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Alaisha Sharma

Mountain View High School

Volunteer Internship Program (VIP)

High School Intern

Mentor: Dr. Jonathan Galazka

Code: SCB

Space Biosciences Division

Perchlorate Reduction by Yeast for Mars Exploration

Martian soil contains high levels (0.6% w/w) of calcium perchlorate ($\text{Ca}(\text{ClO}_4)_2$), which readily dissociates into calcium and the perchlorate ion (ClO_4^-) in water. Even in trace amounts, perchlorates are toxic to humans and have been implicated in thyroid dysfunction. Devising methods to lessen perchlorate contamination is crucial to minimizing the health risks associated with human exploration and colonization of Mars. We designed a perchlorate reduction pathway, which sequentially reduces perchlorate to chloride (Cl^-) and oxygen (O_2), for implementation in the yeast *Saccharomyces cerevisiae*. Using genes obtained from perchlorate reducing bacteria *Azospira oryzae* and *Dechloromonas aromatica*, we plan to assemble this pathway directly within *S. cerevisiae* through recombinational cloning. A perchlorate reduction pathway would enable *S. cerevisiae* to lower perchlorate levels and produce oxygen, which may be harvested or used directly by *S. cerevisiae* for aerobic growth and compound synthesis. Moreover, using perchlorate as an external electron acceptor could improve the efficiency of redox-imbalanced production pathways in yeast. Although several perchlorate reducing bacteria have been identified and utilized in water treatment systems on Earth, the widespread use of *S. cerevisiae* as a synthetic biology platform justifies the development of a perchlorate reducing strain for implementation on Mars.