BIOLOGICAL AND MEDICAL EXPERIMENTS ON THE SPACE SHUTTLE 1981 - 1985

Edited by

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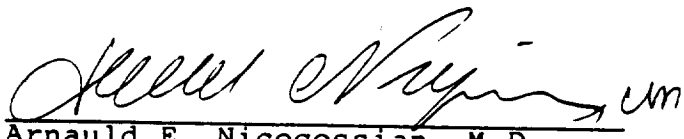
Foreword

The biological effects of gravity have been acknowledged since Galileo's time, yet the inability to control gravity on Earth - to remove its effect for any significant period of time - limited research and stifled scientific interest. With the birth of the space age, three decades ago, the opportunity for experimentation over the full spectrum of G became a reality. But the real impetus to biological and medical space research was the challenge of manned space flight to assure the health, well-being, and performance of people in space.

The United States space program depends upon people living and working in space, and the Space Shuttle is the second stage in our conquest of this new frontier. It is not only a transportation system to space, it is the system that is transporting us to a new era of exploration and research. A growing body of biological and medical data gathered on the Space Shuttle will lay the foundation for the effective use of the Space Station and the ultimate habitation of the moon.

Space research opportunities are limited and precious. This record of all biological and medical experiments involving the Space Shuttle was prepared so that all available data could be used to its fullest potential. It should aid us in our journey to conquer and use space.



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Preface

This volume is the first in a planned series of reports intended to provide a comprehensive record of all the biological and medical experiments and samples flown on the Space Shuttle. Experiments described in this report have been conducted over the past five years, beginning with the first plant studies conducted on STS-2 in November 1981, and extending through STS 61-C, the last mission to fly before the tragic Challenger accident of January 1986.

Experiments were sponsored within NASA not only by the Life Sciences Division of the Office of Space Science and Applications, but also by the Shuttle Student Involvement Program (SSIP) and the Get Away Special (GAS) Program. Independent medical studies were conducted as well on the Shuttle crew under the auspices of the Space Biomedical Research Institute at Johnson Space Center. In addition, cooperative agreements between NASA and foreign government agencies led to a number of independent experiments and also paved the way for the joint US/ESA Spacelab 1 mission and the German (DFVLR) Spacelab D-1.

Many of the biological and medical payloads were tests or preliminary observations, rather than true experiments; however, for the sake of simplicity, all studies are referred to herein as experiments. Experiment descriptions and discussions of results are brief, while investigators' affiliations, supporting organizations and references have been provided in detail, to aid the reader who desires to search for additional information about any experiment. In many cases, results are incomplete or absent due to time constraints or other limitations. To correct these deficiencies, each Principal Investigator is requested to review, correct, and update information concerning his or her experiment. Any necessary revisions and additional data will be incorporated into a second edition, to be published in 1987.

The results from these Shuttle experiments will hopefully provide a positive foundation for ground-based research and help prepare us for future experiments in space, while at the same time, advance our understanding of human adaptation to weightlessness to assure the health and safety of those who work and will ultimately live in space.

Acknowledgement

This manuscript was made possible through the invaluable contributions and cooperation of many individuals from the following organizations: the Life Sciences Division (OSSA, NASA HQ), Headquarters Administration Division (Office of Management, NASA HQ), Shuttle Payload Engineering Division (OSSA, NASA HQ), Shuttle Student Involvement Program (SSIP) and the Get Away Special (GAS) Program (Customer Services, OSF, NASA HQ), Biomedical Research Division (NASA ARC), Life Sciences Flight Experiments Project Office (NASA ARC), Space Biomedical Research Institute (NASA JSC), Air Force Technical Applications Center (Patrick Air Force Base, FL), European Space Agency (ESA HQ), German Aerospace Research Establishment (DFVLR), MATSCO (Management and Technical Services Company, a subsidiary of General Electric), and Science Communication Studies (George Washington University).

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Table of Contents

Introduction

Overview of Space Shuttle Experiments

Life Science experiments or observations have been conducted on Space Shuttle-flown biological materials and subjects ranging from insects to humans and algae to pine. Some experiments have been conducted in space, but most information has been obtained by analysis of materials and data postflight. Experiments have included: (1) medically oriented studies of the crew aimed at identifying, preventing, or treating health problems due to space travel; (2) projects to study morphological, physiological, or behavioral effects of microgravity on animals and plants; (3) studies of the effects of microgravity on cells and tissues, and (4) radiation experiments monitoring the spacecraft environment with chemical or biological dosimeters or testing radiation effects on simple organisms and seeds.

Several sophisticated life sciences experiments with industrial application involving attempts to manufacture biologicals in space have been flown. These experiments have not been included in this report, but non-proprietary information may be added in the future.

Sources of Experiments

A major method used by NASA to obtain life science scientific experiments for Shuttle flights is through a formal solicitation called an "Announcement of Opportunity" (AO). Prospective principal investigators submit research proposals to the NASA Life Sciences Division, within the Office of Space Science and Applications, describing the purpose and design of their experiments in response to the objectives of the AO. The proposals are evaluated for scientific merit by peer review panels, and selections are made by NASA based on flight feasibility, equipment needs, crew time and effort requirements, costs, and crew safety. These experiments usually require Spacelab facilities. An additional avenue to a flight experiment is through an informal process described in a Space Science and Applications Notice entitled "Emerging Opportunities in the Space Biology Program." Prospective investigators submit unsolicited proposals to the Space Biology Program of the NASA Life Sciences Division. Proposals are peer reviewed and selected on the basis of their scientific merit, contribution to the goals of the Program, and flight feasibility. These experi-

ments are targeted primarily for flight in the Shuttle middeck lockers.

Individual experiments are also flown on the Shuttle through cooperative agreements between NASA and foreign governments. An entire Shuttle mission may be jointly sponsored by the United States and a foreign government agency, such as the joint U.S./ESA Spacelab 1 mission. A Shuttle mission may also be fully sponsored by a foreign government, as was Spacelab D-1, which was sponsored by the Federal Republic of Germany.

Another type of medical payload is the DSO (Detailed Supplementary Objective). Medical DSO's are preliminary studies of human responses to microgravity, particularly space motion sickness and cardiovascular deconditioning, on which more detailed experiments may be conducted in the future. These DSO's are conducted and managed by the Space Biomedical Research Institute at NASA's Johnson Space Center. Because the DSO's are basically pilot studies, frequently repeated on several Shuttle missions, these summaries are listed separately in Appendix A. A related category, the DTO or Development Test Objective, involves mainly hardware tests; an example was the test on STS-2 to determine the optimum amount of water required for maximum plant growth.

Two additional NASA programs enable students, other interested individuals, and private companies to fly experiments. The first, the Shuttle Student Involvement Program (SSIP), supports selected high school student experiments. The major purpose of SSIP is to promote interest in science and engineering among U.S. students by encouraging the natural excitement that many young people have about space-related subjects. The students are selected via an annual contest orchestrated by the National Science Teachers Association (NSTA). Each SSIP experiment is sponsored by an individual or organization in the private sector.

The second program, called the Get Away Special (GAS), allows individuals or organizations to purchase space for small, self-contained experiments that can be flown in the Shuttle bay area exposed to the space environment. Each GAS payload is designed to fit in either a 2.5- or 5-cu. ft. aluminum canister that can hold from 60 to 200 pounds. The experimenter must provide power, thermal, and data collection equipment inside the canister. Plant and animal experiments are also limited by Shuttle loading procedures that preclude access to GAS canisters 60 days prior to Shuttle launch.

Location of Experiments on Space Shuttle

Biomedical experiments on humans are performed on and by crew members, both in the middeck area of the Shuttle Orbiter cabin and in the Spacelab. Experiments on nonhuman animals and plants are flown in lockers in the middeck area as well as in Spacelab racks. SSIP experiments have been located solely in the middeck, while GAS canisters are located on the GAS adapter beam or GAS bridge in the Orbiter cargo bay area, which is potentially exposed to extreme environmental conditions. Biological materials are also being flown on the LDEF (Long Duration Exposure Facility), a large, unpowered container placed in orbit by STS 41-C in April 1984.

Scope and Organization of the Report

Summaries include all of the known biological and medical experiments flown on the Space Shuttle from STS-2 (November 12-14, 1981) through STS 61-C (January 12-18, 1986), and are arranged in chronological order by flight. Multiple experiments on a single flight are arranged in alphabetical order by the last name of the principal investigator (the person who designed the experiment).

Each experiment summary contains the Shuttle flight number, experiment title, principal investigator and affiliation, the group sponsoring the experiment, the developer of the experiment and hardware, the organization providing the management and integration for manifesting the experiment on the Shuttle, experiment location on the Shuttle, species studied, objectives, description, results, and references. These summaries do not include critical analyses of the experiments, except as indicated in published scientific reports by the principal investigators.

A glossary of acronyms and terms encountered in various Shuttle mission reports is included as Appendix B, and addresses of organizations involved in Shuttle experiments are listed in Appendix C. Principal investigator and subject indexes are provided.

Sources of Information

Biological experiments on U.S. space missions flown prior to the Shuttle were summarized in a similar manner by Anderson (1979). Results from Skylab were published in a book by Johnston and Dietlein (1977), and a bibliography of publications reporting

results of biological space experiments in the Russian space program was prepared by Buderer (1981). These and other references are listed below to provide additional sources of information about the physiological effects of space flight.

Anderson, M. (Technology Incorporated). BIOSPEX: Biological Space Experiments. A Compendium of Life Sciences Experiments Carried on U.S. Spacecraft. NASA TM-58217. Washington, D.C.: NASA, June 1979.

Buderer, M.D. (MATSCO). Russian Biospex: Biological Space Experiments. A Space Life Sciences Bibliography. Report # JSC-17072. Houston, TX: NASA Lyndon B. Johnson Space Center, March 1981.

Emerging Opportunities in the Space Biology Program. Space Science and Applications Notice. Washington, D.C.: NASA, September 14, 1983.

Get Away Special (GAS) Small Self-Contained Payloads: Experimenter Handbook. Greenbelt, MD: NASA Goddard Space Flight Center, Sounding Rocket Division, October 1979.

Heinrich, M.R. and K.A. Souza (eds.). Final Reports of U.S. Plant and Radiation Dosimetry Experiments Flown on the Soviet Satellite Cosmos 1129. NASA TM 81288. Moffett Field, CA: NASA Ames Research Center, May 1981.

