MATERIALS DISPERSION AND BIODYNAMICS PROJECT RESEARCH

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The University of Alabama in Huntsville

ABSTRACT

The Materials Dispersion and Biodynamics Project (MDBP) focuses on dispersion and mixing of various biological materials and the dynamics of cell-to-cell communication and intracellular molecular trafficking in microgravity. Research activities encompass biomedical applications, basic cell biology, biotechnology (products from cells), protein crystal development, ecological life support systems (involving algae and bacteria), drug delivery (microencapsulation), biofilm deposition by living organisms and hardware development to support living cells on Space Station Freedom (SSF).

Project goals are to expand the existing microgravity science database through experiments on sounding rockets, the Shuttle and COMET program orbiters and to evolve, through current database acquisition and feasibility testing, to more mature and larger-scale commercial operations on SSF. Maximized utilization of SSF for these science applications will mean that service companies will have a role in providing equipment for use by a number of different customers. An example of a potential forerunner of such a service for SSF is the Materials Dispersion Apparatus (MDA) "minilab" of Instrumentation Technology Associates, Inc. (ITA) in use on the Shuttle for the Commercial MDAITA Experiments (CMIX) Project. The MDA wells provide the capability for a number of investigators to perform mixing and bioprocessing experiments in space. In the area of human adaptation to microgravity, a significant database has been obtained over the past three decades. Some low-g effects are similar to Earth-based disorders (anemia, osteoporosis, neuromuscular diseases and immune system disorders). Spending in the area of Earth-based biopharmaceuticals is increasing and is projected to be in the range of $60 billion by the end of this decade, 50 times greater than it is now (Burill, G.S. and Lee, K.B. 1991. Biotech 91: A Changing Environment, Ernst and Young, San Francisco, CA). As new information targets potential profit-making processes, services and products from microgravity, commercial space ventures are expected to expand accordingly. Cooperative CCDS research in the above mentioned areas is essential for maturing SSF biotechnology and to ensure U.S. leadership in space technology.

Currently, the MDBP conducts collaborative research with investigators at the Rockefeller University, National Cancer Institute, and the Universities of California, Arizona and Alabama in Birmingham. The growing database from these collaborations provides fundamental information applicable to development of cell products, manipulation of immune cell response, bone cell growth and mineralization and other processes altered by low-gravity. Contacts with biotechnology and biopharmaceutical companies are being increased to reach uninformed potential SSF users, provide access through the CMDS to interested users for feasibility studies and to continue active involvement of current participants. We encourage and actively seek participation of private sector companies, and university and government researchers interested in biopharmaceuticals, hardware development and fundamental research in microgravity. The project has two industry participants at present. These are Instrumentation Technology Associates, Inc. (ITA), Exton PA (hardware provider) and RANTEK, a biomedical R & D company with headquarters in Florida and offices in Huntsville.

The challenge of new ventures such as SSF, man's presence on the Moon, Mars and beyond, can be met enthusiastically with the philosophy stated by Werher von Buaun: "The value of discovery becomes clear only in the wake of the discovery itself. No one can imagine what may accrue to mankind from the space program any more than Isabella could imagine what would come of Columbus' voyages." The development of bio-processes and biopharmaceuticals in space leading to enhanced quality of life on Earth, ameliorating undesirable space effects and contributing to US leadership in the world economy is a reasonable expectation.

SPACE STATION FREEDOM UTILIZATION CONFERENCE

VON BRAUN CIVIC CENTER
HUNTSVILLE, ALABAMA
JULY 29-AUGUST 5, 1992

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Marian L. Lewis, PhD "Space Station Freedom Utilization Conference " Huntsville, Alabama August 3-6, 1992

MATERIALS DISPERSION AND BIODYNAMICS PROJECT FOCUS

- Materials dispersion and mixing in microgravity
  - Fluids and particles
  - Liquid/liquid
- Dynamics of biological systems
  - Cell-to-cell communication
  - Intracellular molecular trafficking

ACTIVITIES

ACTIVITIES ENCOMPASS SEVERAL BROAD DISCIPLINES.

