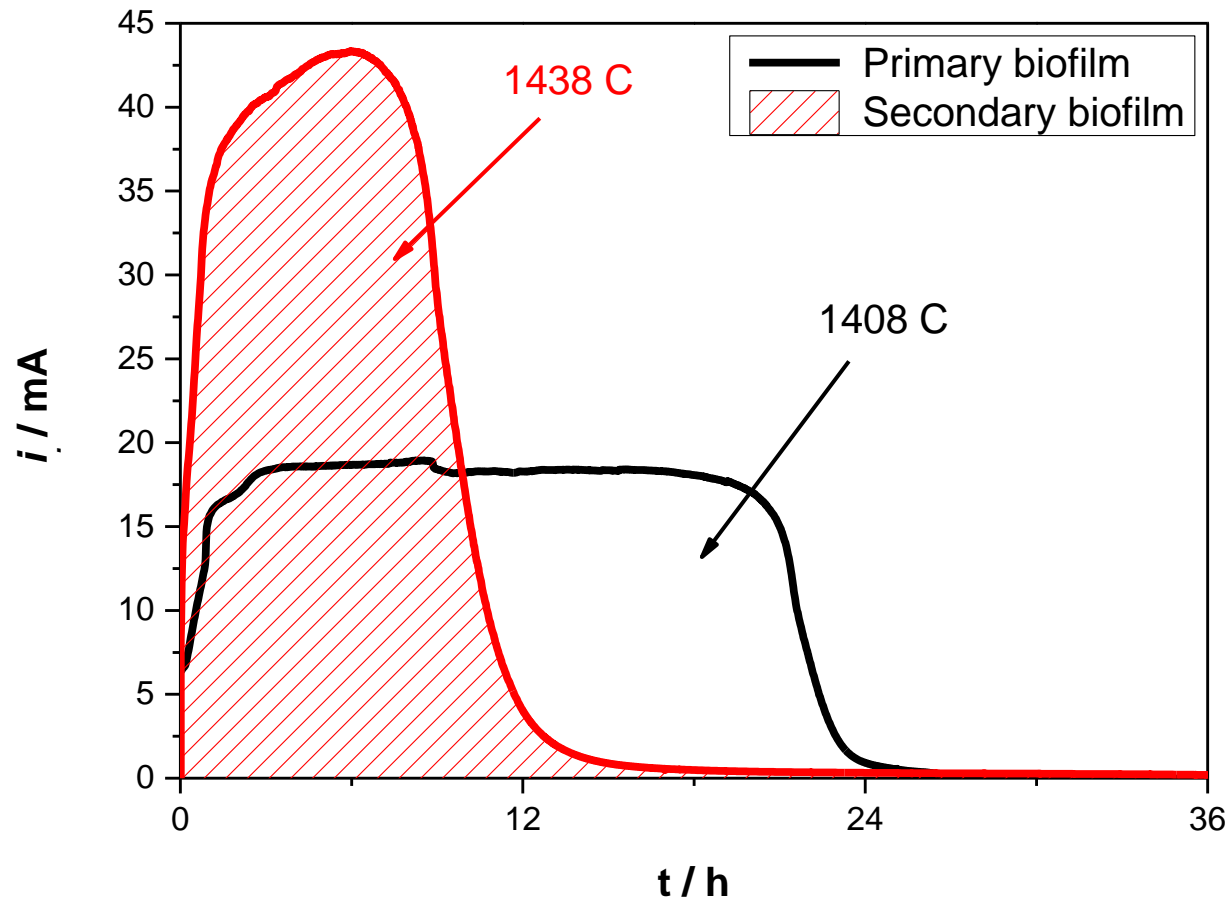
***2017: Estoril, Portugal***

***Plattforminitiative Mikrobielle  
Bioelektrotechnologie***

# Kultivierung elektrochemisch aktiver Bakterien



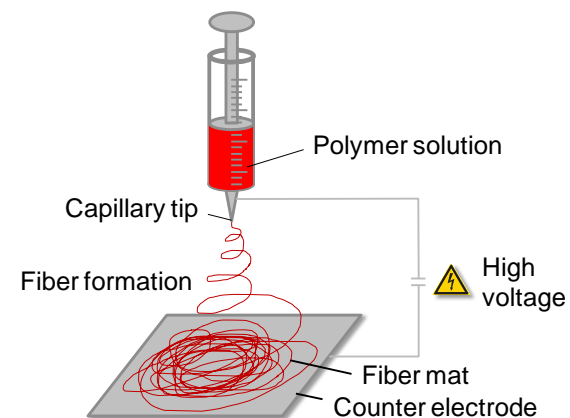
