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May 2004 Report of Progress

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1 Jim Alleman

Solid-Phase Thermophilic Aerobic Reactor (STAR) Processing of Fecal, Food, and Plant Residues

- **Automated Pump Control**

The air diaphragm pump that is utilized for STAR impacts many parameters, including mixing, foaming and oxygen transfer. A Campbell Scientific Micrologger has been programmed to cyclically control the pump operation based on either selected time requirements or in response to on-line data such as ORP and temperature. At present, we are using this pump control strategy on a 55 min 'on' and 5 min 'off' routine.

- **6% Solids Content STAR Study**

During the month of May our STAR system was maintained with a 6% influent solids feedstock consisting of fecal matter, food residuals, and toilet paper. Residuals solids analyses were completed by A&L Great Lakes Laboratories for nutrients, solids, C:N, SOUR, fecal coliform, etc.

- **Training of Undergraduate Summer Assistants**

Four undergraduate students have been hired to maintain the reactor over the summer and to assist with complementary research initiatives. These students will handle routine feeding and maintenance, therefore, as well as conducting individual research projects (e.g., volatile fatty acid off-gas measurements, preliminary plant biomass degradation assessments, etc.).

- **Beginning O₂ and CO₂ Online Analysis and Scrubber Incorporation**

We are beginning off-gas analysis. Rosemount Analytical O₂ and CO₂ analyzers are currently in the installation process, and the scrubber is also being installed.

- **VFA Analysis of Effluent Sludge and Condensate**

In addition to the in-house total and volatile solids analysis, volatile fatty acids analyses were begun on both effluent sludge and condensate. Additionally, we are investigating methods for VFA analysis in the off-gas.

- **Distribution of STAR Products**

Sludge effluent was distributed to Shane Howard for use in the dewatering studies, and Caula Beyl for use with their mushroom growth studies. Condensate was sent to Charles Glass for his zeolite studies.

- **Method Development of Preliminary Plant Biomass Study**

In preparation for the addition of inedible plant biomass to the STAR reactor in late summer, we will be researching the response of various plant species to the STAR treatment process. Individual plant species residuals will be studied on a small bench-scale basis.

2 Charles Glass

Nitrogen Cycling in ALS

- **Optimum Zeolite for Ammonium Adsorption**

Over the past month the selection of the optimum zeolite for ammonium adsorption has been analyzed for 1 gram of zeolite with 200, 300, and 400 mg/L NH₃-N (we have completed the assessment of 100, 500, and 1000 mg/L NH₃-N. One new zeolite (a clinoptilolite) was added to the matrix of zeolites already analyzed and three others are expected to arrive within the next three weeks. Currently, of the zeolites that we have obtained, a chabazite is showing the highest capacity for ammonium adsorption with no pretreatment across the largest majority of the concentrations evaluated. Although the maximum capacity of ammonium adsorption in the literature varies between 11 and 35 mg NH₃ - N/g of zeolite, our highest adsorption capacity measured with no pretreatment is 25 mg NH₃-N/g of zeolite, a clinoptilolite. We will continue to evaluate the capacity of new zeolites as

they arrive. In the upcoming weeks we plan to study the impact of pretreatment on zeolite maximum capacity and the performance of the top three zeolites to treat the condensate from the STAR system.

- **Initial Column Assessment of STAR Condensate**

We received one liter of STAR condensate that contained of 550 mg/L NH₃-N during the past month. The condensate was pumped through a column filled with 200 g of zeolite from our third best untreated zeolite (the top two were depleted when the condensate arrived). The effluent from the column had no detectable NH₃-N, as expected based on the capacity that we measured in our batch experiments with synthetic condensate. We did not measure the organic carbon concentration or the concentration of inorganics that may be present in the condensate and cause interference. We are continuing to receive STAR condensate throughout the summer and will continue to feed it through the current column to assess when the capacity has been reached and breakthrough occurs. In communication with the Project 6 team (BREATHell), this early result is commendable as they are not expecting a significant amount of nitrogen in the effluent from the zeolite treatment.

