LUNA
DESIGN AND INNOVATION

BLUE ORIGIN

MICROGRAVITY LIFE SCIENCES

FOR COMMERCIAL RESEARCH & DEVELOPMENT

ABOUT

This paper frames the opportunity for companies to leverage microgravity for research and innovation in space. It is intended for leaders working within the life sciences and health-care industry, such as scientists, innovation professionals, and R&D leaders. Included are case studies that highlight the scientific and business value of these endeavors as well as guidance on how you can initiate space-based initiatives at your company.

Luna and Blue Origin can support your journey to space. We welcome your ideas about space-based research and building out spaceflight opportunities at your company.

LUNA
DESIGN AND INNOVATION

Luna Design and Innovation helps biotech and pharmaceutical companies envision and plan missions to space. Luna's goal is to advance health for humanity so people can lead full, healthy, and purposeful lives in space and on Earth. Luna is a channel partner for Blue Origin's New Shepard suborbital reusable vehicle, focusing on global life sciences and Canadian payload opportunities.

For questions and support around building your space flight initiative as well as Blue Origin payload opportunities, please contact Andrea Yip, CEO, Luna Design and Innovation: andrea@lunainnovates.com.

BLUE ORIGIN

Blue Origin was founded by Jeff Bezos with the vision of enabling a future where millions of people are living and working in space to benefit Earth. In order to preserve Earth, Blue Origin believes that humanity will need to expand, explore, find new energy and material resources, and move industries that stress Earth into space. Blue is working on this today by developing partially and fully reusable launch vehicles that are safe, low cost and serve the needs of all civil, commercial and defense customers. For more information about Blue Origin, please contact: payloads@blueorigin.com.

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EXECUTIVE SUMMARY

SPACE, A NEW FRONTIER FOR THE LIFE SCIENCES

A burgeoning commercial space industry is ensuring that the infrastructure for space is rapidly being built today, accelerating our ability to live and work in space tomorrow. Life sciences companies are leveraging this momentum by utilizing space as a research platform in order to improve life on Earth. Frontier technologies like reusable suborbital launch vehicles have reduced costs, increased frequency, and demonstrated reliable and repetitive use of space for R&D activities.

SCIENTIFIC VALUE

Microgravity, or weightlessness, is a unique attribute of space-based environments that enables scientists to observe phenomena that are not possible on Earth. While weightless, there is no stress or strain from externally applied contact forces which resist the acceleration of gravity. Convective forces, mechanical stressors, buoyancy, and sedimentation are minimized as gravitational effects fade away. Observations made in microgravity can disrupt and challenge how we understand disease areas, therapeutics, and biological systems here on the ground. For instance, novel gene pathways are activated in organisms in microgravity, leading to new opportunities for improving our understanding of epigenetics and underlying cell mechanisms.

Designing for space can drive new terrestrial approaches to scientific problem solving and innovation, and ultimately support the development of novel commercial offerings on Earth. Three ways that companies have gained value from space-based research for terrestrial applications include:

1. NEW INSIGHTS

Generate insights that enable new ways of thinking about science and scientific process

E.g., organ-chips in space, human T cell gene expression

2. BENCHMARKING

Create unique benchmarking specimens that guide further research inquiry and product development

E.g., protein crystallization, growing tissue models for drug testing

3. MANUFACTURING

Develop novel materials and products in space

E.g., homogenous materials development, 3-D printing soft tissues

As space opens to new users, companies are also developing more technologies (hardware, medical devices, etc.) that support life sciences activities in these unique environments.

BUSINESS VALUE

Access to low-risk and low-cost R&D missions is enabling widespread corporate engagement. An investment in space today positions companies with a competitive advantage to lead space-based research and commercialization tomorrow. Core business benefits include:

- Fostering a culture of innovation: Build a global reputation as an innovative life sciences leader and generate high visibility and marketing output.
- Driving employee engagement: Rally people around a space flight mission, foster collaboration and education, and train employees as commercial astronauts.
- Enabling cross-sector R&D: Build new R&D capabilities and engage in cross-industry knowledge and technology transfer.

CONTACT US

We are excited to help you launch your own microgravity initiative and support your journey to space.

