Outpacing Infectious Disease
Spaceflight Platforms Toward Innovations in Infectious Disease Control

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It is not always easy to get out of your comfort zone!
The most recent U.S. National Laboratory
Designation of the International Space Station (ISS) as a National Laboratory underscores the significance and importance that the United States places on the scientific potential of the microgravity platform for breakthrough biomedical and biotechnological research to globally advance human health and quality of life.
Spaceflight as a unique platform for translation

Benefit human health
George Poste
Founder and Director, Biodesign Institute (BDI)
R&D Scientist of the Year
Chief Science and Technology Officer and President, R&D of SmithKline Beecham

Ray DuBois
Executive Director, BDI
Provost and Executive VP
Professor, cancer medicine and cancer biology, Univ of Texas MD Anderson Cancer Center

Roy Curtiss III
Director, Center for Infectious Diseases and Vaccinology, BDI
National Academy of Sciences
Pioneer in development of live attenuated vaccines
Our Multidisciplinary Collaborative Team in US and Europe

Mechanotransduction, infectious disease, immunology, vaccinology, oncology, cell and computational biology, physics, bioengineering, stem cell therapy, regenerative medicine
How does our lab use the spaceflight platform to benefit human health?
Goals of our Research:

Mitigate risk of infectious disease to crew during space exploration to ensure health, safety, and performance

Critical to provide safe passage for human exploration to moon, Mars, beyond

*New strategies to combat infectious disease on Earth*
- Second leading cause of deaths worldwide – world’s biggest killer of children and young adults
- Major impact on human health, global society, security and economy
- Total cost in US exceeds $120 billion annually
- New and re-emerging infectious disease, antibiotic resistance, bioterrorism threat

WE NEED NEW WAYS TO OUTPACE INFECTIOUS DISEASE!

Source: World Health Organization
• Current estimates of bringing a new drug to market - $1 billion and requires extended development times of over a decade before it reaches patients

• Even incremental decreases in this cost and time are of tremendous importance

• Spaceflight holds tremendous promise to benefit infectious disease research
Infectious Disease Research and Spaceflight

- Major advances in knowledge of biological systems - studying their responses to extreme environments - (ex. temp, pH, etc) - led to major advances in global human health breakthroughs

- Spaceflight is another extreme environment which offers tremendous potential to provide new insight into biological responses - including infectious disease

- Spaceflight produces a fluidic environment (fluid shear) that is relevant to conditions encountered by the pathogen during infection in the human host – but gravity masks key cellular responses on Earth.
Novel Insights into Disease Mechanisms Not Observed using Traditional Methods

Pathogen

Host

Low fluid shear culture environment
Physiologically relevant
Biomedical phenotypes not observed during conventional culture

In-flight infections
Risk assessment/Countermeasures

Vaccines/Therapeutics/Tissue Engineering
Treatment and prevention

ASU-NASA Space Act Agreement
Our Biotechnology:
The NASA Rotating Wall Vessel (RWV) Bioreactor
Using Spaceflight to Advance Human Health on Earth

Heidemarie Stefanyshyn-Piper  
STS-115

Dominic Gorie  
STS-123

Naoko Yamazaki  
STS-131

Sandra Magnus  
STS-135
Cellular Biomechanics plays a critical role in maintaining the balance between normal cell and tissue function and disease progression.

Alterations in physical forces including:
- Fluid shear
- Hydrostatic pressure
- Osmotic pressure
- Cell-cell interactions
- Cell Stretching

Can lead to fundamental changes in:
- Cell shape
- Gene expression
- Protein-protein interactions
- Macromolecule conformation
- Signal transduction

...and ultimately influence:
- Cell growth/differentiation
- Cellular stress responses
- Host-pathogen interactions
- Immune responses
- Drug/vaccine responses
- Disease progression/outcome
Spaceflight produces fluidic environment (fluid shear) that is relevant to conditions encountered by pathogens during infection in human body – but gravity masks key cellular responses on Earth.

Low fluid shear affects bacterial gene expression, physiology, pathogenesis - but mechanism(s) not well understood.

Entire classes of microbial genes/proteins involved in host interactions not previously identified during growth under conventional culture conditions.

New targets for vaccine/therapeutic development.
Salmonella

New ways that pathogens cause disease

Spaceflight uniquely changes:
- Disease causing potential
- Gene expression
- Persistence
Our Recent Spaceflight Experiments

**Spaceflight study to enhance (Recombinant Attenuated Salmonella Vaccine) strain against pneumococcal disease in human clinical trials**

Flown under ASU’s Space Act Agreement with NASA.

**First study to profile infection in living organism in real-time during spaceflight**

**First study to profile the infection process in human cells during spaceflight**

Utilization of ASU’s Space Act Agreement with NASA to use ISS National Lab platform.
Engineering state-of-the-art 3-D tissue models under physiological low fluid shear: Mimicking immune response and underlying tissue microenvironment

Use of the RWV Bioreactor and Decellularized Bioscaffolds in 3-D Lung Tissue Engineering

Advanced 3-D lung models to study respiratory infections, other respiratory diseases, and transplantation

What Does the Microgravity Research Platform Offer?

A unique environment for innovative discoveries to advance human health

- Novel environment offers insight into fundamental biological response parameters from both the host and pathogen perspective that are directly relevant to infectious disease, and advances in tissue engineering - which cannot be observed using traditional experimental approaches

- Scientific advances and commercial potential for innovative solutions toward treatment and control of infectious and other diseases.
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