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Department of Chemical Engineering

Does my Research Need more Math???

The Wonders of Bioelectrochemistry

Dr Mirella Di Lorenzo

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24th February 2017

Today's talk



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1. An introduction to Biological Fuel Cells

Discovering 'electrical' bacteria!

2. Energy from wastewaters

The pee power!

3. Sensors for water

If bugs don't like it, you better don't drink it!

4. Where is the MATH?

I have a vision...



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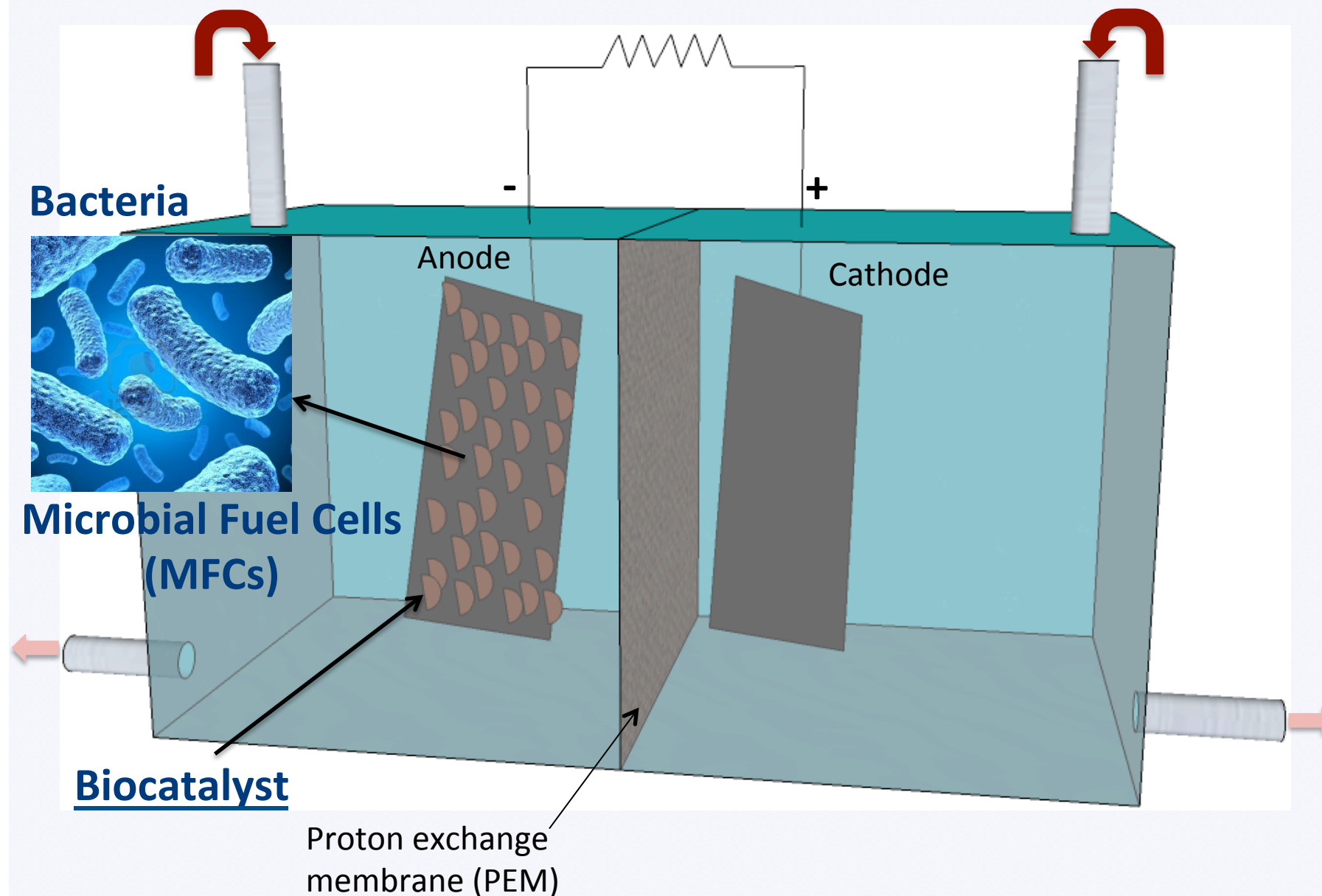
To develop:

1. Effective bioelectrochemical devices for the *renewable* and *carbon-neutral* generation of electricity from wastewaters.
2. *Compact, handy* and *cost-effective* biosensors for quick *on-site* and *real-time* assessment of water quality.

BFCs: Principles of operation



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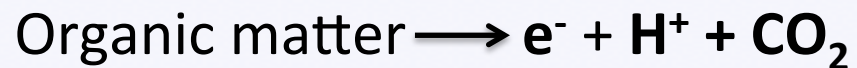
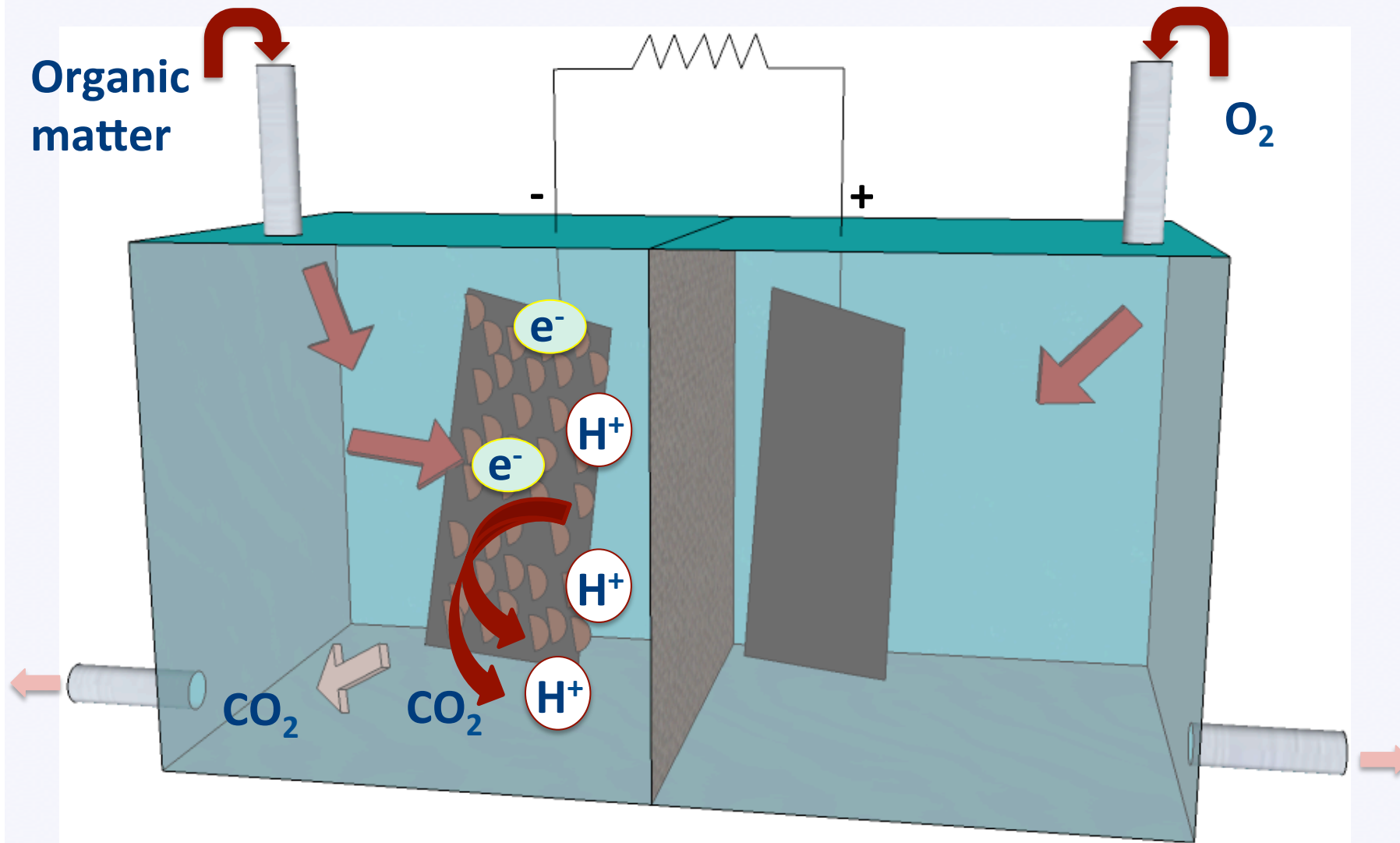