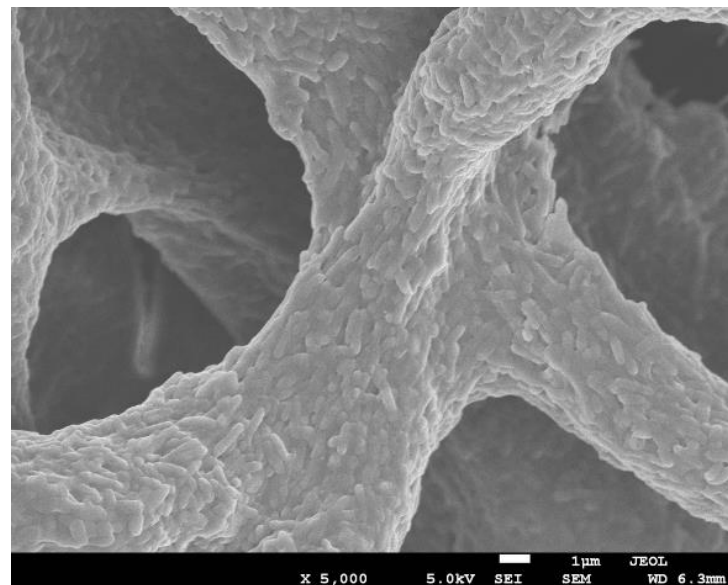
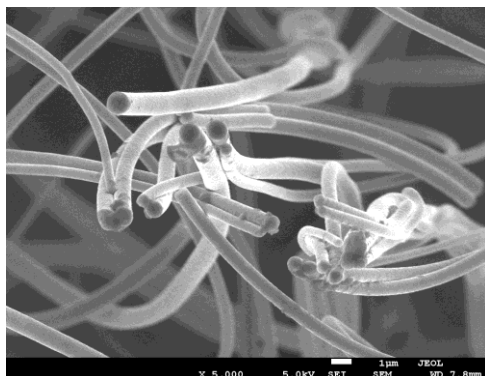
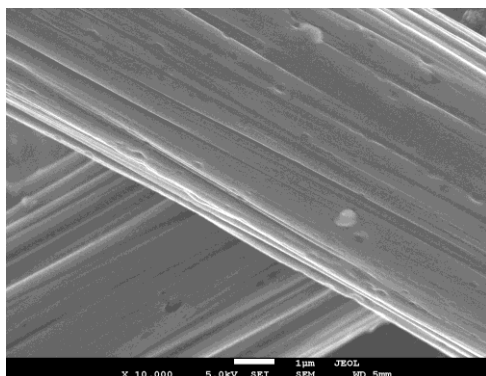
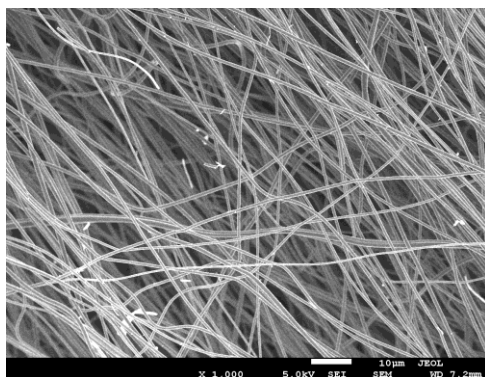
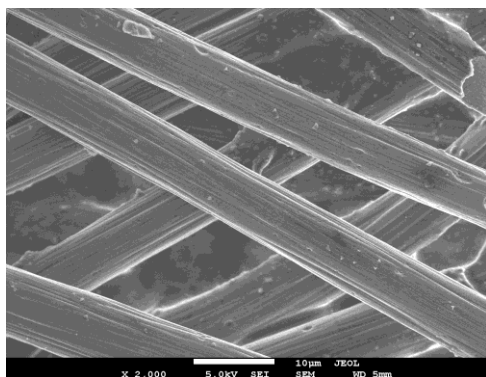
# Kultivierung elektrochemisch aktiver Bakterien