- **Pretreatment of Zeolite with Heat and KCl**

In the literature several methods of pretreatment have been reported and they notably improved the capacity of zeolites to adsorb ammonium (up to 35 mg NH₃ - N/g of zeolite. In addition, we believe that using K⁺ as the primary exchange cation will cause less inhibition in downstream biological processes than the traditional Na⁺ used by other investigators. We are attempting to meet or exceed the capacity of zeolites found in the literature with our heat treatment followed by conditioning with KCl.

3 Jeff Volenec

Solids Separation Water Removal from STAR Biosolids Effluent Using Plants

- **STAR Bio-Solids Dewatering**

The second replicate of the bio-solid dewatering experiment with human fecal waste from the Solid-Phase Thermophilic Aerobic Reactor (STAR) has been completed. Experiment involves three treatments, STAR effluent, Hoagland's nutrient solution, and water, applied to eleven different plant species. Plant biomass and elemental tissue concentrations from second replicate harvest are being analyzed to determine effects of STAR effluent on tissue composition. Water use data will be used, along with biomass and tissue concentrations, to determine plant specie suitability for dewatering STAR effluent. The third replicate will commence in June.

- **STAR Effluent Aeration**

Initial tests to determine if STAR effluent aeration reduces high BOD and reducing conditions in root zone have been completed. Aeration appears to improve plant tolerance to STAR effluent when compared to that of treatments not subjected to aeration. Additional testing will proceed on aeration of STAR effluent to determine if reducing conditions can be decreased in root zone.

- **Plant Growth Substrate**

New plant growth substrates are currently being tested to observe if larger substrate material size promotes oxygen diffusion into root zone.

4 Jim Alleman

Liquid Freeze-Thaw (LiFT) Urine & RO Brine Processing for Advanced Water Recovery and Salt Separation

Sublimation Freeze-Thaw Water Recovery Element

The 3rd generation sublimation unit is complete, but has yet to be utilized due to our current efforts with the ambient pressure freeze-thaw experimentation set-up. In addition, the specific urinary tract infection strain of *E. coli* has yet to be received; therefore, research on microbial fate has not been started.

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Ambient Pressure Freeze-Thaw Water Recovery Element

- Literature research has suggested the feasibility of a spray freeze concentration technology that utilizes the technique of salt separation from water during freezing. In colder regions of the world this technology is an economically feasible choice for drinking water treatment of salt laden waters. The process is relatively simple, where salt water is sprayed into the air during below-freezing temperatures. As a result, ice crystals form and a concentrated brine solution is wasted. This method is reportedly capable of removing 70% of water from salt solutions.
- Based on this idea, an experimental set up has been constructed consisting of an upright freezer modified with input/output points for waste treatment and collection. Experiments will determine feasibility of this technology on urine based on conductivity measurements, as well as to determine droplet size relative to treatment efficiency.