1. An introduction to Biological Fuel Cells (BFCs)

BFCs: Principles of operation



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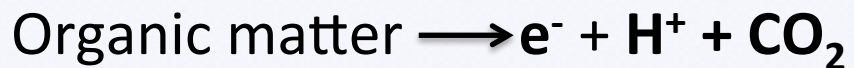
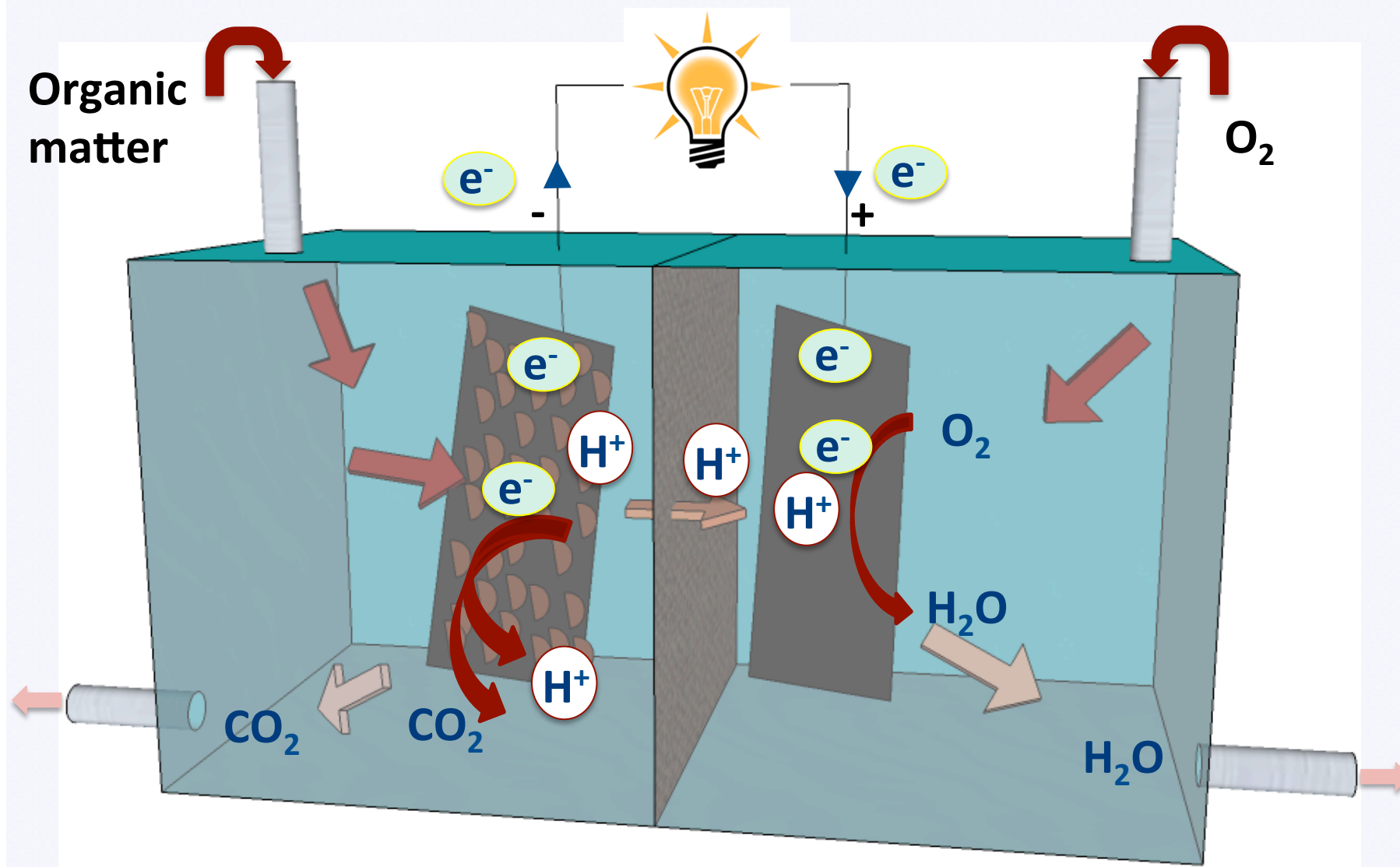


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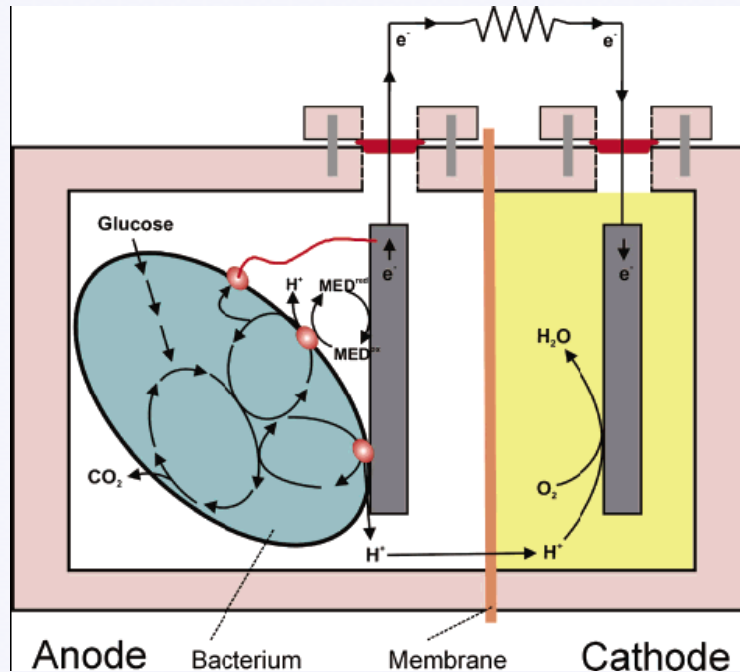


1. An introduction to Biological Fuel Cells (BFCs)

How can bacteria generate electricity?



