MSFC - 753 - ABSTRACT

Title: Lab-on-a-Chip: From Astrobiology to the International Space Station

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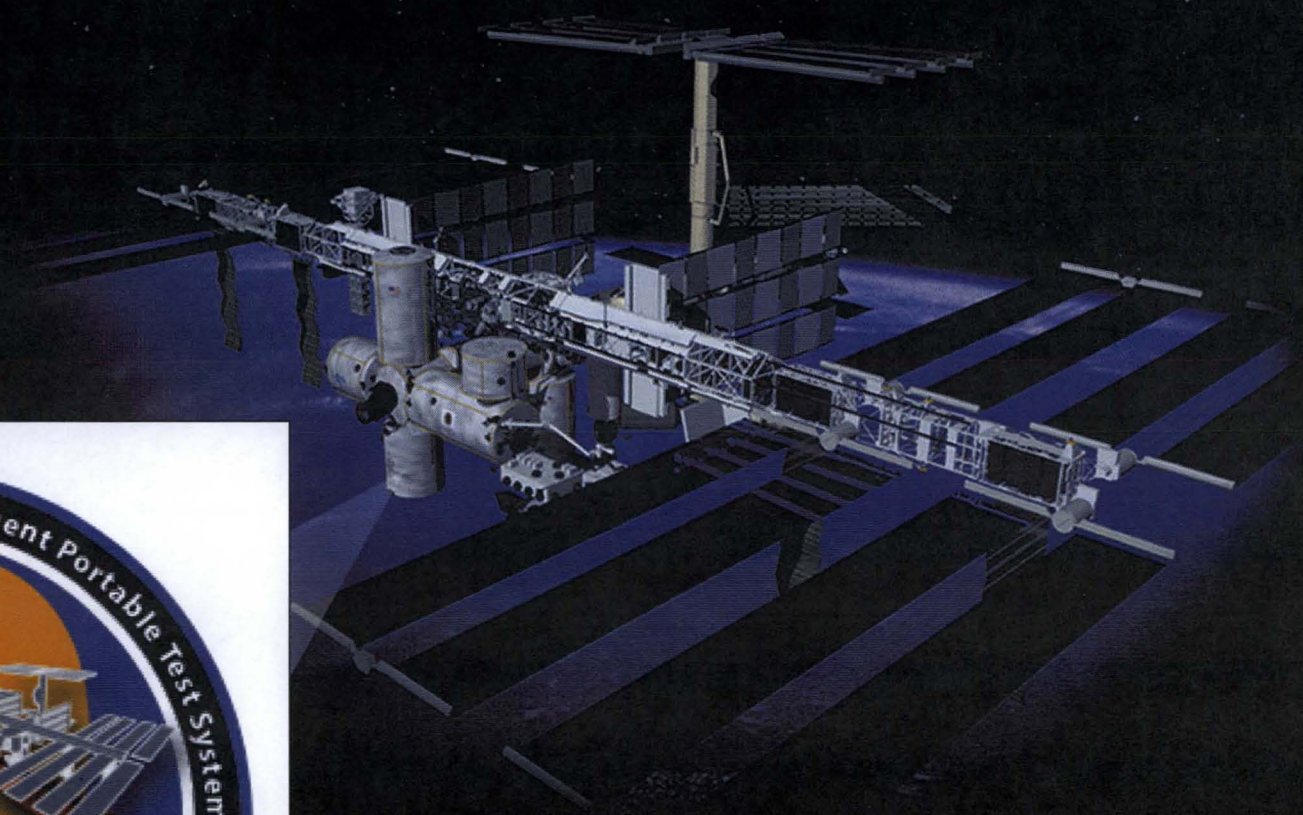
Abstract: The continual and long-term habitation of enclosed environments, such as Antarctic stations, nuclear submarines and space stations, raises unique engineering, medical and operational challenges. There is no easy way out and no easy way to get supplies in. This situation elevates the importance of monitoring technology that can rapidly detect events within the habitat that affect crew safety such as fire, release of toxic chemicals and hazardous microorganisms. Traditional methods to monitor microorganisms on the International Space Station (ISS) have consisted of culturing samples for 3-5 days and eventual sample return to Earth. To augment these culture methods with new, rapid molecular techniques, we developed the Lab-on-a-Chip Application Development - Portable Test System (LOCAD-PTS). The system consists of a hand-held spectrophotometer, a series of interchangeable cartridges and a surface sampling/dilution kit that enables crew to collect samples and detect a range of biological molecules, all within 15 minutes. LOCAD-PTS was launched to the ISS aboard Space Shuttle Discovery in December 2006, where it was operated for the first time during March-May 2007. The surfaces of five separate sites in the US Lab and Node 1 of ISS were analyzed for endotoxin, using cartridges that employ the Limulus Amebocyte Lysate (LAL) assay; results of these tests will be presented. LOCAD-PTS will remain permanently onboard ISS with new cartridges scheduled for launch in February and October of 2008 for the detection of fungi (Beta-glucan) and Gram-positive bacteria (lipoteichoic acid), respectively.

