Biosensors – Detectors for Biological Organisms/Biological Functions

Status, Plans, Connections to NASA's Mission and Vision and to the Space Architect's Capability Requirements

Organizing principles

NASA 2003 Strategic Plan

Goal 3
Create a more secure world and improve the quality of life by investing in technologies and collaborating with other agencies, industry, and academia.
- 3.1
- 3.3
- 3.4*

Goal 7
Engage the public in shaping and sharing the experience of exploration and discovery.
- 7.3*

Goal 9
Extend the duration and boundaries of human space flight to create new opportunities for exploration and discovery.
- 9.1
- 9.2
- 9.5

Goal 10
Enable revolutionary capabilities through new technology.
- 10.1
- 10.2
- 10.6*

* These objectives are reflected in the overall Research Partnership Program and thus not connected to specific requirements of any single research program.

Space Architect Perspective Capability Requirements

- **1.1 Systems Analysis, Integration and Modeling**
  - 1.1.2
  - 1.1.6
  - 1.1.11
- **2.1 Self-Sufficient Space Systems**
  - 2.1.5
- **2.3 Habitation and Bio-astronautics**
  - 2.3.2
  - 2.3.7
  - 2.3.4
  - 2.3.8
  - 2.3.9
- **2.5 Exploration and Expeditions**
  - 2.5.5
- **2.7 In-Space Instruments and Sensors**
  - 2.7.1
  - 2.7.7
  - 2.7.8

OBPR Organizing Questions

1. "How can we assure survival of humans traveling far from earth?"
1a) What knowledge and tools are needed to enable the practice of medicine in space?
1b) How does the human body and its physiology adapt to space flight, when is it appropriate to counteract those adaptive effects, and by what means can we do so?
1d) How can we provide an optimal environment to support behavioral health and human performance in space flight?

2. "What must we know about how space changes life forms, so that humankind will flourish?"
2b) How does long-term exposure to space affect organisms?
2d) How do systems of organisms and their interactions change in space?

4. "What technology must we create to enable the next explorers to go beyond where we have been?"
4b) How can technology help human productivity and well being during extended isolation from Earth?
4c) How can we ensure that the crew is living in a safe and comfortable environment?
4d) What is the optimal way to support environmental health for crewmembers of space flights?

Requirements

Requirement: basic research: tool. Biosensors are required to detect quantitatively the kinetics of organism growth for basic research. They may also need to detect, in parallel, multiple organism antigens to determine differential expression during the growth cycle

Requirement: health: plants & animals. It is important for the health, safety, and well being of plants, animals, and to provide a clean environment for crews of long term space missions.

Requirement: basic research: detect extraterrestrial life forms. A need exists to be able to identify extraterrestrial life forms that might be encountered on other planets.

Requirement: basic research: understand surface antigen and reagent behavior in space. A biosensor for microgravity has to take into account that surface antigens may be presented differently in microgravity and the biosensor reagents developed to detect them may behave differently in microgravity.

Requirement: tools: biosensors: long duration space travel. There is a need to reduce the volume of expendibles required to operate the biosensor for long duration (and possibly deep) space travel since it is assumed that large amounts of reagents can't be stored on the spacecraft (i.e., temporally self-contained).

Requirement: disease diagnosis. Life on earth can benefit from the development of biosensors for microgravity because these will no doubt contain novel and improved technology for incorporation into ground-based devices.

Requirement: detection of toxins, bacteria, fungi, viruses, spores. Quality of the air, water and food from threats of exposure to pathogenic organisms requires a specific biosensor designed for microgravity.

Hypotheses & Projects

Importance: basic research. Identification of new life forms is basic science to understand our universe and for space exploration.

Hypotheses. The environment contains both beneficial and harmful organisms that may need to be identified, controlled, or eliminated to assure health and safety and provide a clean environment for crews of long term space missions. These sensors can be developed.

Hypotheses. Cells derived from multicellular organisms (e.g., mammals) will express surface antigens differently in microgravity (thus potentially changing the cell's function or ability to communicate) and biosensors are needed to detect differential expression.

Project: BIOSENSORS - DETECTORS FOR BIOLOGICAL ORGANISMS
Product description. Development of detectors for biological organisms, for example bacteria, fungi, viruses, spores, etc. in air, water, food, biological fluids (i.e., human samples) and extraterrestrial organisms that have unique detection capabilities for organisms as well as non-DNA based life, microfluidics, microarray, nanoscale, and single molecule detection.
Status: Multiple projects exist in planning or development. In addition, a ground-based prototype for BW pathogen detection has been built. ;
Project Site: Center for Biophysical Science and Engineering (CBSE), University of Alabama at Birmingham

Research Partnership Centers Multiple Benefits

Immediate applications on Earth. This biosensor research will enable American industry to achieve leadership in the diagnosis of disease, improve and maintain quality of the air we breathe and the water we drink and the food we eat and to protect us against threats of exposure to pathogenic organisms.
Leverage NASA research funds. Investment by the DOD in partnership with NASA enables NASA to stretch its research dollars.

Knowns and Unknowns

Unknown. surface antigens may be presented differently in microgravity and the biosensor reagents developed to detect them may behave differently in microgravity. These unknowns must be answered before the microgravity biosensor can be developed.

Unknown. There are a number of hardware capabilities that should be tested in microgravity to determine which would operate satisfactorily.

Known. Technology is available for incorporation into biosensors for the detection of early life forms and pathogens.

Unknown. It is not known what level of sensitivity is required for a specific detection application in either microgravity or on Earth.

Unknown. There are possible unknown life forms (non-DNA based) that could be identified with novel biosensors for their detection.

Known. Pathogens can be detected on earth with biosensors.

Known. Pathogens are known to grow in microgravity.

Status: Prototype, V.5

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