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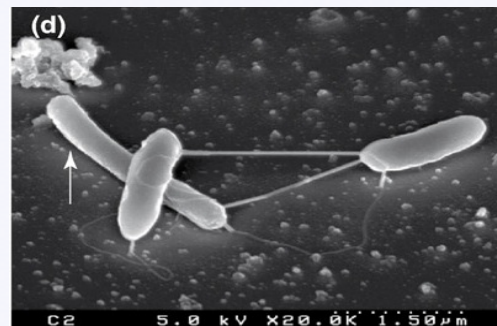


Mediated electron transfer (MET):

- By means of low molecular weight electron shuttles
- Electron shuttling proteins

Direct electron transfer (DET):

- From cell surface of redox active proteins
- Via electron conductive “nano-wires” produced by the bacteria (wired community)
- By other yet undiscovered pathways



Trends in Microbiology, Vol 14, No.12

BFCs harvest energy from waste



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Industries



Agriculture



Farms



Domestic

Waste as a resource

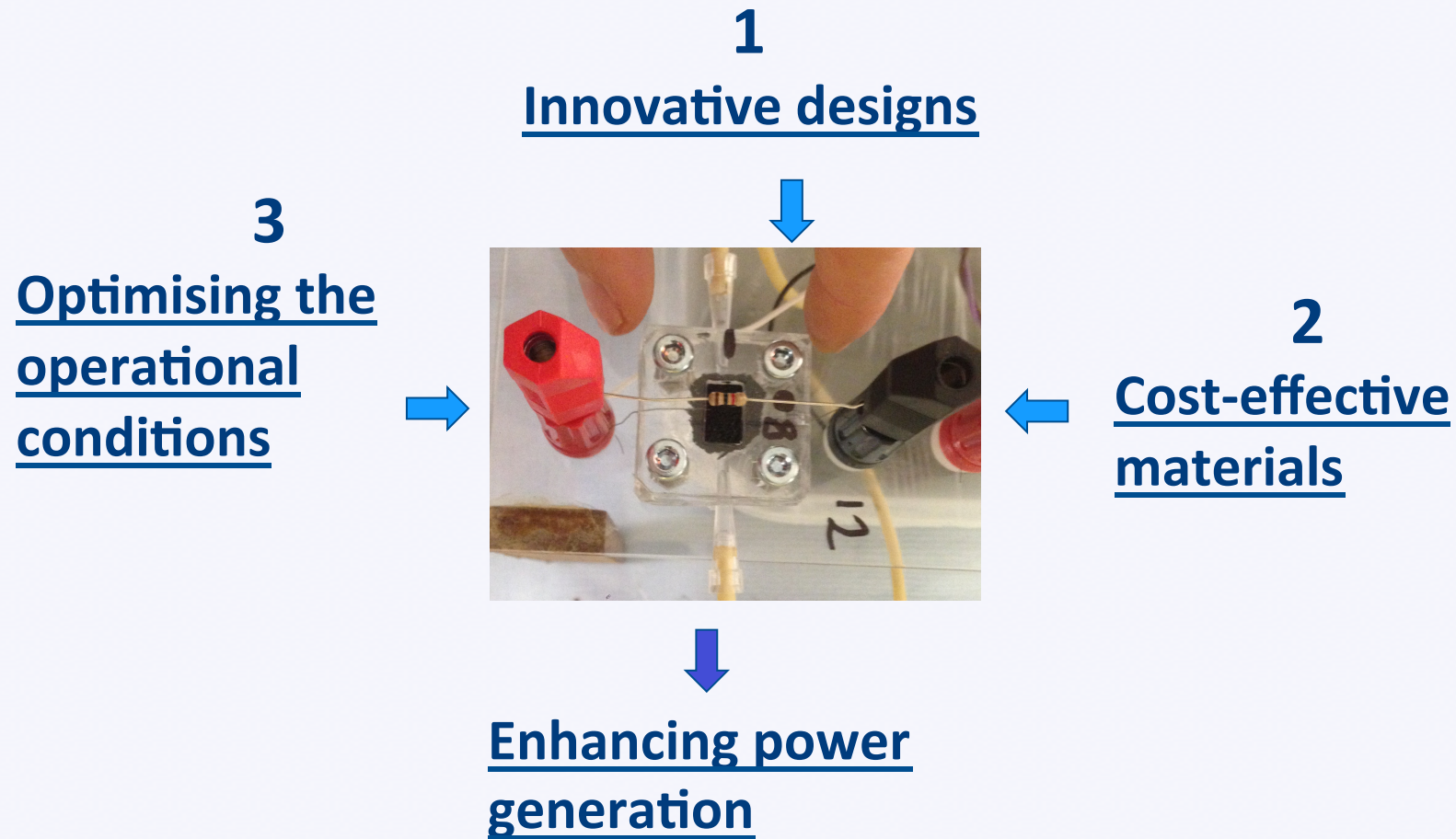


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- 2.4 billion people worldwide have no sanitation
- In UK over 10 bn litres of sewage produced every day
- Almost 2% of the average daily electricity consumption in UK is used to treat sewage
- Wastewaters contain more chemical energy than this!
- Giving value to these wastes would alter economics in favour of deploying treatment, and would improve social conditions, environmental emissions and energy conservation and security

Areas of research



Pee power!



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2. Energy from wastewaters

Powered by a pee

WEE could be used to generate electricity, claim researchers.

They have developed microbial fuel cells that use the natural biological processes of bacteria.

They react an organic matter such as urine passes through the inorganic device, which costs only £1 to £2 each.

The cells were created by experts at the University of Bath, Queen Mary University of London and Bristol Bioenergy Centre.

Chemical engineer Dr Mirilla Di Lorenzo said: "If we can harness the potential power of this human waste, we could revolutionise how electricity is generated."

Battery that has a wee bit more power

A BATTERY powered by urine could become an environmentally friendly source of power.