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INTRODUCTION

SPACE, A NEW FRONTIER FOR THE LIFE SCIENCES

Space is becoming more accessible to the everyday citizen. A burgeoning commercial space industry is ensuring that the infrastructure for space is rapidly being built today, accelerating our ability to live and work in space tomorrow. The rise of spacefaring countries and companies has spawned a new era of exploration and discovery. Today, new and increasingly diverse entrants are participating in global space activities for the first time.

Life sciences companies are actively designing and flying research experiments to space in order to improve life on Earth. Frontier technologies like reusable suborbital vehicles have reduced costs, increased frequency, and demonstrated reliable and repetitive use of space as an R&D platform. This is creating new avenues for research and product and service development. Moreover, private space companies offer a streamlined path to accessing space, reducing the need for government oversight and coordination. In the near future, researchers will also have the opportunity to conduct their own experiments in-flight as qualified commercial astronauts, offering unique opportunities for sensitive research as well as brand ambassadorship.

MICROGRAVITY FOR THE LIFE SCIENCES

Microgravity, or weightlessness, is a unique attribute of space-based environments that enables scientists to observe phenomena that are not possible on Earth. Convective forces, mechanical stressors, buoyancy, and sedimentation are minimized as gravitational effects fade away, allowing surface tension, diffusion, and other quiescence phenomena to dominate. Observations made in microgravity can disrupt and challenge how we understand disease areas, therapeutics, and biological systems here on Earth. For instance, novel gene pathways are activated in organisms in microgravity, leading to new opportunities for improving our understanding of epigenetics and underlying cell mechanisms.[1]

The effects of space and microgravity on the human body has been observed since the inception of the space program. Early research confirmed that humans could survive space travel and helped scientists understand how biological systems respond to microgravity conditions.[2] Today, much of the research is focused on elucidating the mechanisms behind these biological changes. Both the insights gathered and the experience of designing for space itself have helped drive new terrestrial approaches to problem solving, and supported the development of novel commercial offerings.

[1] NASA. (2020, April 9). Understanding Epigenetics Research in Space. Retrieved November 11, 2020 from https://www.nasa.gov/mission_pages/station/research/news/understanding-epigenetics-research-in-space/

[2] Souza, K., Hogan, R., & Ballard R. (1995). Space life sciences experiments, NASA Ames Research Center, 1965-1990. Retrieved November 5, 2020, from https://www.nasa.gov/sites/default/files/life_into_space_vol1.pdf

MICROGRAVITY

WHAT IS MICROGRAVITY?

A hallmark of space is the dynamic of objects in free fall, a phenomenon which produces weightlessness. While weightless, there is no stress or strain from externally applied contact forces which resist the acceleration of gravity. The effects of gravity appear to vanish. Though often referred to as "zero-g", there are still tiny residual forces at play in microgravity such as gravitational effects, aerodynamic interactions, and tidal forces, typically on the order of 10^{-3} to 10^{-5} times standard Earth gravity.[3] A state of perpetual free fall is achieved by putting objects into orbit (e.g., a trajectory around the Earth). Intervals of free fall are achieved by putting objects into a suborbital trajectory (e.g., a high-altitude parabola that does not complete a full orbit of Earth).

Microgravity dramatically alters the dynamics and phenomena that we observe on Earth. If something sinks, floats, flows or grows, it's likely affected by gravity. For example, immiscible fluids tend to separate and segregate by density. We see this in the way oil floats on the surface of water on Earth. In microgravity, these liquids can be intimately mixed together.

The following questions can help you consider phenomena in your own research that may benefit from experimentation in microgravity:

1. How is the system or material being **mechanically stressed** due to gravity?
2. What role does **convection** play in the system and what happens if it is removed?
3. How are gravity-driven **sedimentation and buoyancy** features of the system?
4. Does this process involve **particle formation, nucleation or crystal growth**?
5. How might the formation of more perfect **crystalline structures** advance the research?
6. How might the research benefit from stable mixtures of **immiscible fluids or metastable phases**?
7. How might the formation of new materials with unique **morphology and microstructure** be beneficial?
8. Does my system have **orientation biases**, driven by gravity?
9. How might **containerless processing** reveal new data or permit new fabrication?
10. Does the **absolute energy state** matter to my experiment?
11. How might eliminating **gravitationally generated "noise"** help me better characterize my phenomena?
12. How might removing **dominant gravitationally-driven** factors help me interrogate higher-order effects?
13. Is gravity a variable in my **scientific equations**?