Heinrich, M.R. and K.A. Souza (eds.). Final Reports of U.S. Rat Experiments Flown on the Soviet Satellite Cosmos 1129. NASA TM 81289. Moffett Field, CA: NASA Ames Research Center, August 1981.

Johnston, R.S. and L.F. Dietlein (eds.). Biomedical Results from Skylab. NASA SP-377. Washington, D.C.: NASA, 1977.

Life Sciences Investigations in Space 1986-1991. AO No. OSSA-2-84. Washington, D.C.: NASA, May 15, 1984.

Mains, R.C. and E.W. Gomersall (eds.). Final Reports of U.S. Monkey and Rat Experiments Flown on the Soviet Satellite Cosmos 1514. NASA TM 88223. Moffett Field, CA: NASA Ames Research Center, May 1986.

Nicogossian, A.E. and J.F. Parker, Jr. Space Physiology and Medicine, NASA SP-447. Washington, D.C.: NASA, 1982.

Rosenzweig, S.N. and K.A. Souza (eds.). Final Reports of U.S. Experiments Flown on the Soviet Satellite Cosmos 782. NASA TM 78525. Moffett Field, CA: NASA Ames Research Center, September 1978.

Rosenzweig, S.N. and K.A. Souza (eds.). Final Reports of U.S. Experiments Flown on the Soviet Satellite Cosmos 936. NASA TM 78526. Moffett Field, CA: NASA Ames Research Center, September 1978.

Experiment Summaries Listed

by

Shuttle Flight

STS-2

Launch Date: November 12, 1981

Landing Date: November 14, 1981

Relevant Payloads: OSTA-1 (NASA)

Experiments:

Flight: STS-2 (OSTA-1)

Experiment Title: HEFLEX (*Helianthus* Flight Experiment) Bioengineering Test (HBT)

Principal Investigator: Allan H. Brown
Affiliation: U PA, Philadelphia, PA
Country: U.S.

Sponsor: Life Sciences Div., OSSA, NASA HQ

Developer: U PA, Philadelphia, PA

Management and Integration: Flight Projects Engineering Office, NASA JSC; Shuttle Payload Engineering Div., OSSA, NASA HQ

Experiment Location: middeck

Species Studied: dwarf sunflower, *Helianthus annuus*.

Objectives of Experiment: The HBT was a pilot study for a plant growth experiment planned for Spacelab 1. The study was to determine the optimum soil moisture needed for seed germination in space.

Description: Sealed vials containing dwarf sunflower seeds (*Helianthus annuus*) in soil with different amounts of water (55-77% soil moisture) were placed in a container on the Orbiter middeck and allowed to germinate in space. Root tips of the resulting seedlings were subjected to postflight chromosome analysis.

Results: No results were obtained because the mission was shortened from 5 to 2 days and the seeds did not have enough time to germinate. This study was repeated on the third Shuttle flight. The root tips were adequate for the chromosome analysis. There were fewer cells in division, and chromosomal abnormalities, including aneuploidy and bridge formation, were observed.

References:

Brown, A.H. and D.K. Chapman. A test to verify the biocompatibility of a method for plant culture in a microgravity environment. *Annals of Botany* 54(Suppl 3):19-31, 1984.

Krikorian, A.D. and S.A. O'Connor. Karyological observations. *Annals of Botany* 54(Suppl 3):49-63, 1984.

STS-3

Launch Date: March 22, 1982

Landing Date: March 30, 1982

Relevant Payloads: OSS-1 (NASA), SSIP

Experiments:

Flight: OSS-1 (STS-3)

Experiment Title: HEFLEX (*Helianthus* Flight Experiment) Bioengineering Test II

Principal Investigator: Allan H. Brown
Affiliation: U PA, Philadelphia, PA
Country: U.S.

Sponsor: Life Sciences Div., OSSA, NASA HQ

Developer: U PA, Philadelphia, PA

Management and Integration: Attached Shuttle Payloads Project, NASA GSFC; Shuttle Payload Engineering Div., OSSA, NASA HQ

Experiment Location: middeck

Species Studied: dwarf sunflower, *Helianthus annuus*

Objectives of Experiment: This was a repeat of an experiment flown on OSTA-1 (STS-2). The object was to determine the optimum soil moisture content needed for growth of the dwarf sunflower (*Helianthus annuus*) in weightlessness. Root tips of the seedlings were subjected to chromosome analysis postflight.

Description: Sunflower seedlings were grown from seed at different soil moisture levels (60-81%) in space. The results were compared with those of ground control seedlings grown under temperature conditions similar to those during the spaceflight.

Results: No significant differences (% germination, root orientation, root/shoot morphology, % elevated shoots) between seedlings grown in weightlessness versus Earth's gravity were observed. The growth dependence of seedlings on soil moisture content in microgravity was similar to that at 1-g. Optimal soil moisture content for space seedlings was estimated to be 70%. The number of cells in division in the root tips was less in space-exposed seedlings than in the controls. No chromosomal abnormalities were found; however, evidence of severe root stress from laboratory handling may have affected the results.

References:

Brown, A.H. and D.K. Chapman. A test to verify the biocompatibility of a method for plant culture in a microgravity environment. *Annals of Botany* 54(Suppl 3):19-31, 1984.

Krikorian, A.D. and S.A. O'Connor. Karyological observations. *Annals of Botany* 54(Suppl 3):49-63, 1984.

Flight: OSS-1 (STS-3)

Experiment Title: Study of the Influence of Weightlessness on Lignification in Developing Plant Seedlings (PGU)

Principal Investigator: Joe R. Cowles
Affiliation: U Houston, Houston, TX
Country: U.S.

Sponsor: Life Sciences Div., OSSA, NASA HQ

Developer: U Houston, TX; Lockheed and NASA ARC (PGUs--Plant Growth Units)

Management and Integration: Attached Shuttle Payloads Project, NASA GSFC; Shuttle Payload Engineering Div., OSSA, NASA HQ

Experiment Location: middeck

Species Studied: mung bean, Vigna radiata (L.) Wilcek; oat, Avena sativa L. cv. 'Garry'; pine, Pinus elliotti Engelm.

Objectives of Experiment: This study was designed to determine the effect of zero gravity on the lignin content and growth rate of germinating mung bean seeds, germinating oat seeds, and 4-day-old pine seedlings.

Description: The pine seedlings, oat seeds, and mung bean seeds were flown in a six-chamber plant growth unit (PGU). Each species was planted in two of the chambers (16 seeds or seedlings per chamber). The oat and mung bean seeds germinated into seedlings during the 8-day flight. The results were compared to those of a ground-based control group. Postflight microscope studies and chromosome analyses were performed on the roots. Atmospheric oxygen, carbon dioxide, and ethylene levels in the sealed growth chambers were analyzed postflight.

Results: The space-grown plants were shorter than the ground controls. This difference was partially due to differences in the growth rates between the two groups. Most of the space-exposed plants grew toward the light. Some of the mung beans grew at skew angles, suggesting that light cannot completely substitute for gravity. A preliminary analysis showed that the total lignin content per plant was slightly lower in the weightless group of pine and mung bean seedlings. The lignin contents were difficult to compare, due to the height differences between the control and flight plants. The roots of the space-grown seedlings were fewer and shorter and some of them grew away from the growth medium. Decreased root tip cell division was noted in oats and mung beans. Chromosomal abnormalities were prevalent in oat seedlings, but not in mung beans. Abnormal root cap cell development was noted in

space-exposed mung beans. Ethylene was found in one of the mung bean chambers only. No significant differences were detected in atmospheric carbon dioxide and oxygen levels between flight and control seedlings.

References:

Cowles, J.R. et al. Growth and lignification in seedlings exposed to eight days of microgravity. Annals of Botany 54(Suppl. 3):33-48, 1984.

Slocum, R.D. et al. Cytological and ultrastructural studies on root tissues. Annals of Botany 54(Suppl. 3):65-76, 1984.

Krikorian, A.D. and S.A. O'Connor. Karyological observations. Annals of Botany 54(Suppl. 3):49-63, 1984.

Flight: OSS-1 (STS-3)

Experiment Title: Insect In-Flight Motion Study (SE81-08)

Principal Investigator: Todd E. Nelson
Affiliation: Southland Public High School, Adams, MN (currently U.S. Air Force)
Country: U.S.

Science Advisor: Bill Williams, NASA ARC

Sponsor: SSIP, OSF, NASA HQ; Honeywell, Inc.

Developer: Honeywell, Inc.

Management and Integration: Man-Systems Div., NASA JSC

Experiment Location: middeck

Species Studied: honeybee (adult worker); housefly; velvet bean caterpillar moth

Objectives of Experiment: This student study was designed to investigate the alterations in flight patterns of three insect species in space.

Description: Adult worker honeybees, houseflies, and velvet bean caterpillar moths were flown in special chambers. These species were used because they have different wing-to-body weight ratios. Their flight patterns were observed and recorded by movie camera.

Results: Difficulty in achieving orientation for flight was observed in some of the insects in space. The moths appeared to experience less difficulty than the other species in flying in microgravity. Within a few days many of the insects tended to cling to the walls of the chamber instead of flying.

References:

Bowie, M.L. Space Shuttle Student Involvement Program (Experiment Status/Update). Washington, D.C.: NASA, March 15, 1985.

NASA Educational Briefs.

STS-4

Launch Date: June 27, 1982

Landing Date: July 4, 1982

Relevant Payloads: SSIP, GAS

Experiments:

Flight: STS-4

Experiment Title: The Effects of Space Travel on Levels of Trivalent Chromium in the Body (SE81-04)

Principal Investigator: Karla R. Hauersperger
Affiliation: East Mecklenbury High School, Charlotte, NC (currently at NC State U)
Country: U.S.

Science Advisor: Carolyn S. Leach, NASA JSC

Sponsor: SSIP, OSF, NASA HQ; Explorers Club, New York, NY

Developer: Explorers Club, New York, NY

Management and Integration: Man-Systems Div., NASA JSC

Location of Experiment: middeck

Species Studied: human (blood)

Objectives of Experiment: The purpose was to measure possible changes in chromium levels and carbohydrate metabolism due to spaceflight. Chromium bioavailability has been shown to be decreased due to prolonged bed rest on Earth, and a similar effect may occur in microgravity.

Description: Shuttle crew members and ground management staff served as subjects. For a month prior to launch, the subjects were given diets containing 0.05-0.2 mg chromium, then blood tests for chromium level and glucose tolerance. These tests were to be repeated postflight.

Results: To be included (if available) in next edition.