The pee-powered microbial fuel cell costs as little as £1 to £2, and has been designed to create affordable, renewable, and carbon-neutral energy for power to remote areas.

A single 100 square centimetre fuel cell can generate enough power to power a mobile phone. It is called bacteria to turn organic matter such as urine into electricity.

This can be stored or used directly to power devices. Researchers are now looking at ways of improving the power output of the microbial fuel cells.

Dr Tim Mack, of the University of Bath, where researchers developed the idea with Queen Mary University of London and the Bristol Bioenergy Centre, said: "Renewable 'pee power' is a brilliant idea.

In use in developing countries, it will have huge positive impact on people in areas of rising poverty.

The technology, Dr Mirilla Di Lorenzo added, "It can harness the potential power of human waste, so could revolutionise how electricity is generated."

Microbial fuel cells can play an important role in addressing the triple challenge of finding solutions that support economic, social and environmental sustainability.

MONDAY 18/04/2016

DAILY MIRROR

tim g ops kel ce

McBoatface is top name

BOATY McBoatface has won a poll for the name of a new polar research ship.

It received 124,109 votes, beating Poppy-Mae - named after a 16-month-old cancer victim - on 34,071.

The National Environment Research Council, which set the online poll, said: "We'll now review the names."

Science Minister Jo Johnson will make the decision on the £200-million ship.

Urine mobile power for £1

SCIENTISTS have developed a miniature fuel cell that use urine to generate electricity to power mobile phones.

The inch square device, which costs about £1, was developed by a group including Bath University.

Dr Mirilla Di Lorenzo, from Bath, said: "If we can harness the potential power of this human waste, we could revolutionise how electricity is generated."

Tiny fuel cell uses urine to generate electricity

- Miniature device costs as little as £1
- New design is small and powerful

By CLARE HAWKLEY

Researchers have developed a miniature fuel cell costing as little as £1 that can generate electricity from urine.

The device, a microbial fuel cell, could be used to create a renewable and carbon-neutral way of generating power to remote areas, say scientists.

Each of the fuel cells, developed by researchers at the University of Bath, Queen Mary University of London and the Bristol Bioenergy Centre, cost £1.

Microbial fuel cells use natural biological processes of

"microbes" bacteria to turn organic matter such as urine into electricity.

Urine passes through the microbial fuel cell for this reaction to happen, with the bacteria then generating electricity.

This can be stored or used to directly power electrical devices. Researchers say this miniature microbial fuel cell is smaller, more powerful and cheaper than other similar devices.

The fuel cell measures just one inch square in size and uses a carbon catalyst at the cathode which is derived from glucose and sulphuric acid, a process known as fermentation.

This catalyst is a renewable and much cheaper alternative to platinum, which is commonly used in other microbial fuel cells.

Dr Mirilla Di Lorenzo, lead



Dr Mirilla Di Lorenzo

from the University of Bath, said: "If we can harness the potential power of this human waste, we could revolutionise how electricity is generated."

Mini fuel cell spark of hope from urine

RESEARCHERS have developed a miniature fuel cell costing as little as £1 which can generate electricity from urine. The device, a microbial fuel cell, could be used to create a renewable and carbon-neutral way of generating power to remote areas at very little cost.

Each of the fuel cells, developed by researchers at the University of Bath, Queen Mary University of London and the Bristol Bioenergy Centre, costs £1 to £2. Microbial fuel cells use natural biological

New fuel cells produce electricity using urine



Dr Mirilla Di Lorenzo, left, and chemical engineering PhD student Ben Shuster with equipment used to test a fuel cell that generates electricity from urine

processes of "microbes" bacteria to turn organic matter such as urine into electricity.

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MORE AT DAILYRECORD.CO.UK

Generating electricity-pee

RESEARCHERS have developed a miniature fuel cell that can turn pee into electricity.

The £1 device uses natural biological processes of bacteria to turn organic matter such as urine into electricity.

The technology, Dr Mirilla Di Lorenzo added, "It can harness the potential power of human waste, so could revolutionise how electricity is generated."

Microbial fuel cells can play an important role in addressing the triple challenge of finding solutions that support economic, social and environmental sustainability.

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Fuel cell is re-volt-ing

A FUEL cell made from pee could provide cheap power.

The microbial cell could be used to create a renewable and carbon-neutral way of generating power to remote areas, say scientists.

Each of the fuel cells, developed by researchers at the University of Bath, Queen Mary University of London and the Bristol Bioenergy Centre, cost £1.

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Wee idea that set to have a big impact

By CLARE HAWKLEY

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...and finally

WE ARE always looking for green ways to generate power - and this one sounds, on the face of it, like a winner.

A miniature fuel cell which costs £1 could generate electricity from urine, British researchers say. It may create a renewable and carbon-

neutral way of getting power to remote areas at very little cost.