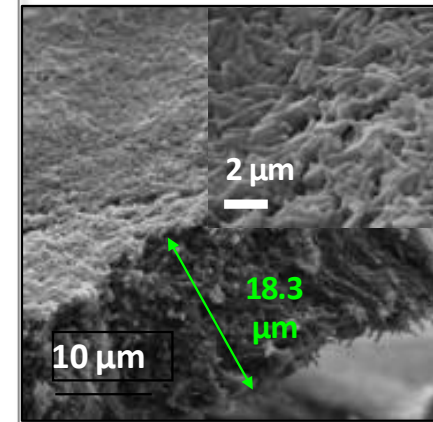
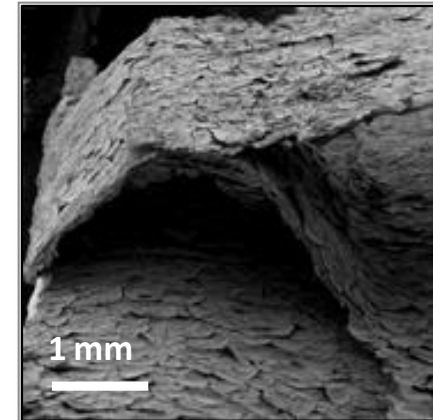
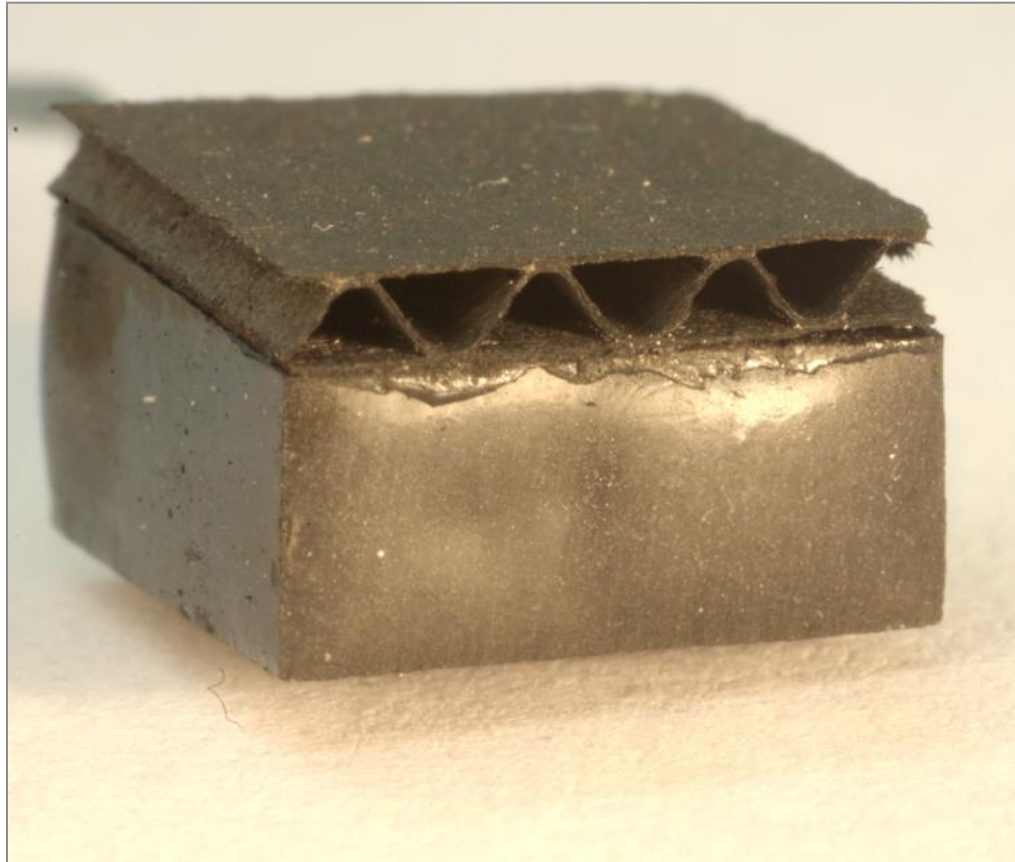
# Maßgeschneiderte 3D-Elektroden

