

## COMMERCIAL OPPORTUNITIES IN BIOSEPARATIONS AND PHYSIOLOGICAL TESTING ABOARD SPACE STATION FREEDOM

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A NASA Center for the Commercial Development of Space  
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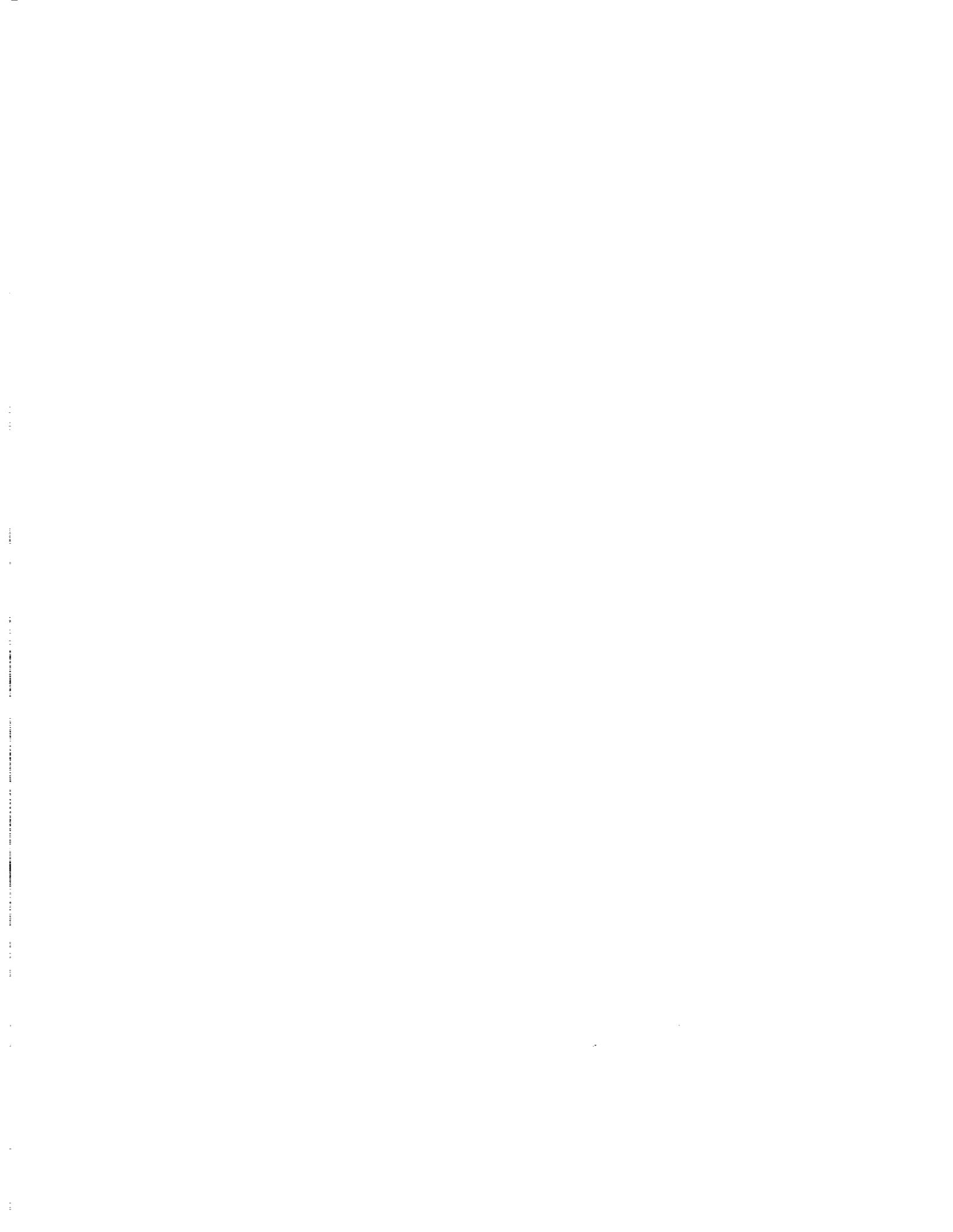
### ABSTRACT

The Center for Cell Research (CCR) is a NASA Center for the Commercial Development of Space which has as its main goal encouraging industry-driven biomedical/biotechnology space projects. Space Station Freedom (SSF) will provide long duration, crew-tended microgravity environments which will enhance the opportunities for commercial biomedical/biotechnology projects in bioseparations and physiological testing.

