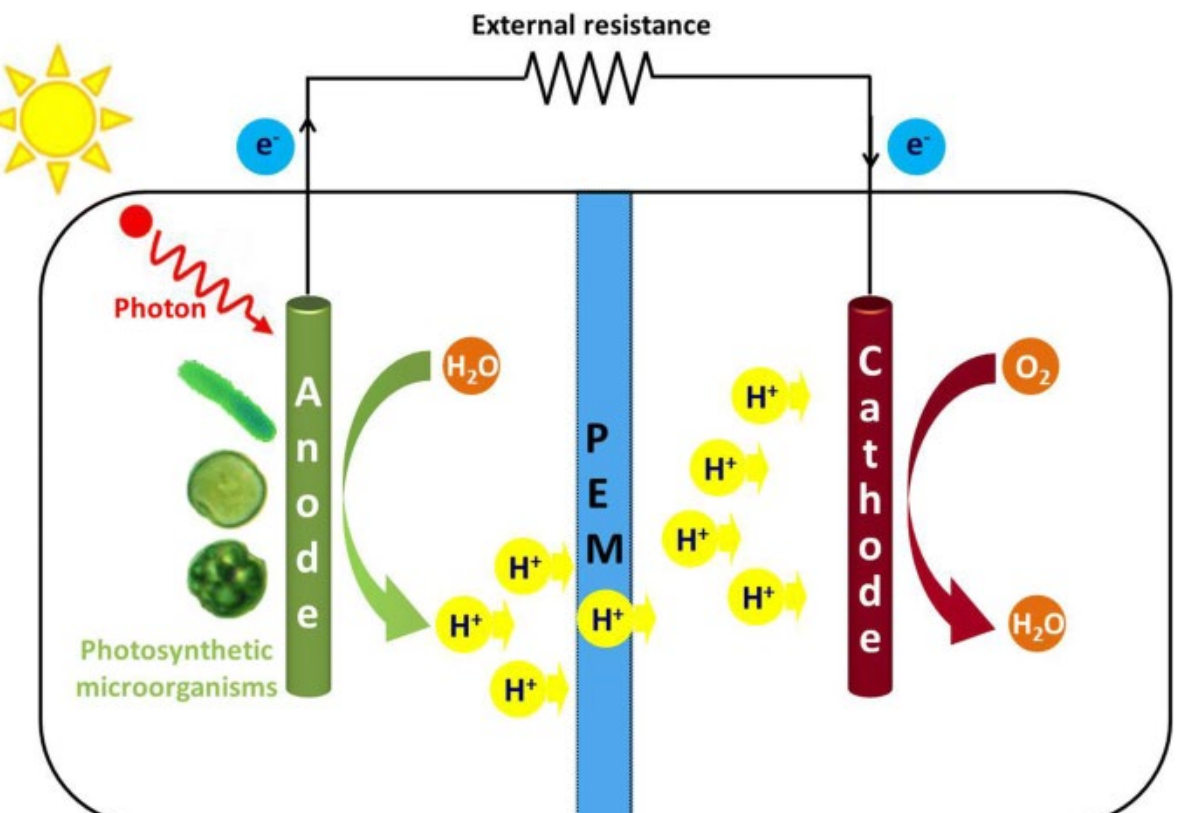


# ABSTRACT

Microbial Fuel Cells (MFC) are a great source of low-cost, renewable energy. They work in all environments and can operate on by-products or waste from other commercial activities. MFCs work by harnessing the electricity produced from bioelectrochemical microbial activity. Anaerobic oxidation at the anode produces free electrons that are transported to a cathode for reduction which allows us to harness that energy.