MICROGRAVITY PLATFORMS

Microgravity platforms vary in terms of cost and performance, as measured by the quality and duration of the microgravity environment. Many flight and ground-based platforms offer highly available and low-cost options for scientists to conduct research in seconds to minutes of microgravity exposure (Table 1). Other flight-

[3] Dunbar, B. (2008, April 12). Microgravity Fact Sheet. Retrieved November 5, 2020, from http://www.nasa.gov/centers/marshall/news/background/facts/microgravity.html

based platforms like satellites, capsules, or the International Space Station (ISS) are higher cost but carry experiments into orbit, allowing for investigations that last days, months, or years.

Human-rated reusable suborbital vehicles are emergent commercial technologies that carry both people and research experiments to suborbital space. This class of vehicles offers ~3 minutes of high-quality microgravity, frequent operations, a 'shirtsleeve' passenger-friendly environment, and potential for human tending so researchers may conduct experiments in-flight. New Shepard is Blue Origin's fully reusable suborbital launch vehicle that is designed to fly past the Kármán line (100 km), the internationally recognized boundary of space. Access to vehicles like New Shepard present a unique opportunity for companies to design and fly experiments frequently and train employees to conduct research as commercial astronauts.

BLUE ORIGIN'S NEW SHEPARD VEHICLE

Figure 1 PLATFORMS FOR ACHIEVING SHORT-DURATION MICROGRAVITY

	GROUND-BASED		FLIGHT-BASED			
PLATFORM	**SIMULATORS**	**DROP TOWER**	**BALLOON DROP**	**PARABOLIC FLIGHT**	**SOUNDING ROCKET**	**REUSABLE SUBORBITAL VEHICLE**
Description	Technology that simulates microgravity (e.g., 2D Clinostat, Random Positioning Machine, Rotating Wall Vessel)	Experiments are hoisted up and dropped, often through a vacuum evacuated tube, in order to achieve free fall	Experiments are carried high into the stratosphere and dropped in free fall until they encounter significant atmospheric drag	Aircraft carry experiments through a parabolic trajectory; parabolas create periods of microgravity	Rockets carry experiments on a suborbital trajectory to space	Vehicles carry people and experiments on a suborbital trajectory to space
Microgravity duration (seconds)	Varies	2 to 10	30 to 50	15 to 30	120 to 600	180+
Microgravity Quality (g)	Varies	10^{-3} to 10^{-5}	10^{-2}	10^{-2} to 10^{-3}	10^{-3} to 10^{-4}	10^{-3} to 10^{-5}
Human Tended Capability	Yes	No	No	Yes	No	Yes
Cost	$	$	$	$$	$$$	$$

[4] Suborbital Reusable Vehicles: A 10-Year Forecast of Market Demand. (2012). Retrieved November 5, 2020, from https://www.faa.gov/about/office_org/headquarters_offices/ast/media/Suborbital_Reusable_Vehicles_Report_Full.pdf

MICROGRAVITY FOR LIFE SCIENCES R&D

Corporate space programs elevate a company's scientific knowledge base and capabilities while promoting innovation, collaboration, and business development. Below we look at the benefits of conducting commercial research in microgravity.

SCIENTIFIC VALUE

A range of life sciences research has been performed in space to benefit life on Earth, from broader and more exploratory experiments to highly sophisticated product R&D. Three ways that companies have gained value from microgravity research include:

1. NEW INSIGHTS

Generate insights that enable new ways of thinking about science and scientific process

2. BENCHMARKING

Create unique benchmarking specimens that guide further research inquiry and product development

3. MANUFACTURING

Develop novel materials and products in space

The case studies below showcase a diverse range of experiments. As an emerging field of study, we anticipate that the volume, sophistication, creativity, and diversity of use cases will only grow. This is, in part, enabled by an increasingly vibrant service ecosystem for space research and wider availability of standardized and low-cost hardware. Following these case studies, we also explore examples where companies are creating unique technologies that support life sciences activities in space.

