Laboratory Analysis Capability for the International Space Station and Future Space Exploration Missions

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Space Environment

- Reduced or micro-gravity
- Radiation
- Limited mass, volume and power
- Limited resources - water, air, food
- Communication lags or blackouts (isolation)

In-Flight Laboratory Analysis Goals

- Perform Research on the ISS
- Demonstrate operations and research capability for Exploration Missions
  - Novel paradigm for flight surgeons and researchers

- Ensure astronaut health and safety due to injury or illness on extended (>30 days) human exploration missions.

- Provide biomedical diagnostics capability to facilitate the recognition and treatment of several medical conditions.

- Provide analysis capability of biological fluids (i.e. blood, urine, saliva, sweat) in any habitable location

In-Flight Laboratory Analysis

Specifications

- Minimize the equipment's mass, volume, consumables, reagents and power.
- Ease of operation; minimal training.
- Ideally, should have FDA approval, or have gone through the rigors of FDA approval type validation.
- As mission duration lengthens, an analyzer’s capability should be readily expanded through software, reagents, dipsticks and/or microfluidic cartridges.
- Short start-up time
- 3- to 5-year shelf life

In-Flight Laboratory Analysis

Operational Requirements

1. Basic Metabolic Panel
2. Blood Gases Panel
3. Hematology - complete blood cell count with 4-part differential
4. Cardiac Panel
5. Liver/Renal Panel
6. Urinalysis + urates

ALT - Alanine aminotransferase
AST - Aspartate aminotransferase
ALP - Alkaline phosphotase

In-Flight Laboratory Analysis

Human Research Requirements

Analyte Class	Examples
Ions (Na, Cl, etc)	Na, Cl, K,…
Blood Gases	pH, pO_2, pCO_2, BUN,...
Small Molecules	Glucose, lactate,…
Amino acids	3-methylhistidine, GABA,…
Proteins	Il-1, leptin, transferrin, troponin,..
Peptides	BNP, helical peptide P, insulin…
Enzymes	ALT, AST, CK-MB,…
Fatty Acids	Triglycerides,…
Minerals	Fe, Zn, Se, Cu, Mg, P,…
Vitamins	Retinol, b-carotene, folic acid..
Steroids	Cortisol, estradiol, DHEA,…
Lipids	Cholesterol, LDL, HDL,…
Metabolites	Bilirubin, creatinine,…
Cell Type	Leukocyte, WBC, hematocrit,…
Cell Markers	P-selectin, CD4,…

Near future needs for –omics research

DNA Microarray analysis

Northern blot tests

SAGE analysis (serial analysis of gene expression)

RT-PCR (reverse transcription polymerase chain reaction)

Current ISS Technology Level

Abbott i-STAT 1

Electrochemistry/immunoassay-based blood analyzer

Pros	Cons
• Self-calibrated, multiplexed assays • Lightweight, portable analyzer • Small blood sample (venous or capillary), no preparation • Space flight certified (PCBA version) • Blood gas, CHEM8, and cardio panels • CLIA, FDA approved • Wireless approved	• Cartridges for specific panels (not necessarily those required by NASA) • Cartridge stowage volume/refrigeration • Expensive new assay development • Short shelf-life (up to 4 months) • Results for certain measurements are inconsistent (reliability) • Does not support hematology or liver panel measurements

**Earlier version (PCBA) iSTAT on ISS*

Current ISS Operations

1. Blood Drawn on ISS

2. Sample is centrifuged

3. Sample is frozen to wait for return

4. Samples are returned on SpaceX

5. Samples arrive back at JSC

6. Samples analyzed and results documented.

Point of Care Platforms and Multiplexing Cartridges being Evaluated at NASA/JSC in March 2013
None were successful in a blind test

DNA Medicine Institute

McDevitt Laboratory

OPKO (Claros)

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Nanomix

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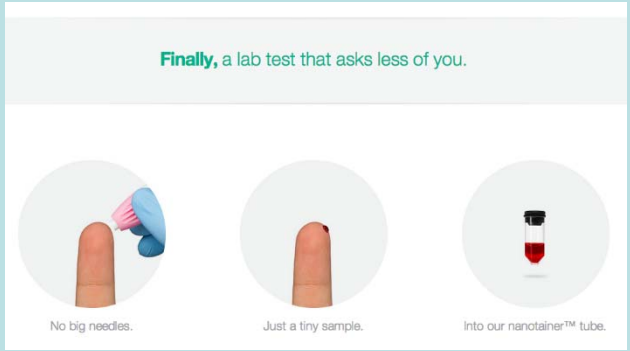
Additional Technologies we are currently evaluating

Theranos



Luminex