



**Section 7  
Science  
Paula Dumars**

**STS-107 Fundamental Biology Project  
NASA Ames Research Center**



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**Arterial Remodeling and Functional Adaptations Induced by Microgravity  
98-HEDS-02-386**

**Principal Investigator: Michael D. Delp, Ph. D., Texas A & M University**

- **Orthostatic intolerance (dizziness while standing) and orthostatic hypotension (abnormal reduction in arterial pressure) are common problems for astronauts following adaptation to spaceflight and return to Earth.**
  - **Researchers have demonstrated that this is due, in part, to a compromised ability to elevate peripheral vascular resistance and maintain normal blood pressure.**
- **This investigator is looking at the involvement of a vascular mechanism underlying this condition.**



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## **Arterial Remodeling and Functional Adaptations Induced by Microgravity (PI: M. Delp)**

### **Experiment Objectives**

- **Determine whether the headward fluid shifts and reduced activity of postural muscles, that occur in microgravity, alter rodent arterial vessel structure and function.**
  - **Arterial vessels are involved in regulating blood flow and arterial blood pressure.**
- **Determine whether arterial smooth muscle atrophy occurs in microgravity and if so, what effect this will have on the ability of arterioles to vasoconstrict.**



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**Arterial Remodeling and Functional Adaptations Induced by Microgravity  
(PI: M. Delp)**

**Experiment Objectives**

- **If arterial smooth muscle atrophy and a diminished ability to vasoconstrict are found to occur in microgravity, this would provide evidence for the involvement of a vascular mechanism in the orthostatic cardiovascular dysfunction that occurs following spaceflight.**
- **This knowledge will provide insights essential to the development of counter-measures aimed at attenuating arterial remodeling and reducing the time required for astronauts to readjust to planetary gravitational fields.**



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## **Arterial Remodeling and Functional Adaptation Induced by Microgravity (PI: M. Delp)**

### **Hypotheses:**

- **Microgravity will attenuate myogenic (contractile) responsiveness of resistance vessels isolated from skeletal muscle.**
  - **This type of vasoconstriction is primarily involved in maintaining arterial pressure during postural changes from the supine to upright position.**
- **Microgravity will attenuate norepinephrine-mediated vasoconstriction in skeletal muscle arterioles.**
  - **This type of vasoconstriction is primarily induced through the sympathetic nervous system, the dominant system involved in regulating arterial pressure. Contractile response and sensitivity to norepinephrine will be determined.**
- **Microgravity will induce the remodeling of skeletal muscle arterioles, i.e., atrophy of arterial smooth muscle cells.**



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## **Arterial Remodeling and Functional Adaptation Induced by Microgravity (PI: M. Delp)**

### **Hypotheses:**

- **Microgravity will enhance skeletal muscle responsiveness to endothelium-dependent vasodilator stimuli.**
  - ◆ **Dilatory response and sensitivity to acetylcholine stimuli will be determined.**
  - ◆ **This alteration could exacerbate vasoconstrictor deficits.**
- **Microgravity will increase the expression of nitric oxide synthase (NOS) mRNA in skeletal muscle arterioles.**
  - ◆ **NOS is an enzyme responsible for the production of the potent vasodilator, nitric oxide.**



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## **Arterial Remodeling and Functional Adaptation Induced by Microgravity (PI: M. Delp)**

### **Research/Validation**

#### **Results of hindlimb suspension studies performed in PI's laboratory:**

- **The headward fluid shifts that take place in rat hindlimb suspension studies resemble the fluid shift in humans that are induced by microgravity.**
- **Significant decreases in the responsiveness of the vessels to elevations and reductions in fluid pressure.**
  - Diminished ability to constrict.
- **Diminished smooth muscle tone of feeder arterioles in the muscles of hindlimbs.**
  - Smooth muscle cells atrophy.
- **Compromised ability to elevate peripheral vascular resistance.**
  - Reduced ability to maintain normal arterial blood pressure.