The CCR bioseparations program, known as USCEPS (for United States Commercial Electrophoresis Program in Space), is developing access for American industry to continuous-flow electrophoresis aboard SSF. In space, considerable scale-up of continuous free-flow electrophoresis is possible for cells, subcellular particles, proteins, growth factors and other biological products. The lack of sedimentation and buoyancy-driven convection flow enhances purity of separations and the amount of material processed/time.

Through the CCR's physiological testing program, commercial organizations will have access aboard SSF to physiological systems experiments (PSEs); the Penn State Biomodule; and telemicroscopy. Physiological systems experiments involve the use of live animals for pharmaceutical product testing and discovery research. The Penn State Biomodule is a computer-controlled minilab useful for projects involving live cells or tissues and macromolecular assembly studies, including protein crystallization. Telemicroscopy will enable staff on Earth to manipulate and monitor microscopic specimens on SSF for product development and discovery research or for medical diagnosis of astronaut health problems.

Space-based product processing, testing, development and discovery research using USCEPS and CCR's physiological testing program offer new routes to improved health on Earth. Direct crew involvement in biomedical/biotechnology projects aboard SSF will enable better experimental outcomes. The current data base shows that there is reason for considerable optimism regarding what the CCDS program and the biomedical/biotechnology industry can expect to gain from a permanent manned presence in space.



# THE CENTER FOR CELL RESEARCH

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COMMERCIAL OPPORTUNITIES IN BIOSEPARATIONS AND  
PHYSIOLOGICAL TESTING ABOARD SSF

SPACE STATION FREEDOM UTILIZATION CONFERENCE

PENNSTATE



AUGUST 5, 1992

PENNSTATE



THE CENTER FOR  
CELL RESEARCH

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NASA

CODE C

CODE S

CODE... \*\*\*\*\*

17 CCDS

CCR

NASA CODE C MISSION

"...TO SEEK AND ENCOURAGE, TO THE MAXIMUM EXTENT POSSIBLE,  
THE FULLEST COMMERCIAL USE OF SPACE."

555

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**CCR COMMERCIAL PARTNER PROGRAM  
FOR  
PRODUCT TESTING AND INDUSTRY-DRIVEN DISCOVERY RESEARCH**

- 1. FLIGHT ACCESS**
- 2. EXPERIMENT PLANNING AND POST FLIGHT ANALYSIS**
- 3. PAYLOAD PLANNING, INTEGRATION, MISSION MANAGEMENT**
- 4. FLIGHT CERTIFIED HARDWARE**
- 5. INTELLECTUAL PROPERTY AGREEMENTS**
- 6. SUPPORT**