5 Kim Jones

Membrane Processes in ALS

Task: Evaluate Suite of Membranes for flux and contaminant rejection

- **Quantify flux decline and rejection in six MF membranes**
Two hydrophilic MF membranes – a 0.22 μm membrane and a 0.1 μm membrane (Millipore) were utilized in a stirred cell to pretreat for the RO/NF system. These membranes were chosen to represent loose RO or NF membranes with relatively high flux and low pressure. Both thin film composite and cellulose acetate membranes are represented. The operating pressures for the MF system range from 10 – 50 psi. Feed water consists of low concentrations of urea, surfactant, salts, and trace organics taken from modeled simulations of expected contaminant effluent concentrations from the BREATHe bioreactor system. Initial flux determinations are underway. Effluent from the MF membranes will be fed directly to the RO membranes. In the future, the effluent will be disinfected by UV radiation prior to RO treatment.
- **Quantify flux decline and rejection in six RO membranes**
A SEPA crossflow RO/NF membrane unit was installed, and membrane testing began. Six membranes were tested, representing a wide range of salt rejection, rated from 92% Na_2SO_4 to 99.5% NaCl . The operating pressures for the RO/NF system ranges from 100 – 500 psi with crossflow velocities from 0.4 - 0.9 m/s. Each membrane is pre-compacted, followed by filtration with simulated feedwater. The flux is recorded every 30 minutes until steady state is achieved. Flux is calculated as $V/(At)$, where V is the permeate volume that has passed through the effective membrane area A of 0.0142 m^2 in time t. The three membranes having the highest flux will be chosen for future experiments with rejection, fouling and hydrodynamic studies. After use, the membranes are stored in DI water in the refrigerator at 5°C with the water being changed daily.

6 Kathy Banks

Treatment of Grey Water Using Gas Biofilters

- **Start up of 6 BREATHe I reactors**

Six replicate BREATHe I reactors have been inoculated with a mixed population of bacteria. Simulant feed, with Pert Plus for Kids surfactants as the primary constituent, will be provided to the system on 5/28/04. Design parameters were based on the previous operation of two BREATHe I reactors. After steady state water treatment is achieved (two weeks projected), STAR gas contaminants will be added to the system sequentially. CO₂ will be added first followed by NH₃ and finally H₂S. Treatment efficiencies will be evaluated in both the liquid and gas phases.

- **Gas Chromatography Methods Development**

A Gas Chromatography instrument has been set up to analyze gaseous constituents and trace organics in BREATHe I system. In addition, Analysis protocol was developed and applied to the GC system. Main constituents analyzed include ammonia, hydrogen sulfide, carbon dioxide, formic acid, acetic acid, propionic acid lactic acid, ethanol, methanol, 1-propanol and ethylene glycol.

- **Isolation of Surfactant Degrading Bacteria**

Based on experiments reported in last month's progress report, it was hypothesized that the two isolates found during operation of a chemostat were the primary degraders of disodium cocoamphodiacetate and sodium laureth sulfate. To test this hypothesis, an experiment was set up where isolates were added to solutions containing surfactants and minimal salts medium. Growth was measured by optical density. However, no growth was observed. When surfactants were added to samples from the chemostat, rapid growth was observed including the formation of biofilms. To further examine the chemostat samples, both the isolates and bacteria from samples were cut with restriction enzymes and examined by gel electrophoresis. Results showed that DNA is present in the chemostat samples which is not present in the isolates. Clearly, we were unable to isolate some bacteria present in the chemostat on LB plates. The isolates have been sequenced and future work will involve finding the bacteria that could not be cultured.

7 Al Heber

Gas-Phase Revitalization Using Biofilters in ALS

- Completed construction of the main body of 24 biofilters, installed fittings and tubings, and ordered and installed liquid pumping system.
- Located source of plastic foam media in Germany.
- Analyzed potential reactions between test gases.
- Performed ammonia calibrations with FTIR spectrometer.

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Chip Blatchley

Potable Water Disinfection Subject to Extended Space Travel Constraints

- **Continuous Flow Experiments employing *Bacillus Subtilis* spores**

Two sets of flow-through experiments were conducted in May on a low-pressure, single-lamp, closed-vessel UV reactor.

The first set of operating conditions included tap water that had been subjected to pretreatment through a reverse osmosis system and had a transmittance of 99.38%. The second experiment was conducted under lower transmittance conditions of 64.85%. This was achieved by adding decaffeinated coffee to the aquatic matrix. For both experiments, 10^7 colony forming units/L of *Bacillus subtilis* spores were added to a 350 L tank of water. This aqueous suspension was then drawn from the tank with a pump and passed through the UV reactor at four different measured flow rates. Samples of the suspension were collected from the tank and at the outlet of the reactor at all flow rates. These samples were then vacuum filtered through 0.45 μm membrane filters and the membranes with the collected spores were incubated on nutrient agar plates for 24 hours at 37°C. Inactivation was measured by comparing the initial number of spores and the number of surviving spores at all flow rates.