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## Arterial Remodeling and Functional Adaptation Induced by Microgravity (PI: M. Delp)

### Research/Validation

- **Ground studies identified during the definition phase are complete.**
  - **Length of time muscle complex is viable post dissection, when placed in cold physiological solution:**
    - ◆ **Vessel physiological responses, gene expression and vessel morphology are viable for at least 8 hrs.**
    - ◆ **Constriction responses and vessel morphology remain intact after 24 hrs.**
    - ◆ **Vessel dilation responses and gene expression are compromised after 24 hrs.**
- **These results establish a reasonable time frame in which to complete the experimental objectives.**
- **However, dilation and gene expression objectives would likely be lost in the occurrence of a Dryden landing.**





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**Arterial Remodeling and Functional Adaptation Induced by Microgravity  
(PI: M. Delp)**

**Science / Validation, Description**

**Experiment Operations Concept:**

**Post-Flight Processing**

- **Following anesthesia and euthanasia, the soleus-plantaris-gastrocnemius muscle complex will be removed (at 15 minute intervals) and stored at 4°C until vessel microdissections can take place.**
- **Vessels will be microdissected and isolated arterioles will be analyzed at KSC for alterations in physiology.**
- **During the collection of physiological data, additional vessels will be removed from the muscles, frozen and shipped at -70°C to PI laboratory for subsequent morphology and gene expression studies.**



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**Arterial Remodeling and Functional Adaptation Induced by Microgravity  
(PI: M. Delp)**

**Science / Validation, Description**

- **Minimum Mission Requirements:**

**Ground studies indicate that hindlimb suspension produces significant alterations in vascular function after 7 days. Thus, shuttle missions of 7 days or more should produce measurable vascular changes. PI will analyze vessels from missions of 4 days or more to determine if vascular changes are evident in animals exposed to microgravity for 4 days.**

- **Contingency Landing Requirements**

**In the event of a Dryden landing muscle complexes, with arterioles, will be dissected and placed in 4°C physiological solution for transport (at 4°C) to KSC as soon as possible for microdissection and analysis. Dilation and gene expression objectives will be lost after 24 hours.**



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**Anatomical Studies of Central Vestibular Adaptation:  
Neurolab Completion Proposal (93-OLMSA-01-127)**

**Principal Investigator:        Gay R. Holstein Ph. D.  
   Mount Sinai School of Medicine**

**Astronauts experience vestibular abnormalities during adaptation to microgravity and again during re-adaptation to Earth's gravity. Vestibular abnormalities may include:**

- Postural illusions, sensations of rotation.**
- Nystagmus (involuntary motion of the eye).**
- Dizziness and vertigo (sense of whirling about, disorientation).**
- Space adaptation sickness.**

**Results from this experiment will:**

- Help identify the the cellular basis underlying the adaptation processes.**
- Provide insights for the development of effective pharmacological therapeutic countermeasures.**



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**Anatomical Studies of Central Vestibular Adaptation:  
Neurolab Completion Proposal (PI: G. Holstein)**

- **Experiment Objectives:**
  
- **Identify the morphologic alterations in rat cerebellar cortex that correlate with re-adaptation to 1 g following adaptation to the microgravity environment. Specific aims are to:**
  - **Compare the nature and extent of the ultrastructural evidence for neuronal degeneration and synaptic plasticity present in vestibular and non-vestibular regions of the rat cerebellar cortex.**
  
  - **Determine if the alterations are pathway and neurotransmitter specific.**



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**Anatomical Studies of Central Vestibular Adaptation:  
Neurolab Completion Proposal (PI: G. Holstein)**

**Hypothesis**

- **Alterations in ultrastructural features accompany adaptation to microgravity and readaptation to 1 g.**
  
- **Alterations are pathway and neurotransmitter-specific.**



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**Anatomical Studies of Central Vestibular Adaptation:  
Neurolab Completion Proposal (PI: G. Holstein)**

**Research/Validation**

- **No additional ground studies are required in development of this experiment for flight.**
- **Results from STS-90 indicate that ultrastructural reorganization occurs in gravity-recipient zones of the cerebellum following exposure to the microgravity environment.**
  - **Marked neuronal degeneration and synapse retraction.**
  - **Unexpected findings that bear important consequences for future space missions.**
- **Focus of the STS-107 E-127 experiment is to**
  - **Confirm the ultrastructural reorganization in perfusion fixed brain tissues.**
    - **Perfusion is the optimal fixation method for ultrastructural tissue preservation.**
    - **Immersion fixative method (not optimal for ultrastructural analyses) was used in the Neurolab experiment due to multi-experiment sharing and flight constraints.**
  - **Evaluate the differences in excitatory and inhibitory amino acid neurotransmission in the vestibular cerebellum of perfusion fixed flight and control rats.**



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**Anatomical Studies of Central Vestibular Adaptation:  
Neurolab Completion Proposal (PI: G. Holstein)**

