

Statement by

James A. Pawelczyk, Ph.D.  
Associate Professor of Physiology, Kinesiology and Medicine  
The Pennsylvania State University

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NASA Budget and Programs: Outside Perspectives

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**Abstract**

At the midpoint between the Apollo program and a human trip to Mars, NASA's recent reductions to scientific funding are unprecedented. In particular, the thoughtfully conceived architecture to explore the Moon, Mars and beyond has produced large reallocations of research funding that jeopardizes the stability and future of space life sciences. Given current budgets, NASA does not appear to have sufficient resources to fully engage the help of the external science community to complete the President's Vision for Space Exploration.

Madame Chairperson and Members of the Committee:

Good afternoon. I thank you for the opportunity to discuss the changes NASA has made to its research funding. I have been a life sciences researcher for 20 years, competing successfully for the past 13 years for grants from NASA. From 1996-1998 I took leave from my academic position at The Pennsylvania State University to serve as a payload specialist astronaut, or guest researcher, on the STS-90 Neurolab Spacelab mission, which flew on the space shuttle Columbia in 1998. Since Neurolab I have had the privilege to serve as a member of NASA's Research Maximization and Prioritization (ReMAP) Taskforce. More recently I helped evaluate NASA's Bioastronautics Research Program for the Institute of Medicine, NASA's International Space Station Research Plan for the National Research Council, and the progress of the National Space Biomedical Research Institute (NSBRI).

During a January 19, 2006 interview with the Orlando Sentinel, Mr. Griffin shared his thoughts about his first 9 months in the position of NASA Administrator. When asked about the lessons learned from the Challenger and Columbia accidents, he stated the following:

If you spend much time on this stuff and aviation accidents, a common theme is that of not listening to the signals the hardware is sending – the test results, the flight results, *the dissenting opinions of the people involved*. So a common theme is not listening. And I don't mean actively shutting out. I mean being so focused on what we're trying to do that *we're not aware of what nature is telling us* [emphasis added].

Those insights are remarkably prophetic, and today I find myself before you as one of those dissenters. I share Mr. Griffin's passion for the human exploration of space, but I must conclude with equal conviction that biological adaptation is a serious risk to an extended human presence in space, and that the scientific research necessary to ensure the health and safety of future astronaut crews beyond low-earth orbit is far from complete.

### ***ReMAP – antecedent to the Vision for Space Exploration***

For several years, NASA has recognized and responded to its need to complete necessary research in a fiscally responsible manner. In the spring and summer of 2002 NASA launched the Research Maximization and Prioritization Task Force, commonly known as ReMAP. Chaired by Rae Silver of Columbia University, the Task Force included two National Medal of Science awardees, one Nobel Prize winner, and more than a dozen members of the National Academy of Sciences, representing the breadth of translational research in the biological and physical sciences.

ReMAP was asked to prioritize 41 areas of research in the former Office of Biological and Physical Research. What was unique to ReMAP was our challenge to consider both the physical sciences and biological sciences simultaneously. This resulted in spirited debate and intellectual foment of the highest caliber. When we completed our task, highest priority was assigned to 13 areas that informed two broad, often overlapping, goals: One is the category of intrinsic scientific importance or impact; research that illuminates our place in the universe, but cannot be accomplished in a terrestrial environment. The other goal values research that enables long-term human exploration of space beyond low-earth orbit, and develops effective countermeasures to mitigate the potentially damaging effects of long-term exposure to the space environment. It should be no surprise to you that over the past 17 years other review panels, both internal and external to NASA, have named similar goals.

The Task Force wrestled with the question whether one goal could be prioritized over the other. In the history of the United States space program both goals have been important, though their relative importance has changed over time. The limited amount of biological and physical research that occurred during early space exploration, particularly the Apollo era, focused on the health and safety of astronaut crews in a microgravity

environment. Significant research questions that did not contribute directly to a successful Moon landing received lower priority. In contrast, more regular access to space provided by the space shuttle afforded an opportunity for “basic” research to take higher priority; the proliferation of space based research in the physical and biological sciences over the past twenty years is a testament to this fact.