1. NEW INSIGHTS

Microgravity can help researchers generate insights that enable new ways of thinking about their science or scientific process. These types of experiments may be useful simply because we do not yet fully understand a scientific concept or process and are open to exploring what new knowledge an investigation may yield. This can lead to "Aha!" moments, helping scientists discover new ways to think about their research, test their assumptions, and complement terrestrial R&D efforts. In the following case studies, we examine how scientists are exploring the effects of microgravity on organ-on-a-chip systems and human T cell gene expression.

Figure 2: A view of the Gut on Chip CubeLab aboard ISS, Image Credit: NASA

Case Study: Organ chips in space

Understanding the effects of microgravity on the gastrointestinal system

Company: Emulate, Inc.

Emulate is a biotechnology startup with ambitions to commercialize Organ-on-a-Chip technology. The chips model the structure and function of human tissue by growing human cells on artificial scaffolding.[5] This allows researchers to simulate human organ systems and dynamic conditions in the body like blood flow, mechanical forces, and other microenvironmental factors.[6] The company will test their Intestine-Chip to study how sensory neurons interact with other cells to maintain gastrointestinal homeostasis, the immune response of the intestinal system to disease-causing bacteria, and the system's overall response to microgravity. Microgravity is a unique environment for this research as it can enable cell functionality that is more true-to-life. Moreover, increased bacterial virulence in cell cultures and suppressed immune function in humans has been previously observed under these conditions.[7] The team has developed compact and entirely autonomous payload technology for ISS that may be applied to future space and terrestrial investigations.

Case Study: Dynamic Gene Expression in Human T Cells

Understanding gene responses in short microgravity

Partnership: Industry and academic collaboration

Historically, microgravity science has been the domain of government and academia, building our foundational knowledge of life sciences research in space. This case study highlights a unique collaboration of academic and industry partners who investigated the initial gene expression response of human Jurkat T lymphocytic cells in short duration microgravity. Previous studies have demonstrated that immune cells are highly sensitive to gravitational changes and that the immune system is compromised in space. In this study, researchers used both parabolic flight and sounding rocket platforms to independently validate that gene expression in T cells responded rapidly to altered gravity.[8] Gene expression was most rapid and extensive among regulatory RNAs. Three gravity-regulated genes were identified: ATP6V1A/D, a vacuolar H+ ATPase (V-ATPase) responsible for acidification during bone resorption, IGHD3-3/IGHD3-10, genes of the immunoglobulin heavy-chain locus participating in V(D)J recombination, and LINC00837, a long intergenic non-protein coding RNA. This advances our understanding of the molecular and cellular basis of T cell responses in microgravity, and has the potential to help uncover new pharmaceutical targets related to the immune system.

[5] ISS National Lab. Emulating human biology with tissue chips (2018, December 19). Retrieved November 5, 2020, from https://www.issnationallab.org/blog/emulating-human-biology-with-tissue-chips/

[6] Elkavich, A. Human emulation on the International Space Station (2019, April 26). Retrieved November 5, 2020, from https://www.issnationallab.org/blog/human-emulation-on-the-international-space-station/

[7] Emulate, Inc. Emulate, Inc. awarded grant to use intestine-chip to study human GI infections about the International Space Station (2018, December 18). Retrieved November 15, 2020, from https://www.emulatebio.com/press/emulate-intestine-chip-human-gi-infections-international-space-station

[8] Thiel et al. (2017). Dynamic gene expression response to altered gravity in human T cells. Scientific Reports, 7, 5204. doi:10.1038/s41598-017-05580-x