**Science / Validation Description**

**Experiment Operations Concept:**

- **Specimen requirements: A minimum of 5 male Fischer 344 rats of sexual maturity at launch (10+ weeks old), and weighing at ~ 240 grams at launch.**
  - 5 animals will provide adequate  $n$  for statistical analysis.
- **Hardware requirements: 1 AEM, with 5 rats,**  
**Total of ~1200 grams biomass at launch.**
- **AEM caged ground control will be run on a 48 hr. delayed basis.**
- **PI will arrive at KSC at ~ L - 1 week for laboratory set up and verification of equipment and post flight experiment processing at KSC.**
- **Post flight dissections and tissue processing will occur on R+1 day.**



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**Anatomical Studies of Central Vestibular Adaptation:  
Neurolab Completion Proposal (PI: G. Holstein)**

**Science / Validation Description**

**Experiment Operations Concept:**

**Post-Flight Processing**

- **Animals will be placed in Vivarium cages for re-adaptation to gravity until R+1 day.**
- **Animals will be euthanized by transcardiac perfusion on R+1day.**
- **After perfusion, brains will be dissected and placed in individual vials containing cold 4% paraformaldehyde in phosphate-buffered saline, maintained and shipped at 4°C for overnight delivery to the PI laboratory.**
- **Tissue processing for electron microscopy and post embedding immunocytochemistry analyses will occur in the PI laboratory.**



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**Anatomical Studies of Central Vestibular Adaptation:  
Neurolab Completion Proposal (PI: G. Holstein)**

**Science / Validation Description**

- **Minimum Mission Requirements:**

**Significant science return is expected after a minimum flight of 24 hrs. PI will process specimens from missions of 24 hrs. or more.**

- **Contingency Landing Requirements:**

**In the event of a Dryden landing, PI team members will fly to Dryden at the announcement of the de-orbit burn. On R+1 day the team will perform perfusions and dissections. Tissues will be maintained at 4°C and shipped to the PI laboratory. Team will return to KSC to process ground controls.**



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**Choroidal Regulations Involved in the Cerebral Fluid Response to Altered Gravity:  
Water Transports and Serotonergic Receptors (98-HEDS-02-409)**

**Principal Investigator: Jacqueline Gabrion, Ph.D.  
Université Pierre & Marie Curie-Paris VI**

**Spaceflight induces a cephalic (headward) fluid shift and adaptation to microgravity involves regulation of fluid compartments.**

**Previous spaceflight experiments with rats suggest that choroidal Cerebral Spinal Fluid (CSF) production is reduced in rats exposed to microgravity.**

**A reduction in CSF may contribute to the headaches, nasal stuffiness and a sense of fullness of the head which are frequently endured by astronauts during adaptation to spaceflight.**

**This experiment will lead to fundamental information about the mechanisms associated with cerebral homeostasis and fluid balance.**



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**Choroidal Regulations Involved in the Cerebral Fluid Response to Altered Gravity:  
Water Transports and Serotonergic Receptors (PI: J. Gabrion)**

**Experiment Objectives**

- **To evaluate the effects of spaceflight on**
  - **Water and ion transport in the brain, hypophysis, kidneys, and lungs.**
  - **Serotonergic regulation and nitric oxide expression in the choroid plexus.**

**Hypothesis**

- **Is the biosynthesis of proteins involved in water (aquaporin) and ion transport impaired in the brain, hypophysis, kidney and lungs?**
- **What is (are) the regulatory pathway(s) responsible for increased cGMP (guanosine cyclic monophosphate) levels previously measured in the choroid plexus of spaceflown rats: serotonin or nitric oxide?**



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**Choroidal Regulations Involved in the Cerebral Fluid Response to Altered Gravity:  
Water Transports and Serotonergic Receptors (PI: J. Gabrion)**

**Research Validation**

- **No additional ground studies are required in development of this experiment for flight.**
- **Results of previous spaceflight experiments suggest that choroidal CSF could be reduced during adaptation to spaceflight.**
- **Results from ground rat hindlimb suspension studies show similar responses.**
- **PI is continuing ground based head down suspension studies and hypergravity studies to investigate expression of the proteins involved in water (aquaporins) and ion (NaK dependent ATPase) transport.**



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**Choroidal Regulations Involved in the Cerebral Fluid Response to Altered Gravity:  
Water Transports and Serotonergic Receptors (PI: J. Gabrion)**