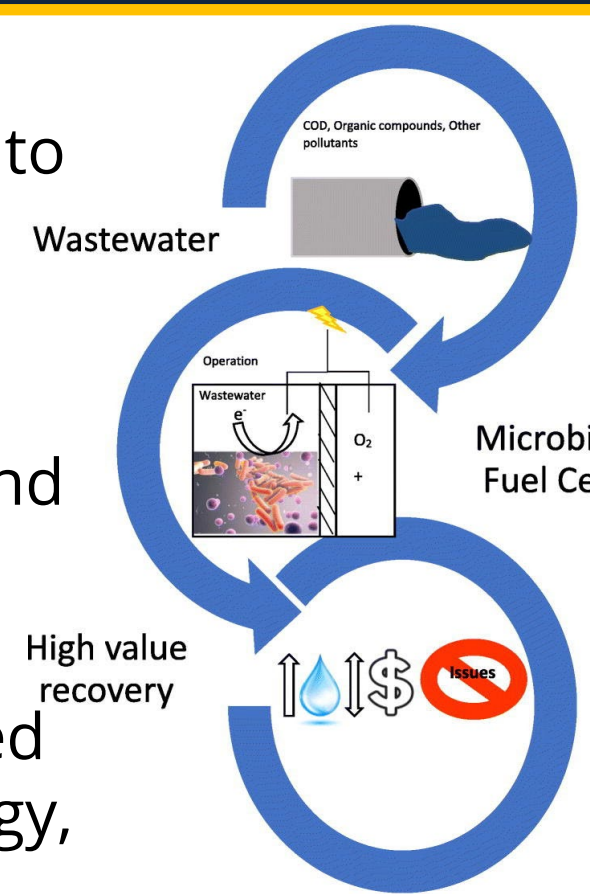
My project attempts to find how environmental factors and substrate affect the electricity production capability to determine the most optimal conditions for an air-cathode MFC. MFCs under different conditions were monitored for over 400 hours and their electric output measured.

# HYPOTHESES

- MFC at higher temperature will produce higher power than colder temperature.
- MFC using acetate rich substrate will produce higher power than one rich in glucose.
- MFC at Neutral pH will produce higher power than alkaline or acidic substrate.

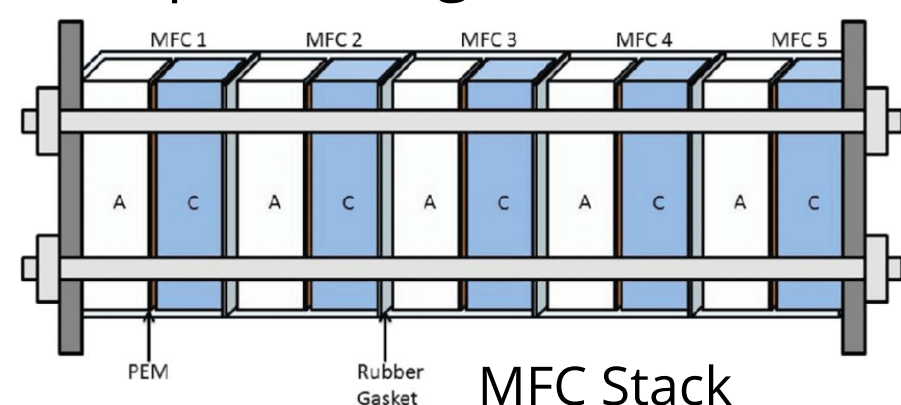
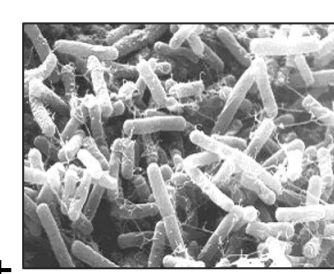
# WHY MFCs

- Sustainable, environmentally safe way to generate electricity.
- Can integrate into commercial microbial systems for wastewater and agricultural waste treatment.
- Offers cheap, decentralized source of renewable energy, ideal for less developed areas of the world.



# BRIEF HISTORY

- The initial idea of using microbes to make electricity was conceived and attributed to M.C. Potter in 1911.
- In 1931, Barnett Cohen built the first MFC stack, by combining multiple MFCs and producing over 35 volts.