References:

Mission Operation Report No. M-989-82-04. Washington, D.C.: Headquarters Administration Div., NASA HQ, 1982.

Bowie, M.L. Space Shuttle Student Involvement Program (Experiment Status/Update). March 15, 1985.

Flight: STS-4

Experiment Title: Root Growth of Duckweed (G-0001)

Principal Investigator: Kelly D. Hunt
Affiliation: Ut State U, Logan, UT
Country: U.S.

Sponsor: GAS Program, OSF, NASA HQ; R. Gilbert Moore (Thiokol, Brigham City, UT)

Developer: R. Gilbert Moore (Thiokol, Brigham City, UT)

Management and Integration: Special Payloads Div., NASA GSFC

Experiment Location: GAS adapter beam in cargo bay

Species Studied: duckweed, Lemna minor L.

Objectives of Experiment: The purpose of the experiment was to study the effects of weightlessness on growth and development of duckweed roots. The sieve tubes (and plastid cells) in the root phloem may be important in the root responses to gravity.

Description: Duckweed plants were grown inside a Plexiglas growth chamber. The duckweed sieve-tube members were examined under an electron microscope and compared both with control plants grown on Earth and with plants subjected to clinostat conditions.

Results: To be included (if available) in next edition.

References:

Overbye, D. Space science for the people. Discover 3(2):36-39, 1982.

Flight: STS-4

Experiment Title: The Effects of Diet, Exercise, and Zero Gravity on Lipoprotein Profiles (SE81-06)

Principal Investigator: Amy M. Kusske
Affiliation: Hill Junior High School, Long Beach, CA
Country: U.S.

Science Advisor: Carolyn Huntoon, NASA JSC

Sponsor: SSIP, OSF, NASA HQ; McDonnell Douglas, Huntington Beach, CA

Developer: McDonnell Douglas, Huntington Beach, CA

Management and Integration: Man-Systems Div., NASA JSC

Experiment Location: middeck

Species Studied: human (blood)

Objectives of Experiment: The object was to determine if lipoprotein profiles change in microgravity.

Description: Pre- and postflight diet and exercise program data were recorded for the crew members. Blood samples taken pre-, during, and postflight were analyzed for lipoprotein profiles (HDL/LDL ratios) and lactic acid levels in crew members.

Results: To be included (if available) in next edition.

References:

Mission Operation Report No. M-989-82-04. Washington, D.C.: Headquarters Administration Div., NASA HQ, 1982.

Bowie, M.L. Space Shuttle Student Involvement Program (Experiment Status/Update). March 15, 1985.

Flight: STS-4

Experiment Title: Effects of Microgravity on the Genetics of Brine Shrimp (G-0001)

Principal Investigator: Bruce Moore
Affiliation: Ut State U, Logan, UT
Country: U.S.

Sponsor: GAS Program, OSF, NASA HQ; R. Gilbert Moore (Thiokol, Brigham City, UT)

Developer: R. Gilbert Moore (Thiokol, Brigham City, UT)

Management and Integration: Special Payloads Div., NASA GSFC

Experiment Location: GAS adapter beam in cargo bay

Species Studied: brine shrimp, Artemia

Objectives of Experiment: This student experiment was designed to study the effects of microgravity on the genetics of brine shrimp eggs.

Description: Brine shrimp cysts (eggs) were mixed with ground rice hulls as food and placed in a sealed chamber containing artificial seawater. The chamber was exposed to light to stimulate shrimp hatching. The shrimp were examined by electron microscopy postflight.

Results: To be included (if available) in next edition.

References:

Overbye, D. Space science for the people. Discover 3(2):36-39, 1982.

Flight: STS-4

Experiment Title: Fruit Fly Experiment (G-0001)

Principal Investigator: Walter M. Moore
Affiliation: UT State U, Logan, UT
Country: U.S.

Sponsor: GAS Program, OSF, NASA HQ; R. Gilbert Moore (Thiokol, Brigham City, UT)

Developer: R. Gilbert Moore (Thiokol, Brigham City, UT)

Management and Integration: Special Payloads Div., NASA GSFC

Experiment Location: GAS adapter beam in cargo bay

Species Studied: fruit fly, Drosophila melanogaster

Objectives of Experiment: This student experiment was designed to study the genetic effects of microgravity on fruit flies.

Description: Fruit flies and fruit fly eggs were housed in a Plexiglas structure containing food cups.

Results: To be included (if available) in next edition.

References:

Overbye, D. Space science for the people. Discover 3(2):36-39, 1982.

Flight: STS-4

Experiment Title: Algal Microgravity Bioassay Experiment (G-0001)

Principal Investigator: Steven M. Walker
Affiliation: Ut State U, Logan, UT
Country: U.S.

Sponsor: GAS Program, OSF, NASA HQ; R. Gilbert Moore (Thiokol; Brigham City, UT)

Developer: R. Gilbert Moore (Thiokol, Brigham City, UT)

Management and Integration: Special Payloads Div., NASA GSFC

Experiment Location: GAS adapter beam in cargo bay

Species Studied: algae, Chlorella vulgaris

Objectives of Experiment: The study was to observe the effects of microgravity on the growth of the green alga, Chlorella.

Description: The Chlorella was contained in a growth chamber while in orbit. Optical density and temperature were recorded during the flight. The algal cells were examined by electron microscopy postflight.

Results: To be included (if available) in next edition.

References:

Overbye, D. Space science for the people. Discover 3(2):36-39, 1982.

STS-5

Launch Date: November 11, 1982

Landing Date: November 16, 1982

Relevant Payloads: SSIP

Experiments:

Flight: STS-5

Experiment Title: The Growth of Porifera in Zero-Gravity (SE81-02)

Principal Investigator: Aaron K. Gillette
Affiliation: Winter Haven Senior High School, Winter Haven, FL
Country: U.S.

Science Advisor: William Knott, NASA KSC

Sponsor: SSIP, OSF, NASA HQ; Martin Marietta Aerospace, Orlando, FL

Developer: Martin Marietta Aerospace, Orlando, FL

Management and Integration: Man-Systems Div., NASA JSC

Experiment Location: middeck

Species Studied: sponge, Microciona porifera

Objectives of Experiment: This experiment was designed to observe the effects of microgravity on the structure and shape of the sponge, a marine invertebrate with a colonial structure (composed of many single-celled organisms living as one animal).

Description: Sponges were flown in an aquarium divided into two sections. In one section, the sponges were dissociated by being squeezed through a wire mesh. The other section contained undissociated control sponges. The effect of spaceflight on the reaggregation of structure/shape and spicule formation in the dissociated sponges was recorded by time-lapse photography.

Results: To be included (if available) in next edition.

References:

Bowie, M.L. Space Shuttle Student Involvement Program (Experiment Status/Update). Washington, D.C.: NASA, March 15, 1985.

STS-6

Launch Date: April 4, 1983

Landing Date: April 9, 1983

Relevant Payloads: GAS

Experiments:

Flight: STS-6 (31-B)

Experiment Title: Seeds in Space (G-0381)

Principal Investigator: George B. Park, Jr.
Affiliation: George W. Park Seed Co., Inc., Greenwood, SC
Country: U.S.

Sponsor: GAS Program, OSF, NASA HQ; George W. Park Seed Co., Inc., Greenwood, SC

Developer: George W. Park Seed Co., Inc., Greenwood, SC

Management and Integration: Special Payloads Div., NASA GSFC

Experiment Location: GAS adapter beam in cargo bay

Species Studied: fruits and vegetables (garden pea, potato, etc.)

Objectives of Experiment: In preparation for future growth of food in space (on the space station and long-term missions), seeds were exposed to the space environment to test the effects on germination and development.

Description: Seeds from over 40 varieties of fruits and vegetables were flown as a Get Away Special. The seeds were placed either in dacron bags or airtight plastic bags either on the perimeter of the canister, which receives extreme temperatures and cosmic radiation, or in the center of the canister, which is more protected from extreme conditions. The seeds were germinated and studied postflight, and the results were compared with those of two identical seed control groups stored on Earth during the flight.

Results: The flight seeds did not appear to be physically damaged during spaceflight. All space-exposed seeds were alive upon germination. A few abnormal seedlings have appeared, but not a significant number to date. No reduced plant vigor or mutations have been observed yet. The corn seeds had about 10% lower germination than controls, possibly due to the corn seed oil content being damaged by the reentry heat. The vented flight seeds of the garden pea and potato germinated significantly better, and the reasons for this are unknown. Additional studies are being conducted on the seeds.

References:

Burkhalter, B.B. and J.P. Curtis. The Get Away Special: A Unique Teaching Means for the Advancement of Education in the Space Age. In: XXXVth Congress International Astronautical Federation, Lausanne, Switzerland, October 7-13, 1984. IAF-84-409.

Flight: STS-6 (31-B)

Experiment Title: The Effects of Weightlessness and Space Radiation on Microorganism Development (G-049)

Principal Investigator: Kenneth R. Shriner
Affiliation: U.S. Air Force Academy, Colorado Springs, CO
Country: U.S.

Sponsor: GAS Program, OSF, NASA HQ; U.S. Air Force Academy, Colorado Springs, CO

Developer: U.S. Air Force Academy, Colorado Springs, CO

Management and Integration: Special Payloads Div., NASA GSFC

Experiment Location: GAS adapter beam in cargo bay

Species Studied: microorganisms (species unspecified)

Objectives of Experiment: The object of this student Get Away Special was to study the effects of microgravity and cosmic radiation on the development of microorganisms.

Description: No details were available.

Results: To be included (if available) in next edition.

References:

Prelaunch Flight Operation Report No. M-989-83-06. Washington, D.C.: Headquarters Administration Div., NASA HQ, 1983.

STS-7

Launch Date: June 18, 1983

Landing Date: June 24, 1983

Relevant Payloads: GAS

Experiments:

Flight: STS-7 (31-C)

Experiment Title: Biostack (G-002)

Principal Investigator: Marcus Buchwald
Affiliation: high school student chosen by the German Youth Fair Program (JUFO)
Country: Federal Republic of Germany

Sponsor: GAS Program, OSF, NASA HQ; Kayser Threde, Federal Republic of Germany; DFVLR, Federal Republic of Germany

Developer: Kayser Threde, Federal Republic of Germany

Management and Integration: Special Payloads Div., NASA GSFC

Experiment Location: GAS adapter beam in cargo bay

Species Studied: plant seeds (species unspecified)

Objectives of Experiment: The object of this student experiment was to study the effects of cosmic radiation on plant seeds.

