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Author: Ms. Erin Richardson
University of Toronto, Canada

SEALED AND AUTOMATED INJECTION SYSTEM FOR TIME-SENSITIVE ANALYSIS OF CELLS IN MICROGRAVITY

Abstract

We designed an experiment to study the effect of changes in gravity on the genetic regulation of human telomeres. The experiment was selected to participate in the Canadian Reduced Gravity Experiment Design flight campaign in collaboration with the Canadian Space Agency, the National Research Council of Canada, and the Students for Exploration and Development of Space Canada, and will be flown on-board the National Research Council's Falcon 20 aircraft on a parabolic flight in August 2021.

Recent studies identified profound changes in human cells' transcriptome in 20 seconds of altered gravity, demonstrating the viability of obtaining meaningful results during a parabolic flight. Post-flight, expression levels of key telomere regulating genes that contribute to extension, degradation, and regulation will be assessed and compared to controls. We hope to further both the understanding of how spaceflight impacts telomere length and how this may impact human health on Earth.

A key challenge in the design of robust space-biology experiments is the ability to capture transient cellular events in flight for post-flight analysis. A sealed and automated injection system capable of distributing lysis solution to cells was designed. It injects ethylene-vinyl acetate infusion bags of cells with a lysis and stabilization solution immediately prior to and at the end of periods of microgravity. This effectively halts cells' metabolic activity while preserving their nucleic acids for analysis after the flight. Control samples help to isolate the effects of microgravity from impacts of our setup and other rigours of flight, including periods of hypergravity and vibration.

The system is designed to meet requirements to ensure it is safe to fly on a parabolic flight. The payload is constrained to fit within a 50 x 50 x 46 cm volume and weigh no more than 45 kg. Components are compatible with the limits of the airplane's power supply. Furthermore, the system ensures biological specimens are not handled during flight and pose no risks to crew or the aircraft. The experiment does not use radiation, human or animal test subjects, and is controlled by an Arduino that is initiated with a button.

This work provides a framework for future automated cellular biology studies in harsh environments. The experiment's ease of use, low cost, volume, mass, and power requirements, portability, and automated operations could be leveraged for use on constrained research platforms such as parabolic flights, suborbital flights, the International Space Station, or in other field work.