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- **UV and Membrane System Collaboration**

Purdue University is in the process of building two UV reactors for use at Howard University. The UV lamps and ballasts ordered for the reactors have not been received, but are expected to arrive in early June. Kelly Pennell (of Purdue University) will travel to Howard University to set-up and test the UV reactors. It is expected that travel to Howard University will occur in mid-June.

- **Analytical Instrument Repairs**

Last month effort was placed on the determination of molar absorptivity values for three different forms of iodine (I^- , I_2 and I_3^-). At the beginning of this month the spectrophotometer went down due to a faulty lamp. The spectrophotometer was repaired and its performance is being compared to past measurements. New molar absorptivity values collected from the repaired instrument are currently being obtained.

9 Bruce Applegate
Mike Ladisch

Bioamplification Using Phage Display for the Multiplexed Detection of Pathogens in Potable Water and Food

- **Work continued using the previously constructed recombination system for the modification of the *E. coli* O157:H7 bacteriophage.**

Key parameters were determined for optimization of the recombination system for reporter gene insertion and gene inactivation. Primers were designed to begin the systematic evaluation of the unknown open reading frames. This work entitled "Development of a Recombination System for Rapid Construction

of *E. coli* O157:H7 Reporter Bacteriophage” was presented at the annual meeting of the American Society of Microbiology in New Orleans May 24, 2004 at a poster session. As previously reported the presentation was highlighted in the ASM press room and a radio interview for the Microbeworld to be aired at later time was performed along with an interview with the NewScientist.

- **Genome annotation of *phi* V10 was completed and we are currently resolving ambiguities in the map.**

Final genome analysis showed as previously reported similarity to the *Salmonella* phage epsilon 15. Electron micrographs of the phage were also prepared to determine size and morphology of the phage. We are currently preparing a manuscript for the Journal of Bacteriology to be submitted in June. A poster presentation entitled “Genome Sequence Analysis and Evaluation of Strain Specificity of *E. coli* O157:H7 Bacteriophage phi V10” was presented at the American Society of Microbiology in New Orleans May 25, 2004.

Work was continued on the insertion of a unique binding epitope in the tailspike protein of the *Salmonella* spp. bacteriophage P22.

Primers were utilized to amplify the tailspike protein from P22 with the appropriate His modifications. We are currently adding the appropriate promoter configurations to allow repressed expression of the His modified tailspike protein in the preparative host strain. The preparative host strain repressor gene cassette was constructed for insertion in to the preparative host strain genome.

10 Paul Brown

Waste Treatment Using Tilapia

- **Waste Products Ground and Pelleted.**

Waste products that are potential food for fish were acquired from collaborators (Alleman and Mitchell), ground and pelleted. Six Wastes will be evaluated in a formal study beginning May 17.

- **Plant Diet Experiments Completed and Reported.**

John Gonzales, graduate student, completed using all plant diets fed to larval tilapia and results reported at an international conference. These data indicate that wastes from ALS can potentially meet the needs of this critical life history stage.

- **Nutrient Analysis Completed.**

Nutrient analyses have been completed with several of the wastes and laboratories have been identified that will analyze wastes and fish upon completion of the next study.

- **Mass Balance Study Underway.**

Megan Rosinski, undergraduate student, is underway evaluating the mass balance of ingested dietary minerals within a fish and the mass balance of fishes within an integrated aquaponics system.

11 Cary Mitchell

Minimizing ESM for ALS Crop Production

- **Lighting system update**

Construction continues on the LED intracanopy lighting system at Orbitec. Mounts for the lightcicles are being assembled at Purdue.