- o Biomedical
- o Basic cell biology
- o Biotechnology (products from cells)
- o Protein crystal development
- o Life support (algae and bacteria)
- o Drug delivery (microencapsulation)
- o Hardware development for cellular life support

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PROJECT OBJECTIVES

To create private sector awareness of R & D potential in the space environment.

To facilitate private sector company growth in the areas of:

Services: hardware for low-g research

Products: (cells, cell products, crystals)

Processes: (ways to achieve products from low-g research)

INSTRUMENTATION TECHNOLOGY ASSOCIATES, INC

CMIX Acronym Definition

COMMERCIAL MDA ITA EXPERIMENTS

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THE COMMERCIAL MDA ITA EXPERIMENTS (CMIX) PROGRAM

OVERVIEW

- Created by - Agreement between NASA, Office of Commercial Programs and UAH.
- Purpose - To provide additional research opportunities on the Space Shuttle for NASA's 17 CCDS's.
- Program managed by the UAH CMDS
- Duration of Agreement - 5-year period or until 5 flights are accomplished.
- First flight scheduled for September 1992

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MDA HARDWARE DESCRIPTION

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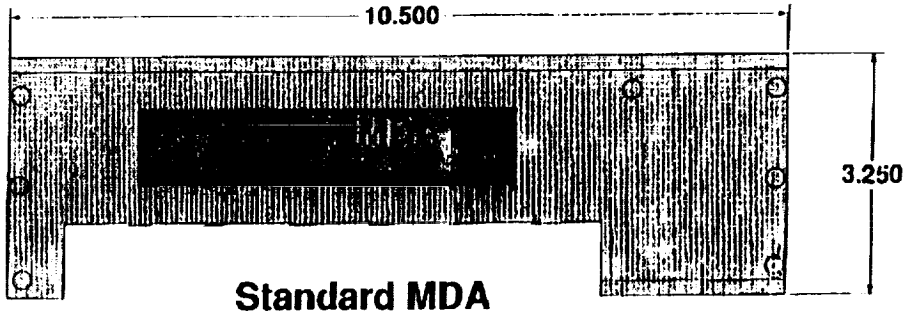
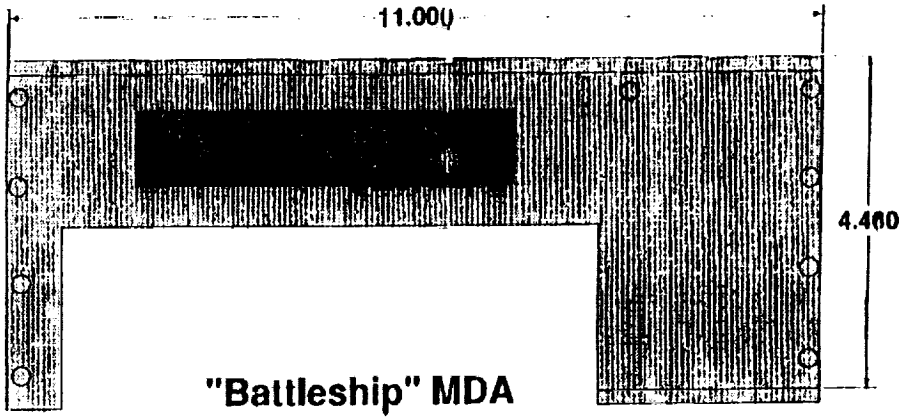
MDA CONFIGURATION COMPARISON



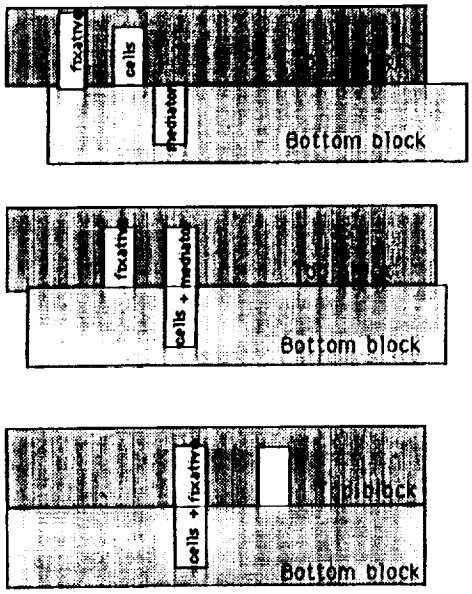
Standard MDA



"Battleship" MDA

THE MDA MINILAB HARDWARE

MDA BLOCK CONFIGURATIONS
FOR FLUIDS MIXING
(Type 3 wells)