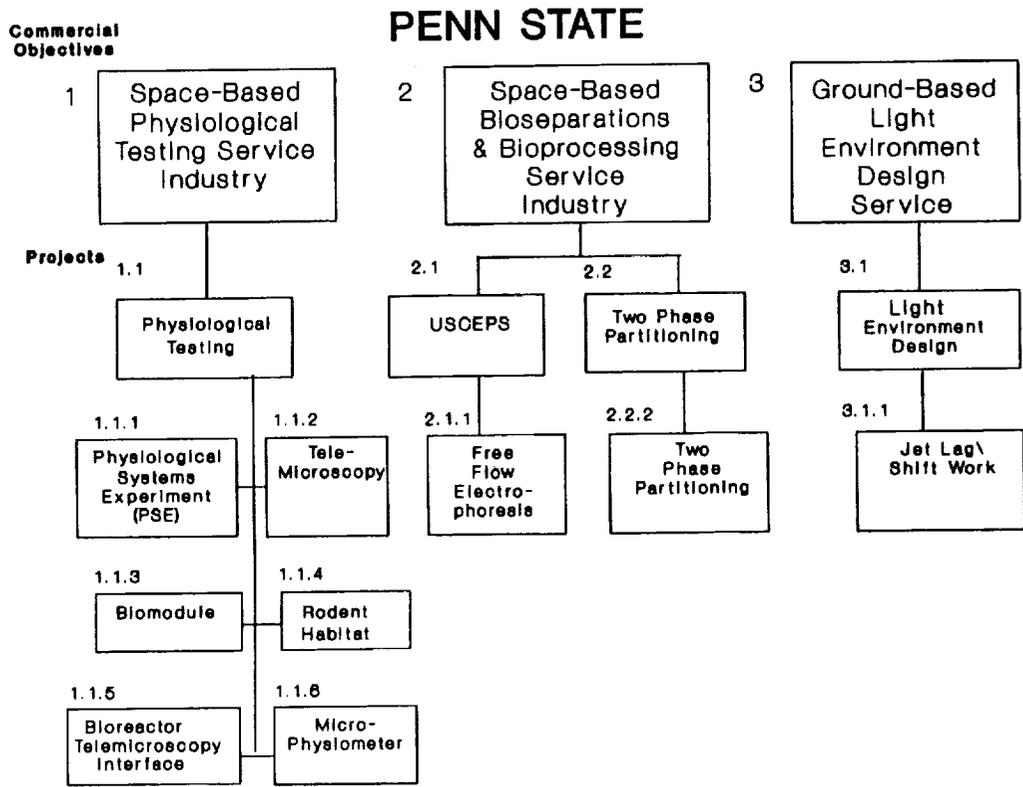


**MAIN GOAL: ASSIST INDUSTRY IN PLANNING AND ACCOMPLISHING  
BIOTECHNOLOGY/BIOMEDICAL SPACE PROJECTS**

**BIOSEPARATION**

**PHYSIOLOGICAL TESTING**

**ILLUMINATION**



**SPACE BIOTECHNOLOGY: OPPORTUNITIES FOR  
INVESTIGATIONS IN CELLULAR PHYSIOLOGY  
AND BIOSEPARATIONS**



## WHY SPACE BIOTECHNOLOGY

### PHYSIOLOGICAL TESTING

EXPOSING ANIMALS AND MAN TO SURPRISINGLY SHORT PERIODS OF MICROGRAVITY CAUSES PHYSIOLOGICAL CHANGES WHICH RESEMBLE HUMAN DISEASES, SUCH AS OSTEOPOROSIS, MUSCLE WASTAGE, ABNORMAL HORMONE SECRETION, LOWERED IMMUNE FUNCTION AND AGING. SPACEFLOWN ANIMALS AND CELLS CAN BE USED AS MODELS FOR THESE CONDITIONS.



## OBSERVED MICROGRAVITY EFFECTS

### SOUNDING ROCKETS

7 MINUTES  $\mu\text{G}$

#### CELL PHYSIOLOGY

Hybridoma production  $\uparrow$   
Oncogene expression  $\downarrow$   
PKC pathway  
Microtubule dysfunction  
Electrophoretic cell separation  $\uparrow$

$\mu\text{g} = 10^3\text{G}$

### U.S. SPACE SHUTTLE/RUSSIAN SATELLITE

7-14 DAYS  $\mu\text{G}$

#### ANIMAL PHYSIOLOGY

Bone demineralization  
Muscle atrophy  
Immune dysfunction  
Endocrine dysfunction  
Low hematocrit  
Loss of body fluids  
Altered liver enzymes  
Wound healing  $\downarrow$   
Bone breaking  $\downarrow$

