IAF MICROGRAVITY SCIENCES AND PROCESSES SYMPOSIUM (A2)
Interactive Presentations - IAF MICROGRAVITY SCIENCES AND PROCESSES SYMPOSIUM (IPB)

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BIOMANUFACTURING IN LOW EARTH ORBIT

Abstract

The promise of Low Earth Orbit (LEO) research and manufacturing is currently unrealized. Biomanufacturing can benefit from the microgravity environment of LEO immensely due to the lack of sedimentation and convection. Biology can be done for the sake of biology. Redwire's BioFabrication Facility (BFF) is the first 3D bioprinter on the International Space Station (ISS) and was designed to harness microgravity to advance 3D bioprinting. The ISS microgravity environment allows for 3D printing without sedimentation of cells and nutrients, instead printed components stay where they are printed. However, a significant number and variety of cells are required to 3D bioprint tissues and organs, representing a major roadblock to realizing the potential of biomanufacturing in microgravity. Research suggests that stemness and proliferative capacity are enhanced in stem cells grown in microgravity. To harness this effect, we have developed the Redwire Cell Factory, a suite of automated hardware committed to large scale production of biologics in all their forms. One part of the Cell Factory suite is the automated cell culture system for reprogramming cells into induced Pluripotent Stem Cells (iPSCs) on the ISS. The microgravity grown iPSCs may then be used aboard the ISS for fundamental research, the preparation of bioinks for 3D bioprinting, and direct cell therapy applications on Earth. The ability to manufacture cells, tissues, and whole organs in space for a patient on Earth, from that patient's own cells, could be regarded as one of the most significant advancements in healthcare in this century. The first element of the Redwire Cell Factory can maintain environmental conditions for cell growth, microscopy using phase, brightfield, or fluorescent imaging, as well as automate media changes on an individual well basis. The double locker payload has demonstrated successful transfection, maintenance, and imaging of primary cells while also maintaining a contamination free culture, and in a highly automated fashion with minimal human intervention. The transfection efficiency and cell viability were comparable between the Cell Factory and standard laboratory approaches. The combination of the Cell Factory technology with the BFF will enhance our ability to leverage microgravity for breakthroughs involving stem cells and 3D bioprinting. This combination of cell production and 3D bioprinting will be regarded as one of the most important and tangible returns on America's investment during the 30-year operation of the ISS.