PRINCIPLE OF OPERATION

- Two blocks of inert material
- Compatible number of wells in upper and lower half
- Held together in lightweight aluminum housing
- Wells are misaligned prior to launch (materials are separate)
- In microgravity, blocks aligned allowing materials to contact
- In type 3 wells, blocks move again prior to re-entry

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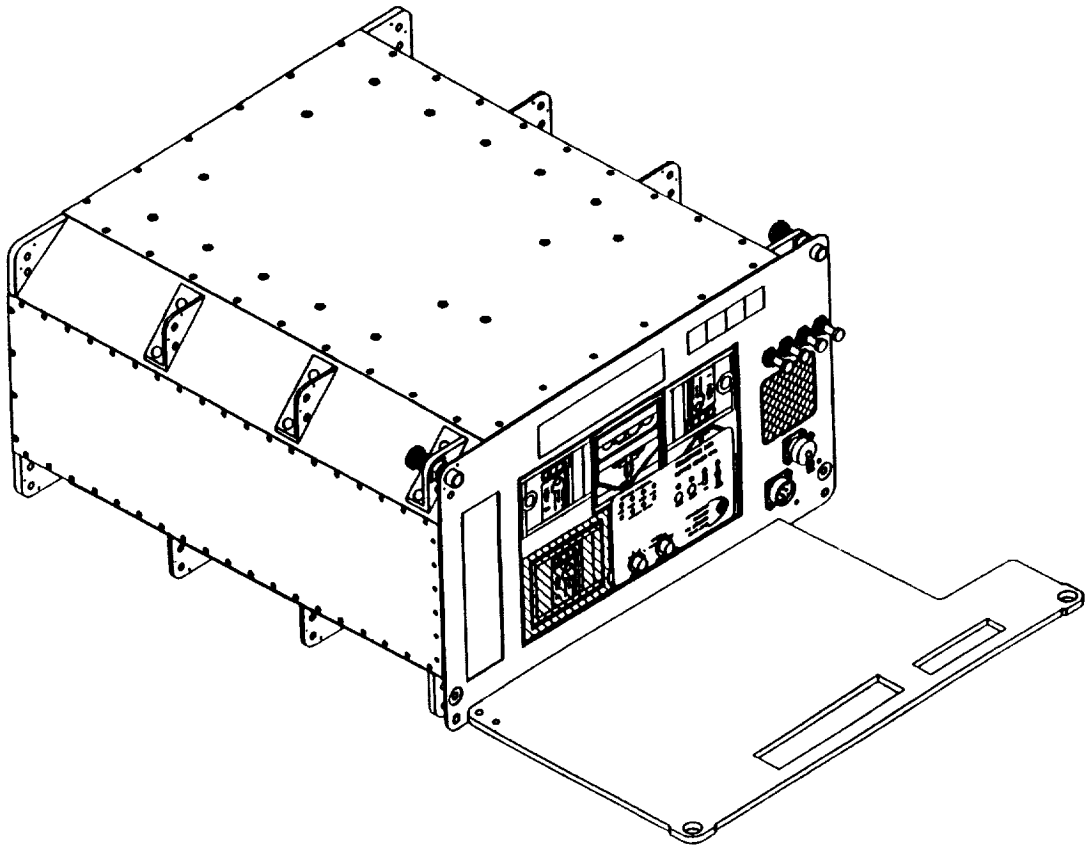

