SYNTHETIC BIOLOGY FOR CLIMATE CHANGE:

APPLYING MODIFIED CARBON DIOXIDE CONSUMING E.COLI TESTED IN SPACE TO CARBON SCRUBBING TECHNOLOGY IN SPACE AND ON EARTH

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Abstract

Compared to conventional production methods, a genetically modified strain of E. coli made to consume carbon dioxide could contribute to previous efforts made to improve air quality. With the results from a NASA sponsored research I worked on to send this E.coli to the ISS, the applications to climate change can reach to and beyond using this bacteria in carbon scrubbing technology. In a fluid containing enclosure, we observed E.coli's growth in a weightless environment. This investigation proposal strives to build upon our results by expanding the applicability of this modified microbe in both gravity and microgravity environments.

Introduction

Despite growing awareness of climate change, global greenhouse gas emissions are taking their toll. Taking this into consideration and thought, scientists have, in recent years, worked to implement improvements that have been made in synthetic biology (Milo et. al, 2019). Synthetic biology refers to the implementation of engineering principles to studies pertaining to the ways in which organic life is driven (Biotechnology Innovation Organization). Such principles are being utilized to aid in combating some of our most pressing environmental challenges.

The Genetic Modification of *Escherichia coli* for a Carbon Dioxide-Based Diet

Taking matters into hand, researchers in the Middle Eastern region have been tapping synthetic organisms in hopes of converting atmospheric carbon dioxide into various forms for human use including food, fuel, and organic chemicals..

Although organisms that are capable of using energy from light to fix carbon dioxide into the four macromolecules of life could be difficult to modify, successful attempts have been made to genetically modify *Escherichia Coli* (E. coli)*,* a group of bacteria usually found in human and animal intestines. Due to its rapid growth and relatively simple process of engineering, changes in the behavior of E. coli could be easily modified to compute with genetic alterations. In fact, over the past decade, these researchers endeavored in the development of a strain of E. coli capable of growing by consuming carbon dioxide instead of the sugars and other organic molecules.

This bacterium was modified by removing genes that usually process sugar compounds and inserting ones that encode a specific pair of enzymes. This type of enzyme allows photosynthetic organisms to convert carbon dioxide into organic carbon. Using metabolic rewiring, this bacteria was able to resemble consumption of carbon dioxide by photosynthetic organisms.

Products fashioned this way could eventually work to remove gases from the air. Giving them only minimal quantities of sugar and two hundred fifty times greater concentrations of carbon dioxide exceeding that available in Earth's atmosphere, Ron Milo, a systems biologist, with his team of researchers, cultured several generations of this modified strain of bacteria. In this collaborated study, it was found that after 200 days, cells that became inclined to using carbon dioxide as their sole source of carbon started appearing (Milo et. al, 2019). A hundred days later, these bacteria were able to grow faster than the controlled bacteria groups that could not consume carbon dioxide (Milo et. al, 2019).

E.coli as a Model Bacterium for Microgravity

Spaceflight-analogue studies have disclosed that microgravity could have a major impact on the physiology, molecular biology, and stress resistance of microbes (Callaway, 2019). It is because of the possession of such attributes that E. coli has proven to be an ideal bacterium for microgravity investigations. This could work as a crucial component in the ecosystems vital to sustaining space life as it could be expanded to include renewable fuels, food, and other resources.

My Personal Journey to NASA and the ISS

After reaching out to the bacteria's owners, my team and I got a hold of a sample of this modified bacteria from their main lab. Competing against students from different universities and high schools to send the first Kuwaiti experiment to the International Space Station, I have earned the privilege of being the first in the nation's history to send a project that my partner and I designed and executed. Flying out to NASA's base, I got the opportunity to finalize our work with our Nanoracks and DreamUp mentors and see the Falcon 9 Dragon 2 vehicle that carried our experiment from the Vehicle Assembly Building.

While accentuating a biological and environmental approach, our research, directed towards assessing the effect of microgravity on the ability of E.coli to consume carbon dioxide, we investigated the effect that microgravity has on the ability of E. coli to rely on carbon dioxide as its sole food source. We specifically observed the behavior of the E. coli in a weightless environment so see if this variable may increase the likelihood of E. coli resorting to carbon dioxide for obtaining its necessary carbon. Contained in its M9 minimal media and 30mM sodium formate in an 8.4 mL fluid containing enclosure called a MixStix, astronaut Shannon Walker carried out the experiment on the ISS according to our written protocol before it got back to our lab in the beginning of January. Ever since, we have been conducting experiments to evaluate the effect that microgravity had on this bacteria's growth to provide us with further insight on the pervasive fundamentality of E.coli behavior.

Investigation Plan Climate Change Applicability

Our investigation found that the E. coli resorted to consuming available carbon dioxide and converted it into the necessary nutrients usually acquired from other resources to remain alive. In addition to growth, changes in the morphology of this specific strain were also observed. This calls for the real-life significance of this research which emerges from the fact that microbes built to rely on carbon dioxide for growth could ultimately aid in the reduction of global warming by decreasing carbon dioxide concentration in the air.

With its effective growth in microgravity conditions, the modified E.coli used in my research could function as a biologically active substance in a bioreactor within carbon dioxide scrubbing technology. Now having proved that a sample of this E.coli can grow on the ISS, a starting point to a cleaner atmosphere could be with using this bacteria in carbon scrubbing systems on the Station. This could set the stage for the development of this scrubbing technology using this modified bacteria in areas with high quantities of carbon dioxide. This kind of scrubbing system could function on Earth in an industrial setting or personal rebreather or even in outer space settings including spacecrafts and the ISS. By testing with this E.coli in space and proving its efficacy in microgravity conditions, this will hopefully pave the way for new reformation policies that can be incorporated at the local level to other places on the globe.

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