- **Crop production**

Cultivar selection continues on four varieties of day neutral strawberries, four varieties of short blueberries and eight varieties of basil. Blueberries and cranberries have been moved to a cooler climate and flowering and vegetative growth have been reinitiated. Blueberry and basil production from cuttings is being evaluated, and most of the cuttings appear to be rooting successfully.

- **Hydroponic pH control**

Components of a hydroponic pH control system including switching valve and industrial grade electrode have been tested. Progress continues on design and construction of the systems and the feedback software.

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12 Caula Beyl

Solid Waste Processing Using Edible Fungi

- **Growth of *P. ostreatus* (Grey dover) on single and paired substrates**

P. ostreatus (strain Grey dover) was tested on 2 mm particle size inedible residues of wheat, rice, tomato, basil, sweet potato, soybean and cowpea placed singly or mixed in a 1:1 ratio with either rice or wheat straw in 750 ml transparent food containers. The dry substrates were sufficiently moistened by adding 250 ml of distilled water, prior to autoclaving at 121°C and 1.1kg cm⁻² for 40 min. Seeded cultures were incubated at 25°C for growth and colonization of the substrate and subsequent fruiting. Initial growth and colonization was rapid (attaining up to 9 cm diameter of surface mycelial spread in 7 days) in the legume substrates and their combinations with rice or wheat straw. Growth and colonization was very slow in sweet potato and almost suppressed in basil. However, growth was significantly improved in their combinations with wheat or rice straw. This indicates that pairing the difficult substrates with the legumes or wheat and rice straw will be required for their effective degradation. A similar observation was made using two strains of shiitake previously. Further tests using other strains of *P. ostreatus* have been initiated.

- **Growth of *P. ostreatus* on wheat straw mixed with STAR Effluent**

P. ostreatus (strain Grey dover) was inoculated on approximately 80g of autoclaved wheat straw supplemented with 0, 20, 40 and 60 % (v/v) dilutions of STAR effluent in 750 ml food containers. Cultures were incubated as described earlier. Initial mycelial growth (diameter of surface spread from center of substrate) was rapid covering 8 cm in 7 days. The rate of initial colonization was not affected by concentration of STAR effluent in the substrate mixture suggesting that at least 60% of STAR effluent is supportive to *P. ostreatus* growth and that higher concentrations of the STAR effluent may be tolerated and effectively recycled by this strain.

- **Acquisition of additional crop substrates and strains of *P. ostreatus***

Residual biomass of five crop species (soybean, cowpea, basil, sweet potato and tomato) are being obtained from the LED root crop growth chamber at Purdue while additional strains of *Pleurotus ostreatus* have been ordered from Field and Forest Products Co., Wisconsin. More than six strains will be evaluated on basil and sweet potato biomass and their paired combinations with the legumes or wheat or rice straw.

13 Lisa Mauer

Novel Storage and Packaging Operations

- **ICES paper accepted entitled: “2004-01-2525 Equivalent System Mass of Producing Yeast and Flat Breads From Wheat Berries, A Comparison Of Mill Type”**

This work built on a study presented at the 2003 ICES meeting entitled “Comparison of Equivalent System Mass (ESM) of Yeast and Flat Bread Systems”. Wheat is a candidate crop for the Advanced Life Support (ALS) system, and cereal grains and their products will be included on long-term