Thus, the relative priority of these two goals of research - enabling long-term human exploration of space and answering questions of intrinsic scientific merit - has shifted during NASA’s history. This conclusion is critical, as it suggests that one goal can receive higher priority over the other, though this ranking may change depending on NASA’s definition of programmatic needs at a particular point in time.

When the President announced the Vision for Space Exploration in January of 2004, the relative balance between these two categories of research changed again. Items in NASA’s research portfolio that most contributed to exploration goals would take precedence over experiments with intrinsic scientific importance and impact, and substantial realignment has occurred as a result. At the same time, the Office of Biological and Physical Research, the entity responsible for funding biological and physical research at NASA, was absorbed into the Exploration Systems Mission Directorate.

I share Mr. Griffin’s view that aligning research with exploration goals is a good thing. However, naïve or wholesale elimination of scientific themes is not, and biological and physical research has certainly suffered from this effect. To the alarm of the scientific community, the process that began with ReMAP has taken a dangerous turn. Areas that we rated as highest priority, including those that contribute to exploration goals, have been de-scoped or eliminated completely.

### ***Where is “science” at NASA today?***

In many ways, the reorganization of “science” at NASA orphaned biology, and I encourage caution when you and your colleagues use the term in your discussions. Logically, “science” would seem an appropriate, generic label for research activities that occur throughout the agency. However, within NASA it appears to have a more specific meaning, often referring exclusively to the activities funded by the Science Mission Directorate, which includes the following disciplines only:

- Astrophysics - the study of matter and energy in outer space.
- Earth Science - the study of the origins and structure of our planet.
- Heliophysics - the study of planets, interplanetary space, and the sun.
- Planetary Science - the study of the origins, structure, and features of planets beyond our own.

Please note that the term, “biology,” or the study of life, does not appear at all. To my more skeptical colleagues, the science of biology is disappearing at NASA.

The available evidence provides some support for this conclusion. While the Science Mission Directorate has suffered modest cuts, over the past two years, funding for biological and physical research (i.e., science not managed by the Science Mission Directorate) has decreased almost 75%, from \$1,049M in FY05 to \$274M in the FY07 Budget Summit. This includes the cancellation of virtually all research equipment for the International Space Station that supports animals and plants, the elimination of 20% of the funding for external research grants, and the premature termination of 84% of these grants. Approximately 500 life science graduate students in 25 states will be affected.

The next generations of space life scientists perceive a bitter lesson that is difficult to assuage: as the result of a shell game of agency-wide reorganization, life science is no longer recognized or valued within NASA.

### ***Biological research is essential and obligatory to the Vision for Space Exploration***

I wholeheartedly endorse the President's goal to return humans to the Moon and Mars, but the current reductions in biological research funding appear sorely at odds with this goal. Simply put, the biological risks associated with exploration-class spaceflight are far from being mitigated.

This conclusion is based on analysis of 30 years of NASA-sponsored research. Since the days of Skylab NASA-funded investigators conducted an aggressive and successful biological research program that was robust, comprehensive, and internationally recognized. Beginning with those early efforts, and continuing with our international partners on the *Mir* and the International Space Station, we have built a knowledge base that defines the rate at which humans adapt during spaceflight up to six-months duration, with four data points exceeding one-year duration.

Musculoskeletal deconditioning remains a paramount concern. In the past two years our ability to differentiate the trabecular bone network in the hip has helped us to appreciate that the risk to bone during spaceflight may be even greater than we previously anticipated. The rate of osteoporosis in astronauts equal patients with spinal cord injury, and exceeds that seen in post-menopausal women by a factor of 10 or more. Extrapolating from published studies of astronauts and cosmonauts spending up to six months in low-earth orbit, we can offer preliminary estimates of the changes that would occur if humans made a 30-month trip to Mars today:

- 100% of crew members would lose more than 15% of their bone mineral in the femur and hip
- Approximately 80% would lose more than 25% of their bone mineral
- More than 40% would lose greater than 50% of their bone mineral
- Approximately 20% would lose more than 25% of their exercise capacity
- Approximately 40% would lose experience a decline in leg muscle strength of 30% or more

Each of these predictions takes into the account the fact that astronauts would be using the best countermeasures available currently! To my knowledge, no engineer would accept a spaceflight system where such degradation is expected. Nor should it be so for astronauts.