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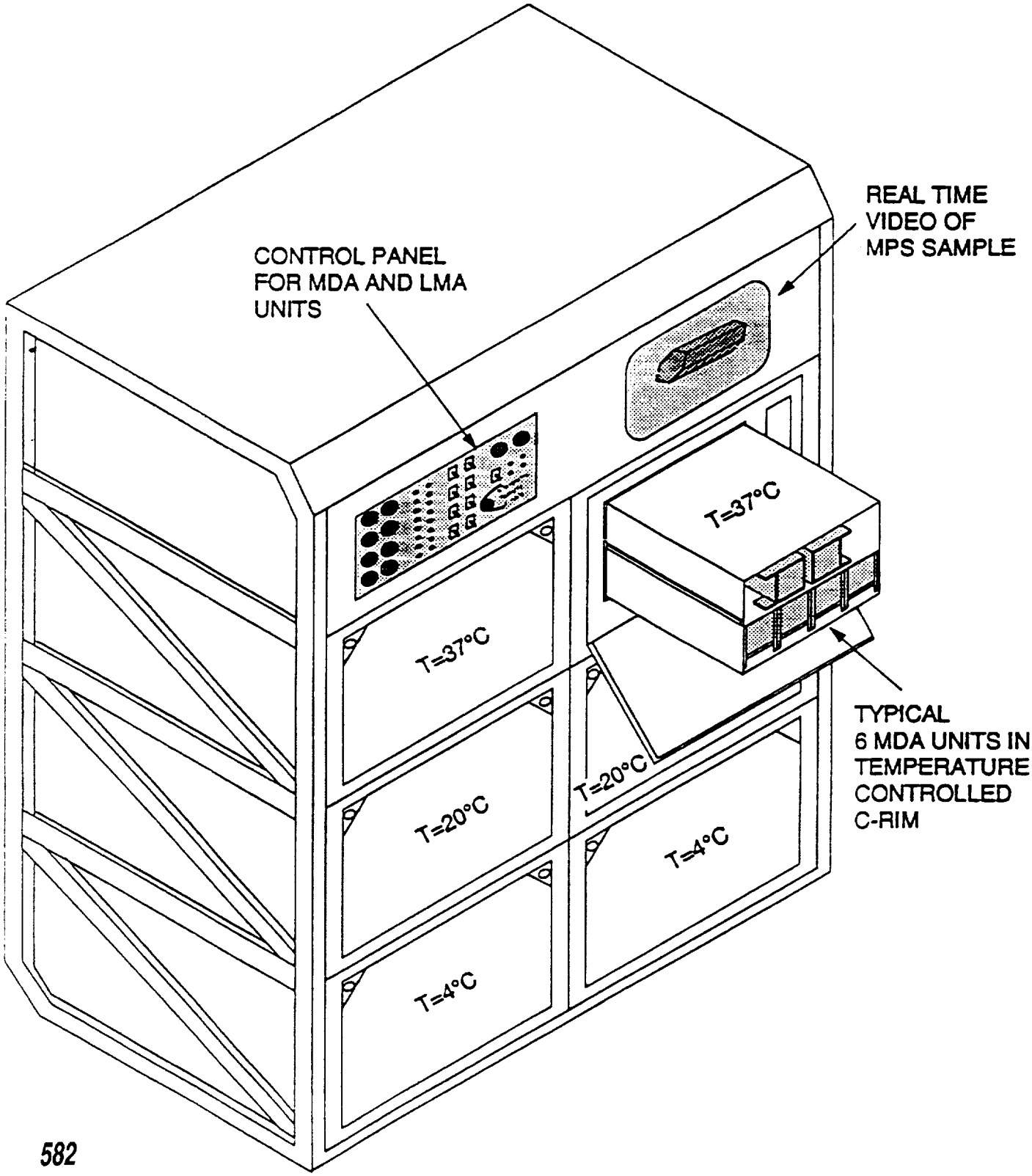
ITA COMMERCIAL MPS RACK FOR SPACE STATION