Description: Seeds of various varieties were flown in four containers. The cosmic radiation dose was monitored using a diallyladiglycolcarbonate foil.

Results: To be included (if available) in next edition.

References:

Prelaunch Flight Operations Report No. M-989-83-07. Washington, D.C.: Headquarters Administration Div., NASA HQ, June 1983.

Flight: STS-7 (31-C)

Experiment Title: Plant Contamination by Heavy Metals (G-002)

Principal Investigator: Heinz Katzenmeire
Affiliation: high school student chosen by the German Youth Fair Program (JUFO)
Country: Federal Republic of Germany

Sponsor: GAS Program, OSF, NASA HQ; Kayser Threde, Federal Republic of Germany; DFVLR, Federal Republic of Germany

Developer: Kayser Threde, Federal Republic of Germany

Management and Integration: Special Payloads Div., NASA GSFC

Experiment Location: GAS adapter beam in cargo bay

Species Studied: watercress

Objectives of Experiment: The object was to study heavy metal contamination in plants.

Description: The transport of cadmium was studied in watercress shoots.

Results: To be included (if available) in next edition.

References:

Prelaunch Flight Operations Report No. M-989-83-07. Washington, D.C.: Headquarters Administration Div., NASA HQ, June 1983.

Flight: STS-7 (31-C)

Experiment Title: Orbit '81 (G-0012)

Principal Investigator: high school students
Affiliation: Camden and Woodrow Wilson High Schools, Camden, NJ
Country: U.S.

Sponsor: GAS Program, OSF, NASA HQ; RCA

Developer: RCA

Management and Integration: Special Payloads Div., NASA GSFC

Experiment Location: GAS adapter beam in cargo bay

Species Studied: carpenter ant

Objectives of Experiment: The object of this student experiment was to study the effects of weightlessness on a colony of carpenter ants.

Description: The ant colony in a wooden ant farm was placed inside a 5 cubic foot Getaway Special canister. Sphagnum moss, sugar cubes, and O-tabs (slow release oxygen tablets) were placed in the ant farm. The ant colony in spaceflight was recorded on videotape and still photographs by a movie camera. Both cameras were controlled by an onboard computer.

Results: All of the ants died in the canister before the launch. After the canister returned to Earth, the same wooden ant farm was restocked with ants and experiments were carried out to reproduce some of the space conditions in order to determine the cause of the ants' death. The tests showed that the ants did not die from suffocation or contamination of soil, bacteria, or fungus. It was concluded that the ants died (within a few days of being placed in the canister) from dehydration, due to the purging of the canister with dry air (required by NASA to prevent condensation buildup in GAS experiments).

References:

The Final Report of Orbit '81: An Investigation into the Cause of Death of a Colony of Ants Launched Aboard the Second Flight of Challenger June 18, 1983. (submitted by students at Camden High School and Woodrow Wilson High School, Camden City New Jersey Public Schools)

Flight: STS-7 (31-C)

Experiment Title: Plant Gravireception (G-0033)

Principal Investigator: university students
Affiliation: California Institute of Technology, CA
Country: U.S.

Sponsor: GAS Program, OSF, NASA HQ; Stephen Spielberg, Culver City, CA

Developer: California Institute of Technology, CA

Management and Integration: Special Payloads Div., NASA GSFC

Experiment Location: GAS adapter beam in cargo bay

Species Studied: radish

Objectives of Experiment: The object was to study plant gravireception at different acceleration levels in microgravity.

Description: Germinating radish seedlings were placed on a centrifuge with multiple disks in order to revolve the seedlings at different rates.

Results: To be included (if available) in next edition.

References:

Prelaunch Flight Operations Report No. M-989-83-07. Washington, D.C.: Headquarters Administration Div., NASA HQ, June 1983.

Flight: STS-7 (31-C)

Experiment Title: The Seed Germination Experiment (G-0009)

Principal Investigator: university students (faculty advisor: John T. Snow)
Affiliation: Purdue U, West Lafayette, IN
Country: U.S.

Sponsor: GAS Program, OSF, NASA HQ; Purdue U, West Lafayette, IN

Developer: Purdue U, West Lafayette, IN

Management and Integration: Special Payloads Div., NASA GSFC

Experiment Location: GAS adapter beam in cargo bay

Species Studied: sunflower

Objectives of Experiment: The object was to study the effect of microgravity on germination and geotropism in sunflower seeds.

Description: Sunflower seeds were to be allowed to germinate in space at different radii on a rotating drum (e.g., subjected to different levels of acceleration).

Results: This experiment was not activated after launch, due to an electrical short; therefore, no results were obtained.

References:

Prelaunch Flight Operations Report No. M-989-83-07. Washington, D.C.: Headquarters Administration Div., NASA HQ, June 1983.

Prouty, C.R. (ed.). 1984 GAS Experimenter's Symposium. NASA CP-2324. Washington, D.C.: NASA, 1984, pages 9-15.

STS-8

Launch Date: August 30, 1983

Landing Date: September 5, 1983

Relevant Payloads: SSIP

Experiments:

Flight: STS-8 (31-D)

Experiment Title: Biofeedback (SE81-01)

Principal Investigator: Wendy A. Angelo
Affiliation: Arlington High School, Pleasant Valley, NY
Country: U.S.

Science Advisor: Len Gardner, NASA JSC

Sponsor: SSIP, OSF, NASA HQ; U.S. Air Force, Brooks Air Force Base, TX

Developer: U.S. Air Force, Brooks Air Force Base, TX

Management and Integration: Man-Systems Div., NASA JSC

Experiment Location: middeck

Species Studied: human

Objectives of Experiment: This student experiment was designed to determine the efficacy of biofeedback training in improving the sleep of Shuttle crew members.

Description: Half of the crew received biofeedback training 30 minutes daily for 1 month prior to launch. The trained crew members were to practice biofeedback to produce sleep prior to their assigned sleep periods during the flight. The sleep patterns of the trained subjects were compared to those of the untrained subjects by examining medical records and flight logs postflight.

Results: To be included (if available) in next edition.

References:

Bowie, M.L. Space Shuttle Student Involvement Program (Experiment Status/Update). Washington, D.C.: NASA, March 15, 1985.

STS-9

Launch Date: November 28, 1983
Landing Date: December 8, 1983
Relevant Payloads: Spacelab 1
Experiments:

Flight: Spacelab 1 (STS-9; 41-A)

Experiment Title: Radiation Environment Monitoring

Principal Investigator: E.V. Benton
Affiliation: U San Francisco, CA
Country: U.S.

Sponsor: Life Sciences Div., OSSA, NASA HQ

Developer: U San Francisco, CA

Management and Integration: Spacelab Payloads Project Office, NASA MSFC; Shuttle Payload Engineering Div., OSSA, NASA HQ

Experiment Location: Spacelab

Species Studied: none

Objectives of Experiment: The radiation environment in space may be the most significant limitation to long-term manned space missions. This experiment was designed to gather data on the variations in radiation levels in spacecraft.

Description: Radiation levels inside Spacelab 1 were monitored by passive radiation detectors inside the module and the access tunnel and outside on the pallet. Overall dose measurements of low-LET (linear energy transfer) were made with type 200 and type 700 thermoluminescence detectors (TLDs), HZE particles (high charge and energy galactic cosmic rays) were measured with CR-39 plastic nuclear track detectors, and data on the fragmentation of galactic cosmic rays as they penetrate spacecraft shields and the directionality of radiation fields were obtained using AgCl (silver chloride) detectors.

Results: Low-LET levels ranged from 102-190 millirads, which is an average low-LET dose rate of 11.2 millirads/day inside the module. This level is about twice the low-LET dose rate determined on prior shuttle flights. Large fluxes of highly ionizing HZE particles were observed. The shuttle orbit on Spacelab 1 was 57 degrees compared with 28.5 degrees on previous shuttles. A higher inclination orbit results in higher radiation doses, as does higher altitude. The overall average mission dose equivalent was about 150 millirems compared with about 50 millirems on previous shuttles.

References:

Benton, E.V. et al. Radiation measurements aboard Spacelab 1. Science 225(4658):224-226, 1984.

Flight: Spacelab 1 (STS-9; 41-A)

Experiment Title: Nutation of Helianthus annuus in a Microgravity Environment

Principal Investigator: Allan H. Brown
Affiliation: U PA, Philadelphia, PA
Country: U.S.

Sponsor: Life Sciences Div., OSSA, NASA

Developer: U PA, Philadelphia, PA

Management and Integration: Spacelab Payloads Project Office, NASA MSFC; Shuttle Payload Engineering Div., OSSA, NASA HQ

Experiment Location: Spacelab

Species Studied: dwarf sunflower, Helianthus annuus

Objectives of Experiment: The study was designed to help explain if nutation (spiral growth patterns in plants) is dependent on gravity.

Description: Growth patterns in dwarf sunflower seedlings under infrared illumination were recorded by time-lapse videotapes in flight.

Results: Circumnutational patterns were observed in sunflower seedlings flown on Spacelab 1, indicating that gravity is not required for the stimulation or maintenance of nutation in this species.

References:

Brown, A.H. and D.K. Chapman. Circumnutation observed without a significant gravitational force in spaceflight. Science 225(4658):230-232, 1984.

Flight: Spacelab 1 (STS-9; 41-A)

Experiment Title: Advanced Biostack Experiment

Principal Investigator: Horst Bücker
Affiliation: DFVLR, Cologne
Country: Federal Republic of Germany

Sponsor: DFVLR, Federal Republic of Germany; ESA

Developer: DFVLR, Cologne, Federal Republic of Germany

Management and Integration: Spacelab Payloads Project Office, NASA MSFC; Shuttle Payload Engineering Div., OSSA, NASA HQ

Experiment Location: Spacelab

Species Studied: brine shrimp, Artemia salina; bacteria, Bacillus subtilis; tobacco, Nicotiana tabacum; Arabidopsis thaliana; Sordaria fimicula

Objectives of Experiment: The experiment was designed to study the hazard of high energy and high charge cosmic radiation to biological materials and various organisms.

Description: Biostacks, monolayers of biological test organisms between thin foils containing nuclear track detectors, were exposed to cosmic radiation at several locations in the module and on the pallet. In addition, ground controls were subjected to a similar temperature range as the mission, and flight control cells were flown but not exposed to heavy ion bombardment.