### ***What is the status of NASA's human biological risk mitigation plan?***

In 2005 NASA's Chief Medical Officer asked the Institute of Medicine to evaluate NASA's Bioastronautics Roadmap, the comprehensive plan to document and reduce the biological risks to human spaceflight. Despite the alarming data I just described to you, we found that concern for these risks varied widely among astronauts, flight surgeons, and mid-level management. None of the 183 proposed risk mitigation strategies had been implemented for spaceflight, and approximately 2/3 of these strategies were considered to be so incompletely developed that they would not be addressed further.

In his 2001 book, Enlightened Experimentation: The New Imperative for Innovation, Harvard Business professor Stefan Thomke offered the following four rules for enlightened experimentation: organize for rapid experimentation; fail early and often, but avoid mistakes; anticipate and exploit early information; and combine new and old technologies. While these principles are recognizable in NASA's Constellation System architecture, they are wholly absent in the implementation of NASA's Bioastronautics Roadmap.

We desperately need to increase human capabilities in space by translating findings from cell culture to reference organisms and mammalian models such as mice and rats to future flight crews. Translational research is the "gold standard" of the NIH, and it is what the research community, and the American people, should expect from the International Space Station. We need the capability to house and test model organisms on the ISS. But equally important, we need adequate time for crew to prepare and conduct these experiments, and that time can be found only when the ISS moves beyond the core complete configuration. The potential return is immense; the application of this research to our aging public could become one of the most important justifications for an extended human presence in space.

### ***Challenges for the future***

Earlier this year, Congress received The National Research Council's review of NASA's plans for the International Space Station, which identified several serious concerns about NASA's prioritization process for current and planned life and physical sciences research.

First, allocations to research did not appear to be based on risk, but convenience. Second, little emphasis was given to future lunar or Martian outposts, opting instead for short stays on the Moon. Third, the current ISS payload and the processes used to prioritize

research areas appeared to be neither aligned with exploration mission needs nor sufficiently refined to evaluate individual experiments. Finally, no process was in place to plan or integrate future research needs that may not be recognized currently.

To restore scientific credibility at NASA, a coordinated strategy is necessary. I offer several recommendations for your consideration:

- First, add sufficient funding to NASA's budget, both to answer the questions essential to the Vision for Space Exploration and to replace the Space Shuttle in a timely fashion. An addition of \$150M would restore biological funding to the level of the President's FY06 budget request, but a minimal biological research program, directed primarily to external investigators, could be conducted with the addition of approximately \$50M/year.
- Second, articulate a timeframe for delivering and completing a risk mitigation plan for humans exploring the Moon and Mars, and vet both the plan and the timeframe with the external scientific community.
- Third, develop a comprehensive plan for conducting research on board the International Space Station without the space shuttle, including addition of essential equipment for animal research, deployment of a crew of at least six people, and logistics that are sufficient to keep these crews safe and supplied.
- Finally, establish sufficient oversight to hold NASA accountable to these goals.

Madame Chairperson, members of the committee, make no mistake about this: in the long-term, we are retaining and accumulating human risk to spaceflight in order to progress with an under-funded Vision for Space Exploration. We have an ethical obligation to our current and future space explorers, and to the American public, to do better. Given sufficient resources, I remain optimistic that NASA can deliver the rigorous translational research program that the scientific community expects, and the American people deserve. I sincerely thank you for your vigilant support of the nation's space program, and the opportunity to appear before you today.