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Enhancement and Retention of Space Bioscientists and Students

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Overall Topic & Goal

With the advent of space exploration to the Moon and Mars, increased commercialization of aerospace flights, and the essential need for human exploration, capitalizing on enhancing the workforce in the emerging fields of space biology, astrobiology, and aerospace physiology is required. Importantly, retention of individuals within this specialized workforce is particularly essential for enhancing and maintaining a strong space bioscience institution in the United States.

Backgrounds & Current Limitations

Currently, space biosciences are limited to selected NASA centers, some specialized aerospace companies, and a few academic institutions in the United States. Space biosciences encompasses space biology, astrobiology, and aerospace physiology. The expansion of space biosciences education and research is required to pursue exploratory endeavours for human inhabitation on the Moon and Mars. It is an essential step to make these goals possible. Importantly, current programs in these specialized fields are finite, with limited opportunities for further enhancement and research opportunities. Therefore, programs, institutes, and functions that can retain trained space bioscientists and students in these select fields are essential for the continuity of space biosciences.

Proposed Plan

In brief, an absolute requirement for more opportunities within multiple educational levels for *expansion* of space biosciences workforce is listed but not limited to, space biology, astrobiology, and aerospace physiology. This can be achieved in the form of increased educational programs (i.e. graduate fellowships at Academic institutions), institutional opportunities for paid or unpaid internships, cooperative agreements, extended contracts, civil servant positions, advertisements across non-space centric universities, and improved mentorship programs. We have expanded on these points below.

ENHANCEMENT of space biosciences should be led by experts at NASA, being a beacon of strong reputation and respect in the aerospace community, as a workforce end goal. Additional government institutions that have focused research in space biosciences, including the United States Air Force, Department of Defense, Department of Energy, the National Institutes of Health, and the National Science Foundation, would also be intimately involved in development of expert workforce. Following suit, private/commercial companies, including SpaceX, Virgin Galactic, Sierra Space and Blue Origin also play a role in space biosciences research. Additionally, and arguably most importantly, academic institutions and their programmatic offerings with research focused on human performance in space and the space biosciences will be essential in development of this field. For example, Embry-Riddle Aeronautical University's aerospace physiology program is the first undergraduate life sciences program focused on space which provides students an avenue to other developing programs like TRISH. Collectively, these important facilities are necessary for *enhancement* of space biosciences.

Bridging connections among government, academic and private aerospace organizations is key in maintaining a strong and specialized workforce in space biosciences.

RETENTION of space bioscientists and students includes providing opportunities in order to expand and improve the field of space biosciences. Opportunities at the aforementioned institutions are necessary to provide a workforce of space bioscientists and next generation space bioscientists (students in training), and should be critically important considerations for the next decade of space research, in particular, with elevated human missions both within and beyond low-Earth orbit. Thus, increased funding toward opportunities to boost this essential need of retention is an absolute requirement. Current suggestions include amplified mentorship programs, increased communication among institutions, grant opportunities, civil servant positions, long-term contractor positions, institutional partnerships, and academic advancement in space biosciences.

Programs: Hosted by NASA. While we understand that these programs are already in place, we recommend *additional funding* to these current programs to enhance these opportunities.

a. Current programs focused on space biosciences in circulation.