Results: Preliminary results indicate that the test organisms were not influenced by the experimental conditions or spaceflight as such. Survival of flight controls was over 90% in most species, but only 50% in brine shrimp (as in prior biostack experiments). Only about 5% of the brine shrimp eggs that were hit by the heavy ions formed swimming larvae, and development seemed to be more retarded than in prior spaceflight experiments.

References:

Bucker, H. et al. Radiobiological advanced biostack experiment. Science 225(4658):222-224, 1984.

Flight: Spacelab 1 (STS-9; 41-A)

Experiment Title: Effect of Weightlessness on Lymphocyte Proliferation

Principal Investigator: Augusto Cogoli
Affiliation: Eidgenossische Technische Hochschule, Zurich
Country: Switzerland

Sponsor: Swiss National Science Foundation; Swiss Institutes of Technology; ESA

Developer: Eidgenossische Technische Hochschule, Zurich, Switzerland

Management and Integration: Spacelab Payloads Project Office, NASA MSFC; Shuttle Payload Engineering Div., OSSA, NASA HQ

Experiment Location: Spacelab

Species Studied: human lymphocytes

Objectives of Experiment: The experiment was designed to study the effects of weightlessness on the immune system and on basic cellular mechanisms.

Description: Cultures of human lymphocytes were exposed to the mitogen, concanavalin A, which can induce T lymphocyte activation (cell proliferation) in spaceflight. The results were compared with ground and flight control lymphocyte cultures with and without mitogen exposure.

Results: Microgravity markedly depressed lymphocyte proliferation, compared with hypergravity which tends to stimulate cell proliferation as shown in previous ground-based experiments. Lymphocyte activation in the stimulated flight cultures was less than 3% of ground controls. The amount of the effect was unexpected. Although the results indicate that lymphocytes are sensitive to gravity, the mechanism of the effect of microgravity on cells is unknown. Lymphocyte aggregation and glucose uptake were not significantly affected by spaceflight.

References:

Cogoli, A. et al. Cell sensitivity to gravity. Science 225(4658):228-230, 1984.

Tschopp, A. and A. Cogoli. Low gravity lowers immunity to disease. New Scientist 102(1418):36, 1984.

Flight: Spacelab 1 (STS-9; 41-A)

Experiment Title: Personal Miniature Electrophysiological Tape Recorder

Principal Investigator: H. Green
Affiliation: Clinical Research Centre, Harrow
Country: England

Sponsor: British Medical Research Council; Belgian National Science Foundation; ESA

Developer: Clinical Research Centre, Harrow, England

Management and Integration: Spacelab Payloads Project Office, NASA MSFC; Shuttle Payload Engineering Div., OSSA, NASA HQ

Experiment Location: Spacelab

Species Studied: human

Objectives of Experiment: The objective was to obtain human physiological data, particularly on sleep, in the space environment.

Description: Battery-powered Medilog electrophysiological tape recorders connected to electrodes attached to different areas of the body were worn on the belt of one payload specialist. Data on the heart, brain, and eyes were collected continuously in space; data were also collected pre- and postflight.

Results: The number of eye movements during sleep increased in the initial sleep period in flight; the number of eye movements returned to normal the second night. The percentage of REM (rapid eye movement) sleep to total sleeping time increased to 50% (compared with the normal value of 20-25%) the first night. A decrease in REM discharges was expected; however, the long preflight training period of the payload specialist may have prevented the expected responses.

References:

Quadens, Q. and H. Green. Eye movements during sleep in weightlessness. Science 225(4658):221-222, 1984.

Flight: Spacelab 1 (STS-9; 41-A)

Experiment Title: Microorganisms and Biomolecules in Hard Space Environment

Principal Investigator: Gerda Horneck
Affiliation: DFVLR, Cologne
Country: Federal Republic of Germany

Sponsor: DFVLR, Federal Republic of Germany; ESA

Developer: DFVLR, Cologne, Federal Republic of Germany

Management and Integration: Spacelab Payloads Project Office, NASA MSFC; Shuttle Payload Engineering Div., OSSA, NASA HQ

Experiment Location: Spacelab

Species Studied: bacteria, Bacillus subtilis

Objectives of Experiment: The objective was to record the effects of the space environment (vacuum and high energy radiation) on Bacillus subtilis spores.

Description: B. subtilis spores (316 dry samples) of strains HA 101, HA 101F, and TKJ 6312 were exposed to the vacuum of space and to the full solar ultraviolet spectrum (greater then 170 nm or peak wavelengths of 220, 240, 260, or 280 nm). Flight control samples were kept at 1 atm and not subjected to vacuum. Ground controls were exposed to simulated temperature and vacuum conditions or to 1 atm. The samples were examined postflight for survival, mutations, reparability of ultraviolet damage, and photochemical changes in DNA and protein.

Results: Vacuum exposure reduced bacterial viability to 50% and increased mutation frequency by a factor of 10 compared with bacteria kept at 1 atm. B. subtilis was more sensitive to ultraviolet in vacuum than at 1 atm. Additional analyses on the samples will be reported later.

References:

Horneck, G. et al. Microorganisms in the space environment. Science 225(4658):226-228, 1984.

Flight: Spacelab 1 (STS-9; 41-A)

Experiment Title: Measurement of Central Venous Pressure and Determination of Hormones in Blood Serum during Weightlessness

Principal Investigator: Karl A. Kirsch
Affiliation: Free U Berlin
Country: Federal Republic of Germany

Sponsor: DFVLR, Federal Republic of Germany; ESA

Developer: Free U Berlin, Federal Republic of Germany

Management and Integration: Spacelab Payloads Project Office, NASA MSFC; Shuttle Payload Engineering Div., OSSA, NASA HQ

Experiment Location: Spacelab

Species Studied: human

Objectives of Experiment: This study was designed to collect data on body fluid shifts in space.

Description: Venous pressure measurements and blood samples were taken in four male crew members before, during, and after spaceflight.

Results: During Spacelab 1 the hematocrit was elevated and the venous pressure lowered compared with preflight data. The hematocrit decreased, venous pressure was elevated, and a 4-5% body weight loss was observed 1 hour after landing. Venous pressure reached the minimum point 12 hours later. The fluid shift upward occurs in the first few hours of spaceflight. The reversal of this fluid shift occurs within 3-6 hours after landing.

References:

Kirsch, K.A. et al. Venous pressure in man during weightlessness. Science 225(4658):218-219, 1984.

Flight: Spacelab 1 (STS-9; 41-A)

Experiment Title: The Effects of Space Flight on Erythrokinetics in Man

Principal Investigator: Carolyn S. Leach
Affiliation: Medical Sciences Div., NASA JSC
Country: U.S.

Sponsor: Life Sciences Div., OSSA, NASA HQ

Developer: Medical Sciences Div., NASA JSC

Management and Integration: Spacelab Payloads Project Office, NASA MSFC; Shuttle Payload Engineering Div., OSSA, NASA HQ

Experiment Location: Spacelab

Species Studied: human

Objectives of Experiment: The purpose of this study was to determine the cause of temporary anemia due to spaceflight, which has been observed as a postflight reduction in circulating red blood cell (RBC) mass in prior U.S. and Soviet space missions (Gemini, Apollo, Skylab, ASTP, Soyuz-Salyut).

Description: Blood samples were collected from four male crew members before, during, and after Spacelab 1 and analyzed for hemoglobin level, hematocrit, RBC mass, and other hematological parameters. A control group of six male subjects in a ground-based bed-rest study was selected on the basis of similar age, weight, and physical condition to the crew members.

Results: Preliminary results included a significant decrease in mean reticulocyte number, a lowered but not statistically significant erythropoietin level, a 1%/day decrease in mean RBC mass, and increased hemoglobin and hematocrit during spaceflight. Decreased RBC mass, plasma volume, hematocrit, hemoglobin, and reticulocyte number were observed on landing. Hematocrit, hemoglobin, and reticulocyte number were lower than the corresponding preflight values for the 2-week postflight sampling period. Oxygen exposure could not account for the reduced RBC mass, because the Spacelab 1 crew was not exposed to 100% oxygen.

References:

Leach, C.S. and P.C. Johnson. Influence of spaceflight on erythrokinetics in man. Science 225(4658):216-218, 1984.

Flight: Spacelab 1 (STS-9; 41-A)

Experiment Title: Vestibulospinal Reflex Mechanisms

Principal Investigator: Millard F. Reschke
Affiliation: Space Biomedical Research Institute, NASA JSC
Country: U.S.

Sponsor: Life Sciences Div., OSSA, NASA HQ

Developer: Space Biomedical Research Institute, NASA JSC

Management and Integration: Spacelab Payloads Project Office, NASA MSFC; Shuttle Payload Engineering Div., OSSA, NASA HQ

Experiment Location: Spacelab

Species Studied: human

Objectives of Experiment: The study tested the hypothesis that exposure to microgravity alters otolith input, producing physiological adaptations that include changes in postural control and spinal reflexes.

Description: The pathway linking the otolith organs with the spinal motoneurons was studied in four crew members, using the Hoffmann reflex (H reflex) during brief, unexpected linear acceleration and dynamic postural testing on a moving platform pre- and postflight.

Results: The H reflex amplitude was low in flight after adaptation to weightlessness. The postflight potentiation of this reflex may have been due to the rate of adaptation. The severity of inflight symptoms of motion sickness was related to the postflight H reflex amplitude. Responses to dynamic posture tests were significantly different postflight compared with preflight results. An otolith signal reinterpretation seems to occur in weightlessness, which may fit into the sensory conflict theory of space motion sickness. Less severe symptoms of motion sickness may be experienced in individuals whose central nervous systems are better able to modify response patterns.

References:

Reschke, M.F. et al. Vestibulospinal reflexes as a function of microgravity. Science 225(4658):212-214, 1984.

Reschke, M.F. et al. Experimental Brain Research (in press)

Flight: Spacelab 1 (STS-9; 41-A)

Experiment Title: Mass Discrimination During Weightlessness

Principal Investigator: Helen E. Ross
Affiliation: U Stirling
Country: Scotland, UK

Sponsor: Medical Research Council, Scotland; Leverhulme Trust, Scotland; ESA

Developer: Institute of Aviation Medicine, RAF, Farnborough, UK

Management and Integration: Spacelab Payloads Project Office, NASA MSFC; Shuttle Payload Engineering Div., OSSA, NASA HQ

Experiment Location: Spacelab

Species Studied: human

Objectives of Experiment: This experiment was designed to compare human perception of mass in space with weight on Earth, in order to examine the influence of gravity on the sensory cues used to discriminate mass versus weight.

