

RESEARCH OPPORTUNITIES WITH THE CENTRIFUGE FACILITY

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ABSTRACT

The Centrifuge Facility on Space Station Freedom will consist of a 2.5-meter diameter Centrifuge accommodating two concentric rings of Habitats and providing variable g forces between 0.01g and 2.0g; Modular Habitats providing housing and life support for rats, mice, and plants; a Habitat Holding System providing power, water, airflow and other utilities to several Modular Habitats; and a Life Sciences Glovebox, an isolated work volume accommodating simultaneous operations by at least two scientists and providing lighting, airflow, video and data access, and other experiment support functions.

The Centrifuge Facility will enable long-duration animal and plant microgravity research not previously possible in the NASA flight research program. It will offer unprecedented opportunities for use of on-board 1-g control populations and statistically significant numbers of specimens. On-orbit 1-g controls will allow separation of the effects of microgravity from other environmental factors. Its selectable-g and simultaneous multiple-g capabilities will enable studies of gravitational thresholds, the use of artificial gravity as a countermeasure to the effects of microgravity, and ready simulation of Lunar and Martian gravities.

Many exciting research opportunities stem from the permanent presence of the Centrifuge Facility on-orbit. Long-duration exposure to microgravity will permit extended studies directly relevant to the health and welfare of crew members on long space mission. It will also allow studies that encompass both significant portions of a subject's life span and, of special interest, studies that examine microgravity effects over several generations of both plants and animals. In the process of supporting multigeneration studies, the Facility will simultaneously support the derivation of spaceadapted colonies of subjects for future use. The permanent presence of scientist-astronauts will enable real-time experiment manipulation, alteration, and replication. To capitalize on this capability, many Facility elements are being designed for maximum flexibility and on-orbit reconfigurability.

The Centrifuge Facility will accommodate studies in all life sciences disciplines, from behavioral experiments to detailed investigations of physiologic systems, e.g., cardiovascular, musculoskeletal, and neurovestibular. It will support the collection of on board samples and fixation of samples for return to Earth for sophisticated analyses which cannot be performed on-orbit. However, there will be a wide variety of on board laboratory equipment and analytical instruments. While initially designed for use with rodents and plants, it will ultimately accommodate a wide range of biospecimens, including small primates, fish, amphibians, arthropods, and microbial and cell cultures. The Facility will provide variable housing configurations, well-controlled environmental parameters, water and nutrient delivery, waste management, video, and access to biotelemetry and other data. It will also accommodate a variety of add-on experiment-unique equipment such as special video cameras, unique specimen chambers, and custom sensors.

For the first time, the Centrifuge Facility and Space Station Freedom will permit systematic research to understand the physiological and biochemical changes in living organisms that take place in the space environment.



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THE CENTRIFUGE FACILITY

- **CENTRIFUGE**
 - 2.5-meter diameter; provides variable-g capability (0.01-2.0 g)
- **MODULAR HABITATS**
 - Interchangeable between Centrifuge, Holding System and Glovebox
 - Provide housing and life support for plants and rodents
- **HABITAT HOLDING SYSTEM**
 - Provides utilities and services to Modular Habitats
- **LIFE SCIENCES GLOVEBOX**
 - Provides bioisolated work volume for experiment and maintenance procedures
- **RODENT TRANSPORTER**
 - Provides housing for rodents during transport to orbit



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ACCOMMODATIONS

- **THE CENTRIFUGE FACILITY WILL SUPPORT ALL OF NASA'S LIFE SCIENCES RESEARCH DISCIPLINES:**
 - **Cardiopulmonary**
 - **Musculoskeletal**
 - **Neuroscience**
 - **Plant Biology**
 - **Cell & Developmental Biology**
 - **Regulatory Physiology**
 - **Environmental Health & Radiation**
 - **Behavior and Performance**

- **THE CENTRIFUGE FACILITY WILL ACCOMMODATE A VARIETY OF DIFFERENT BIOSPECIMEN TYPES:**
 - **Initially:** Rats, mice, and plants
 - **Post-2000:** Squirrel monkeys
 - **Ultimately:** Fish, birds, amphibians, arthropods, microbial and tissue cultures, etc.