MSFC-753-PRESENTATION

Lab-on-a-Chip: From Astrobiology to the International Space Station

LOCAD-PTS



Jake Maule - Project Scientist, LOCAD

Co-authors: Norm Wainwright, Andrew Steele, Dan Gunter, Lisa Monaco, Mark Wells, Heather Morris and Mark Boudreaux

April 16th, 2008

LOCAD Team & Partnerships

Industry

Charles River Laboratories
Dr. Norm Wainwright

Government

NASA – MSFC
Mark Boudreaux, Dr. Lisa Monaco,
Heather Morris and LOCAD Team

NASA – JSC
Mark Ott, Duane Pierson (Microbiology)
Jeff Jones (Exploration Medicine)
Dean Eppler, Jo Kosmo, Amy Ross (EVA Systems)
Dan Burbank, Suni Williams (Astronaut Office)

NASA – HQ
John Rummel (Planetary Protection)

Academia

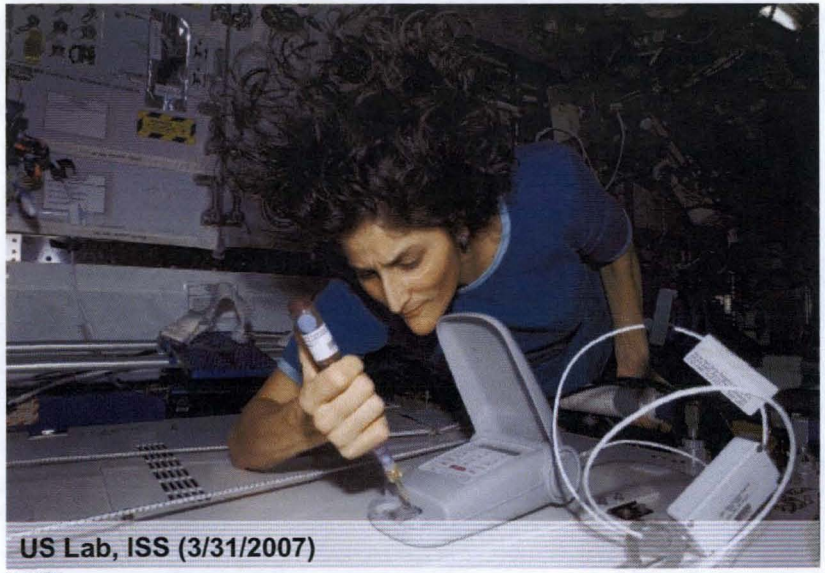
Carnegie Institution for Science
Dr. Jake Maule, Dr. Andrew Steele

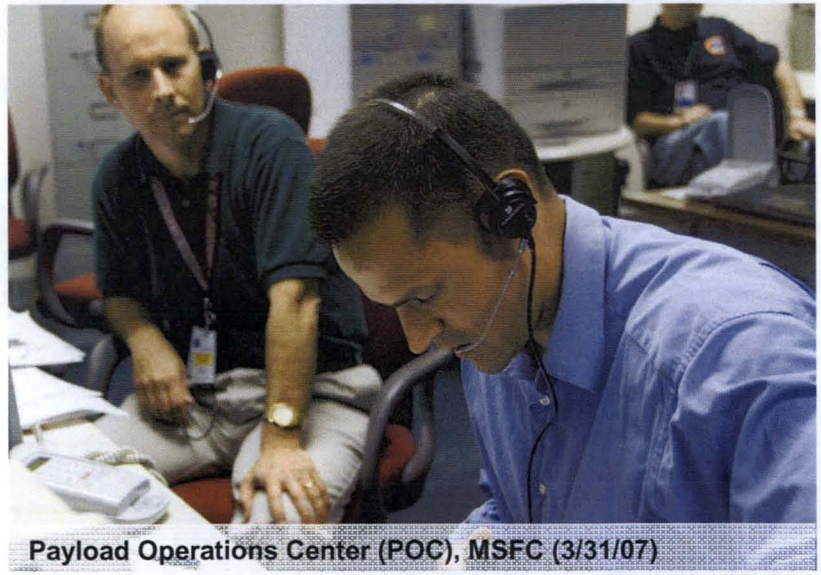
University Alabama at Huntsville
Dr. Pat Reardon