### SKYLAB-MIR

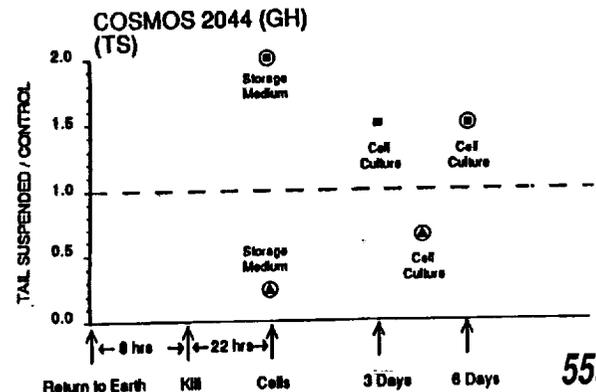
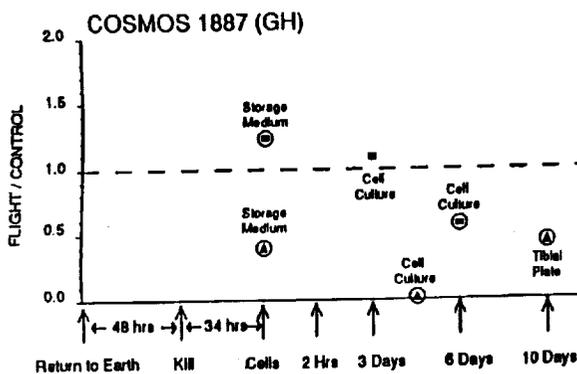
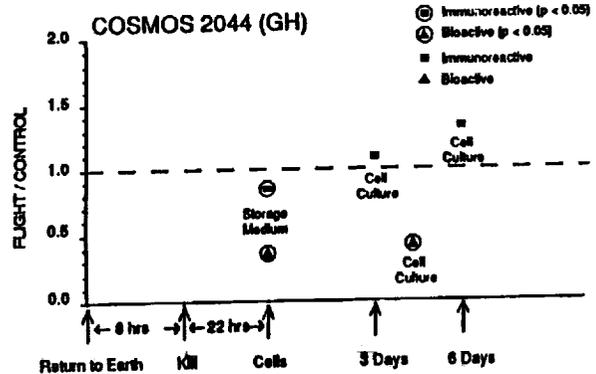
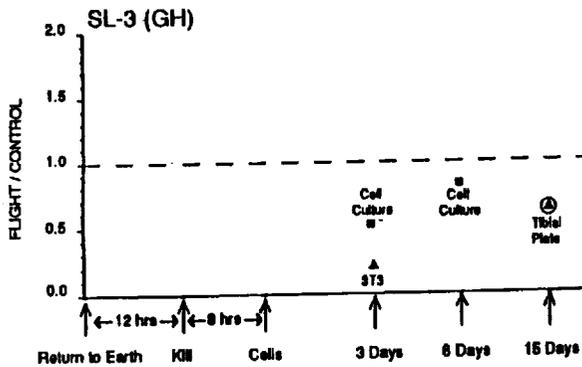
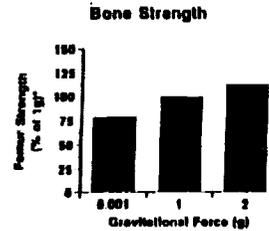
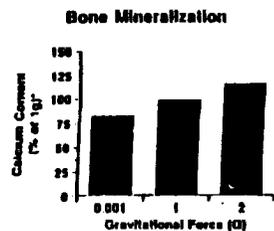
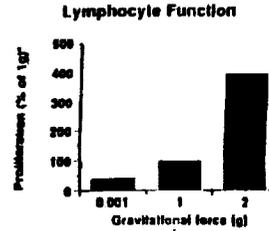
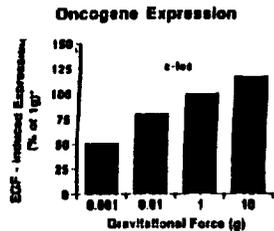
3-12 MONTHS  $\mu\text{G}$