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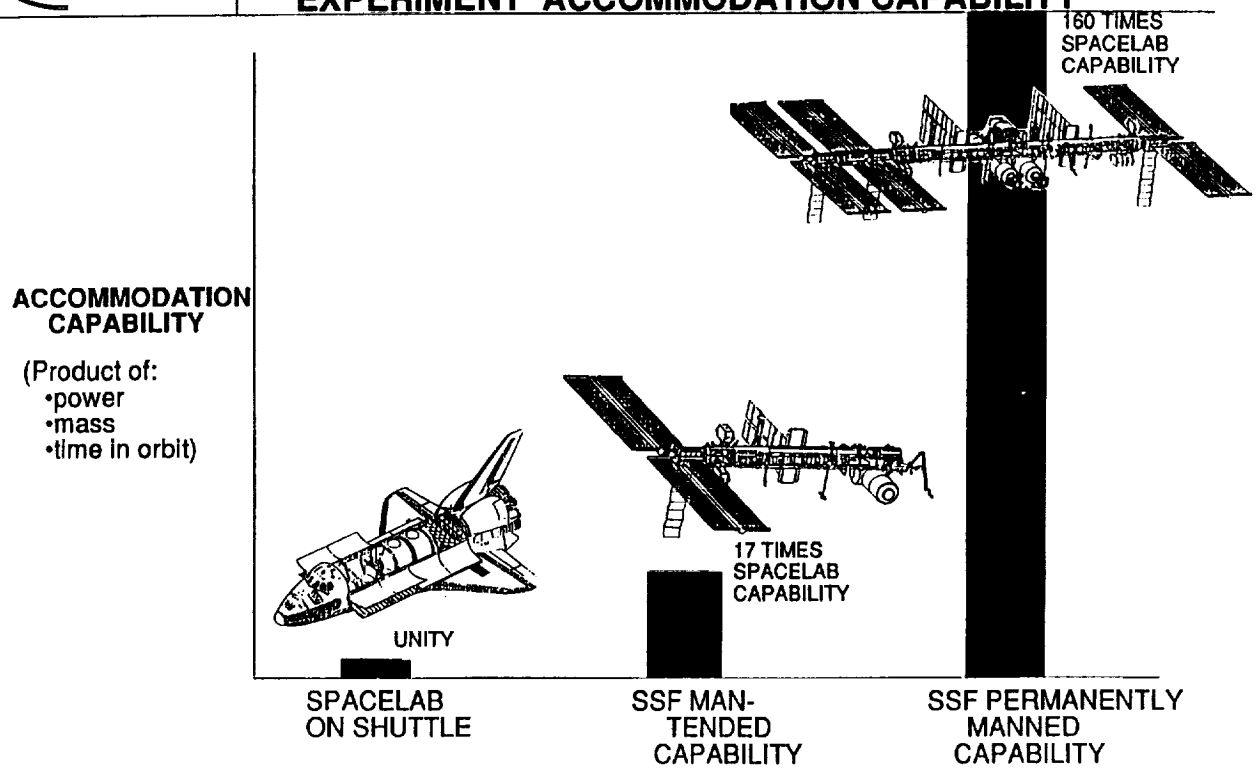
SPACE STATION FREEDOM GREATLY INCREASES EXPERIMENT ACCOMMODATION CAPABILITY



PROJECT GOALS

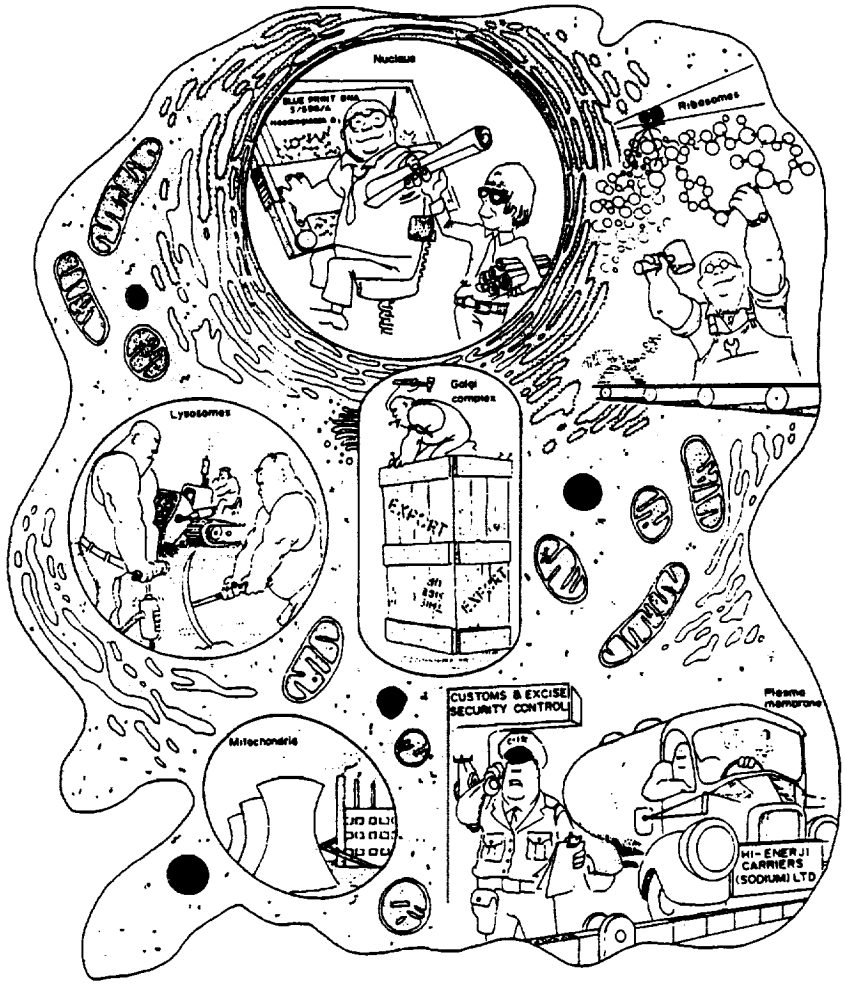
- 0 To expand the knowledge gained in the past three decades of microgravity research.
  - o Historic - effects of low-gravity on human physiology
  - o Recent and ongoing - low-gravity effects on single cells
- 0 To apply this information to develop SSF experiments and utilization in the areas of:
  - o Commercialization
  - o Basic science