Description: Two payload specialists and two mission specialists were trained to perform the discrimination tests, which were done on Earth four times in the 5-month period prior to launch and 2-5 times per subject in space. Each discrimination trial lasted 12-17 minutes and consisted of the subject recording which of two identically shaped but different weight steel balls felt heavier for a total of 72 pairs of balls. The combinations were determined from a set of 24 weighted balls of 30 mm diameter and masses of 50-64 g. Each ball had a unique letter identifier. The subjects were given cards with the various letter combinations of balls, of which no combinations were repeated.

Results: All subjects made more errors in mass discrimination in space than in weight discrimination on Earth by an average factor of 1.84. In space, weight discrimination is made by accelerating objects to utilized inertial cues. Humans may be less sensitive to inertial mass than to weight. This difference was still observed after 9 days in orbit, indicating that adaptation to 0-g does not completely compensate for loss of gravity. Weight discrimination was also impaired for 2-3 days postflight. The results show that gravity is important in weight discrimination.

References:

Ross, H. et al. Mass discrimination during prolonged weightlessness. Science 225(4658):219-221, 1984.

Ross, H. Dexterity is just a fumble in space. New Scientist 103(1418):16-17, 1984.

Flight: Spacelab 1 (STS-9; 41-A)

Experiment Title: Three-Dimensional Ballistocardiography in Weightlessness

Principal Investigator: Aristede Scano
Affiliation: U Rome
Country: Italy

Sponsor: Piano Spatiale Nationale, Rome, Italy; ESA

Developer: U Rome, Italy

Management and Integration: Spacelab Payloads Project Office, NASA MSFC; Shuttle Payload Engineering Div., OSSA, NASA HQ

Experiment Location: Spacelab

Species Studied: human

Objectives of Experiment: The object was to compare cardiovascular performance in weightlessness versus in Earth's gravity.

Description: Two crew members were each fitted with a backpack containing a mini-accelerometer and an EKG (electrocardiogram) connected to a miniature tape recorder. A series of breathing and physical exercises were performed to elevate the heart rate while the physiological data were being recorded.

Results: Presented in the Second European Life Sciences Symposium, Cologne, Germany, June 4-7, 1984. ESA SP-212. ESA/DFVLR, August 1984.

References:

Spacelab 1. Marshall Space Flight Center, AL: NASA MSFC.

Flight: Spacelab 1 (STS-9; 41-A)

Experiment Title: Preliminary Characterization of Persisting Circadian Rhythms During Spaceflight: *Neurospora* as a Model System

Principal Investigator: F.M. Sulzman
Affiliation: State U NY, Binghamton, NY
Country: U.S.

Sponsor: Life Sciences Div., OSSA, NASA HQ

Developer: State U NY, Binghamton, NY

Management and Integration: Spacelab Payloads Project Office, NASA MSFC; Shuttle Payload Engineering Div., OSSA, NASA HQ

Experiment Location: Spacelab

Species Studied: fungus, *Neurospora crassa*

Objectives of Experiment: The objective was to test whether circadian rhythms are independent of environmental cues and whether the rhythms persist outside the 24-hour Earth day.

Description: *Neurospora crassa* is a fungus with a characteristic growth pattern of vegetative spore formation (conidiation). The conidiation rhythm of *Neurospora* was monitored during the flight. The fungus was grown in culture tubes kept in continuous darkness, except during the monitoring on day 7.

Results: On day 7 of Spacelab 1, the conidiation rhythm of *Neurospora* was visibly different from that of cultures grown on Earth, with respect to greater variation in growth rates among culture tubes, decreased clarity of the rhythm, and increased variance of the circadian period. The circadian rhythm had ceased in some of the tubes on day 7, but the rhythm was present in all the tubes at the end of the flight. These results are preliminary, and it is not known whether the effects on circadian rhythm were due to removal from the 24-hour day.

References:

Sulzman, F.M. et al. *Neurospora* circadian rhythms in space: a reexamination of the endogenous-exogenous question. *Science* 225(4658):232-234, 1984.

Flight: Spacelab 1 (STS-9; 41-A)

Experiment Title: Effects of Rectilinear Accelerations, Optokinetic, and Caloric Stimulations in Space

Principal Investigator: Rudolph von Baumgarten
Affiliation: U Mainz
Country: Federal Republic of Germany

Sponsor: DFVLR, Federal Republic of Germany; ESA

Developer: U Mainz, Federal Republic of Germany; French Centre Nationale d'Etudes Spatiales (CNES)

Management and Integration: Spacelab Payloads Project Office, NASA MSFC; Shuttle Payload Engineering Div., OSSA, NASA HQ

Experiment Location: Spacelab

Species Studied: human

Objectives of Experiment: The purpose of the experiments was to study the effects of exposure to microgravity on vestibular function and visual-vestibular interaction.

Description: Various tests using optokinetic, caloric, and acceleration stimuli were run on four male crew members before, during, and after Spacelab 1. Caloric stimulation was produced by introducing heated or cooled air into both ears.

Results: Caloric nystagmus of the same direction as on Earth could be produced in space. Additional results will be reported in the next edition of this report.

References:

von Baumgarten, R. et al. Effects of rectilinear acceleration and optokinetic and caloric stimulations in space. Science 225(4658):208-212, 1984.

Flight: Spacelab 1 (STS-9; 41-A)

Experiment Title: Effects of Prolonged Weightlessness on the Hormonal Immune Response of Humans

Principal Investigator: E.W. Voss, Jr.
Affiliation: U IL, Urbana, IL
Country: U.S.

Sponsor: Life Sciences Div., OSSA, NASA HQ

Developer: U IL, Urbana, IL

Management and Integration: Spacelab Payloads Project Office, NASA MSFC; Shuttle Payload Engineering Div., OSSA, NASA HQ

Experiment Location: Spacelab

Species Studied: human

Objectives of Experiment: Changes in antibody levels were studied in crew blood samples to determine if weightlessness acts as a stress factor on the immune response.

Description: Serum samples from four male crew members were collected before, during, and after the Spacelab 1 flight (this served as a control for circadian rhythms in blood composition). The samples were analyzed for immunoglobulin content. Immunoglobulin levels in serum samples from 20 white males served as a control group to establish the normal range of values.

Results: Minor alterations in immunoglobulins G, M, A, and E were observed during Spacelab 1. No significant effects of microgravity on immunoglobulin levels, in terms of the level of each immunoglobulin class, were observed during the 10-day flight. Activated immune lymphocytes appear to continue producing immunoglobulins in weightlessness. The effect of microgravity on the lymphocyte activation process is unknown.

References:

Voss, E.W., Jr. Prolonged weightlessness and humoral immunity. Science 225(4658):214-215, 1984.

Flight: Spacelab 1 (STS-9; 41-A)

Experiment Title: Vestibular Experiments

Principal Investigator: Laurence R. Young
Affiliation: MIT, Cambridge, MA
Country: U.S.

Sponsor: Life Sciences Div., OSSA, NASA HQ

Developer: MIT, Cambridge, MA

Management and Integration: Spacelab Payloads Project Office, NASA MSFC; Shuttle Payload Engineering Div., OSSA, NASA HQ

Experiment Location: Spacelab

Species Studied: human

Objectives of Experiment: The goal of the experiment series was to monitor the sensory-motor adaptation to weightlessness and study the causes of space motion sickness. It was hypothesized that vestibular afferent signals are centrally reinterpreted to represent linear acceleration rather than tilt and that the abatement in symptoms of space motion sickness after 2-4 days in orbit is due to this central adaptation.

Description: Various responses mediated by the otolith organs and semicircular canals were evaluated in four crew members using measurements of eye movements, postural control, perception of orientation, and space sickness susceptibility.

Results: Preliminary results are as follows: 1) Visual cues regarding orientation seem to become more important in weightlessness and localizable tactile cues become less important; 2) space sickness appears to be a form of motion sickness; 3) postflight postural instability may be the result of altered proprioceptive or tactile sensation or muscle wasting as opposed to modified vestibulo-spinal reflexes; 4) awareness of position decreased in weightlessness compared with preflight responses.

References:

Young, L.R. et al. Spatial orientation in weightlessness and readaptation to Earth's gravity. Science 225(4658):205-208, 1984.

Young, L.R. Tilted astronauts reveal the brain's balancing act. New Scientist 23(1418):14-15, 1984.

STS 41-B

Launch Date: February 3, 1984

Landing Date: February 11, 1984

Relevant Payloads: GAS, SSIP

Experiments:

Flight: STS 41-B

Experiment Title: Arthritis (SE81-10)

Principal Investigator: Dan Weber
Affiliation: Hunter College High School, New York, NY (currently at Cornell U)
Country: U.S.

Science Advisor: Emily Morey-Holton, Biomedical Research Div., NASA ARC

Sponsor: SSIP, OSF, NASA HQ; Pfizer, Groton, CT

Developer: Pfizer, Groton, CT

Management and Integration: Man-Systems Div., NASA JSC

Experiment Location: middeck

Species Studied: rat (male, Lewis strain)

Objectives of Experiment: This student experiment was flown to study the effects of weightlessness on the course of adjuvant-induced arthritis in rats and to evaluate the Animal Enclosure Module (AEM) for housing rats on Shuttle experiments. Arthritis symptoms may be alleviated in microgravity, as indicated in ground-based experiments using simulated weightlessness (unloading of hind limbs). The AEM was first flown on STS-8 (31-D).

Description: The AEM was flown with three healthy rats and three arthritic rats. Arthritis was induced in the animals by the injection of Freund's adjuvant into the hind paws. Ground control groups included a total of six healthy and six arthritic rats. All rats were germ-free (gnotobiotic). Food and water consumption and body weight data were recorded for all animals. Postflight autopsies of the rats, including histologic and radiologic tests, were performed to determine if weightlessness had a therapeutic effect on adjuvant arthritis.

Results: Spaceflight did not inhibit the development of adjuvant arthritis compared to ground controls (no significant differences in the degree of swelling in the injected hind paws). Flight crew members observed that the spread of arthritis was less extensive in the Shuttle rats compared to rats in prior ground-based studies, indicating some possible beneficial effects of weightlessness. The results may have been affected because the Shuttle reentry occurred while the systemic stage of the disease was still developing. Further studies may be required to fully understand the effects of gravity on arthritis. Healthy control rats on the flight consumed more food and weighed more at

the end of the mission than healthy ground controls. The AEM was able to successfully maintain all rats during spaceflight.