**Science / Validation, Description**

**Experiment Operations Concept:**

- **Specimen requirements: A minimum of 8 male Sprague-Dawley weighing ~ 300 grams at launch. Animals will be shared with Dr. Delp.**
- **Hardware requirements:                   2 Flight AEMs, with 4 rats each**  
**Biomass: ~ 1200 grams per AEM at launch**
- **AEM caged and Vivarium controls will be run on a 48 hr. and 96 hr. delayed basis**
- **PI team will arrive at KSC for laboratory set-up at ~L-2 weeks.**
- **PI team will participate in the Facility Trial Run with Dr. Delp's team to verify proper equipment function and dissection flow.**



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**Choroidal Regulations Involved in the Cerebral Fluid Response to Altered Gravity:  
Water Transports and Serotonergic Receptors (PI: J. Gabrion)**

**Science / Validation, Description**

**Experiment Operations Concept:**

**Post-Flight Processing**

- **Following anesthesia and euthanasia, the brain, hypophysis, kidneys and lungs will be removed and either placed in fixative, frozen or embedded, prior to shipment to PI's laboratory.**
- **Ultrastructural, immunocytochemistry, and *in situ* hybridization analyses will be performed at the PI's laboratory.**



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### **Choroidal Regulations Involved in the Cerebral Fluid Response to Altered Gravity: Water Transports and Serotonergic Receptors (PI: J. Gabrion)**

#### **Science / Validation, Description**

- **Minimum Mission Requirements:**

**Little is known about the effect of microgravity on the expression of proteins involved in water and ion transport. Significant science return is expected after a mission duration of 24 hrs.**

- **Contingency Landing Requirements:**

**In the event of a Dryden landing, the PI will have a team available to dissect the tissues and freeze them or place in proper fixative. The tissues will then be transported to KSC as soon as possible for continued processing prior to shipment to PI's laboratory. All science objectives can be achieved.**



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## Fundamental Rodent Experiments Supporting Health (FRESH-02)

- **Biocompatibility Test and Experiment Verification Test (EVT) are not required for the 3 FRESH-02 Experiments due to the successful flight history of the AEM.**
  - **Previous flights (over 16 missions) with adult rats in the AEM demonstrate that the AEM provides a safe environment that maintains the health and well being of adult rats in microgravity.**
  - **PI (Dr. Holstein) is requesting SPACEHAB environmental data (vibration, temperature, etc.) to determine necessity for additional ground testing.**



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## Fundamental Rodent Experiments Supporting Health (FRESH-02)

### FRESH-02 Pre-Flight Activities

<b>L-6 weeks</b>	<b>Sentinel animals sent from vendor to Anmed for SPF verification</b>
<b>L-4 weeks</b>	<b>Animal receipt</b> <ul style="list-style-type: none"><li>- Oral/fecal samples taken for microbiology analysis and SPF verification</li><li>- Housed in Vivarium cages and placed on flight food bar diet.</li><li>- Water bottles with modified lixits</li><li>- 12/12 hr light cycle</li><li>- Temperature expected in AEM in SPACEHAB during flight.</li></ul>
<b>L-4 wk - L+0</b>	<b>Daily health checks will be performed.</b> <b>Food, water and body weight data will be recorded every third day.</b>
<b>L-1 wk</b>	<b>Animals will be placed into flight groups in Vivarium cages.</b> <ul style="list-style-type: none"><li>- Acclimation to cage mates and similar cage floor space</li></ul>
<b>L-2 days</b>	<b>Animal selection for flight will be based on normal weight gain and daily health observations.</b>
<b>L-43-31 hrs</b>	<b>Animals will be loaded into the AEMs for turnover to SPACEHAB.</b>



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## Fundamental Rodent Experiments Supporting Health (FRESH-02)

### FRESH-02 Scrub Turnaround Scenario

- **Animals will be loaded at launch minus 43-31 hrs. In the event of a 24 hour scrub the animals will remain on-board. Upon the announcement of a second 24 hour scrub the animals will be removed from the SPACEHAB. At that time there will be a 96 hour stand down. Another group of animals (Launch Contingency Group 1) will then be loaded at launch minus 43-31 hrs prior to the next launch attempt.**
  - ◆ **Animals will be on the pad for no longer than 72 hours.**
- **Planning includes support for launch attempts through 30 days.**



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## **Fundamental Rodent Experiments Supporting Health (FRESH-02)**

