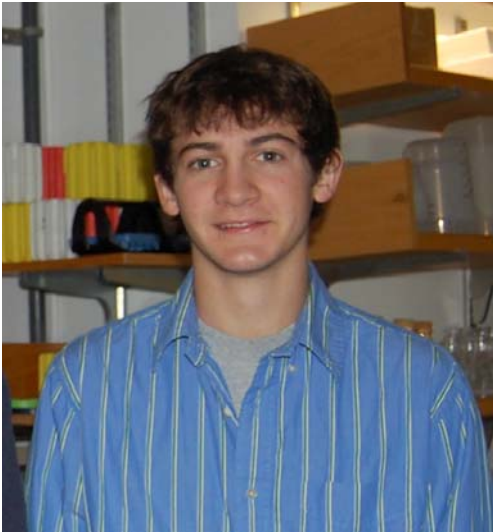




MASSACHUSETTS CLEAN TECHNOLOGY AWARDS

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Region IV: Northeastern MA

Sam Melton, Lexington High School

"Anode Composition and Cost Efficiency of Microbial Fuel Cells"

I was born in Massachusetts and have lived in Lexington my entire life with my mother, father, and sister. I attended Lexington Montessori School during grades K through 5th, and then switched to Shady Hill School in Cambridge for grades 6 through 8. My freshman year of high school I began at Lexington High, where I am now a junior.

I have participated in the science fair since my freshman year, although started working on microbial fuel cells just last year. Beyond that, I am on the debate team at Lexington High School; debate is one of my primary activities. I am a member of the Varsity Crew Team at Community Rowing in Cambridge, and I enjoy rowing in my free time.

MY PROJECT:

The impending global energy crisis renders alternative energy sources highly relevant in the social, political, and scientific progression of humanity. In this respect, development of an economically viable source of environmentally friendly energy will be necessary in the near future to replace fossil fuels. As a clean and efficient source of power, microbial fuel cells may be this solution.

Harnessing the power of bacterial respiration, a microbial fuel cell utilizes natural anaerobic processes to create a charge. A microbial fuel cell works in an anaerobic (oxygen limited) environment, but it simulates an aerobic system in that the anode acts as an electron acceptor, filling a role very similar to that which oxygen fills in an aerobic system. In aerobic conditions, bacterial respiration culminates in the deposition of electrons onto O_2 molecules, creating CO_2 and H_2O . In contrast, with no oxygen available, a microbial fuel cell has an anode which accepts the electrons, creating flow of electrons as they are deposited on the anode (the negatively charged electrode).

A microbial fuel cell, similar to many batteries, consists of an anode and cathode compartment. As electrons are deposited on the anode, it becomes negatively charged; it has a higher concentration of electrons; the cathode has a more positive charge, or lower concentration of electrons. The gradient



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between the two results in a flow of electrons between them via the path of least resistance. In a microbial fuel cell, a membrane separates the cathode from the anode, and the electrons instead flow through a wire, just as in any other battery – creating an energy source that can easily be used to power electric devices.

In the microbial fuel cells used in this experiment, the anode compartment is placed at the bottom of the cell, in this case a bucket or similar structure. This compartment contains some type of "fuel" – compost, dirt, or another biodegradable material – and an electronegative material to function as the (anode) electrode. A layer of gravel or sand is positioned above the anode and acts as a membrane preventing the mixing of bacteria between compartments. The cathode consists of a similarly electronegative material, usually the same as the one in the anode compartment, which is placed in salt water. If possible, pumping oxygen into the cathode compartment also helps increase productivity.

In the anode compartment, bacteria in the compost respire using glucose in the decomposing material as an energy source. Since oxygen is absent due to the anaerobic conditions under water, the bacteria deposits electrons on the most readily available electronegative material, that being the electrode (anode). As no bacteria are in the cathode compartment, no electrons are deposited there, creating the gradient.

The microbial fuel cell's potentially inexpensive and efficient nature make it a potentially useful source of energy, one that could be scaled up and remain cost effective. The objective of this project is to explore ways to minimize the cost and resources needed to construct a fuel cell by focusing on the most expensive material: the electrode. As conventional graphite electrodes are expensive, this experiment explores the possibility of using almost any material coated in graphite paint, and comparing its efficiency to that of a solid graphite electrode.

By minimizing cost to under a dollar, and utilizing common materials such as wood as the electrodes, this experimentation opens the door to large-scale distribution of microbial fuel cells. In areas where clean water and electricity are scarce, a microbial fuel cell can use any readily available organic materials to provide the energy needed to insure a healthy supply of water, or other needs.