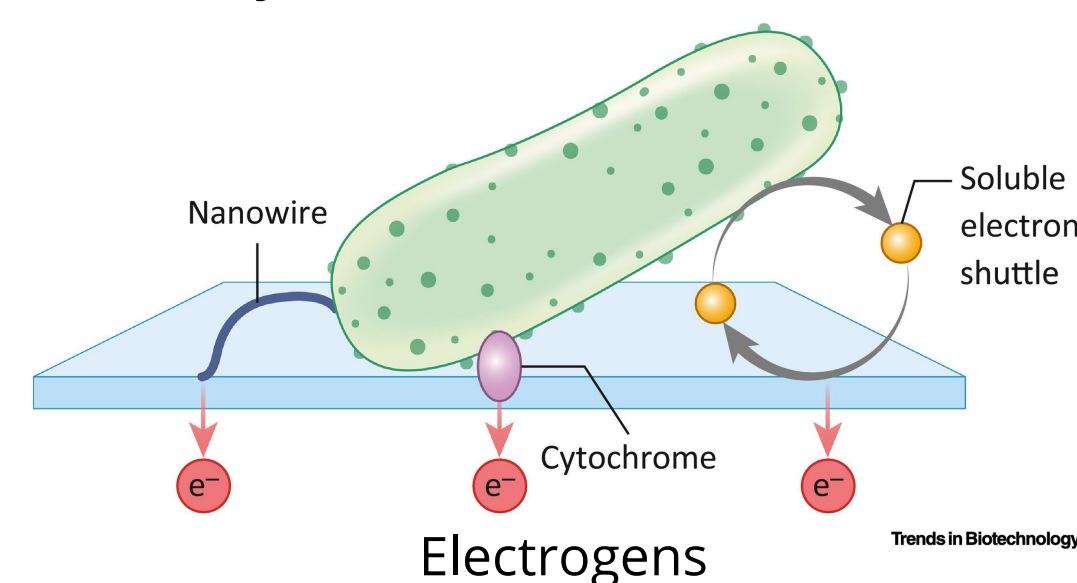


# FINDING THE MOST OPTIMAL CONDITIONS FOR A MICROBIAL FUEL CELL

## RESEARCH

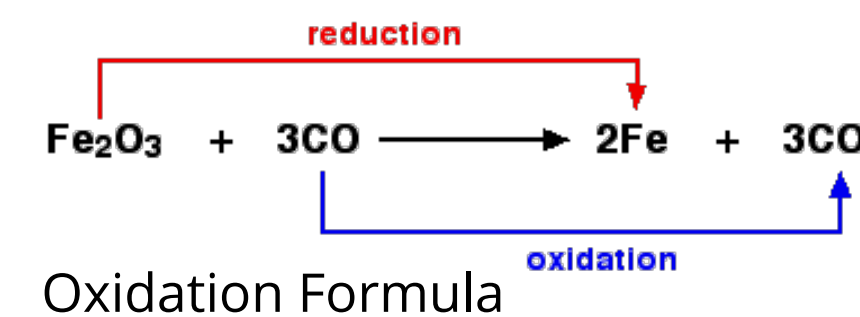
### Electrogenic Bacteria

The main type of bacteria used in MFCs are electrogens which are found in anaerobic areas characterized by the absence of free oxygen but may contain atomic oxygen bound in compounds such as nitrate (NO3), nitrite (NO2), and sulfites (SO3) - i.e. soil. The best MFC candidate electrogens are also gram-negative bacteria which have a thin peptidoglycan layer. Electroens tend to colonize on the anode and released electrons carried externally to the cathode. Geobacter sulfurreducens and Shewanella oneidensis are two electrogenic bacteria commonly found in soil and wastewater.



