UNAMBIGUOUS IN-SITU LIFE DETECTION USING A MICROBIAL GROWTH SENSING ARRAY.
M. V. Clark[1], J. Heinz[2], J. Schirmack[2], S. P. Kounaves[1,3], and D. Schulze-Makuch[2,4]. [1]Department of Chemistry, Tufts University, Medford, MA, USA (miles.clark@tuft.edu; samuel.kounaves@tufts.edu); [2]Center for Astronomy and Astrophysics, Technical University of Berlin, Germany (j.heinz@tu-berlin.de; j.schirmack@tu-berlin.de; dirksm@astro.physik.tu-berlin.de); [3]Department of Earth Science & Engineering, Imperial College London, UK; [4]School of the Environment, Washington State University, Pullman, WA, USA (dirksm@wsu.edu)

Introduction: Because the question of extraterrestrial life has such profound scientific and philosophical implications, the evidence obtained must be definitive and unequivocal [1]. Anything less than that will be unacceptable to a large segment of both the public and the scientific community. A variety of instruments and methods have been proposed and/or implemented for detection of extant organisms. They range from direct microscopic observation, impedimetric transduction, nanoscale vibrations, culturing, biomarker identification, sample return, and a human landed mission [2-6]. All of these present a myriad of obstacles, scientific, engineering, political, or exorbitant cost.

To explore the possibility of life beyond earth, we must use *in situ* life detection schemes that make the fewest assumptions about the biology of extraterrestrial organisms. As terrestrial organisms are the only example of life known to us, the degree of conformity between terrestrial biology and alien biology is unknown. The sensor technologies described here will allow for the unambiguous detection of both growth and reproduction. The new detection scheme is based on the *ion selective electrode* (ISE) sensor array used in the Phoenix Mars Lander *Wet Chemistry Lab* (WCL) [7], but now includes a new set of sensors whose signal is modified by the presence of large macromolecules or whole cells on its surface. This novel use of ISE sensors for life detection has not been previously attempted. The new "growth detector" sensors are comprised of a specially doped polymeric membrane that produce a change in electrical potential when a cellular organism attaches and/or reproduces on its surface.

Methodology: The overall basis of this microbial detection system is a set of two growth chambers, both containing identical membrane-based sensors whose signal is modified by the presence of any adsorbed organic macromolecules or whole cells, and both of which are initially sterile. A schematic diagram of the prototype growth detection instrument is shown in Figure 1. There are several crucial and necessary aspects of the detection system to insure that the results obtained are truly unambiguous. These include; (1) the use of two differential sensor arrays/chambers, one as a control and the other for the inoculate, (2) the sterilization and inoculation processes, (3) use of an indigenous sample as growth medium, and (4) the ability to carry out multiple replications of the experiment. Assuming that all conditions and operations are the same in both cells, except for the inoculation, then the sensor response in the inoculated chamber could only be caused by an entity that is replicating and/or altering the chemistry. Introducing only a small sub-milligram quantity of sample into the test chamber will rule out a chemical reaction. Non-biological reactions should be observable and can be accounted for or allowed to proceed to completion. Any sample reactions with the water would also be observed when the original addition of the material is made. Replicate experiments in new sets of chambers and constant monitoring of the chemistry will allow for the discrimination between an authentic growth response and a chemical interference.

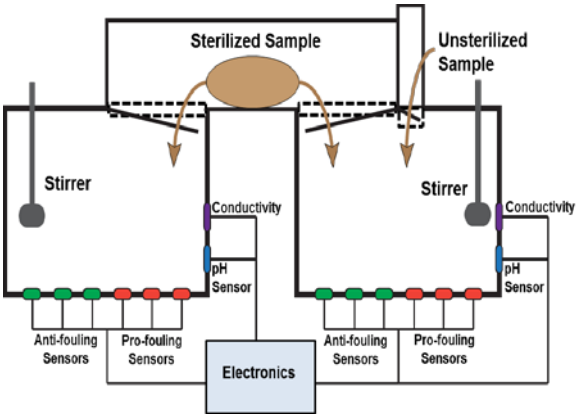

Figure 1: Basic components and operation. Sterilized sample is introduced into both beakers and a small unsterilized sample added to the test chamber.

Results: Our research has been focused in two areas, the use of a high pressure sterilization processes that will not affect the indigenous soil being used as a nutrient source, and the optimization of the membrane-based growth detection and chemical monitoring sensors. An update of our progress on instrumentation and results of our recent experiments will be presented.

References: [1] Schulze-Makuch, D. et al. (2015) *Astrobiology*, *15*, 413-19. [2] Brosel-Oliu et al. (2015) *Electroanalysis*, *27*, 656-62. [2] Kasas et al. (2015) *PNAS*, *112*, 378-81. [3] Sims et al. (1997) *Proceedings of SPIE*, *3111*, 164-74. [4] Mujumdar, et al. (1996) *Bioconj. Chem. 7*, 356-62. [5] Merek et al. *Appl. Microbiol.*, *16*, 724-31. [6] Kounaves et al. (2009) *JGR*, *114*, E00A19.