Laidlaw Scholars Program Research Proposal

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A primary goal for astrobiology is to find another example of life. To fully understand our origins, we look to our genesis and the possible genesis of life elsewhere. In this research, we will examine lava tubes on Earth and Mars to identify components of life present in them. Once we are able to define life in the extreme environments of our planet, we will be better equipped to search for it on extraterrestrial planets, notably, Mars.

Early Mars, containing liquid water on the surface and milder climates, may have been hospitable for life. Currently, the surface of Mars is oxidized and radiative, destroying any organic materials and making it unlikely that life could exist on the surface. Therefore, we search for remnants of life beneath the surface such as in lava tubes, where organisms might have survived. Lava tubes rise from basaltic flows, where outer lava crust hardens and inner lava continues flowing outwards, creating a hollow, cave-like interior. Studying the biosignatures of lava caves on Earth translates to studies of lava caves on the red planet, the most likely place for the presence of life.

Initial studies at the Stockwell Lab by Professor Brent Stockwell and graduate student Joleen Csuka on data from lava tubes in Iceland show commonalities between the biology in lava tubes, including the presence of proteobacteria. I aim to expand on this research further by determining common factors related to life. Lipids are universally used in cells and are important for cellular barrier functions; lipids are not generally formed abiotically, providing a good indicator for life. We will focus on complex lipids such as phospholipids, diacylglycerol and triacyglycerol, which will be detected by liquid chromatography-mass spectrometry (LC-MS). We will conduct LC-MS analysis of the samples collected from Laki and Ódáðahraun lava fields in south-eastern and northern Iceland. Our controls will be blanks and sterilized sand samples which are nonbiological. Additionally, we will be requesting a sample from the nonbiological interstellar Murchison meteorite. We will treat lava tube samples and controls with the same technique. We hypothesize the presence of complex lipids in lava tube samples, but not in abiotic control

samples. By proving our hypothesis, we will establish a viable lipid biosignature for developing detection and extraction techniques for future sampling, on and off Earth.

This interdisciplinary project includes multiple institutions and labs from Iceland, Germany, and the Netherlands. The next step of the project involves cooperating with the partnered labs, and I will have the opportunity to conduct studies abroad. This could involve expanding the research further from a microbiology standpoint in Iceland where the existence of lava tubes provides the opportunity for expedition and collection of samples.

Through this project, my goal is to identify biosignatures that can indicate life, past or present, on Mars. I will be able to learn from and interact with mentors and members of the Stockwell Lab. This research will bring us one step closer to answering the famed question: is there life on Mars?