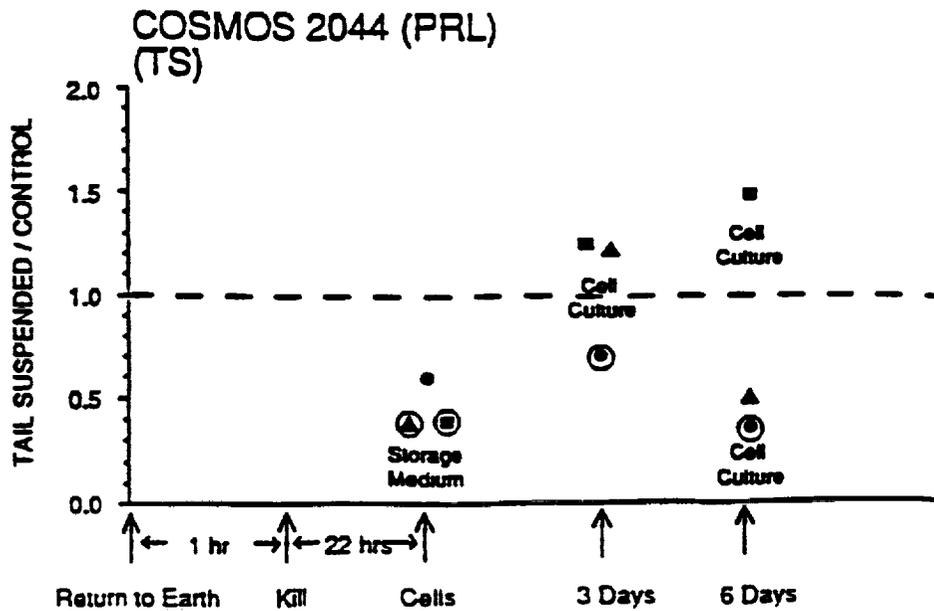
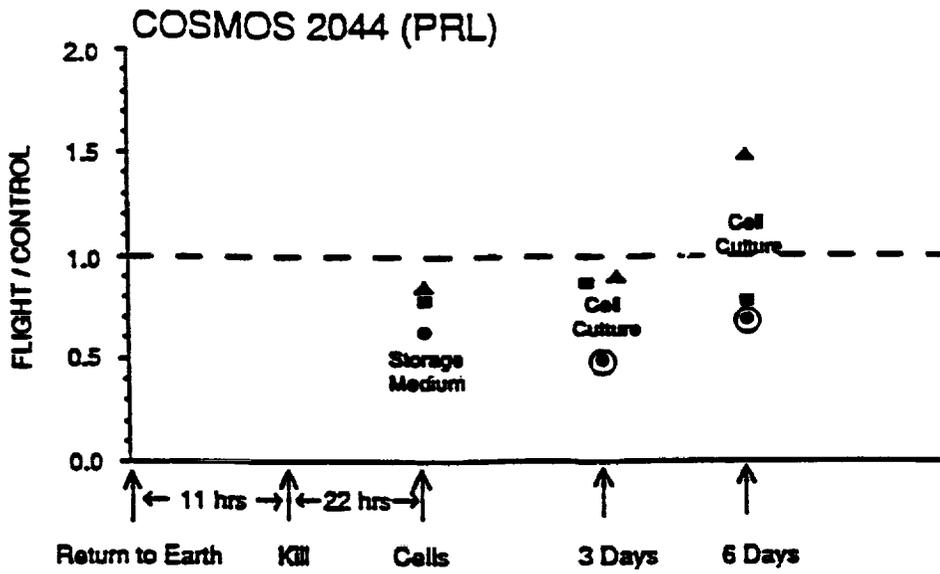
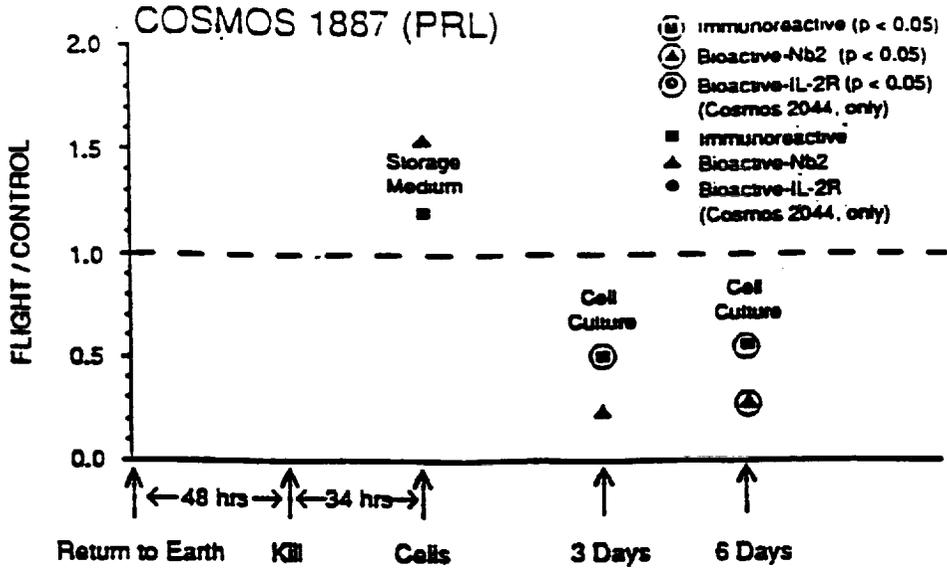
#### EFFECTS IN HUMANS

Spinal decompression  
Edema  
Negative calcium balance  
Muscle weakness  
Cardiovascular changes  
Neurovestibular changes



# OBSERVED MICROGRAVITY EFFECTS







## SINGLE CELLS IN REDUCED GRAVITY

- BACTERIAL PROLIFERATE MORE RAPIDLY
- BACTERIAL CONJUNCTION RATE INCREASED
- INCREASED RESISTANCE OF E. COLI TO ANTIBIOTICS
- REDUCTION IN SPORULATION RATE
- 4 FOLD INCREASE IN PROLIFERATION OF PARAMECIUM TETRAURELIA
- VIRTUAL TOTAL SUPPRESSION OF BLASTOGENIC RESPONSE IN T-LYMPHOCYTES EXPOSED TO CON-A
- RAT PITUITARY CELLS SHOW 20 FOLD SUPPRESSION OF BASAL GH RELEASE POSTFLIGHT
- 5 FOLD INCREASE IN GAMMA-INTERFERON PRODUCTION IN  $\mu$ G
- INCREASE IN MEMBRANE FUSION EVENTS (HYBRIDOMA)
- DECREASED GLUCOSE CONSUMPTION IN HUMAN EMBRYONIC LUNG FIBROBLASTS