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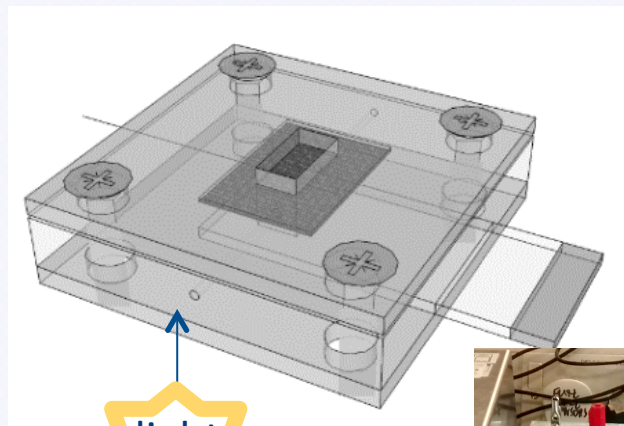
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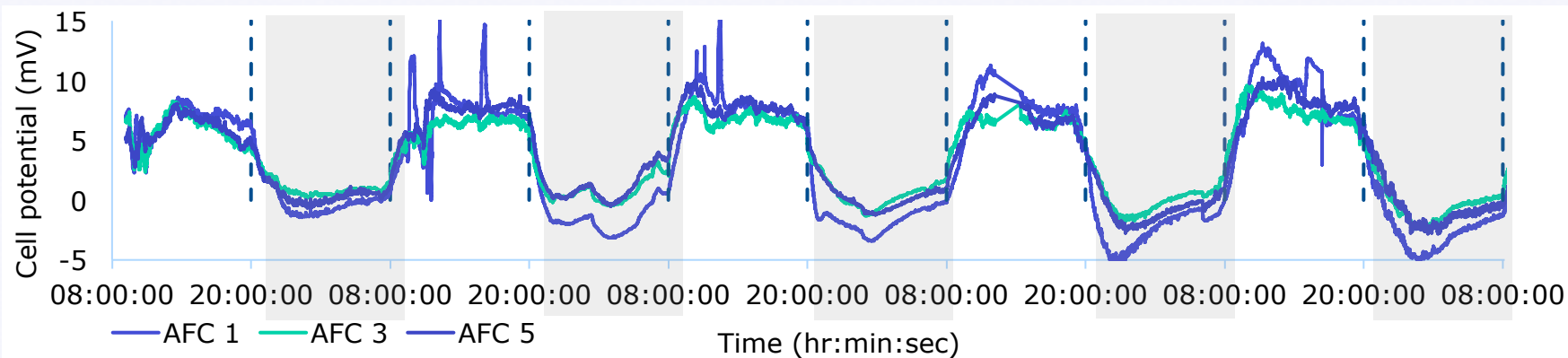
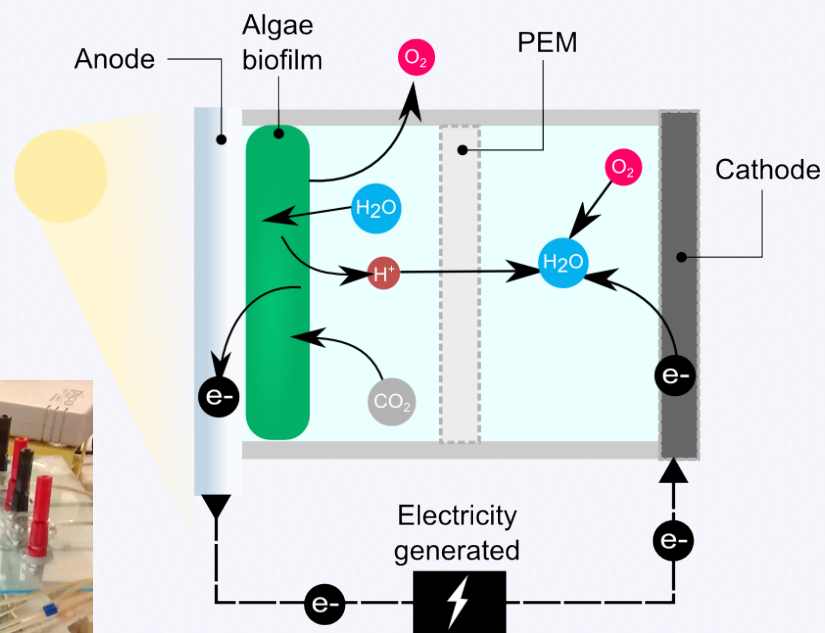
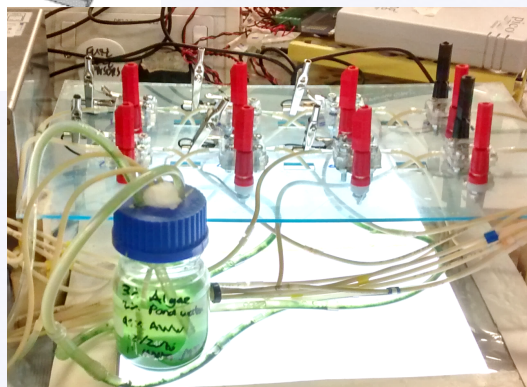
Photo-BFCs



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light

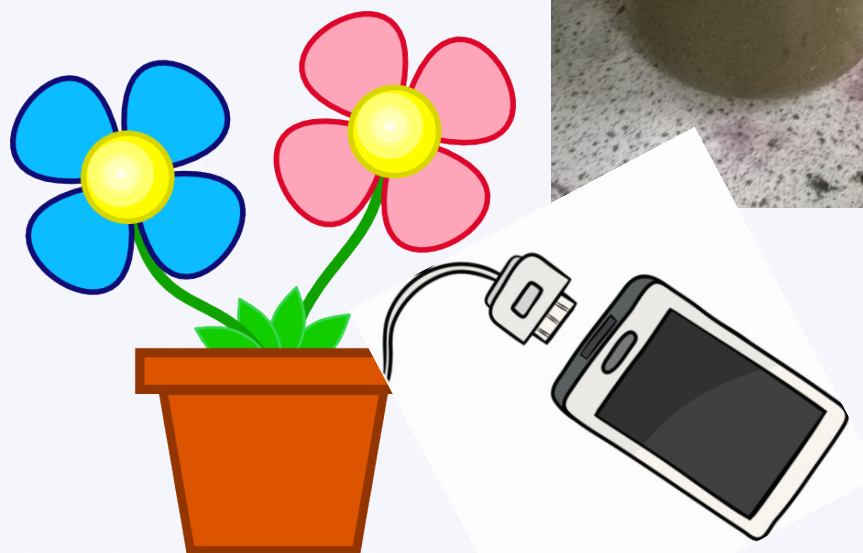
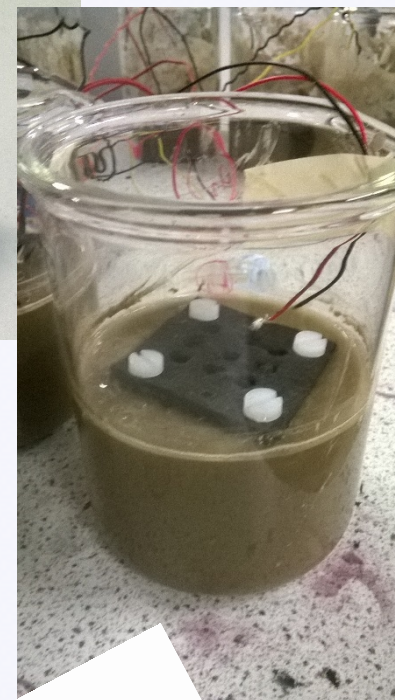
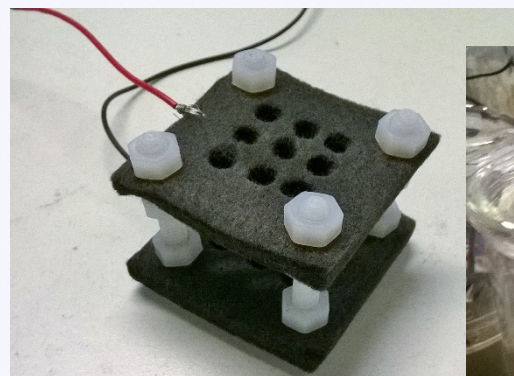
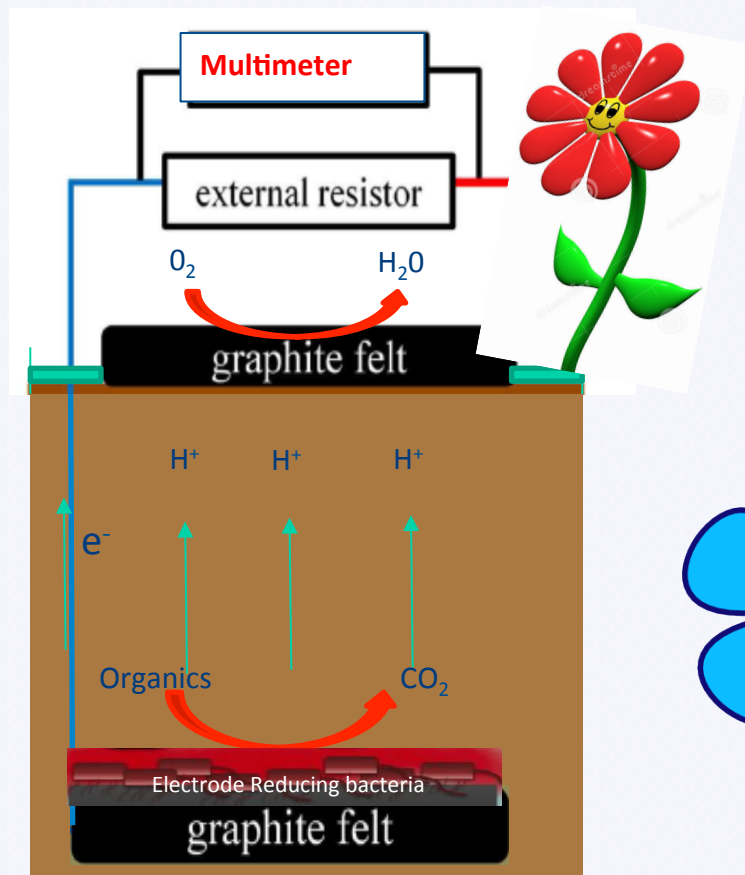