Current Status and Flight History

- Launched to ISS on 12A.1 (Dec., 2006)
- Operated 10 sessions so far
  (March 31st 2007 to February 3rd 2008)
- Provides rapid onboard test of endotoxin, beta-glucan (1JA) and liopteichoic acid (ULF2)
- Complements existing culture methods and prepares for exploration beyond LEO


Launch of LOCAD-PTS, STS-116, December 9th 2006

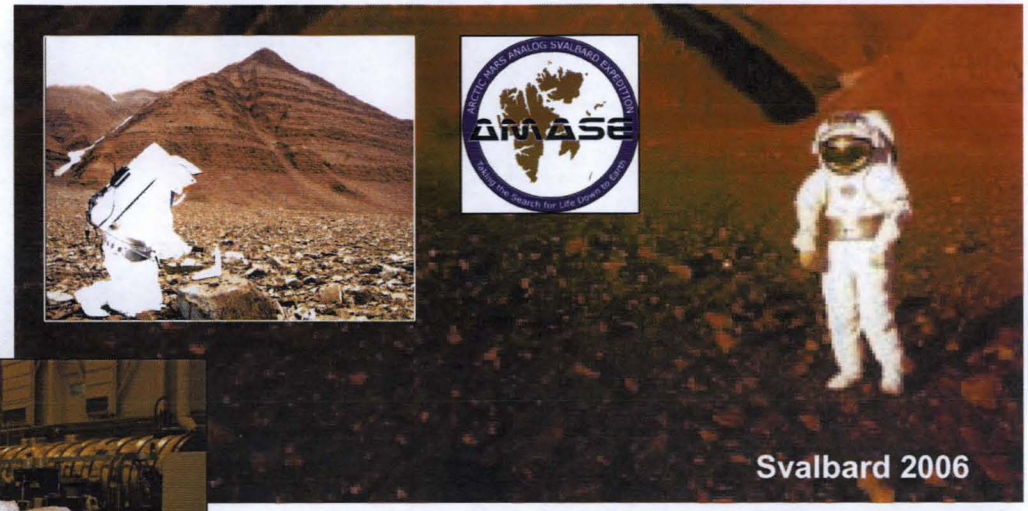

US Lab, ISS (3/31/2007)

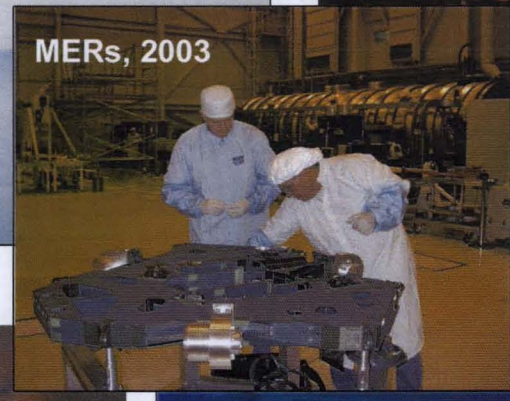

Payload Operations Center (POC), MSFC (3/31/07)