## FIRST COMMERCIAL PHYSIOLOGICAL TESTING

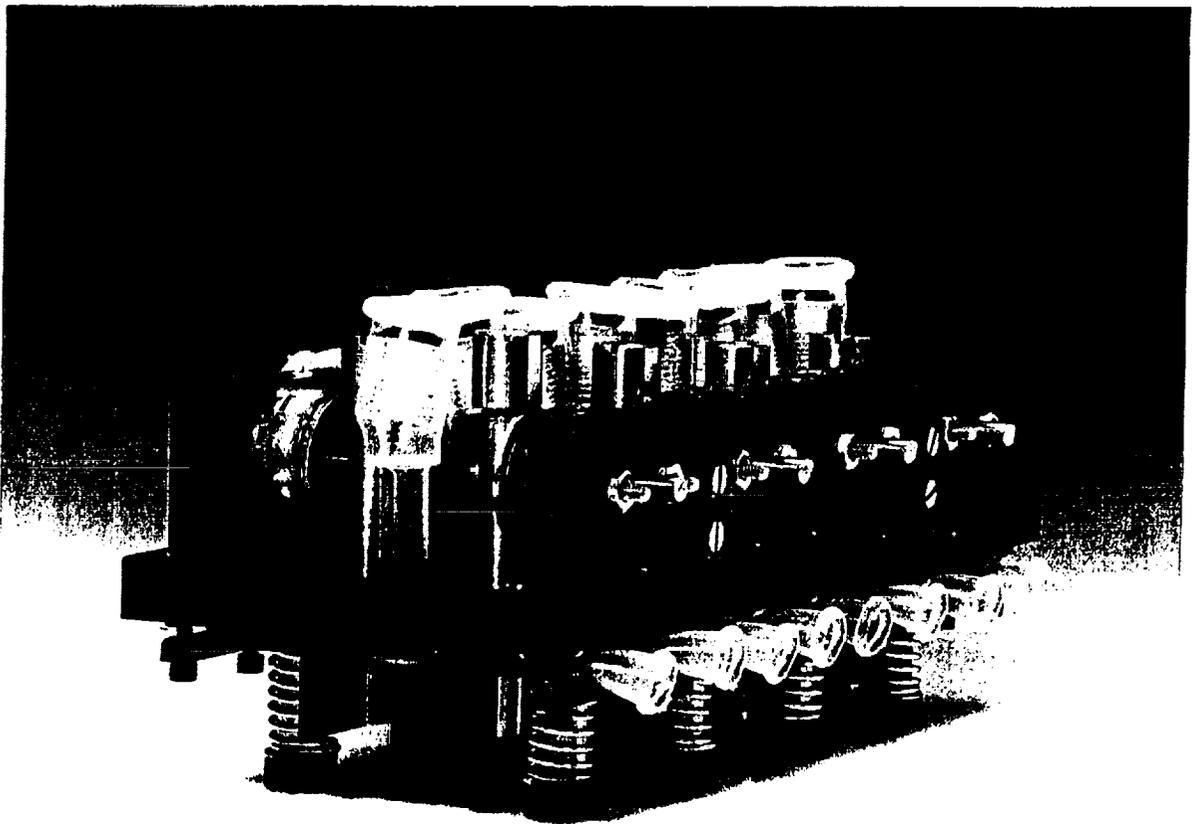
### EXPERIMENT IN SPACE

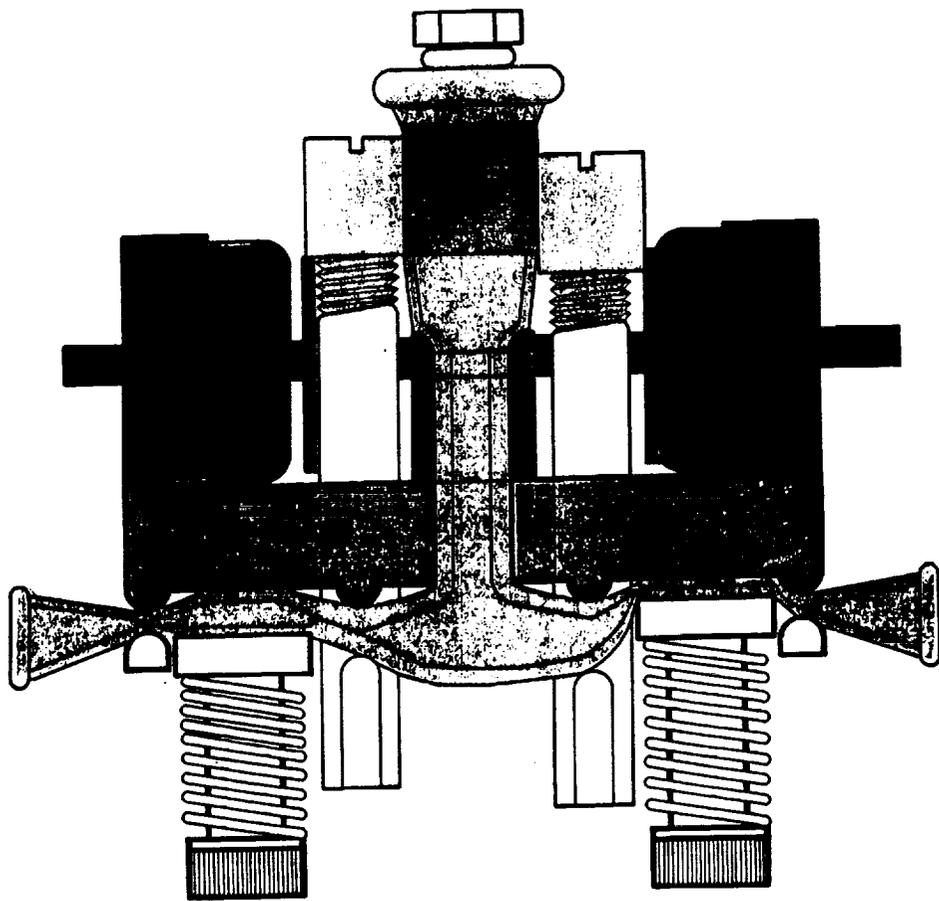
- GENENTECH, INC. AND CENTER FOR CELL RESEARCH
- SPACE SHUTTLE DISCOVERY OCTOBER 6, 1990
- COMMERCIAL GOAL: PROPRIETARY
- EXPERIMENT MEASURED THE EFFECT OF A NUMBER OF PROTEINS
- GENENTECH'S ASSESSMENT: "THE SYSTEM CAN WORK WITH PRIVATE ENTERPRISE"