*Electrospun and solution blown three-dimensional carbon fiber nonwovens for application as electrodes in microbial fuel cells*

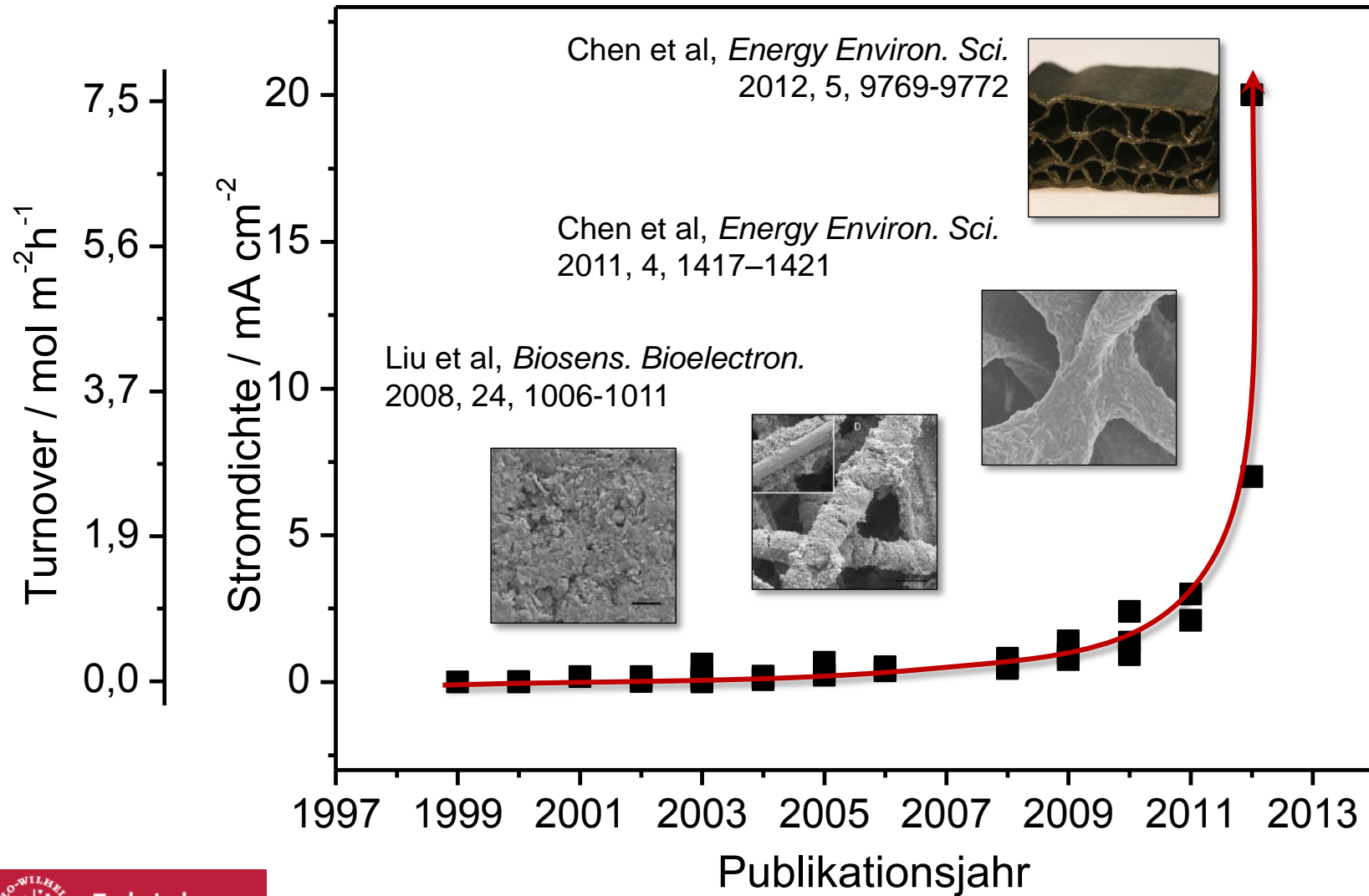