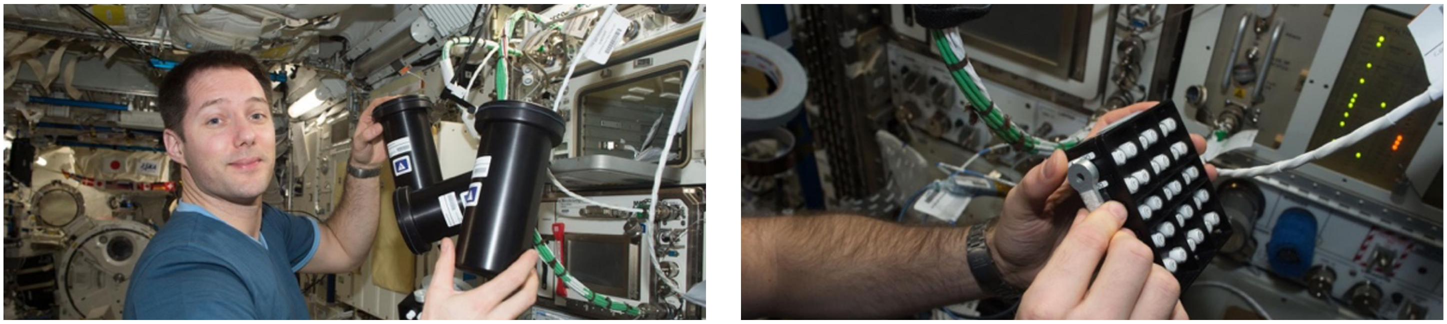


Figure 3: Images taken of astronaut Thomas Pesquet during Protein Crystal Growth (PCG-5) hardware deactivation and stow from Merck's investigation to crystalize a monoclonal antibody, Image Credit: NASA.

2. BENCHMARKING

Benchmarking refers to the creation of specimens or models in microgravity that are used to guide research inquiry and product development on Earth. These specimens or models can contain information relating to a material itself or its production. This presents an opportunity to refine and improve terrestrial models and processes. In the case studies below, we examine how microgravity has been used to create more perfect protein crystals in space and help model in vivo-like tissue environments for drug testing.

Case Study: Keytruda® in Space

Creating model protein crystals in microgravity

Company: Merck & Co.

For nearly a decade, Merck has been engaged in protein crystallization research in space. Recently, Merck sent their blockbuster immunotherapy drug pembrolizumab or Keytruda® to ISS. Pembrolizumab is a monoclonal antibody (mAb) that is used to treat a variety of cancers. The goal of Merck's study was to use microgravity to understand what variables would affect mAb crystallization in order to identify ideal conditions for pembrolizumab crystallization. Identifying these conditions could allow Merck to apply these learnings toward the development of a highly concentrated mAb formulation on Earth with the potential to reduce time and costs associated with patient therapy and develop a more stable drug that can be transported without refrigeration.[9] The study produced high-yield crystalline

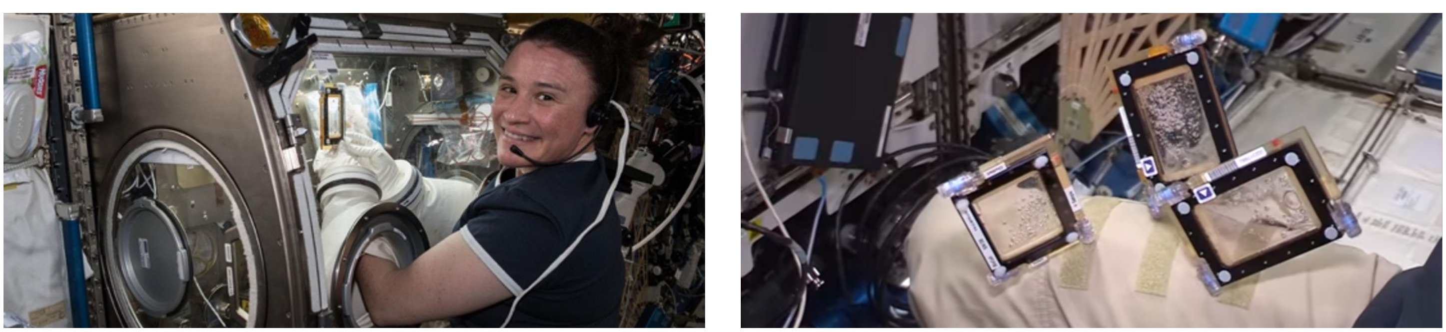


Figure 4: NASA astronaut Serena Auñón-Chancellor conducts research operations for the Angiex Cancer Therapy Study inside the Microgravity Science Glovebox (Left) and demonstrates the hardware (Right), Image Credit: NASA.