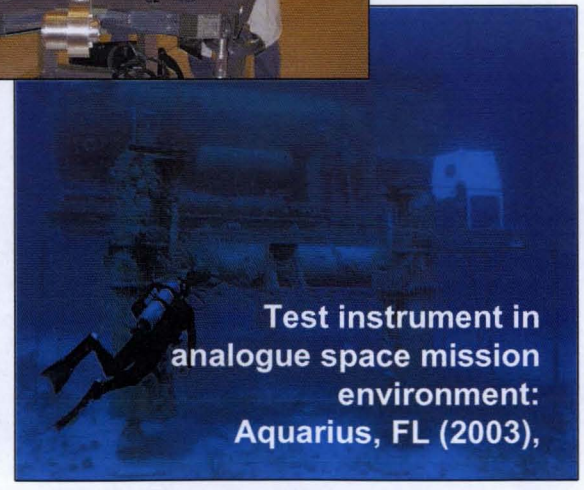
I14E18818

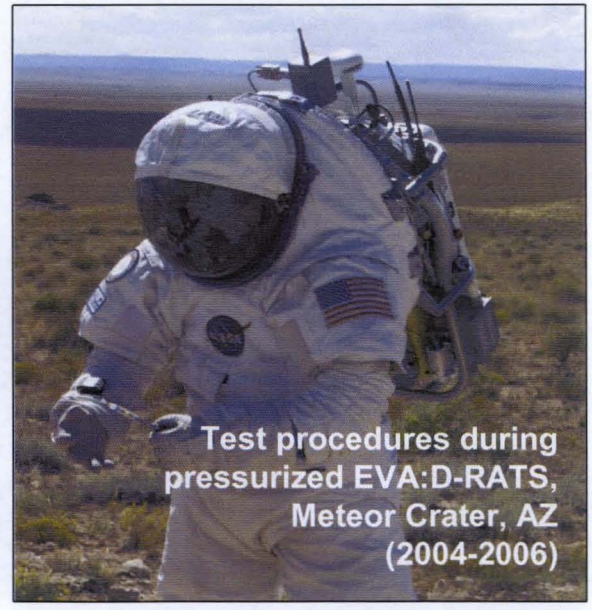
Background and Pre-flight History

Test procedures and instrument in zero, lunar and Martian gravity (2002-2007)