References:

Martello, N. (Johnson Engineering). Biomedical Research Division: Significant Accomplishments for FY 1984. NASA TM-86692. Moffett Field, CA: NASA Ames Research Center, February 1985.

Weber, D.J. The Effects of Weightlessness on Arthritis. Report prepared for the NASA/NSTA Shuttle Student Involvement Program. 1985.

Flight: STS 41-B

Experiment Title: The Phototropic Effect on Seedling Orientation in a Microgravity Environment (G-008)

Principal Investigator: high school students
Affiliation: Brighton High School, Salt Lake City, UT
Country: U.S.

Sponsor: GAS Program, OSF, NASA HQ; Utah State U, Logan, UT; American Institute of Aeronautics and Astronautics, New York, NY

Developer: Brighton High School, Salt Lake City, UT; Utah State U, Logan, UT

Management and Integration: Special Payloads Div., NASA GSFC

Experiment Location: GAS adapter beam in cargo bay

Species Studied: radish

Objectives of Experiment: The object of this student Get Away Special was to study the effect of microgravity on radish seedling growth.

Description: Radish seedlings were placed in a Plexiglas growth chamber. The progress of the seedlings was to be recorded by camera every 2 hours.

Results: The experiment was not activated due to an electrical malfunction and no results were obtained.

References:

Prouty, C.R. (ed.). 1984 Get Away Special Experimenter's Symposium. NASA CP-2324. Washington, D.C.: NASA, 1984, pages 95-101.

STS 41-C

Launch Date: April 6, 1984

Landing Date of Shuttle: April 13, 1984

LDEF Retrieval: To Be Scheduled

Relevant Payloads: LDEF-1, SSIP

Experiments:

Flight: STS 41-C (LDEF-1)

Experiment Title: Free-Flyer Biostack Experiment

Principal Investigator: Horst Bücker
Affiliation: DFVLR, Cologne
Country: Federal Republic of Germany

Sponsor: DFVLR, Federal Republic of Germany

Developer: DFVLR, Federal Republic of Germany

Management and Integration: LDEF Project Office, NASA LaRC

Location of Experiment: in orbit on LDEF

Species Studied: bacteria, Bacillus subtilis; tobacco, Nicotiana tabacum; corn, Zea mays; fungi, Sordaria fimicola; rice; brine shrimp, Artemia salina; Arabidopsis thaliana

Objectives of Experiment: The object of this series of experiments was to study the effects of cosmic radiation (HZE particles, etc.) on a number of biological specimens in space. The hazards of cosmic radiation to humans are of particular concern.

Description: Monolayers of various biological specimens (biomolecules such as rhodopsin, bacterial spores, plant seeds, fungal ascospores, and brine shrimp cysts) and nuclear track detectors were mounted in special trays. After retrieval of the LDEF, the biological effects will be correlated with the radiation doses received by the specimens. The results will be compared with those of ground-based experiments in accelerators on Earth.

Results: The LDEF has not been retrieved, and the retrieval mission has not been scheduled yet.

References:

Clark, L.G. et al. (eds.). The Long Duration Exposure Facility (LDEF): Mission 1 Experiments. NASA SP-473. Washington, D.C.: NASA, 1984.

Flight: STS 41-C (LDEF-1)

Experiment Title: Space-Exposed Experiments Developed for Students (SEEDS)

Principal Investigator: Doris K. Grigsby
Affiliation: Public Affairs Div., Office of External Relations, NASA HQ
Country: U.S.

Sponsor: Public Affairs Div., Office of External Relations, NASA HQ; George W. Park Seed Co., Inc.

Developer: Public Affairs Div., Office of External Relations, NASA HQ; George W. Park Seed Co., Inc.

Management and Integration: LDEF Project Office, NASA LaRC

Experiment Location: in orbit on LDEF

Species Studied: tomato

Objectives of Experiment: The object was to give students the opportunity to participate in evaluating seed survivability in space and to determine possible mutations by growing tomatoes from the seeds after they are returned to Earth.

Description: From 11-12 million tomato seeds were stored on the LDEF in five sealed containers in a tray. Radiation dosimeters were also placed in the containers. Control seeds were maintained on Earth to be evaluated along with the space-exposed seeds after the LDEF retrieval. The George W. Park Seed Co., Inc. will package the seeds for distribution to interested teachers and students. Each package will contain test and control seeds for experiments, on which the students will write reports for NASA.

Results: The LDEF has not been retrieved, and the retrieval mission has not been scheduled yet.

References:

Clark, L.G. et al. (eds.). The Long Duration Exposure Facility (LDEF): Mission 1 Experiments. NASA SP-473. Washington, D.C.: NASA, 1984.

Flight: STS 41-C (LDEF-1)

Experiment Title: Seeds in Space Experiment

Principal Investigator: George B. Park, Jr. and Jim A. Alston
Affiliation: George W. Park Seed Co., Inc., Greenwood, SC
Country: U.S.

Sponsor: Park Seed Co., Inc., Greenwood, SC

Developer: Park Seed Co., Inc., Greenwood, SC

Management and Integration: LDEF Project Office, NASA LaRC

Experiment Location: in orbit on LDEF

Species Studied: plant seeds (many varieties)

Objectives of Experiment: Data are needed on the effects of space exposure on seeds, future seed germination and mutation rates, and on how seeds must be packaged for survival on space missions.

Description: About two million seeds were stored on the LDEF under sealed and vented conditions. Radiation dosimeters were placed between the layers of seeds. After the LDEF is retrieved, the seeds will be germinated along with unexposed control seeds of each variety. The germination and development of the plants will be monitored for possible abnormalities.

Results: The LDEF has not been retrieved, and the retrieval mission has not been scheduled yet.

References:

Clark, L.G. et al. (eds.). The Long Duration Exposure Facility (LDEF): Mission 1 Experiments. NASA SP-473. Washington, D.C.: NASA, 1984.

Flight: STS 41-C (LDEF-1)

Experiment Title: A Comparison of Honeycomb Structures Built by Apis millifera (SE82-17)

Principal Investigator: Dan M. Poskevich
Affiliation: Waverly Central High School, Waverly, TN
Country: U.S.

Science Advisor: Mel Coplin, Coplin Bee Farms, Arcadia, TX

Sponsor: SSIP, OSF, NASA HQ; Honeywell

Developer: Honeywell

Management and Integration: Man-Systems Div., NASA JSC

Experiment Location: middeck

Species Studied: Italian honeybee, Apis millifera

Objectives of Experiment: The object was to see if bees could build a normal honeycomb in space.

Description: A colony of 3500 bees was flown in the middeck area of the shuttle. A comparison group of bees on Earth was used.

Results: The bees in space produced 30 square inches of normal honeycomb during the 1-week flight; the ground-based controls produced a much smaller comb. The space bees were able to walk, float, fly, and link into a chain of bees 10 inches long. The queen produced 35 eggs in the honeycomb.

References:

Of balls and bees in zero-G. Science 84 p. 12.

Committee on Science and Technology (U.S. House). Results of Space Shuttle Flight 41-C. Hearing before the Committee on Science and Technology, 98th Congress, 2nd Session, No. 83. Washington, D.C.: Government Printing Office, 1984.

STS 41-G

Launch Date: October 5, 1984

Landing Date: October 13, 1984

Relevant Payloads: CANEX (SASSE), GAS

Experiments:

Flight: STS 41-G

Experiment Title: Comparative and Morphological Study of the Radish Root System (G-007)

Principal Investigator: Guy A. Smith (student); Konrad Dannenberg
Affiliation: Johnson Environmental and Energy Center, University of Alabama Huntsville; Alabama Space and Rocket Center, Huntsville, AL
Country: U.S.

Sponsor: GAS Program, OSF, NASA HQ; Alabama Space and Rocket Center, Huntsville, AL (cosponsors--American Institute of Aeronautics and Astronautics; Alabama A&M; University of Alabama Huntsville)

Developer: Alabama Space and Rocket Center, Huntsville, AL; Marshall Amateur Radio Club, Huntsville, AL; University of Alabama Huntsville

Management and Integration: Special Payloads Div., NASA GSFC

Experiment Location: GAS adapter beam in cargo bay

Species Studied: radish

Objectives of Experiment: The objective was to study the effects of space on the primary root system of radish seeds.

Description: Radish seeds were flown as a student Get Away Special. The seeds were placed on filter paper on the ground. A pump was to send water and fertilizer to the seeds, once the Shuttle was in orbit, to stimulate germination. Another pump was to apply a buffered formaldehyde solution to the seedlings 120 hours later to preserve them for postflight analysis.

Results: The experimental apparatus was never activated during the mission. Therefore, no results were obtained. This experiment was reflown later on STS-61C.

References:

STS 41-G Information Summary. U.S. Govt. Memorandum SD2/84-T44. NASA JSC, September 6, 1984.

Prouty, C.R. (ed.). 1984 Get Away Special Experimenter's Symposium. NASA CP-2324. Washington, D.C.: NASA, 1984.

Thomas, L.R. and F.L. Mosier (eds.). 1985 Get Away Special Experimenter's Symposium. NASA CP-2401. Washington, D.C.: NASA, 1985.

Flight: STS 41-G

Experiment Title: Assessment of Proprioceptive Illusions

Principal Investigator: Douglas Watt
Affiliation: McGill U, Montreal
Country: Canada

Sponsor: National Research Council of Canada (cooperative agreement with Life Sciences Div., OSSA, NASA HQ)

Developer: McGill U, Montreal, Canada

Management and Integration: Flight Projects Engineering Office, NASA JSC; Shuttle Payload Engineering Div., OSSA, NASA HQ

Experiment Location: middeck

Species Studied: human

Objectives of Experiment: This experiment was to determine if there are any proprioceptive illusions during or after spaceflight and if the mechanism of efference copy is disrupted by prolonged weightlessness.

Description: Data on illusions of the world moving, particularly the phase relationship and degree of the apparent movement relative to the limb or eye movement, were recorded by a male crew member while performing various movements (deep knee bends, arm bends, eye movements, etc,).

Results: The only illusion recorded was when the arms were used to move toward the rail and back. The illusion was that the rail was moving toward the subject and was present only going toward the rail and with eyes closed. No evidence of adaptation was observed during the flight.

References:

STS 41-G Information Summary. U.S. Govt. Memorandum SD2/84-T44. NASA JSC, September 6, 1984.