i. STAR program (Spaceflight Technologies, Applications, and Research) - TARGETS: Postdoctoral researchers, Scientists, and Principal Investigators. BENEFITS: Collaboration opportunities and introduction to spaceflight applications. LIMITS: No research/lab-based experiences.
ii. SLSTP (Space Life Sciences Training Program) - TARGETS: Undergraduates. BENEFITS: experience in space biology and astrobiology research, fully funded. LIMITS: limited formal learning objectives, no set avenue for workforce integration, limited number of NASA mentors that can dedicate full dedication to the program since NASA mentor civil servants have been drastically reduced and are overburdened by bureaucratic tasks and potential contractor mentors are generally limited to specific tasks.
iii. GL4HS (GeneLab for High Schools) - TARGETS: High school students. BENEFITS: omics research to open source spaceflight data, fully funded program, LIMITS: no formal avenue for workforce integration and limited to omics-based research with no lab component.
iv. NASA Postdoctoral Program: https://npp.usra.edu - TARGETS: Postdoctoral Fellows. BENEFITS: collaboration and individual scientific growth. Fully funded. LIMITS: no formal learning objectives, no set avenue for workforce integration. Research limitations for NASA as only those NASA PIs that have NASA funded grants can accept NPP fellows (very selective process).
v. NASA Established Program to Stimulate Competitive Research (EPSCoR) - TARGETS: Graduates/Undergraduates. BENEFITS: program for universities throughout the US to fund specific research questions and provides opportunities to participate in NASA BPS relevant research. LIMITS: Selective.
vi. Blue Marble Young Scientist Program: https://bmsis.org/ysp/ – TARGETS: post-baccalaureate. BENEFITS: continued research program to work with other centers. Due to contractor limitations to maintain NASA credentials, this institute provides an avenue for NASA contractor support and student grant participation on NASA-funded projects. Additional training in science communication as well. LIMITS: Does not work with graduate students or post-doctoral fellows.
vii. SPACElife Sciences website: https://www.nasa.gov/audience/foreducators/spacelife/home/index.html - TARGETS: educators and students of all ages, emphasis K-12. BENEFITS: lesson plans in diverse topics to facilitate introduction of space biosciences into the classroom. LIMITS: material needs updating and consistent oversight to keep on top of ever-changing scientific literature; some topics (genomics, microbiology) lack coverage.
viii. Higher Orbits, Go for Launch! https://higherorbits.org - TARGETS: high school students. BENEFITS: opportunity for students to engage in real spaceflight research; multidisciplinary STEAM learning enrichment. LIMITS: week-long only program.
ix. NASA STEM Gateway: https://nasacentral.force.com/s/ - TARGETS: STEM students' high school and collegiate levels. BENEFITS: underrepresented group support, opportunities for NASA-center research participation. LIMITS: Funding sources must be in place to participate in research, therefor e enhancing support for these sources, i.e. MUREP or Space Grant for example would be of benefit to this program.
x. Pathways Programs – TARGETS: Graduate Students. BENEFITS: pathway designed to produce civil servants workforce. LIMITS: Underfunded and limited to engineering fields.

b. Recommendations of offered programs required for **enhancement and retention** of space biosciences.
i. Undergraduate/Graduate Programs - There is currently a lack of basic/entry-level space sciences courses that can provide a basis space sciences education. These programs can work in conjunction with other NASA-hosted programs, such as SLSTP, whereby course offerings could be provided prior to initiation of SLSTP. This could

provide a solid primer of space science education for students prior to engagement of SLSTP functions and research. This could also be developed independent to NASA-hosted programs and open to a wider reach and retention of students. Virtual courses would make this outreach possible, with a possible practical component.

ii. There are also very limited opportunities for graduate students to conduct funded space biosciences projects at academic institutions, even though graduate students are an essential part of academic labs. A dedicated space biosciences graduate student fellowship program spanning multiple years (at least 3) and including funding for both stipend/tuition and some research dollars would critically enhance the ability of Academic scientists to include graduate students in space biosciences research.

iii. Web-based/Interactive courses or research programs that promotes space biosciences outreach - Primary need at the undergraduate/graduate level and enhanced in underrepresented communities. However, additional earlier educational levels could benefit from this platform.

iv. Raising educators' awareness of the resources that are available to underrepresented groups and to provide the educators support in these areas that are lacking materials and computers, that are required for engagement.