space missions beyond low earth orbit. While the exact supply scenario has yet to be determined, some type of post-processing of these grains must occur if they are shipped as bulk ingredients or grown on site for use in foods. Understanding the requirements for processing grains in space is essential for incorporating the process into the ALS food system. The ESM metric developed by NASA describes and compares individual system impact on a closed system in terms of a single parameter, mass. The objective of this study was to compare the impact of grain mill type on the ESM of producing yeast and flat breads. Hard red spring wheat berries were ground using a Brabender Quadrumat Jr. or the Kitchen-Aid grain mill attachment (both are proposed post-harvest technologies for the ALS system) to produce white and whole wheat flour, respectively. Yeast bread was made using three methods (hand+oven, bread machine, mixer with dough hook attachment + oven). Flat bread was made using four methods (hand+oven, hand+griddle, mixer+oven, mixer+griddle). Data on all inputs (active time, passive time, mass and volume of ingredients and equipment, power) were measured and used to calculate ESM. Assumptions were based on data in NASA documents. Data were analyzed using PC-SAS with significance at $P < 0.05$. Grain mill type significantly ($P < 0.05$) influenced the ESM of making both bread types; and the Brabender Quadrumat Jr. contributed significantly ($P < 0.05$) more mass than the Kitchen-Aid grain mill to the ESM for producing both types of bread. Additionally, the approach used for measuring ESM for a food production scenario can be used for evaluating ESM of producing any food and can be a useful template for future investigations.

- **ICES paper accepted entitled: “2004-01-2526 Equivalent System Mass (ESM) Estimates for Commercially Available, Small-Scale Food Processing Equipment”**

One of the challenges NASA faces today is developing an Advanced Life Support (ALS) system that will enable long duration space missions beyond low earth orbit (LEO). This ALS system must include a food processing subsystem capable of producing a variety of nutritious, acceptable, and safe edible ingredients and food products from pre-packaged and re-supply foods as well as salad crops grown on the transit vehicle or other crops grown on planetary surfaces. However, designing, building, developing, and maintaining such a subsystem is bound to many constraints and restrictions. The limited power supply, storage locations, variety of crops, crew time, need to minimize waste, and other ESM parameters influence the selection of processing equipment and techniques. Several researchers have calculated ESM of select types of food processing equipment to compare ESM for individual food types; however, a complete survey of ESM parameters for currently available food processing unit operations has not been completed.

In order to direct NASA's research and technology efforts related to the food subsystem, the technologies available on Earth for food processing, preservation, and packaging must be identified and the viability of these technologies must be assessed. Minimizing mass, volume, and energy consumption are important factors to be considered when locating available food processing equipment and evaluating feasibility for use in an ALS system. Once the ESM has been estimated for available equipment, modifications can be suggested to improve efficiency and reduce ESM. The objective of this study was to compile ESM-parameter information (mass, volume, and power) for currently available, small-scale food processing

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equipment and to provide average, high, and low ESM values for each class of equipment (hand-held and bench-top mixers, etc.) that performs the following unit operations: mixing, size reduction, heat transfer (heating and cooling), and extraction (water, oil, and juice). In this study, each piece of equipment was assumed to perform a single task, the power required for cooling was set equivalent to the power needed to operate the equipment, and the crew-time was not considered in the preliminary ESM estimates. An additional discussion on other parameters important to consider for ESM of the food system, including multi-functional equipment and power, is provided. All data are provided in appendices for use in future investigations.

- **Lisa Mauer was on maternity leave April and May and will return part time in June**
- **Ilan Weiss has successfully defended his M.S. thesis entitled “Characterization of equivalent system mass (ESM), chemical, and physical properties of select wheat products and cultivars intended for long-term space missions”**
- **Work is continuing on an experimental design for determining effects of irradiation on oil quality parameters**
Oil and antioxidant samples have been obtained and preliminary studies into the best analytical methods for evaluating oil (TBARS, GC-MS, FTIR) and antioxidant stability (TRAP, FRAP, ORAC, Randox test kit) are underway.
- **We are beginning to develop a foods lab to be used in the Purdue NASA camp August 4-6 and to develop a presentation on foods to be included in a space exploration course for the Wabash Area Lifetime Learning Association that will begin in October.**

14 Leonard Williams **Optimal Food Safety in ALS**

- **Determination of critical points**
AAMU Graduate Student has completed preliminary work on determination of critical points in pre-harvest salad crop production.
- **Determination of Biofilms on Salad Crops**
Graduate student continue work on biofilm formation on salad crops and microenvironments or “niches” created by spoilage and pathogenic bacteria

15 J. Pekny, G. Chiu, Y. Yih **Systems Modeling of ALS**

System process map:

- The remaining uncertainties have been resolved about the prospective NSCORT design to be assessed in a mass balance model. Responses from the PIs have indicated changes or otherwise approved of the assumptions we have made. The graphic is available on request.