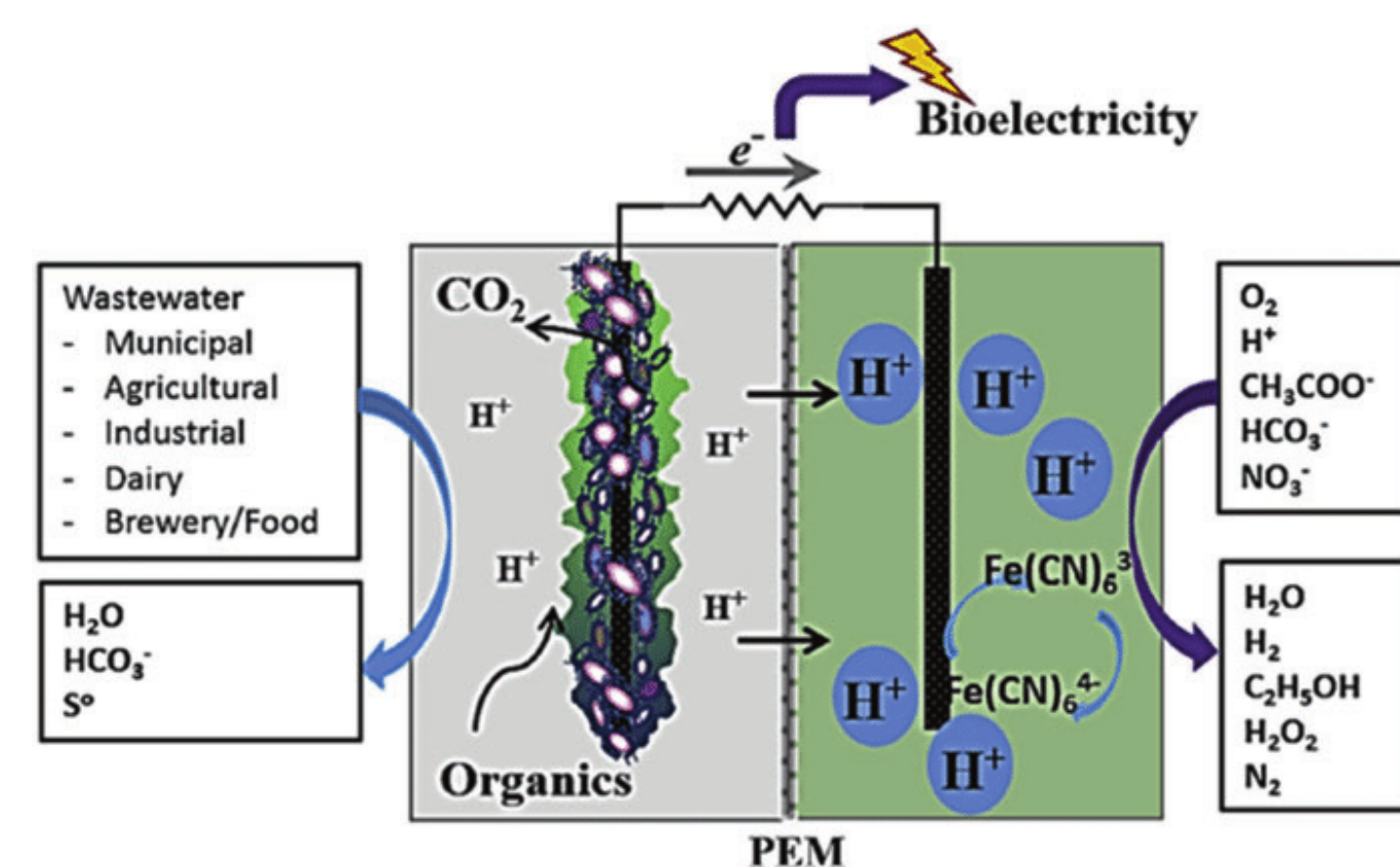
### Oxidation/Reduction

Oxidation is the process by which electrogens create electricity by releasing electrons from the organic substrate. Oxidation occurs when an atom, molecule, or ion loses at least 1 electron. In MFCs, the electrons are harnessed by the anode and moved through a conducting medium to the cathode where oxygen reduction takes place.



### Commercial Application of MFCs

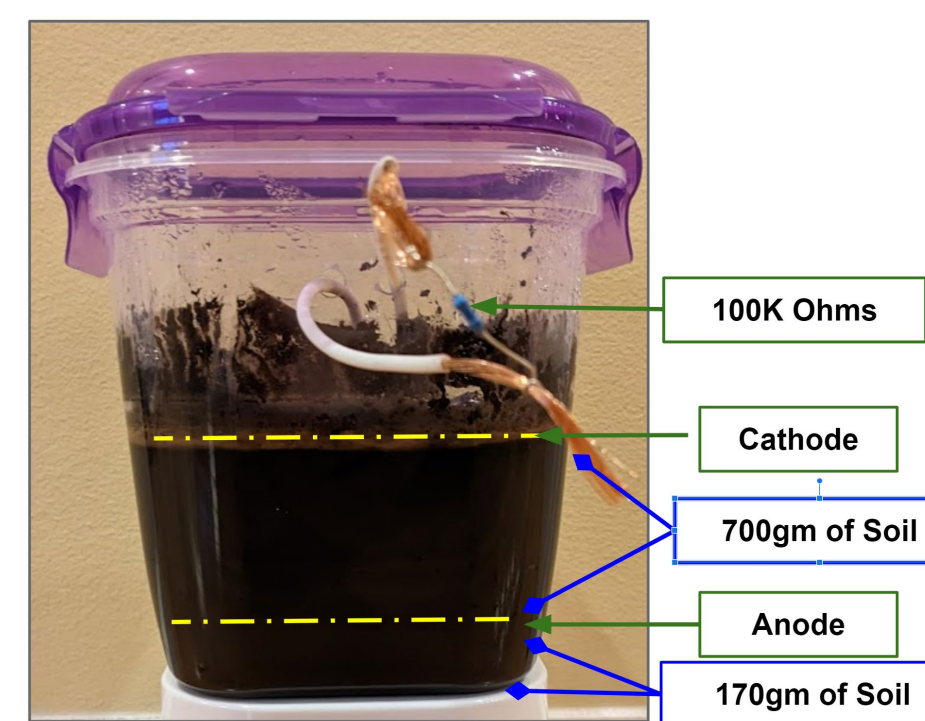
Most people see wastewater as waste. However, they have the potential to produce electricity. Huang et al.[6] found that an anaerobic fluidized bed combined with a MFC can produce electricity from wastewater plants at a large scale.