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WHAT DOES THE CF OFFER?

- **ON-BOARD CONTROL POPULATIONS**
- **STATISTICALLY SIGNIFICANT NUMBERS OF SPECIMENS**
- **FRACTIONAL GRAVITY CAPABILITIES**
 - **Hypo-g studies:** Gravitational thresholds
Lunar, Mars and other g simulations
Countermeasures
 - **Hyper-g studies:** Extension of ground-based centrifuge studies
Countermeasures
- **LONG-DURATION MICROGRAVITY EXPOSURE**
 - **Significant fraction of normal life span**
 - **Multigeneration studies**
 - **Space-adapted colonies**



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ASSOCIATED FEATURES

- **ON-BOARD ADJUNCT CAPABILITIES**
 - ***Gravitational Biology Facility:*** a suite of generic laboratory equipment and biospecimen habitats to support the Cell & Developmental and Plant Biology disciplines
 - ***Laboratory Support Equipment:*** a suite of generic laboratory instruments to support life sciences microgravity research, e.g., refrigerators, freezers, mass measurement devices, etc.
 - ***Biomedical Monitoring and Countermeasures:*** common equipment items
 - ***Crew Health Care System:*** common equipment items
 - Scientist/Astronaut crew
 - Telescience/Remote coaching (eventually)
- **ACCOMMODATION OF EXPERIMENT-UNIQUE EQUIPMENT (EUE)**
 - Unique specimen chambers (e.g., mating, birthing/rearing)
 - Specialized video cameras (e.g., lenses, spectral qualities)
 - Custom sensors



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FLIGHT VERIFICATION SCIENCE

- **THREE SEQUENTIAL 90-DAY FLIGHT INCREMENTS ONLY**
- **PLANNED FOR YEAR 2000**
- **GOAL IS TO VERIFY THE PROPER PERFORMANCE OF THE CENTRIFUGE FACILITY ON-ORBIT**
 - Engineering
 - Science
- **INVESTIGATORS WILL BE SOLICITED**
 - Normal Headquarters-directed solicitation process
 - Research plans must meet verification goals first
 - Research plans must minimize need for EUE



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ONGOING SCIENCE

- **ONGOING SCIENCE PROGRAM TO BEGIN FOLLOWING SUCCESSFUL COMPLETION OF FLIGHT VERIFICATION**
- **ANTICIPATED START IN YEAR 2001**
- **NORMAL HEADQUARTERS-DIRECTED SOLICITATION PROCESS**
- **90-DAY INCREMENTS WILL BE DISCIPLINE-ORIENTED**
- **WILL PROVIDE:**
 - **On-orbit sampling and storage, some processing and analysis**
 - **Data acquisition, processing, storage and downlink**



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STATUS AND PLANS

- **CENTRIFUGE FACILITY HARDWARE**
 - **Phase A and B studies complete**
 - **Phase C/D RFP released July 7, 1992**
 - **Phase C/D start 1993**

- **CENTRIFUGE FACILITY SCIENCE**
 - **Verification increment science NRAs - 1994**
Investigators to be on-board by CDR (early 1995)
Verification experiment development 1995-2000
 - **Ongoing science NRAs ~1997**
Experiment development ~1998 on



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CONCLUSION

**THE CENTRIFUGE FACILITY WILL MAKE POSSIBLE THE
SYSTEMATIC RESEARCH NECESSARY TO UNDERSTAND
THE PHYSIOLOGICAL, BIOCHEMICAL AND GENETIC
CHANGES IN LIVING ORGANISMS THAT TAKE PLACE IN
THE SPACE ENVIRONMENT**