### **FRESH-02 In-Flight Activities**

- **Daily on-orbit observations and recording of animal health**
- **Daily hardware check**
- **Water refill operation every three to four days**

### **FRESH-02 In-Flight Contingency Procedures**

- **In the unlikely event of an AEM hardware failure or an animal crisis the NASA Chief Veterinarian will be available, by call down, to evaluate the severity of the crisis and will determine whether euthanasia is necessary. The AEM CO<sub>2</sub> System (ACOS), currently under development, will provide the crew with a safe and rapid means of euthanizing the animals.**



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### **Fundamental Rodent Experiments Supporting Health (FRESH-02)**

#### **FRESH-02 Ground Activities**

- **Ground controls will be conducted at KSC in AEM cages**
- **Daily observations and recording of animal health**
- **Daily hardware check**
- **Water refill every three to four days**

#### **FRESH-02 Post-Flight Activities**

- **Rats will be removed from the Shuttle by R+6 hrs.**
- **The animals will be unloaded from the AEMs upon receipt at the receiving facility**
- **A health check will be performed by the NASA attending veterinarian.**
- **Animals will then be transferred to the investigators for post-flight processing.**



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## Fundamental Rodent Experiments Supporting Health (FRESH-02)

### FRESH-02 Contingency Landing Site Activities

- **Project team will be at Dryden Payload Receiving Facility for receipt of animals at L+24 hrs.**
- **Dr. Gabrion will have team available to support dissections for mission length of 24 hours.**
- **Dr. Holstein will have team available to support dissections for mission length of 24 hours.**
- **Dr. Delp will have team available to support dissections for mission length of 4 days.**



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## Fundamental Rodent Experiments Supporting Health (FRESH-02)

### Summary of FRESH-02 Experiments

- **Investigating adaptations induced by microgravity and their underlying mechanisms. The experiments will provide fundamental information about mechanisms associated with:**
  - **Post - spaceflight orthostatic intolerance.**
  - **Vestibular and sensory motor adaptation to space flight and re-adaptation to Earth's gravity.**
  - **Cerebral homeostasis and fluid balance.**
- **In the event of a nominal flight we should be able to meet all the research objectives for these experiments.**
  - **PIs have plans and personnel ready to cover pre-flight, post-flight and scrub turn-around activities.**
  - **PIs have plans and personnel ready to cover contingency requirements.**



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**Bacterial Physiology And Virulence On Earth And In Microgravity  
96-HEDS-04/05-406**

**Principal Investigator: Barry Pyle, Ph.D., Montana State University**

**In the context of human life support in spaceflight, there is a need for high quality drinking water to limit the risks of infections in human occupants and minimize water system deterioration.**

**The immune system suppression observed in astronauts after spending time in microgravity may lead to an increased susceptibility to infections caused by waterborne pathogens which are normally not pathogenic.**

**Some bacteria subject to microgravity have an increased resistance to anti-microbial agents and their growth rates are greater than those observed on earth.**



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## Bacterial Physiology And Virulence On Earth And In Microgravity (PI: B. Pyle)

### *Pseudomonas aeruginosa:*

- **Are among the most common pseudomonads isolated from Space Shuttle water systems.**
- **The *Pseudomonas* species is a diverse group of micororganisms that are widely distributed in the environment and are part of the normal intestinal flora of healthy humans.**
- **An opportunistic infectious microorganism that can cause disease by producing Exotoxin A, a toxin that affects the cells and physiologic function of the host.**
- **Typically causes infections in people only when they are severely immuno-compromised.**



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## Bacterial Physiology And Virulence On Earth And In Microgravity (PI: B. Pyle)

### Experiment Objectives:

- **Determine if spaceflight and microgravity affects the growth, physiology, and virulence of *Pseudomonas aeruginosa*.**

### Hypothesis

- **Microgravity and/or spaceflight conditions affects the growth, physiology and virulence of *Pseudomonas aeruginosa*.**
- **The specific virulence and physiological factors to be considered are Exotoxin A production, viable cell numbers, total cell numbers, membrane integrity, respiratory activity, and esterase activity.**



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## **Bacterial Physiology And Virulence On Earth And In Microgravity (PI: B. Pyle)**