2. Energy from wastewaters

Power from the pot!



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5. New materials

Why water quality monitoring



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The heavy use of chemicals (agricultural, industrial and domestic) has increased the risk of freshwater contamination.

The detection at very low concentration (*micropollutants*: picograms per litre to nanograms per litre) via traditional analytic tools can be difficult.

Real time on site monitoring is important to:

- Undertake *immediate action*;
- *Map the distribution* of micropollutants in surface water;
- Assess and *monitor the efficacy* of the wastewater treatment.

MFC sensors



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Microbial fuel cells as sensors for water quality:

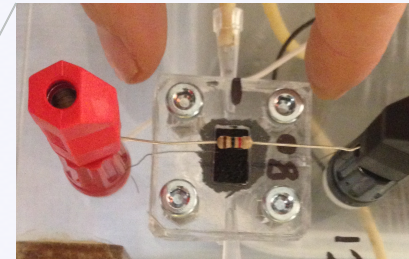
Bioactivity investigations

Online monitoring

On site operation

Cost-effective and simple

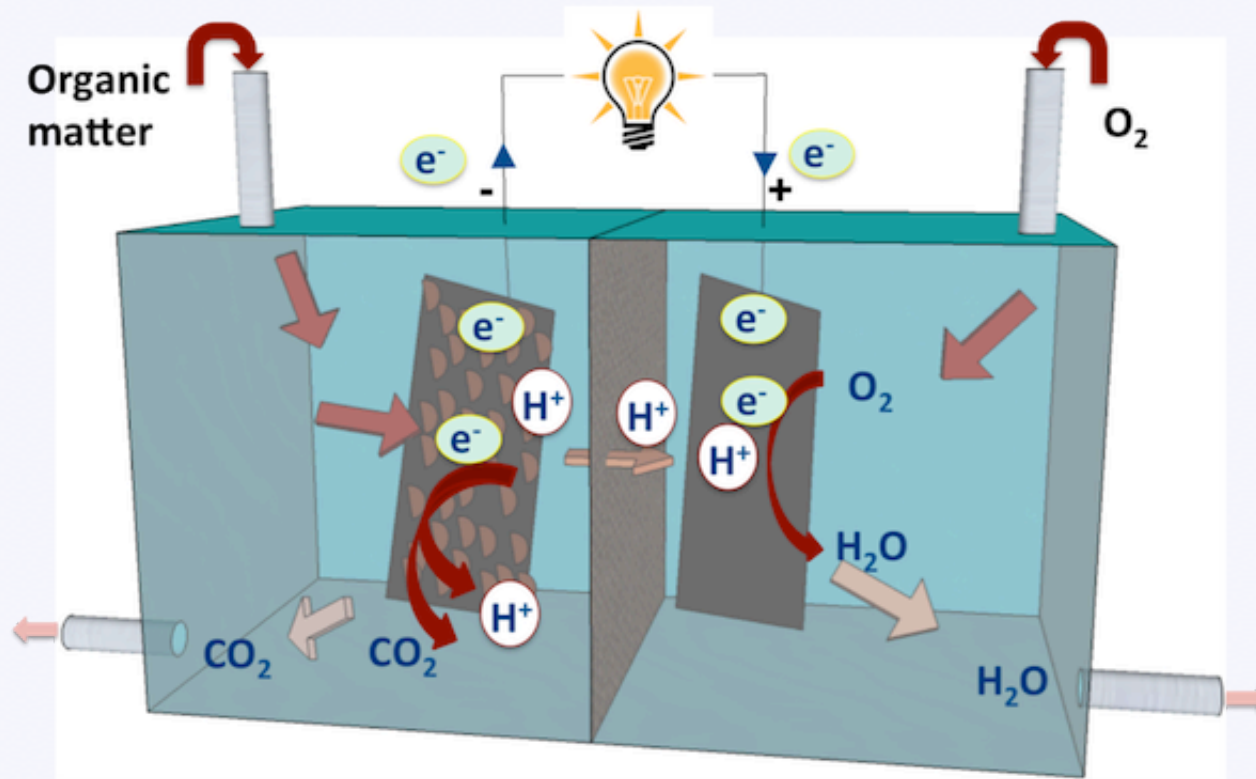
Self-powered operation



How BFC can be used as biosensors?



