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# SYNTHESIZING THE FUTURE OF ASTROPHARMACY: ENABLING ON-DEMAND PROTEIN PRODUCTION IN SPACE THROUGH CELL-FREE SYSTEMS

**Abstract**

The VITA (Visualizing In-space Tx-Tl Astropharmaceuticals) mission will be conducted in the International Space Station (ISS), Ice Cube Facility (ICF) as part of the Academy Experiments Programme of the European Space Agency (ESA). Prior Earth-based experiments have successfully utilized a novel Cell-Free Protein Synthesis (CFPS) system for high-level expression of fluorescent proteins, laying the groundwork for the VITA mission's methodology. Unlike traditional methods of therapeutic protein production that require live cell cultures, CFPS leverages cell extracts, specifically from E. coli, mixed with DNA and other reagents to produce proteins. The team has also developed a lightweight, low-cost platform for on-site protein synthesis by freeze-drying CFPS reagents onto cellulose paper discs, which are later rehydrated to initiate protein production. The fluorescence spectrometer will measure the fluorescence of the proteins, which determines their ability to fold and function. Hence, this approach can be effectively applied in extreme environments, both on Earth and space, compared to cell-based manufacturing. The mission's primary scientific objectives include demonstrating the longterm viability of freeze-dried CFPS cellulose stack systems for spaceflight stowage and their subsequent rehydration for in-situ fluorescent protein synthesis. This process will be monitored through fluorescent spectroscopy and imaging, with results transmitted in near-real time. Post-mission analysis will compare the space-synthesized proteins' purity and functionality against Earth-based controls. Observations will foster an understanding of the kinetics of the cell-free reaction and protein synthesis in a microgravity environment, and the overall feasibility of such systems for producing on-demand therapeutic proteins in space. This study details the experimental approach and methodology for production of therapeutic proteins and other compounds. As result, on-demand medication and therapeutics may be produced in space with fully automated 1 procedures. The findings could significantly impact future lunar and interplanetary missions, offering a sustainable solution to the logistical challenges of long-duration space travel and isolated research outposts. This technique's adaptability to extreme terrestrial environments, such as polar research stations, underscores its potential for wide-ranging applications, from space exploration to remote medical support.