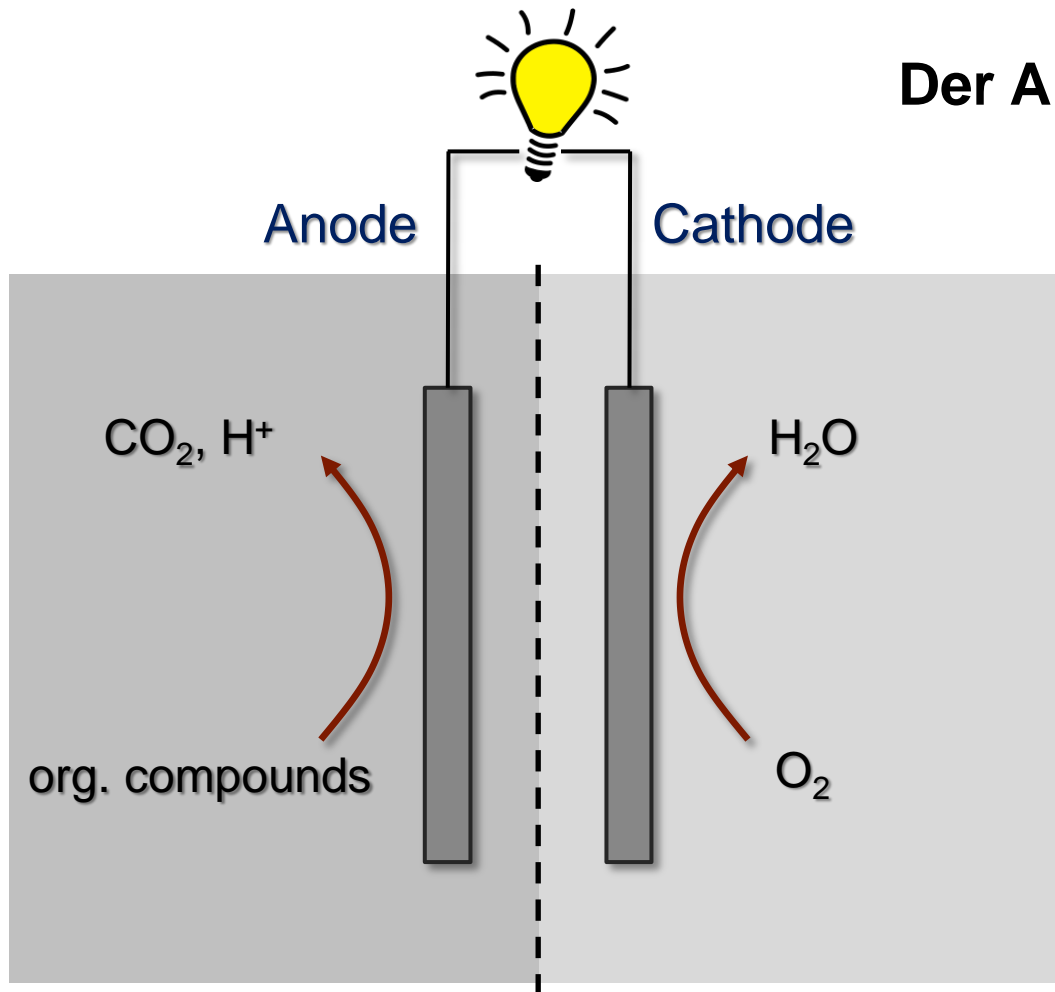
# Maßgeschneiderte 3D-Elektroden



# Leistungsfähigkeit von Biofilmanoden



# Wohin führt der Weg?

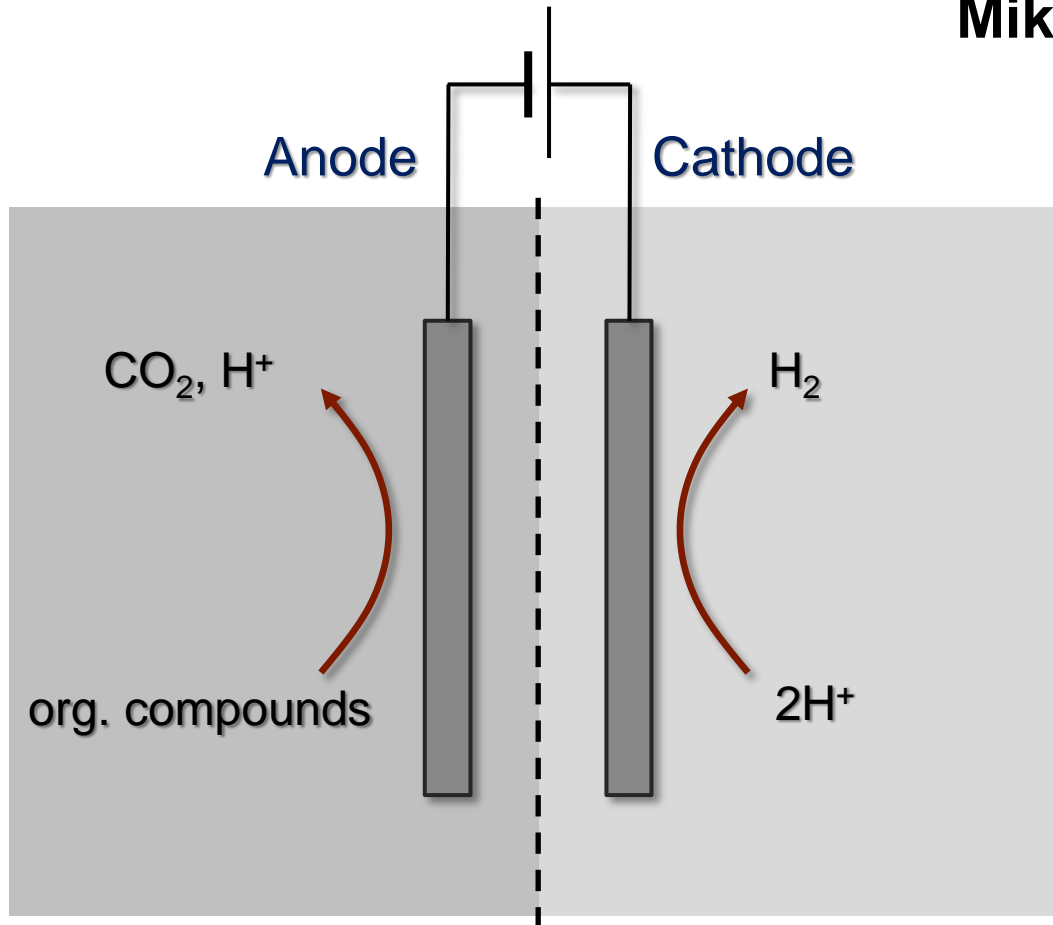


## Der Archetypus – Mikrobielle Brennstoffzelle

- Abwasserreinigung
- Energierückgewinnung
- Entfernung persistenter Stoffe
- Rückgewinnung von Ressourcen