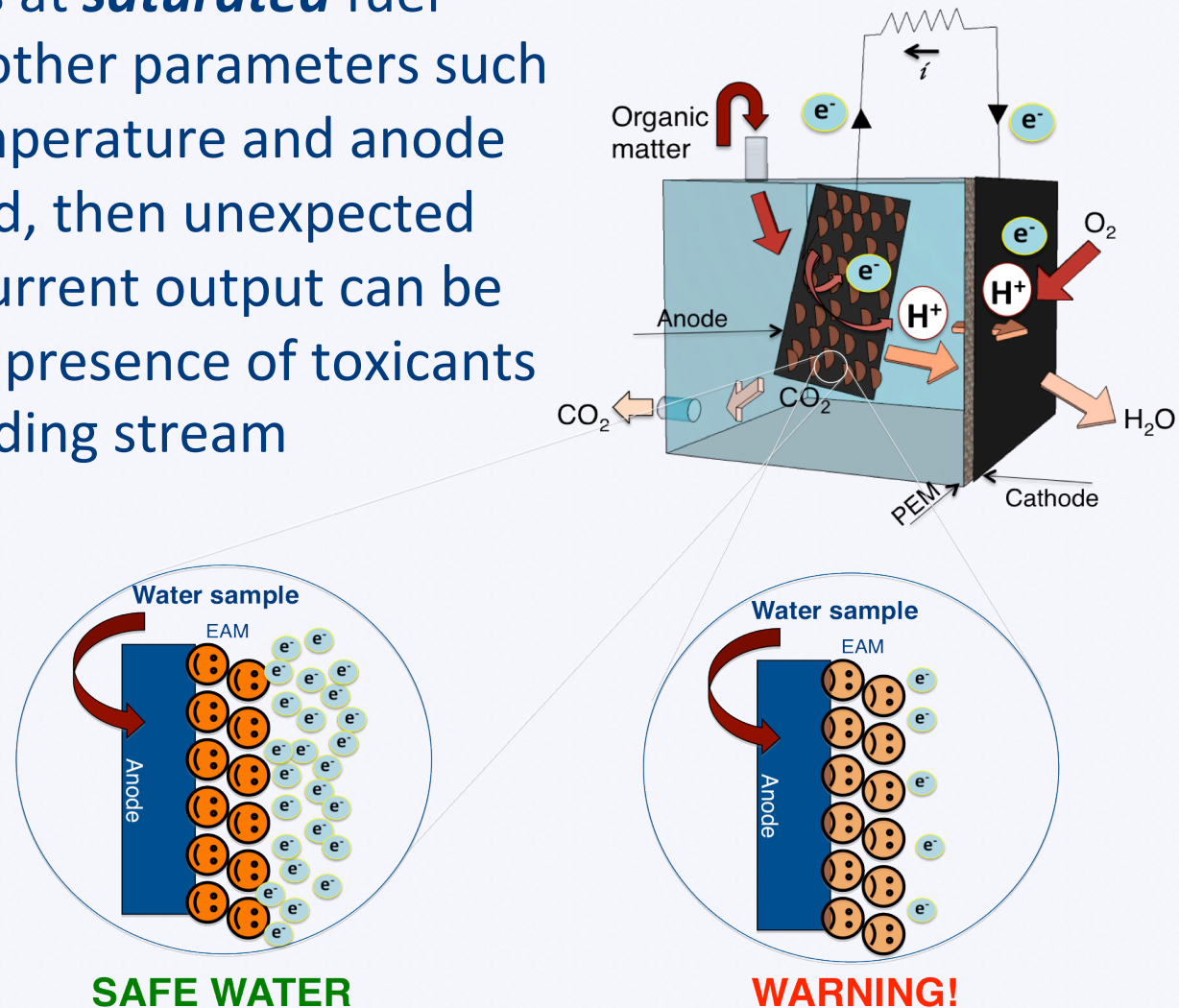
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The current generated by the BFC is an *indicator* of the *metabolic activity* of the electroactive bacteria at the anode

Detection of toxicants

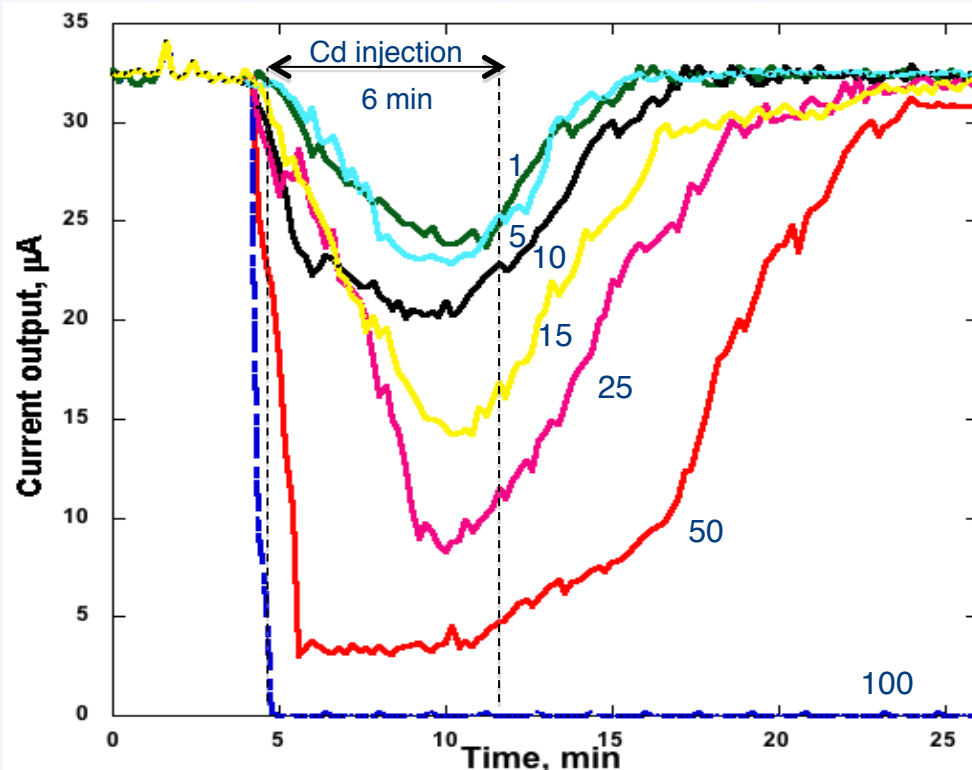
If the BFC works at **saturated** fuel concentration, and other parameters such as pH, salinity, temperature and anode potential are fixed, then unexpected variations in the current output can be associated with the presence of toxicants in the feeding stream