v. Designated Space Science accredited courses, focused on space biosciences, astrobiology and aerospace physiology. Integration with bioengineering/technology is also crucial for tailoring health sciences in spaceflight as well. Accrediting space biosciences courses either universally or to a specific institution for formality and authentication. Universal accreditation would be under NASA and partnerships with universities to provide course integration into each program/department to expand the footprint of space biosciences to the academic community.

vi. Expanding space bioscience opportunities for K-12, underrepresented student groups, and resource information by providing information to these groups regarding potential collegiate opportunities to study space bioscience research. Important for next steps and retention within the space biosciences fields.

vii. Engage of institution-specific recruiters to initiate a cross-communication recruitment program among each other to connect students to opportunities in space biosciences.

viii. Training programs for mentorship enhancement. Hosted by NASA- or institution-specific programs with NASA support. Ideally, accompanied by additional support and incentives for scientists to engage in mentorship.

ix. Polling NASA funded and unfunded investigators to see who would be willing to play an advisory role to some undergrad programs, and facilitating connections between undergrads and those investigators. Specifically, some undergrad programs have "capstone projects" for their students, for example California Alliance for Minority Participation, Louis Stokes Alliance for Minority Participation, McNair Scholars, UC Leads, etc. Having NASA PIs who are willing to work with undergraduate seniors might be a way to increase interest without increased funding requirements. For example, bioinformatics undergraduates could work with investigators affiliated with GeneLab.

x. Expand scientist Civil Servants workforce - focused on lab-based research, training for space biology at NASA centers or offsite.

xi. Distribution of funding for undergraduate/graduate research opportunities is necessary for supporting development of students into career scientists. There needs to be more opportunities in this realm. Working in collaboration with programs such as ASGSR to promote student research grants for 2-3 yearlong research opportunities.

xii. Expansion of opportunities in aerospace industry in collaboration with government and academia. Increased communication across these space biosciences institutions to provide navigation of workforce and funding opportunities are required.

xiii. Research opportunities utilizing analog facilities that can promote the study of human factors and physiology in simulated space settings. Enhancing both the scientific

queries and development goals, and making space biosciences research more accessible without requiring additional flight opportunities.

xiv. A major challenge for junior scientists interested in entering space biosciences is a lack of awareness and understanding of the unique technical and logistical considerations of space bioscience study design. Describing these specific navigation schemes through offered courses, such as STAR, would assist with recruitment and retention.

Outreach: Creative ideas and activities that can promote and engage space biosciences.

c. Mechanisms for **enhancement** of space biosciences:
   i. STEM outreach earlier in educational development and enhanced in underrepresented communities. For example, middle school participation is shown to be critical age for students deciding if their interested in a career in STEM (https://doi.org/10.1186/s40594-018-0118-3).
   ii. Web-based advertising of space biosciences on NASA and non-NASA, but aerospace-centred webpages.
   iii. Promotion of space bioscience advertising at traditionally non-aerospace centric conferences.
   iv. Offering more scientist/postdoctoral positions within NASA, aerospace industry, and at aerospace-specialized institutions.

d. Mechanisms for **retention** of space scientists:
   i. Providing direct grants/fellowships in space biosciences research (NSF, NIH or NASA sponsored), similar to current NIH Training or NSF undergraduate bridge fellowship programs for universities.
   ii. Create retaining programs, such as training grants or interim positions, to provide immediate/transitioning opportunities.
   iii. Create more pathway-like programs: from academia to civil service positions.
   iv. Develop long term contractors - current limitations to 3-4 years with renewal, suggest extensions to 5+ years.
   v. Development of more support programs for marginalized groups to sustain interest and commitment to space biosciences.

Outcome & Prospective Future Development with Integration

Enhancement and retention of space bioscientists will enhance the economy and put the United States in a prominent ***leadership position for space bioscience research***. Producing institutions and centers hyper focused on space biosciences, through degrees and scientific research, will enhance education and interest in this specialized topic. *Retaining* space bioscientists will also create subject-matter experts in this specialized field, not only further *enhancing* the focal area but it's applications to contribute to other scientific domains.