MICROARRAY TECHNOLOGY FOR SPACE EXPLORATION.

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The development of microarray technology has revolutionized medical diagnostics and can fulfill a unique purpose in space exploration. Possible applications of this technology includes; the detection as well as potential characterization of life on Earth and other solar system bodies as well as health and environmental monitoring of Astronauts and their environment. Microarrays offer a way to monitor tens to thousands of target analytes in an ultrasensitive, fast and efficient format.

In preparation for space missions, NASA has refocused research toward testing technology that will be required by human exploration beyond low Earth orbit. These systems/technology include bio-regenerative environmental control and life support systems (ECLSS) that includes health screening and monitoring including monitoring of microbial pathogens, in situ resource utilization (ISRU) and techniques for purposes of life detection (LD) and planetary protection (PP).

It is evident that microorganisms affect many of the goals and systems listed above and that rapid, onboard microbial monitoring will contribute toward mission safety and success. In order to monitor microbial communities a group of institutions has teamed up to develop a DNA re-sequencing array chip² for the identification of microorganisms relevant to human space exploration. This team includes the Lab-on-a-Chip Applications and Development (LOCAD) department at NASA Marshall Space Flight Center, Carnegie Institution of Washington, the Marine Biological Laboratory (Woods Hole), NASA Astrobiology Institute (NAI), Affymetrix (Sunnyvale, CA) and potential interested parties at NASA Johnson Space Center (Astromaterials Research and Exploration Science (ARES) office, Microbiology laboratory, ECLSS personnel, EVA office, flight surgeons and astronaut office).

A microarray is a collection of microscopic spots (DNA or RNA) attached to a solid surface, such as glass, plastic or silicon chip forming an

Figure 1: Application for microarray technology in space exploration:
- Environmental Control and Life Support System (ECLSS), In-situ Resource Utilization (ISRU), Life Detection (LD), Medical Testing (M), Planetary Protection program (PP)
array. Researchers currently use microarray technology mostly to study the genetic structure and function of genes. Most often DNA microarrays are applied to measure the expression levels of large numbers of genes simultaneously. DNA-microarrays are also being used to identify and/or resequence genetic variation in individuals and across populations. In regards to those generally termed "genotyping" applications, DNA microarrays may be used in this fashion for environmental application like the detection of microorganisms through their genome.

A resequencing microarray is a specific application of gene sequencing that precisely determines the sequence of bases in DNA. Targeted resequencing of genomic DNA from organisms such as microorganisms is an important tool enabling access to variation within the species and between similar species. Affymetrix GeneChip® Resequencing Arrays will facilitate us to perform large-scale resequencing of 16S or 18S rRNA and rpoB gene sequences for the identification of microorganisms in the environment. The microarray consists of several sequences, which cover pathogens, extremophiles, and other microorganisms of all three domains of life - bacteria, archaea, and eukaryota and applicable to each area of Figure 1. At this time 120 organisms have been outlined for the initial chip and this is summarized in Figure 2.

This initial chip will be a first demonstration and proof of principle that this technology can detect these microorganisms. The long-term goal is that this chip will support crews of future human exploration missions.

Figure 2: Taxonomy tree of microorganisms, which are planed to be on the microarray. Functional genes are not included in this list.