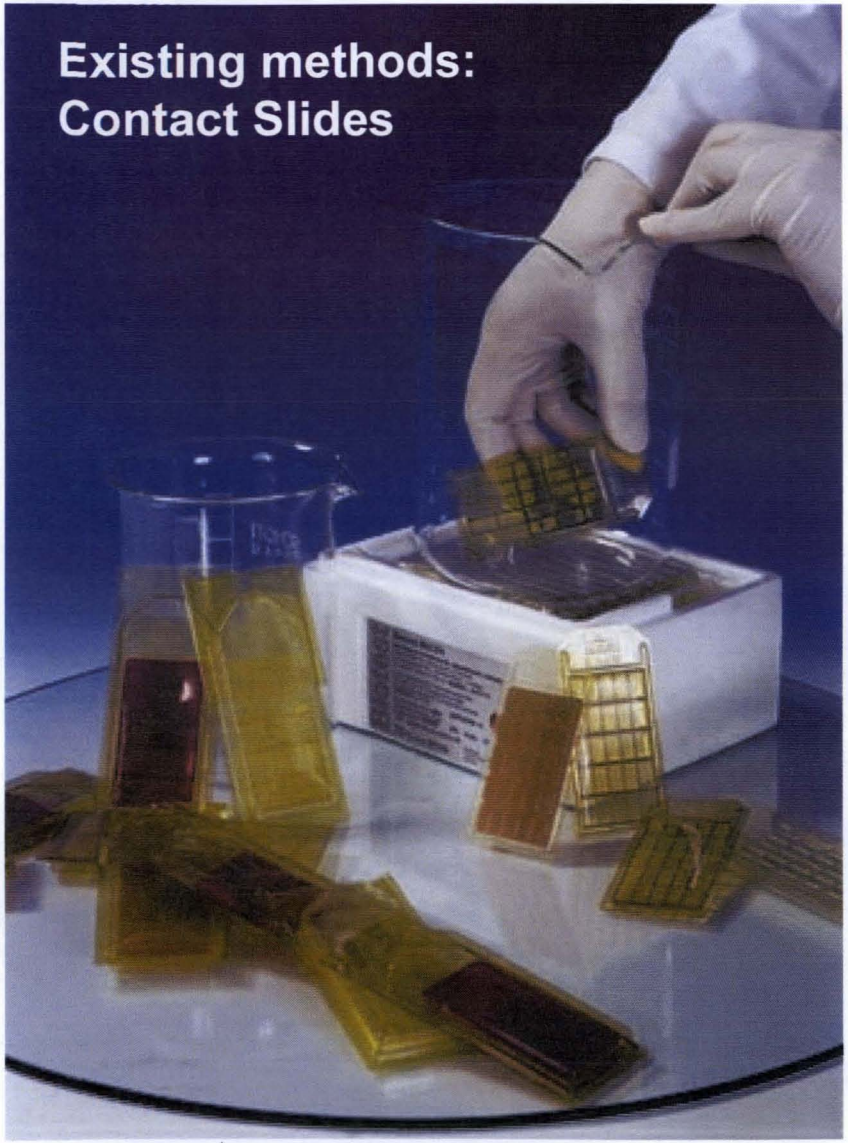


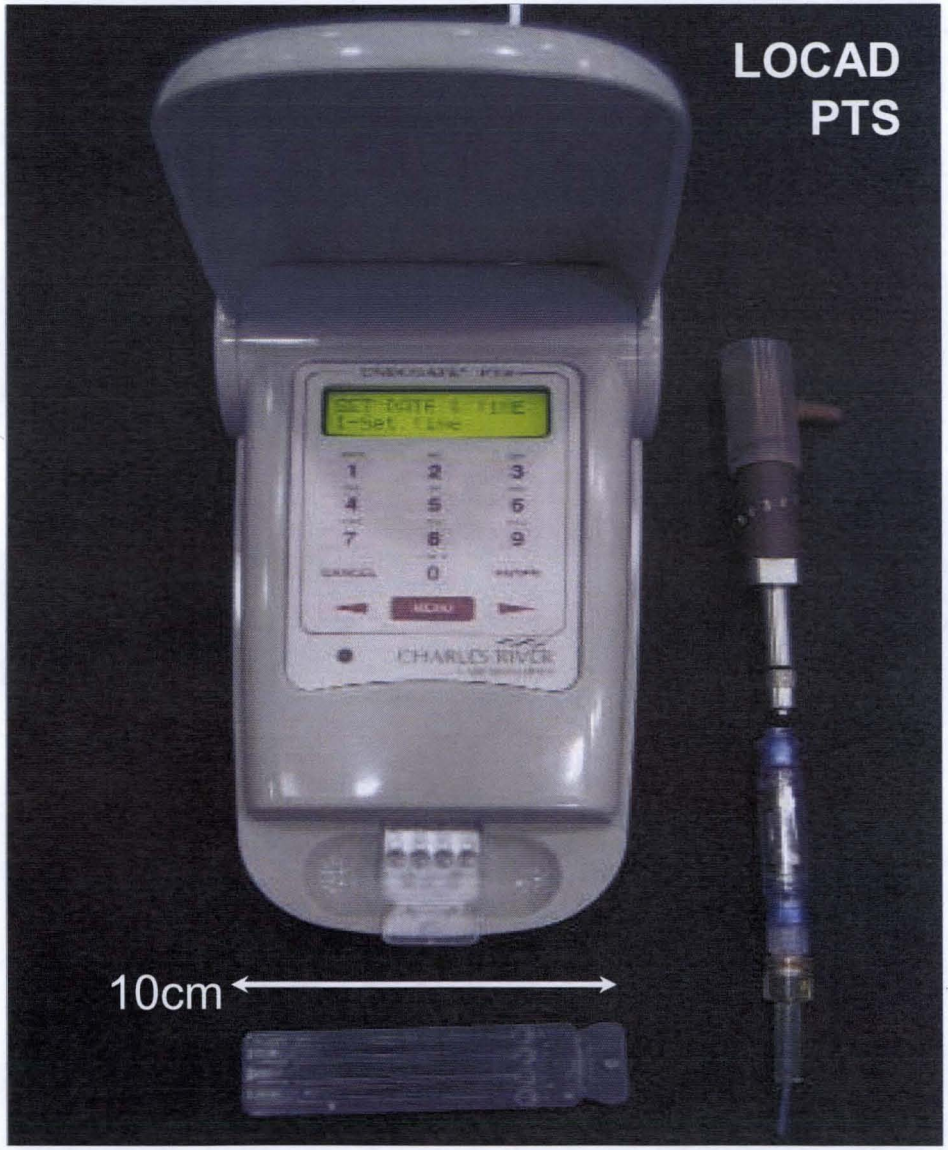
Rationale for LOCAD-PTS

- Immediate analysis often more accurate than following sample return (microbes may degrade, grow, and/or change composition over time)
- No down-mass (important following Shuttle retirement)
- 99% microbes cannot be cultured
- Used media potential biohazard
- Increases crew autonomy and prepares for exploration missions