EFFECTS OF LOW-GRAVITY ON HUMAN PHYSIOLOGY

SOME LOW-G EFFECTS	CORRESPONDING EARTH-BASED DISORDER
Bone demineralization	Osteoporosis due to aging
Immune response blunted	Immune deficiency, leukemias
Cardiac deconditioning	Hypertension, heart failure
Muscle deconditioning	Muscle wasting diseases
Decreased red blood cell count	Anemia

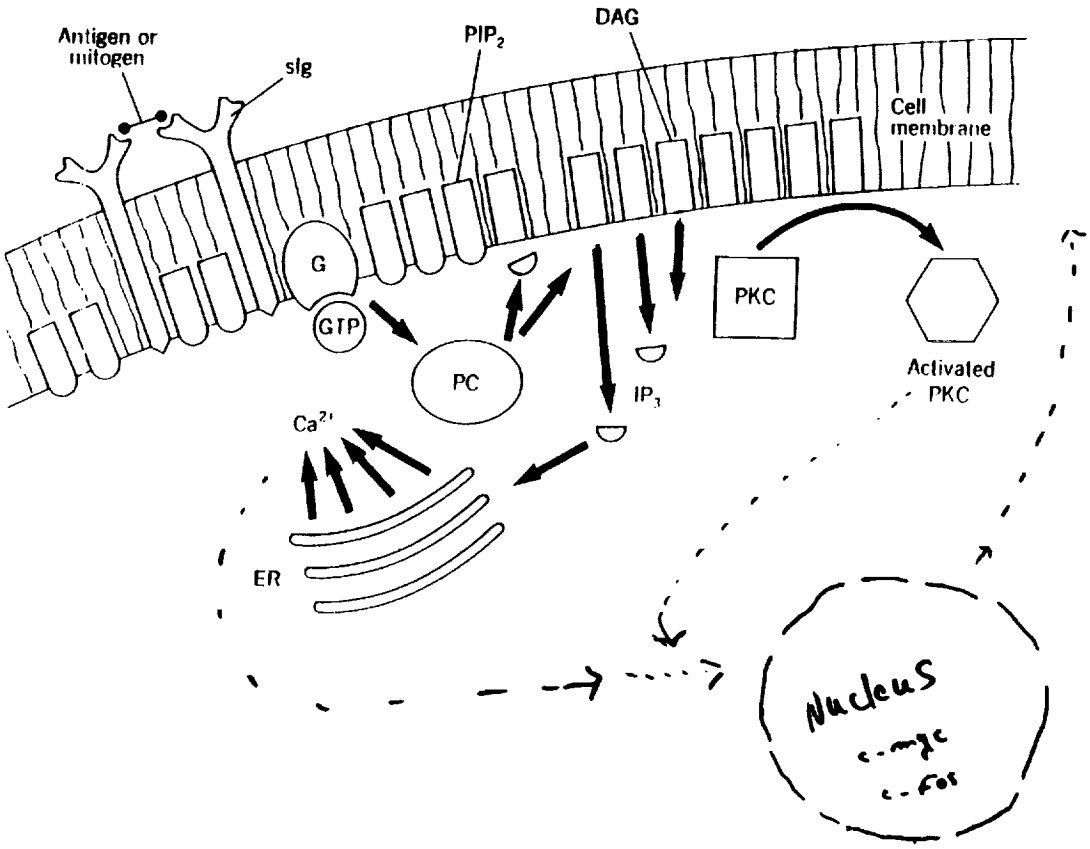
TO ENSURE SAFETY AND MAXIMIZE PRODUCTIVITY OF HUMANS IN SPACE, CONTINUOUS RESEARCH IS NEEDED IN THE FOLLOWING AREAS:

- Cellular differentiation (i.e. stem cells to RBC's)
- Interactions of cells with drugs and medications in microgravity
- Remediation of bone mineral loss and reduced bone cell growth
- Mechanisms of reduced immune cell response and selective immunotherapy
- Mechanisms of virus infectivity in microgravity (cell receptors/cell mediated immunity)
- Nerve cell responses to stimuli (intracellular mechanisms)



MICROGRAVITY EFFECTS AT THE CELLULAR LEVEL

PROCESS ALTERED	EFFECT OF SPACEFLIGHT
Gene expression	Suppression of some types
Cellular metabolism	Glucose use rate lowered
Secretory processes	Decreased or increased - cell type
T-lymphocytes	Reactivity suppressed
Plant cell metabolism	Fatty acid content shifts



MEDICAL/BIOLOGICAL UTILIZATION OF SSF

- **SSF long-term, continuous lwo-g environment can provide research capability to determine**
  - **Cellular mechanisms**
  - **Develop remedies**
- **Resulting in**
  - **Spinning off new technologies**
  - **Development of new biopharmaceuticals**
  - **Advanced knowledge of fundamental biological processes.**

POTENTIAL AREAS OF MEDICAL COMMERCIAL APPLICATION

Potential Markets	Application
Companies producing natural cell products	Infectious disease, cancer
Institutions supplying cells	Transplantation
Biodynamic cell culture	Cellular and tissue development
Biodeposition (mammalian cells)	Osteoporosis/bone regeneration
Pharmaceutical	Liposome and drug delivery technology
Pharmaceutical	Protein crystals, drug design

BENEFITS FROM SSF RESEARCH

IMPROVED QUALITY OF LIFE ON EARTH RESULTING FROM LONG-TERM RESEARCH CAPABILITY ON SSF

ENSURE SAFETY AND MAXIMIZE PRODUCTIVITY OF HUMANS IN SPACE

NON-TERRESTRIAL ENVIRONMENT REQUIRES DEVELOPMENT OF NEW MATERIALS AND TECHNOLOGIES TRANSFERABLE TO PRIVATE SECTOR INDUSTRIES

KNOWLEDGE GAINED ON FUNDAMENTAL PROCESSES APPLICABLE TO EARTH-BASED PROCESSING AND TECHNOLOGY

SOME STRATEGIES TO FACILITATE COMMERCIAL SPACE

- Increase private sector awareness of potential areas for commercialization
- Continued contact with private sector companies
- Collaborative research with university researchers
- Dissemination of knowledge gained to scientific community by publications, conferences, seminars, displays.
- Education
  - Involvement of students at the intermediate and high school and university levels

PROSPECTS FOR THE FUTURE

Commercial space ventures are expected to increase as the database targets potential profit-making processes and products from microgravity technology development.

- Spending in the area of biopharmaceuticals is increasing.
  - Earth-based spending for biopharmaceuticals by the end of this decade is projected to be in the range of $60 billion, 50 times greater than it is now.
- Cooperative CCDS research in the above mentioned areas is essential for maturing SSF biotechnology
- New technologies are expected to develop and to ensure U.S. leadership in space technology.