B13E-0648: Instrumentation for Examining Microbial Response to Changes In Environmental Pressures

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The Automated Adaptive Directed Evolution Chamber (AADEC) is a device that allows operators to generate a micro-scale analog of real world systems that can be used to model the local-scale effects of climate change on microbial ecosystems. The AADEC uses an artificial environment to expose cultures of micro-organisms to environmental pressures, such as UV-C radiation, chemical toxins, and temperature. The AADEC autonomously exposes micro-organisms to selection pressures. This improves upon standard manual laboratory techniques: the process can take place over a longer period of time, involve more stressors, implement real-time adjustments based on the state of the population, and minimize the risk of contamination. We currently use UV-C radiation as the main selection pressure, UV-C is well studied both for its cell and DNA damaging effects as a type of selection pressure and for its related effectiveness as a mutagen; having these functions united makes it a good choice for a proof of concept. The AADEC roadmap includes expansion to different selection pressures, including heavy metal toxicity, temperature, and other forms of radiation.

The AADEC uses closed-loop control to feedback the current state of the culture to the AADEC controller that modifies selection pressure intensity during experimentation, in this case culture density and growth rate. Culture density and growth rate are determined by measuring the optical density of the culture using 600 nm light. An array of 600 nm LEDs illuminate the culture and photodiodes are used to measure the shadow on the opposite side of the chamber.

Previous experiments showed that we can produce a million fold increase to UV-C radiation over seven iterations. The most recent implements a microfluidic system that can expose cultures to multiple different selection pressures, perform non-survival based selection, and autonomously perform hundreds of exposure cycles. A scalable pump system gives the ability to pump in various different growth media to individual cultures and introduce chemical toxins during experimentation; AADEC can perform freeze and thaw cycles. We improved our baseline characterization by building a custom UV-C exposure hood, a shutter operates on a preset timer allowing the user to set exposure intensity consistently for multiple iterations.

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