[9] Upward. Reshaping drug delivery millions of crystals at a time (2018, March 26). Retrieved November 5, 2020, from https://upward.issnationallab.org/millions-of-crystals-at-a-time/

[10] Reichert et al. (2019). Pembrolizumab microgravity crystallization experimentation. Npj Microgravity, 5, 28. doi:10.1038/s41526-019-0090-3https://upward.issnationallab.org/millions-of-crystals-at-a-time/

Figure 5: The BioFabrication Facility and the Advanced Space Experiment Processor comprise a 3D tissue bioprinting system for ISS (Left). Astronaut Christina Koch handles media bags that enable the manufacturing of organ-like tissues using BFF (Right). Image Credit: NASA.

suspensions of homogenous monomodal particle size distribution with improved viscosity and more uniform sedimentation compared to ground experiments.[10] Researchers identified sedimentation and temperature gradients as key variables in controlling crystal nucleation and growth. The results were applied to ground experiments, allowing scientists to achieve crystalline suspensions suitable for an injectable formulation. This study demonstrates the value of Merck's long-term investment in space for improving product development on Earth.

Case Study: Testing cancer therapy in space
Evaluating drug toxicity using human-like models in microgravity

Company: Angiex

Angiex, a biotherapeutics company, has developed a novel cancer therapy that regresses tumors through a dual mechanism of action against tumor cells and tumor blood vessels. Having demonstrated the drug's effectiveness in animal models, Angiex was seeking a way to test the drug's toxicity in models relevant to normal blood vessels in humans. In microgravity, cell cultures grow in three-dimensions and behave more similarly to the way they would in the human body, making this environment more optimal for such testing. Endothelial cell cultures in space remain in a persistent state of reduced cell growth like those in vivo (inside the body).[11] Through this study, Angiex confirmed that endothelial cells move or proliferate less in microgravity and proved resistant to therapy compared to ground control cells, which were nearly destroyed. Spaceflight cells also displayed different morphology and behavior and maintained these changes on ground, indicating long-term epigenetic changes in the cells.[12]

3. MANUFACTURING

Microgravity manufacturing enables companies to develop novel materials and products in

[11] Carney, S. Endothelial explorations. (2018, July 02). Retrieved November 5, 2020, from https://www.issnationallab.org/blog/endothelial-explorations/

[12] Jaminet, P. Pioneering the wild west of spaceflight research (2019, October 22). Retrieved November 5, 2020, from https://www.issnationallab.org/blog/masschallenge-technology-space-prize-angiex/

space. Several companies have already started to explore manufacturing of high-value products in space for return to terrestrial markets. Microgravity can optimize materials development by eliminating convection currents and buoyancy. The following case studies demonstrate the use of microgravity for creating novel medical devices and organ tissues.

Case study: Improving retinal implants in space
Medical device materials development and manufacturing

Company: LambdaVision, Inc.

LambdaVision is a biotechnology startup that is developing a protein-based retinal implant to restore meaningful vision and quality of life for patients living with advanced retinal degenerative diseases such as retinitis pigmentosa (RP) and age-related macular degeneration (AMD). Patients living with these diseases experience blindness or significant sight impairment due a loss of cells in the retina. LambdaVision's implant uses light activated proteins derived from bacteria to replace the function of damaged photoreceptors in the retina. Microgravity offers a novel opportunity to develop a more homogenous protein solution and layer-by-layer manufacturing process by minimizing the effects of gravity induced sedimentation.[13] This can lead to improved form, lifespan, and stability of the device, reducing the amount of materials and cost required for manufacture. In 2020, LamdaVision received additional funding from NASA to continue product development efforts in space.[14]

Case Study: 3D Printing Human Tissues on ISS
Printing soft tissues in space for transplant on Earth

Companies: Techshot, Inc. and nScrypt

In January 2020, the first human heart tissue constructs were printed aboard ISS by the 3D BioFabrication Facility (BFF), a 3D printer capable of manufacturing human tissue in space.[15] BFF is a joint effort between Techshot, a commercial operator of microgravity research and manufacturing equipment, and nScrypt, a manufacturer of industrial 3D bioprinters and electronics. In-space technology is optimal for 3D printing soft human tissue like blood vessels or muscle: on Earth the forces of gravity cause these structures to collapse under their own weight, whereas in microgravity they maintain their integrity. BFF's bioink is comprised of adult human cells (e.g., pluripotent stem cells) and adult tissue-derived proteins. Once printed, tissue structures are placed into a cell-culturing system where they become viable and are expected to remain solid upon arrival on Earth. Manufacturing viable organs in space may increase the availability of organs for transplant, reduce reliance on human organ donors, and allow for patient-specific replacement tissues or patches.