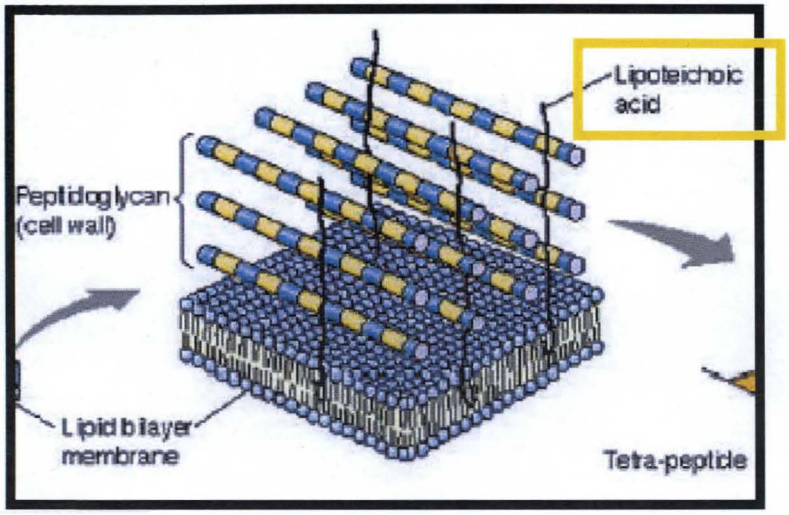
Fungi in Zarya module, 2001

Surface Sampling: Existing methods and LOCAD-PTS

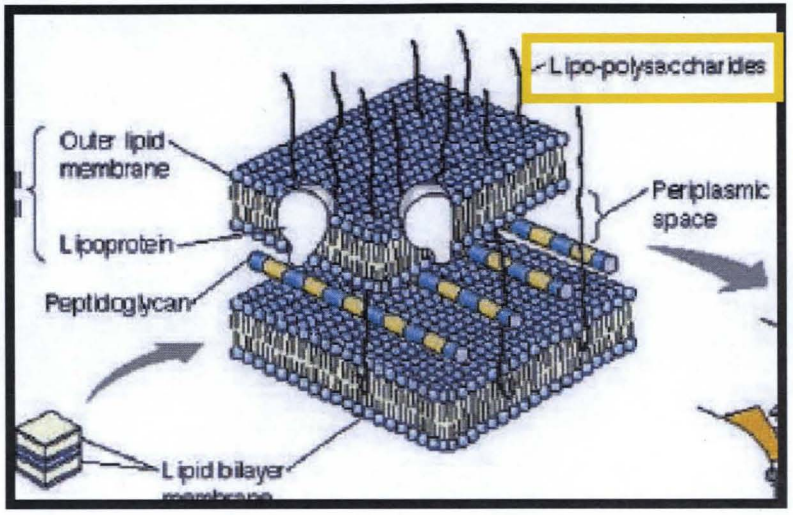




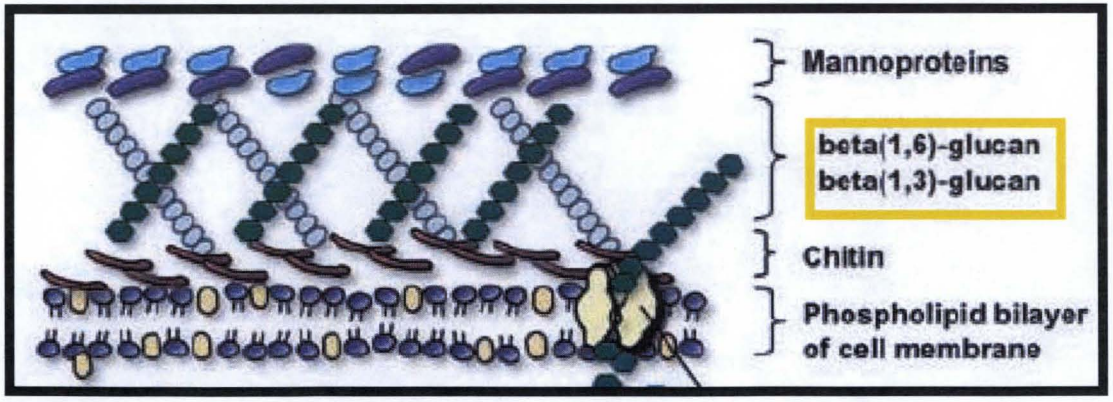
Target molecules



Gram Positive (Strep Throat) Cell Wall

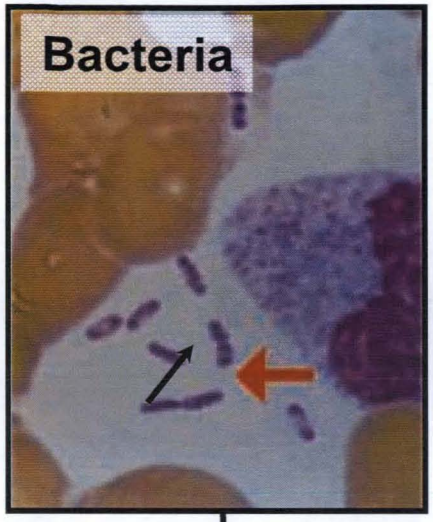


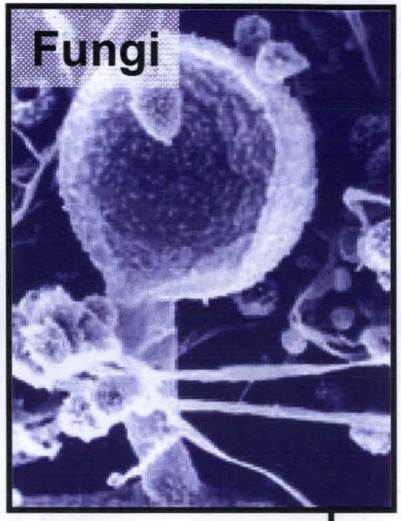
Gram Negative (*E. coli*) Cell Wall

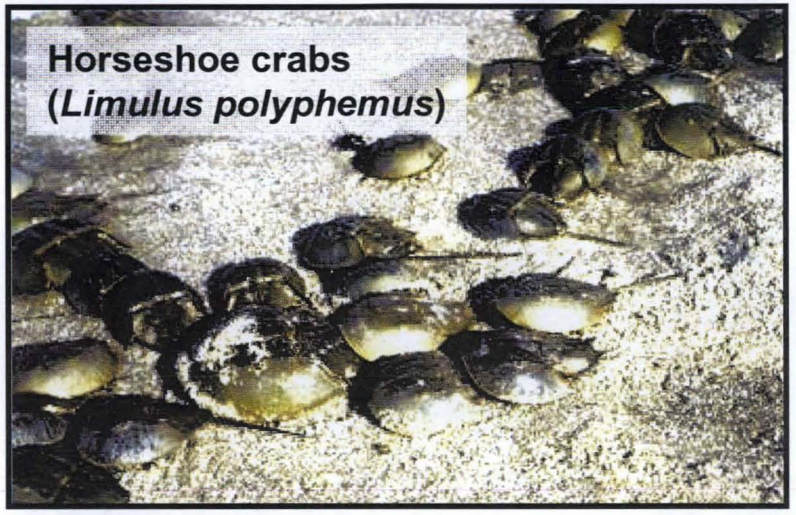


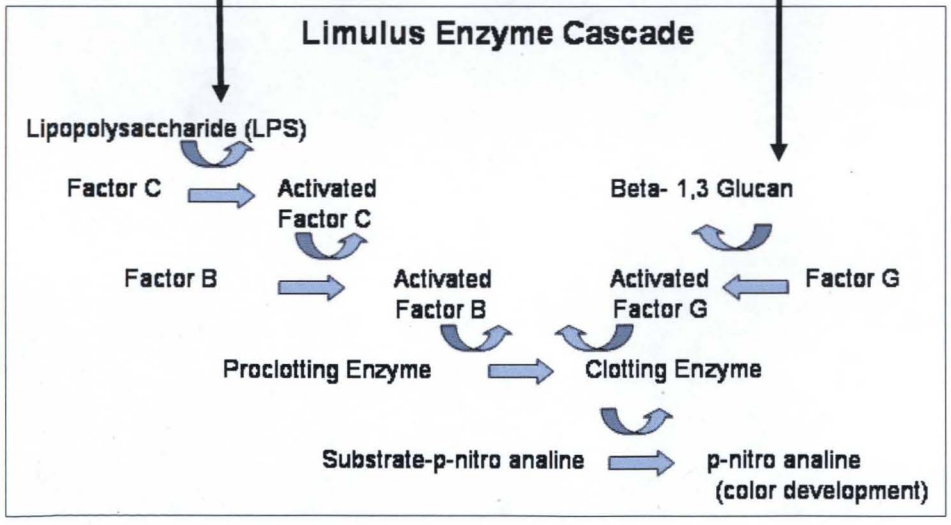
Fungal (Mold in Fridge) Cell Wall

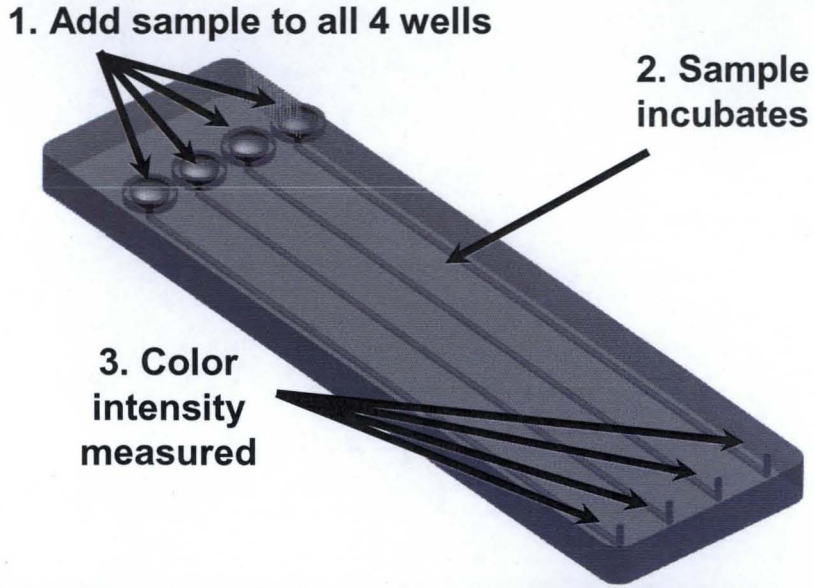