# Wohin führt der Weg?

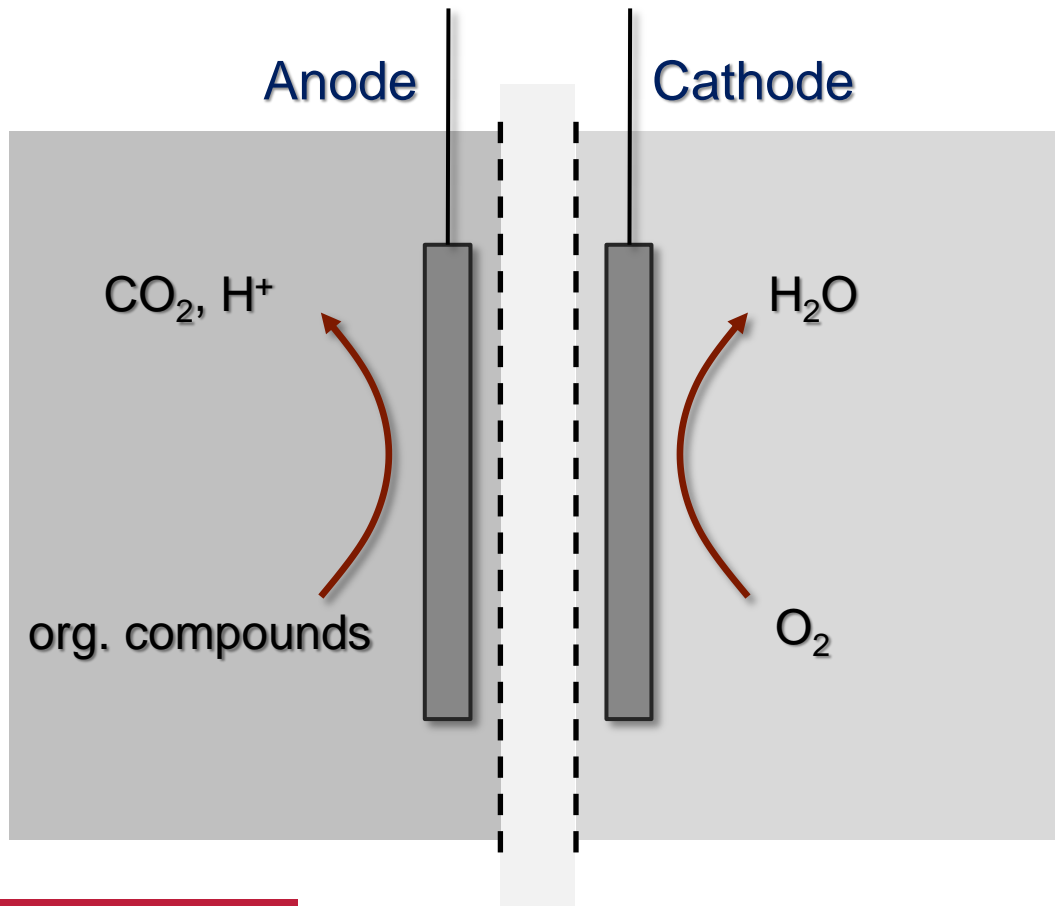
## Mikrobielle Elektrolysezelle



- Höherwertige Produkte (Wasserstoff, Methan anstelle elektrischen Stroms)

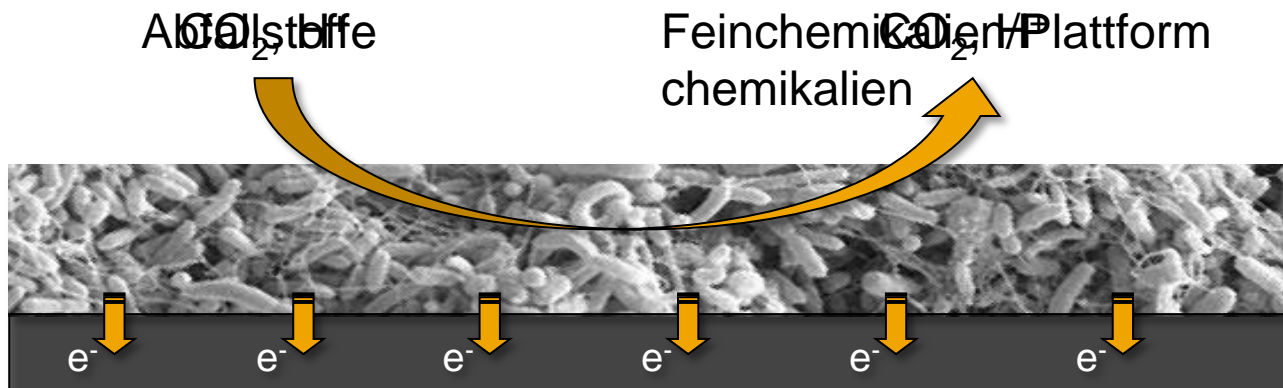
# Wohin führt der Weg?