Modeling:

- The “first order” steady state mass balance model has been almost completely specified in a uniform format in Excel, with new code written to validate user inputs and generate equations. We have resolved issues

surrounding diet modeling; the masses of 15 crop species, edible fungi, and tilapia will be tracked throughout food processing, and so a diverse human diet can be required, meeting activity-dependent caloric needs and other constraints.

Documentation and testing:

- The assumptions about the subsystems are being documented extensively in a separate plain English format. The clear and compact specification of the model is designed to ease the future transition of responsibility. Testing will involve selection of input parameters based on mission and technology assumptions and then solution of the model to illustrate impacts of NSCORT processes. These results will be mentioned in this summer's reports.

16 John Trimble

A System Dynamics Approach to Modeling the Advance Life Support System

- We are currently wrapping up the documentation for the modeling process and our current work. Methods, Analysis Artifacts, verification/validation process and algorithms will be described in this document.
- In addition, Charita Brent is currently preparing a paper(s) to present at the 2004 International Multiconference in Computer Science and Computer Engineering (Joint Int'l Conference-Modeling conference) and National Technical Association Conference

17 Julia Hains-Allen

Outreach

- **Summer Fellowship Program**

Seven undergraduate students will participate in the summer fellowship program beginning June 6, 2004. Four students from Howard University and three students from Alabama University were chosen by the fellowship committee. Research Fellowship assignments are as follows:

Two Howard students - Dr. Kim Jones and Dr. Charles Glass

One Howard student - Dr. Caula Beyl

One Howard student – Dr. Chip Blatchley

One Alabama A&M student – Dr. Bruce Applegate

The fellowship summer program will be expanded to include education undergraduate students who will train with Julia Hains during the summer and extend the summer program into the school year by doing ALS/NSCORT outreach activities in Alabama during 2004-2005 academic year.

Education Fellowship assignments are as follows:

Two Alabama A&M students – Julia Hains

- **Key Learning Explore Mars Camp**

150 high school students will attend a summer camp program August 4-6, 2004 on Purdue's campus. Funding has been obtained this month from NASA, Great Lakes Chemical Corporation, NSF Nanotechnology Center, Purdue Engineering Department, Frito-Lay and Kroger.

- **Project Lead The Way**

A full semester educational activity "Equivalent System Mass Analysis of Plant Growth", developed by ALS/NSCORT Outreach has been accepted by the national engineering program **Project Lead The Way** (PLTW). Equivalent System Mass Analysis of Plant Growth will be piloted by ALS/NSCORT in the fall 2004 throughout Indiana followed by nationwide dissemination by PLTW in 2005. This activity incorporates research grade plant growth chambers developed by Orbitech for NASA into national engineering and science high school curriculum.

- **Mission To Mars**

A partnership with IVY Technological Community College has been formed. During the summer, Julia Hains will present professional development workshops for area educators on the 5-8th grade Mission To Mars module.



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In addition, distance learning professional developments will be offered throughout Indiana via IVY Tech on this module.

18 Dave Kotterman

ALS NSCORT Center Activities

- **Space Advanced Life Support Class.**
Dr. Jim Alleman completed the first semester in this long distance learning, web-based course.
- **External Advisory Committee Meeting Date and Site Set**
The meeting will be held at Howard University on November 17 and 18, 2004.
- **Center to support Strategic Research to Enable NASA's Exploration Missions in Cleveland Ohio.**
The Center to support this important conference with one or two representatives.