How LAL and Beta-Glucan Cartridges Work



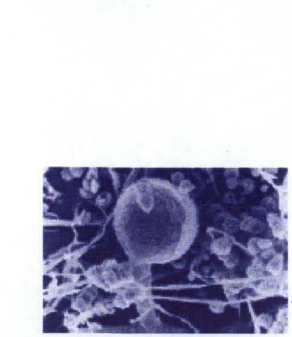






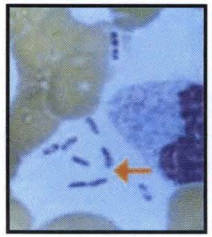


One instrument, Multiple Cartridges, Multiple Applications



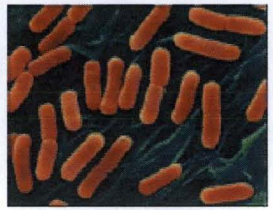
LAL
(Bacteria & fungi)

Beta-glucan

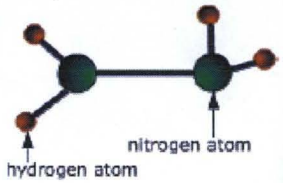


LTA

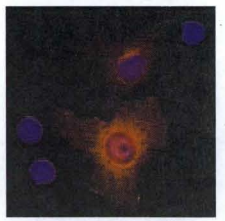
Hazardous
viruses



Hazardous
bacteria

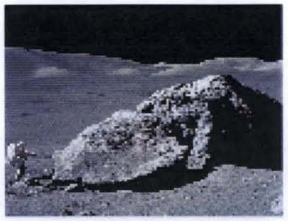


Dangerous
chemicals
e.g. hydrazine

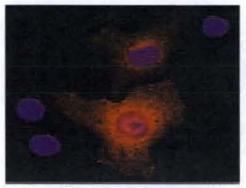


Biomedical
markers

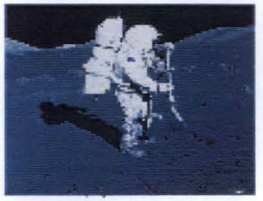
Applications for Human Lunar Exploration



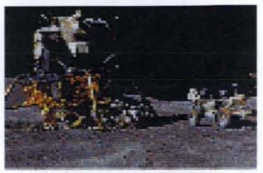
Monitor biological material on lunar surface (SMD)



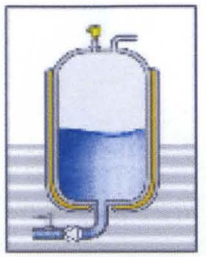
Monitor specific proteins in blood, urine & saliva of crew (SOMD)



Monitor hazardous chemicals on spacesuit (ESMD)



Monitor bio-mediated corrosion of spacecraft materials (Supportability, ESMD)



Monitor endotoxin in WFI (SOMD)

Monitor microbes in water, air and on surfaces of habitat (SOMD)

Monitor endotoxin, glucan and other early signs of spoilage in food (SOMD)