LIFE SCIENCES TECHNOLOGY FOR SPACE

Tools for facilitating and enabling life sciences activities in space are becoming more important as access to space increases. This can include hardware for conducting microgravity research

[13] Smith, L. Setting sights on vision (2018, December 18). Retrieved November 5, 2020, from https://www.issnationallab.org/blog/setting-sights-on-vision/

[14] Smith, A.W. LambdaVision Receives $5 million award from NASA for additional ISS research (2020, April 10). Retrieved November 5, 2020, from https://www.issnationallab.org/blog/lambdavision-space-tango-5-million-award-from-nasa-additional-retinal-research/

[15] Techshot. Success: 3D bioprinter in space prints with human heart cells (2020, January 7). Retrieved November 5, 2020, from https://techshot.com/success-3d-bioprinter-in-space-prints-with-human-heart-cells/

and medical devices that support human life in space. Below we take a look at examples of technologies that are being tested on suborbital microgravity platforms.

Case Study: Studying Live-Cell Investigations on Suborbital Flights
Creating space hardware for life sciences experiments

Company: HNu Photonics LLC

Microgravity has a wide range of effects on cell growth and function including gene expression and cell signalling.[16] HNu Photonics is developing the BioChip SubOrbital Lab (BCSOL), an automated microfluidic and imaging platform that allows for real-time investigations of live cells during a suborbital flight. Currently, few facilities offer real-time investigations of live cells in microgravity, and most experiments may only capture protein or RNA expression at a discrete "end point" or moment in time.[17] The BCSOL hardware will allow for more robust investigations of cell biology in space by allowing researchers to monitor subcellar processes and characterize transient cellular responses to microgravity. The technology is being validated through stepwise testing on New Shepard and aims to be available for commercial use in the near future. HNu Photonics has flown related technologies to ISS.[18]

Case Study: Treating Medical Emergencies in Microgravity
Developing medical devices for space exploration

Company: Orbital Medicine Inc.

Today the equipment available to treat injuries involving chest trauma, a collapsed lung (pneumothorax), or decompression rely on gravity to operate and may only be used for patients on ground. Orbital Medicine is developing a medical suction device that is designed to operate in microgravity and treat injuries that occur in space. The company's novel solution uses a specially designed passive fluid management architecture that leverages surface tension effects. It involves a thoracic drainage device with a two-phase separator that uses suction to collect and store blood and continuously inflate the lung in microgravity.[19] The company has used both parabolic flights and New Shepard to validate the technology and prepare it for testing in orbital environments.

BUSINESS VALUE

Life sciences companies have an opportunity to leverage the momentum of a rapidly growing global space industry that is actively pursuing missions to low Earth orbit, the moon, and beyond. This is allowing companies to engage in low risk and low-cost R&D missions today, positioning them with a competitive advantage to lead space-based research and commercialization tomorrow.

[16]Becker, J. and Souza, G. (2013). Using space-based investigations to inform cancer research on Earth. Nat Rev Cancer, 13, 316-327. doi:10.1038/nrc3507

[17]NASA Flight Opportunities. BioChip SubOrbitalLab: An Automated Microfluidic and Imaging Platform for Live-Cell Investigations in Microgravity (2018, November 16). Retrieved November 12, 2020, from https://flightopportunities.nasa.gov/technologies/181/

[18]ISS National Lab. Demo mission for automated complex cell culture imaging launching to the ISS National Lab (2020, February 7). Retrieved November 26, 2020, from https://www.issnationallab.org/press-releases/hnu-mobile-spacelab-onboard-ng-crs13/

[19]NASA Flight Opportunities. Evolved medical microgravity suction device (2018, November 16). Retrieved November 12, 2020, from https://flightopportunities.nasa.gov/technologies/162/