MFCs in Wastewater Plants  
MFCs are also commercially used in biosensors and powering underwater robots and devices. Commercial trials are underway to harness or enhance bacterial fermentation.

## PROCEDURES & METHODS

- 7 identical MFC's were constructed. Base soil was collected from storm water drainage area. Cathode and anode were made with 10cmx10cmx5mm carbon graphite sheet with 100K Ohms load resistor.



MFC Design

- Control MFC** - Soil mixed with distilled water and stored at 68F (room temperature).
  - Experiment 1: Effect of Temperature**
    - Hot MFC - Soil mixed with distilled water and stored at 80F
    - Cold MFC - Soil mixed with distilled water and stored at 37F
  - Experiment 2: Effect of Nutrients in the substrate**
    - Acetate MFC - Soil mixed with acetate (produced by mixing vinegar with baking soda) and stored at 68F
    - Glucose MFC - Soil mixed with Glucose (produced by mixing 1 part Glucose with 5 parts distilled water) and stored at 68F
  - Experiment 3: Effect of Soil pH**
    - Acidic MFC - Soil mixed with distilled Vinegar to a pH of 5
    - Alkaline MFC - Soil mixed with alkaline water (from Costco) to a pH of 9
- Every 12 hours, the voltage and current of each MFC was measured with a multimeter. The experiment spanned 400 hours in total.

# CONCLUSIONS & FUTURE RESEARCH

- My results indicate that colder temperature produces more electricity than hotter temperature over a longer duration. I also found that acetate is a better nutrient for bacteria than glucose, and my MFC output is still increasing! Finally, I found that more alkaline soil is better for an MFC than acidic soil.
- I plan to repeat the experiments with a salt bridge liquid cathode MFC to see which design is better for each environment.
- My future research will focus on the type of bacteria and which bacteria are best suited for a specific environmental condition.

# BIBLIOGRAPHY

- <https://www.sciencedirect.com/topics/biochemistry-genetics-and-molecular-biology/microbial-fuel-cell>
- [https://chem.libretexts.org/Bookshelves/Analytical\\_Chemistry/Supplemental\\_Modules\\_%28Analytical\\_Chemistry%29/Electrochemistry/Redox\\_Chemistry/Definitions\\_of\\_Oxidation\\_and\\_Reduction](https://chem.libretexts.org/Bookshelves/Analytical_Chemistry/Supplemental_Modules_%28Analytical_Chemistry%29/Electrochemistry/Redox_Chemistry/Definitions_of_Oxidation_and_Reduction)
- <https://fabo.osu.edu/mfcfacts>
- <https://www.sciencedirect.com/science/article/abs/pii/S0959652616309362#:~:text=An%20MFC%20typically%20contains%20two,the%20anode%20to%20the%20cathode.>
- <https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0260528>
- <https://www.sciencedirect.com/science/article/abs/pii/S0011916411003067>
- [https://www.researchgate.net/figure/Stacked-MFC-of-five-individual-cells-PEM-Proton-Exchange-Membrance-A-Anode-C\\_fig2\\_322077574](https://www.researchgate.net/figure/Stacked-MFC-of-five-individual-cells-PEM-Proton-Exchange-Membrance-A-Anode-C_fig2_322077574)
- <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7676329/>
- <https://sciencenotes.org/what-is-oxidation-definition-and-examples/>
- <https://pubmed.ncbi.nlm.nih.gov/19345574/>
- <https://pubmed.ncbi.nlm.nih.gov/24350446/#:~:text=The%20effect%20of%20temperature%20on,13.24%25%20at%2043%20degrees%20C.>
- [https://assets.researchsquare.com/files/rs-151072/v1\\_covered.pdf?c=1631851989](https://assets.researchsquare.com/files/rs-151072/v1_covered.pdf?c=1631851989)
- <https://mnsi-journal.springeropen.com/articles/10.1186/s40486-017-0048-8>
- <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5610400/>
- <https://www.webmd.com/a-to-z-guides/difference-between-gram-positive-bacillus-gram-negative-bacillus#:~:text=In%201884%2C%20a%20bacteriologist%20named,it's%20classified%20as%20gram%20negative.>
- <https://www.azom.com/article.aspx?ArticleID=19737#:~:text=One%20such%20developing%20technology%20is,%2C%20bioenergy%20production%2C%20and%20biosensors>

# RESULTS