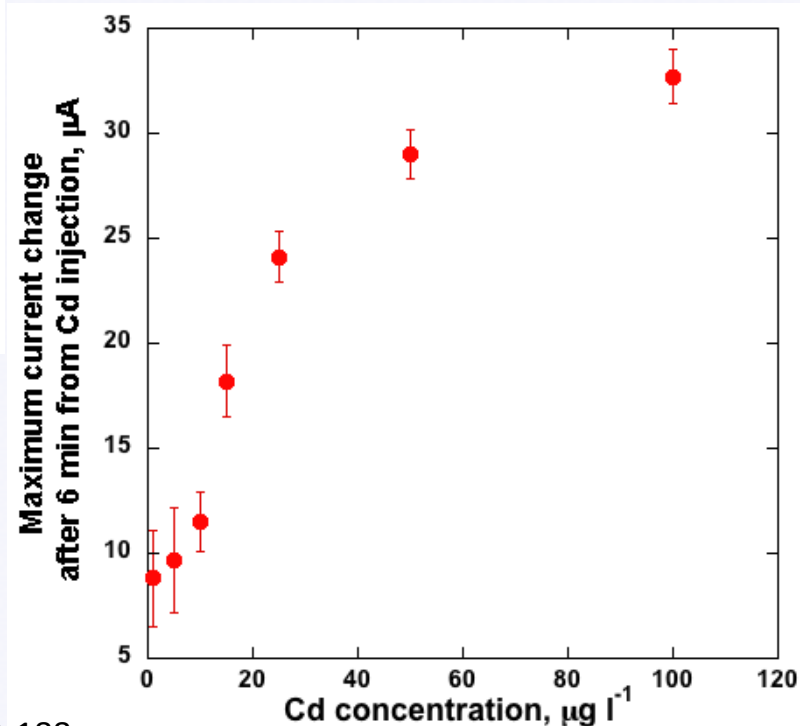
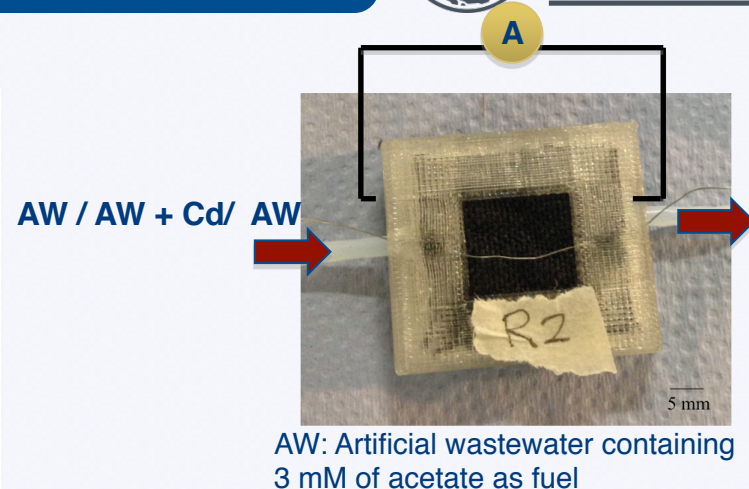
Response to cadmium (as $\text{Cd}^{2+}\text{SO}_4^{2-}$)



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- Dynamic range: 1 - 25 $\mu\text{g l}^{-1}$
- Lower detection limit: 1 $\mu\text{g l}^{-1}$
- Sensitivity (with respect to anode surface area):
0.2 $\mu\text{A } \mu\text{M}^{-1} \text{cm}^{-2}$

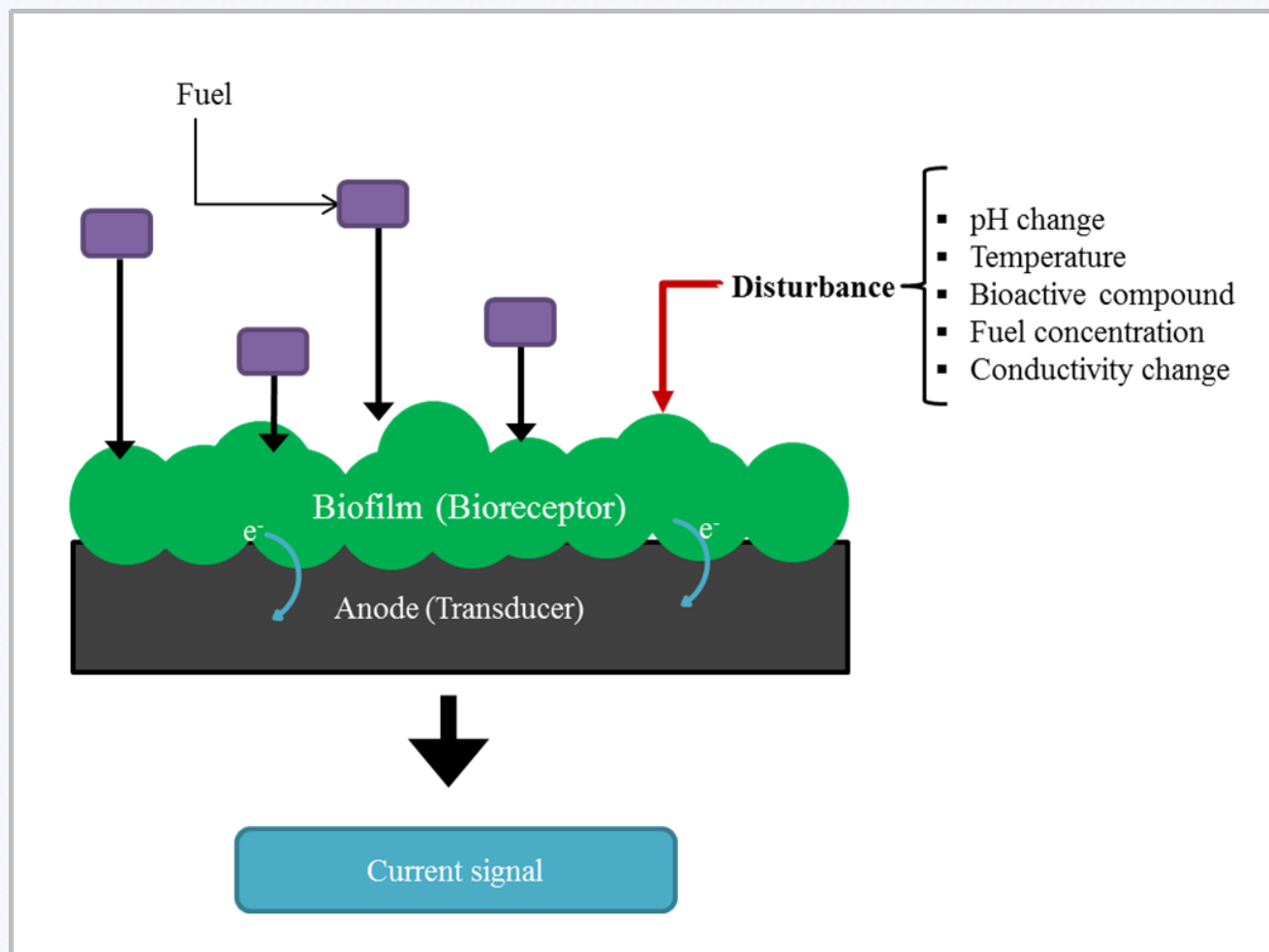


3. Sensors for Water

Does my research need more math?



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3. Sensors for Water

Does my research need more math?



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- **Need for:**
- **A consistent method to interpret the output signals of the BFC sensor and filter out all the noise and disturbances to prevent false positives or false negatives;**
- **A way to ‘display’ complex data in a user-friendly way that also non-experts can easily understand;**
- **A way to support effective device designs with mathematical models**