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REPORT IN BRIEF

Recapturing a Future for Space Exploration: Life and Physical Sciences Research for a New Era

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While great strides have been made in human space exploration since the dawn of the space age, further progress will require overcoming substantial scientific and technical challenges. The scientific agenda for meeting these challenges can also bring substantial terrestrial benefits. To help set this agenda, Congress in the FY2008 Omnibus Appropriations Act directed NASA to request from the NRC a "decadal survey" of life and physical sciences research in microgravity and partial gravity environments. Among other tasks, this study was to define research areas, recommend a research portfolio and timelines, identify terrestrial benefits, and specify whether the results of the research would directly enable exploration or produce fundamental new knowledge.

Source: NASA Images

Since its inception, NASA's progress in human space exploration has depended on its ability to overcome a wide range of biomedical, engineering, and physical science challenges. In the past decade, however, the agency's life and physical science research program has declined substantially, leaving it in a poor position to continue that progress and take advantage of the fully equipped International Space Station (ISS). Nevertheless, a focused science and engineering program can make possible the achievements needed to ensure that the Nation is ready for the next significant phase of human space flight. This report presents an examination of the science and technology that can bring about these achievements such as a deeper understanding of the role of gravity in the regulation of biological systems, controlling critical fluid behavior in space exploration systems, research on fire-safety, and water production in an extraterrestrial environment. The assessment has two foci; research that enables space exploration, and research that is enabled by access to space.

Programmatic Issues

Currently, life and physical science research has no clear institutional home in NASA. Successful renewal of such research requires high-level, strong leadership that facilitates the necessary research and integration with the mission activities. Life and physical science research should be central to NASA's space exploration mission and integral to space flight operations. In addition, a renewed stable funding base for this research is essential, and the budget must be sufficient, sustained, and appropriately balanced. Regular research solicitations are also necessary and the review process must be transparent and incorporate the rationale for setting priorities. A research advisory committee to oversee and endorse the process would enhance the quality of the research. Finally, a long-term strategic plan to maximize research opportunities would improve the efficiency of translating discoveries to solutions.

Research Priorities

The priorities below are presented as broad topic areas that will allow the development of an integrated portfolio of enabling and enabled-by research. Further priority setting, however, will require the specification of policy directions.

- Plant and microbial biology research to understand its evolution in a low gravity environment, to determine how plants can play a role in biologically-based life support systems, and the role of microbes during long-duration missions
- Behavior and mental health research to develop new methods to minimize psychiatric and sociopyschological costs of long-duration missions, and enhance selection, training, and support of astronaut crews
- Animal and human biology research to better understand factors that limit human exploration of space, to enhance understanding of fundamental biological mechanisms, and develop countermeasures to current limiting factors
- An integrated research approach to cross-cutting issues for humans in the space environment to address the sum effect of a range of physiological and behavioral changes taking place during long-duration missions
- Research in fundamental physical sciences to help address important questions about the laws of nature using the unique environment of space and to discover and understand organizing principals of complex systems.
- Research in applied physical sciences to enable new exploration capabilities and new insights into a range of physical phenomena in space
- Translation to space exploration systems to identify technologies that enable extended space missions and to develop these enabling technologies

Portfolio Implementation

Flexibility of implementation of this portfolio is aided by a set of metrics that can also be used as a basis of policy-related ordering of an integrated research portfolio. These metrics include the extent to which the research would reduce uncertainty about risks and benefits; reduce exploration costs; lead to new exploration options; provide answers to grand science challenges; lead to developments uniquely needed by NASA and/or are synergistic with other agency needs; and result in solutions to terrestrial problems.

Facilities, platforms, and the ISS

Facilities such as suborbital flights and drop towers offer unique advantages for selected experiments. Eventually access to lunar and planetary surfaces will allow critical scientific and testbed studies with reduced gravity, increased radiation, vacuum and planetary atmosphere exposure, and human isolation. In particular, the capabilities provided by the ISS are vital to addressing many of the important research questions identified in the report. A unique platform, it is essential that the ISS be fully utilized for life and physical science research in the next decade. Interaction with the commercial sector, particularly flight providers, is also important.

Science impact on defining space exploration

The report offers integrative visions for the science advances necessary to underpin and enable evolutionary systems and bold architectures for human space exploration. It specifies the scientific resources and toolboxes to define and develop future space exploration and scientific discovery.

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