### **Research/Validation**

- **Results from PI tests have determined:**
  - **Incubation time required - 24 hours will yield better Exotoxin A production.**
  - **Silicon versus steel plungers for Phorbol - Silicon plungers will be used.**
  - **Chemo-luminescence versus ELISA assay - Determined ELISA will be used for Exotoxin A analysis.**
  - **Feasibility of Phorbol hardware – Determined *P. aeruginosa* can grow and produce Exotoxin A in Phorbol volume.**
  - **Feasibility of Plunger Box units - Plunger Box hardware will no longer be used.**
  - **Media to be used (SMDII).**
  - **Fixative to be used (Formalin, 0.24% and Sodium Azide, 3.3%)**
  - **Effects of returning cultures at ambient temperature (28°C) - Slight increase in Exotoxin A occurs on days 10-14 at 28°C. PI prefers to return all samples at 5°C.**
  - **The effects of a 24 hour launch delay and turn around timeline - Cells are inducible after an additional 48 hours at 5°C. Launch delay will not effect samples.**



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**Bacterial Physiology And Virulence On Earth And In Microgravity  
(PI: B. Pyle)**

**Research/Validation**

**Continued PI tests include:**

- **Improving the post-flight sample processing assays.**
- **Resolving issues with bacteria culturability after storage at 5°C.**

**Preliminary results indicate that the new growth media has improved culturability of the bacteria. Further tests in the Phorbol hardware are currently underway.**

- **Variability in bacteria growth within the Phorbol hardware has been observed.**

**The PI believes residual contamination in the hardware may cause variability.**

**The ESA Phorbol hardware will be refurbished by the manufacturer which should remove any contamination.**



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**Bacterial Physiology And Virulence On Earth And In Microgravity  
(PI: B. Pyle)**

**Science / Validation, Description**

**Biocompatibility Studies:**

- **Biocompatibility test has determined adequate growth and production of Exotoxin A in the Phorbol cassettes.**
- **Experiment integration will be verified at the ESA Experiment Sequence Test (EST) scheduled for September 2000.**



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**Bacterial Physiology And Virulence On Earth And In Microgravity  
(PI: B. Pyle)**

**Science / Validation, Description**

**Experiment Operations Concept**

- **Specimen requirements: *Pseudomonas aeruginosa* (cultured in PI laboratory).**
- **Hardware requirements: - 8 Flight Phorbol cassettes incubated in ESA Biopack facility (4 stationary & 4 on in-flight centrifuge). - 8 Phorbol cassettes incubated in ESA Ground Biopack facility (4 stationary & 4 in centrifuge).**



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**Bacterial Physiology And Virulence On Earth And In Microgravity  
(PI: B. Pyle)**

**Science / Validation, Description**

**Experiment Operations Concept**

**Minimum Mission Requirements**

- **PI will require 24 hour incubation of samples which is currently scheduled to occur on MET Day 7.**
- **In the event of a shortened mission incubation for 24 hours on an earlier flight day will meet PI requirements.**

**Contingency Landing Requirements**

- **Samples are to be maintained at 5°C and sent back to KSC by ESA as soon as possible for processing at KSC by the PI team. Samples need to be received and processed by R+24 hrs. to achieve science objectives.**

**Scrub Turnaround Requirements**

- **Cells are inducible after an additional 48 hours at 5°C. Launch delay will not effect samples.**



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**Bacterial Physiology And Virulence On Earth And In Microgravity  
(PI: B. Pyle)**

**Science / Validation, Description**

**Experiment Operations Concept**

- **Pre-flight Operations:**
  - **Bacterial cultures will be grown in PI laboratory and transported to KSC.**
  - **PI will load samples into Phorbol containers prior to hand over at ~L-18 hrs.**
  
- **In-flight Operations:**
  - **Specimens will be maintained at 5°C in the OSRF (Oceaneering SPACEHAB Refrigerator Freezer) from load through FD7.**
  - **FD7 Crew will activate samples and place in Biopack incubator for 24 hrs.**
  - **FD8 Crew will fix samples and place in Biopack refrigerator (5°C).**



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**Bacterial Physiology And Virulence On Earth And In Microgravity  
(PI: B. Pyle)**

**Science / Validation, Description**

**Experiment Operations Concept**

- **Post-flight Operations:**
  - **Processing will occur at KSC and samples will be shipped to PIs lab for further analysis.**
  
- **In the event of a nominal flight we should be able to meet all the research objectives for this experiment.**
  - **PI has plans and personnel ready to cover pre-flight, in-flight, post-flight and scrub turn-around activities.**
  - **PI has plans and personnel ready to cover contingency requirements.**