## Mikrobielle Entsalzungszellen

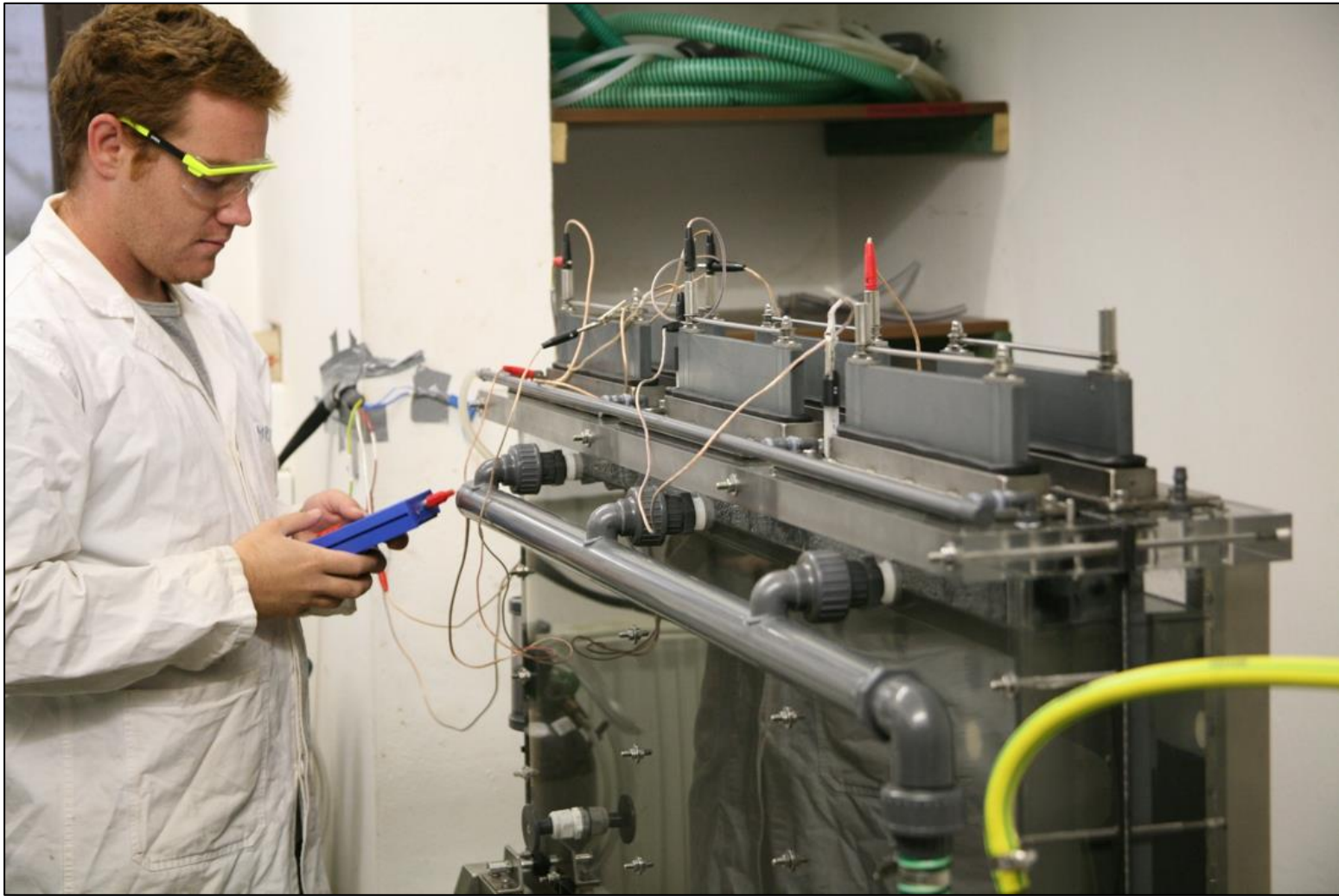


# Wohin führt der Weg?

## Mikrobielle Elektrosynthese



# Von der Grundlagenforschung in die Anwendung





Vielen Dank!