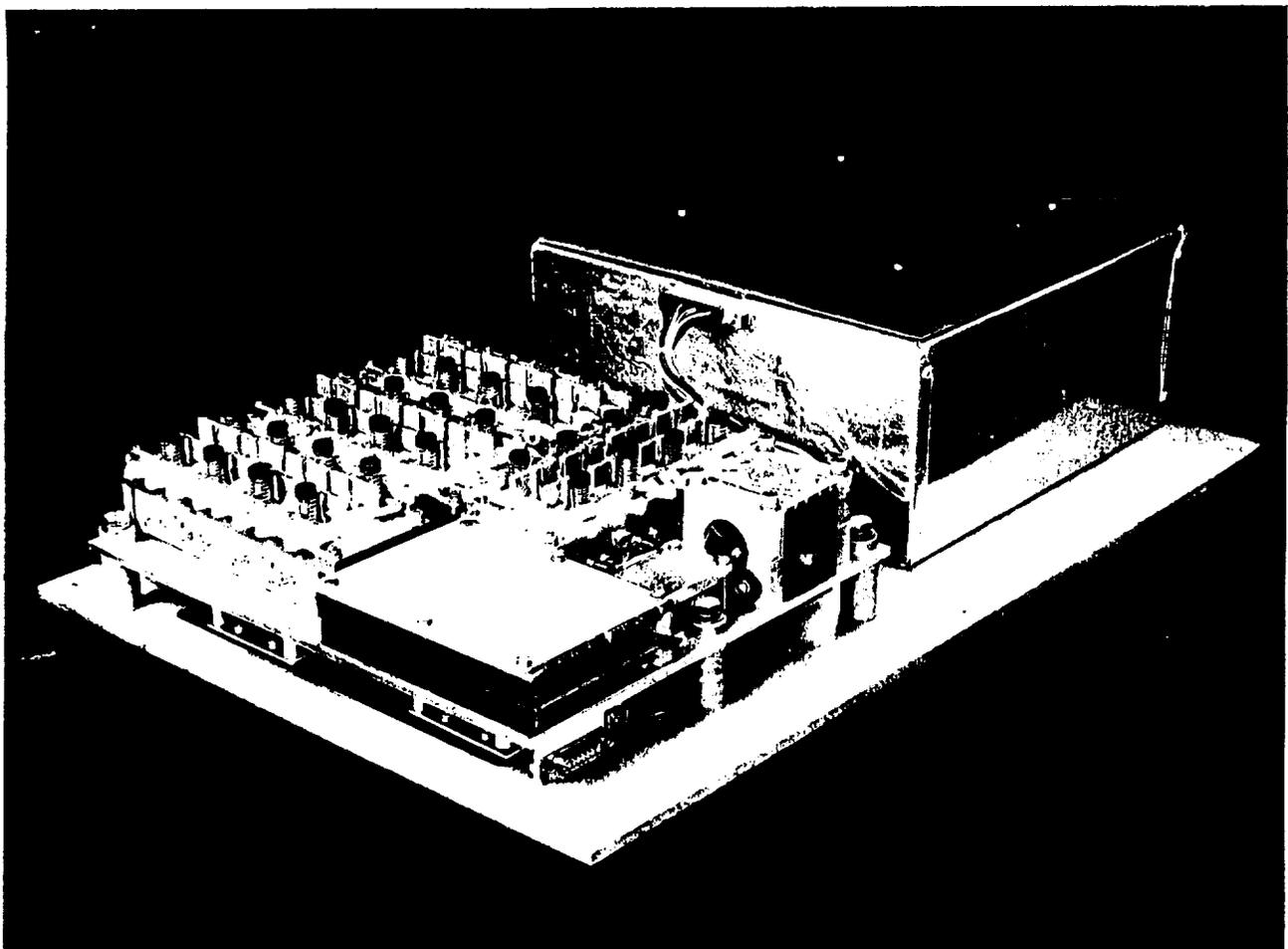
## CENTER FOR CELL RESEARCH

### HARDWARE





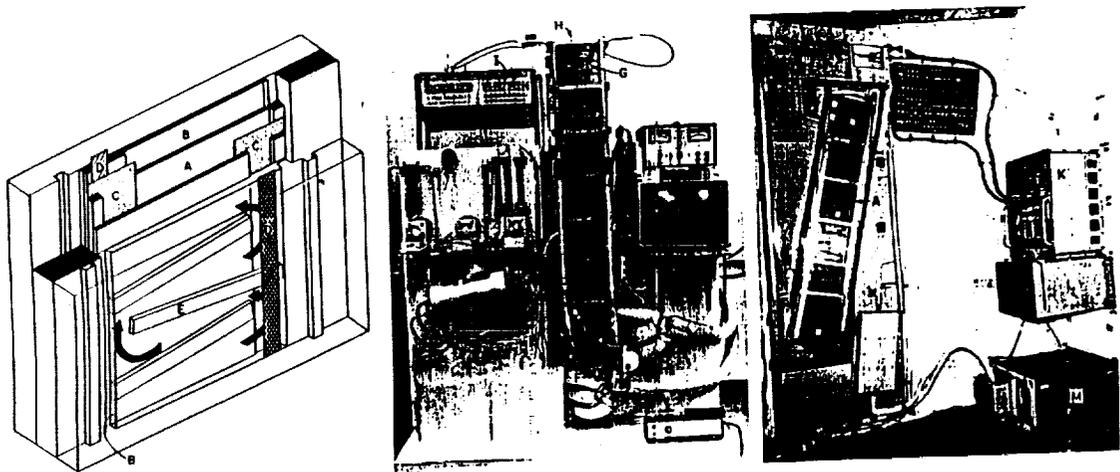
PENN STATE BIOMODULE SCHEMATIC





## CONSORT SOUNDING ROCKET MISSIONS DEMONSTRATE VERSATILITY OF BIOMODULE

ABOARD CONSORT 4, THE PENN STATE BIOMODULE WAS USED SUCCESSFULLY FOR THE FIRST TIME TO STUDY MICROGRAVITY EFFECTS ON MAMMALIAN CELLS, PLANT TISSUES AND PROTEIN CRYSTALS EXTENDING ITS UTILITY TO THREE MORE CLASSES OF BIOLOGICAL MATERIALS OF COMMERCIAL INTEREST.





## TELEMICROSCOPY

THE CORABI/CCR TELEMICROSCOPY PROJECT WILL PROVIDE THE COMMERCIAL BIOMEDICAL/BIOTECHNOLOGY COMMUNITY WITH THE OPPORTUNITY TO STUDY MICROSCOPIC SPECIMENS ABOARD SPACE STATION FREEDOM FROM THE GROUND.

APPLICATIONS:      MONITOR PRODUCT PROCESSING, PRODUCTION,  
                                 TESTING COMMERCIAL DISCOVERY RESEARCH

                                 ASTRONAUT HEALTH





## CONCLUSION

SPACE-BASED PRODUCT PROCESSING, TESTING, DEVELOPMENT AND DISCOVERY RESEARCH USING USCEPS AND CCR'S PHYSIOLOGICAL TESTING PROGRAM OFFER NEW ROUTES TO IMPROVED HEALTH ON EARTH.

THE CCR AND SSF WILL HELP AMERICAN INDUSTRY TO TAKE THOSE ROUTES AND TO USE MICROGRAVITY AS AN ENABLING FORCE TO ACHIEVE PRODUCT-ORIENTED GOALS.