Spaceflight is a unique way to engage employees in science-driven initiatives that capture the imagination of the enterprise. The process of designing a space experiment — from a lab bench on Earth to a compact payload in space — in itself encourages scientists to consider their research from a new perspective, optimizing for safety, sustainability, and cost-efficiencies. Core business benefits include:

FOSTERING A CULTURE OF INNOVATION

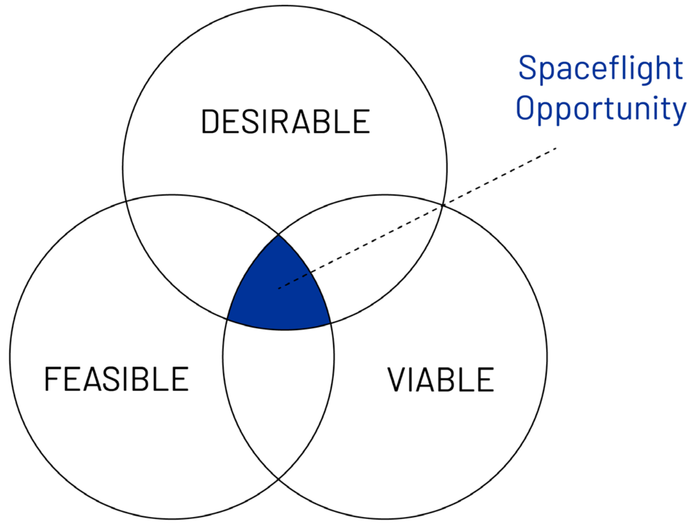
- Build a global reputation for innovation and thought leadership
- Attract the next generation of employees and grow a STEM-driven talent pipeline
- Generate high media and marketing output
- Develop core competencies in an emerging field with long-term market opportunities

DRIVING EMPLOYEE ENGAGEMENT

- Foster collaboration and teamwork amongst employees through space-based projects
- Rally employees and their communities around space flight, creating opportunities for awareness building and education
- Train employees as commercial astronauts to drive deep results and visible brand opportunities

ENABLING CROSS-SECTOR R&D

- Support cross-industry technology and knowledge transfer
- Build new perspective and R&D capabilities by designing and building space flight research
- Access subject matter experts leading space exploration and technology development



LAUNCHING A SPACE-BASED MICROGRAVITY INITIATIVE

Launching a space-based initiative can generate curiosity, excitement, and engagement. Create a vision for microgravity research and identify how it can add scientific and business value to your company. Through your initiative you will design and build your experiments, prepare them for flight, and gather, analyze and apply your findings. Consider a design thinking approach to innovation[20] to help you build a research initiative that is:

DESIRABLE: What makes sense to people and for people?

FEASIBLE: What is technically possible and builds on our capabilities as a company?

VIABLE: What is likely to become a part of a sustainable business model?

[20] IDEO U. Design thinking (2020). Retrieved November 5, 2020, from https://www.ideou.com/pages/design-thinking

HERE ARE SOME BEST PRACTICES FOR GETTING YOUR IDEAS OFF THE GROUND:

1. **Contact Luna Design and Innovation or Blue Origin** to help you plan your initiative and ensure mission success. Luna supports life sciences companies in planning research missions to space, working directly with Blue Origin, a commercial launch services provider that provides frequent and affordable access to suborbital spaceflight.
2. **Explore the opportunity** by understanding how microgravity can benefit your company's current R&D efforts and broader organizational goals. Review past space research and technical documents like the Blue Origin Payload User's Guide to familiarize with the launch technologies that will enable your mission. Consider hosting a facilitated, internal ideation session and/or gathering ideas from across your company to identify relevant research opportunities.
3. **Make a plan** for spaceflight that identifies program milestones and required resources including people, materials, and budget. Funding for your initiative may come from government grants, external partners, and/or internal budgets.
4. **Engage decision makers and internal allies** who can help you champion the work internally and secure resources for your initiative.
5. **Promote education and awareness building** to generate excitement and familiarity for space-based research and your space initiative. Share how it adds value to your company and build personal connections for team members.

WE LOOK FORWARD TO WORKING WITH YOU!

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