Chambers, L.P. (Life Sciences Div., NASA HQ). Preliminary results of Canadian and Hungarian STS 41-G mission. Memorandum. Washington, D.C.: NASA, December 7, 1984.

Flight: STS 41-G

Experiment Title: Awareness of Limb Position

Principal Investigator: Douglas Watt
Affiliation: McGill U, Montreal
Country: Canada

Sponsor: National Research Council of Canada (cooperative agreement with Life Sciences Div., OSSA, NASA HQ)

Developer: McGill U, Montreal, Canada

Management and Integration: Flight Projects Engineering Office, NASA JSC; Shuttle Payload Engineering Div., OSSA, NASA HQ

Experiment Location: middeck

Species Studied: human

Objectives of Experiment: The purpose of the experiment was to measure changes in perception of the external world under blindfolded and weightless conditions; the time course of the perceptual changes during flight was also noted.

Description: Crew member subjects viewed various target locations and then were asked to point to the targets with a light pointer while blindfolded.

Results: Both subjects were very inaccurate in the pointing experiment while in orbit for the duration of the flight.

References:

STS 41-G Information Summary. U.S. Govt. Memorandum SD2/84-T44. NASA JSC, September 6, 1984.

Chambers, L.P. (Life Sciences Div., NASA HQ). Preliminary results of Canadian and Hungarian STS 41-G mission. Memorandum. Washington, D.C.: NASA, December 7, 1984.

Flight: STS 41-G

Experiment Title: Gastrointestinal Gas Elimination

Principal Investigator: Douglas Watt
Affiliation: McGill U, Montreal
Country: Canada

Sponsor: National Research Council of Canada (cooperative agreement with Life Sciences Div., OSSA, NASA HQ)

Developer: McGill U, Montreal, Canada

Management and Integration: Flight Projects Engineering Office, NASA JSC; Shuttle Payload Engineering Div., OSSA, NASA HQ

Experiment Location: middeck

Species Studied: human

Objectives of Experiment: The object was to see if the elimination of intestinal gas is more difficult in weightlessness.

Description: A male crew member swallowed air, then tried to eliminate it by mouth. The occurrence of belching or flatulence was recorded during the flight.

Results: To be included (if available) in next edition.

References:

STS 41-G Information Summary. U.S. Govt. Memorandum SD2/84-T44. NASA JSC, September 6, 1984.

Chambers, L.P. (Life Sciences Div., NASA HQ). Preliminary results of Canadian and Hungarian STS 41-G mission. Memorandum. Washington, D.C.: NASA, December 7, 1984.

Flight: STS 41-G

Experiment Title: Measurements of Vestibulo-Ocular Reflex (VOR) Gain

Principal Investigator: Douglas Watt
Affiliation: McGill U, Montreal
Country: Canada

Sponsor: National Research Council of Canada (cooperative agreement with Life Sciences Div., OSSA, NASA HQ)

Developer: McGill U, Montreal, Canada

Management and Integration: Flight Projects Engineering Office, NASA JSC; Shuttle Payload Engineering Div., OSSA, NASA HQ

Experiment Location: middeck

Species Studied: human

Objectives of Experiment: The objective was to study basic aspects of nervous system adaptation to microgravity.

Description: The VOR gain (Head Deviation-Gaze Deviation/Head Deviation) was calculated from data gathered by the payload specialist. Data were collected from experiments in which the subject recorded the point of his eye gaze (via a beam of light pointer) on a scale 3-4 feet ahead of him before and after rotating his head 10-15 degrees left, right, up, and down, while trying to keep his gaze at the original point.

Results: No evidence of VOR gain (before, during, or after the flight) was observed.

References:

STS 41-G Information Summary. U.S. Govt. Memorandum SD2/84-T44. NASA JSC, September 6, 1984.

Chambers, L.P. (Life Sciences Div., NASA HQ). Preliminary results of Canadian and Hungarian STS 41-G mission. Memorandum. Washington, D.C.: NASA, December 7, 1984.

Flight: STS 41-G

Experiment Title: Pre- and Postflight Testing

Principal Investigator: Douglas Watt
Affiliation: McGill U, Montreal
Country: Canada

Sponsor: National Research Council of Canada (cooperative agreement with Life Sciences Div., OSSA, NASA HQ)

Developer: McGill U, Montreal, Canada

Management and Integration: Flight Projects Engineering Office, NASA JSC; Shuttle Payload Engineering Div., OSSA, NASA HQ

Experiment Location: middeck

Species Studied: human

Objectives of Experiment: The objective was to generate data from provocative ground testing on space motion sickness.

Description: Tests on VOR (Vestibulo-Ocular Reflex) gain, proprioceptive illusions, sensory function, and awareness of position were to be performed on crew members 12, 6, and 2 weeks preflight and on days 0, 1, and 7 postflight.

Results: To be included (if available) in next edition.

References:

STS 41-G Information Summary. U.S. Govt. Memorandum SD2/84-T44. NASA JSC, September 6, 1984.

Chambers, L.P. (Life Sciences Div., NASA HQ). Preliminary results of Canadian and Hungarian STS 41-G mission. Memorandum. Washington, D.C.: NASA, December 7, 1984.

Flight: STS 41-G

Experiment Title: Studies of Space Motion Sickness

Principal Investigator: Douglas Watt
Affiliation: McGill U, Montreal
Country: Canada

Sponsor: National Research Council of Canada (cooperative agreement with Life Sciences Div., OSSA, NASA HQ)

Developer: McGill U, Montreal, Canada

Management and Integration: Flight Projects Engineering Office, NASA JSC; Shuttle Payload Engineering Div., OSSA, NASA HQ

Experiment Location: middeck

Species Studied: human

Objectives of Experiment: The purpose was to measure the time course of space motion sickness symptoms.

Description: Symptoms of, therapy for, and recovery from space motion sickness were recorded during spaceflight.

Results: The payload specialist did not experience motion sickness and did not do the provocative testing. A preflight test using magnifying lenses over the eyes was able to predict that the subject was not susceptible to motion sickness. This indicated that a type of visual modification test may be useful in predicting motion sickness susceptibility.

References:

STS 41-G Information Summary. U.S. Govt. Memorandum SD2/84-T44. NASA JSC, September 6, 1984.

Chambers, L.P. (Life Sciences Div., NASA HQ). Preliminary results of Canadian and Hungarian STS 41-G mission. Memorandum. Washington, D.C.: NASA, December 7, 1984.

Flight: STS 41-G

Experiment Title: Survey of Sensory Function

Principal Investigator: Douglas Watt
Affiliation: McGill U, Montreal
Country: Canada

Sponsor: National Research Council of Canada (cooperative agreement with Life Sciences Div., OSSA, NASA HQ)

Developer: McGill U, Montreal, Canada

Management and Integration: Flight Projects Engineering Office, NASA JSC; Shuttle Payload Engineering Div., OSSA, NASA HQ

Experiment Location: middeck

Species Studied: human

Objectives of Experiment: The object was to detect alterations in tactile or proprioceptive functions during weightlessness.

Description: Tactile acuity and proprioceptive ability were measured in an arm and a leg of crew subjects.

Results: No changes in tactile acuity in arms or legs were observed during flight, indicating that the nerves were functioning normally. Major changes were noted in proprioceptive functions, particularly with limbs relaxed. The subjects could not detect the locations of their limbs upon waking with their eyes closed and at other times during passive arm or leg movements.

References:

STS 41-G Information Summary. U.S. Govt. Memorandum SD2/84-T44. NASA JSC, September 6, 1984.

Chambers, L.P. (Life Sciences Div., NASA HQ). Preliminary results of Canadian and Hungarian STS 41-G mission. Memorandum. Washington, D.C.: NASA, December 7, 1984.

Flight: STS 41-G

Experiment Title: Tests of Taste Sensitivity

Principal Investigator: Douglas Watt
Affiliation: McGill U, Montreal
Country: Canada

Sponsor: National Research Council of Canada (cooperative agreement with Life Sciences Div., OSSA, NASA HQ)

Developer: McGill U, Montreal, Canada

Management and Integration: Flight Projects Engineering Office, NASA JSC; Shuttle Payload Engineering Div., OSSA, NASA HQ

Experiment Location: middeck

Species Studied: human

Objectives of Experiment: The purpose was to determine if taste sensitivity is affected by microgravity.

Description: The payload specialist tasted various substances and measured the detection threshold for sweet, bitter, salty, and sour compared with the taste of distilled water.

Results: To be included (if available) in next edition.

References:

STS 41-G Information Summary. U.S. Govt. Memorandum SD2/84-T44. NASA JSC, September 6, 1984.

Chambers, L.P. (Life Sciences Div., NASA HQ). Preliminary results of Canadian and Hungarian STS 41-G mission. Memorandum. Washington, D.C.: NASA, December 7, 1984.

STS 51-C

Launch Date: January 24, 1985

Landing Date: January 27, 1985

Relevant Payloads: ARC (NASA)

Experiment:

Flight: STS 51-C

Experiment Title: Aggregation of Human Red Blood Cells (ARC)

Principal Investigator: Leopold Dintenfass
Affiliation: Kanematsu Institute, U Sidney
Country: Australia

Sponsor: Microgravity Science and Applications Div., OSSA, NASA HQ (cooperative agreement with Dept. of Science and Technology, Australia)

Developer: Kanematsu Institute, U Sidney, Australia

Management and Integration: Spacelab Payloads Project Office, NASA MSFC; Shuttle Payload Engineering Div., OSSA, NASA HQ

Experiment Location: middeck

Species Studied: human (blood)

Objectives of Experiment: The object was to determine if blood coagulation is regulated by gravity and to improve blood tests for various human diseases. Red blood cell (RBC) aggregation increases in certain diseases (e.g. heart disease, diabetes, and cancer). Gravity affects buoyancy and sedimentation of blood, so that it may be more meaningful to study RBC aggregation in microgravity.

Description: Eight blood samples from healthy people and from people with cancer of the colon, diabetes, hypertension, heart disease, cystic kidneys, hepatitis, and multiple myeloma were flown. The effects of weightlessness on various coagulation mechanisms (RBCs, antibodies, etc.) were studied and compared with those of control blood samples from healthy humans. The blood samples were drawn the day before Shuttle launch and stored at 4°C. The samples were passed through a viscometer, a device that measures and records blood viscosity. Photographs of RBC aggregates in the samples were taken by two 35 mm cameras for postflight analysis. An identical experiment was conducted on the ground for comparison purposes.

Results: To be included (if available) in next edition.

References:

Blood cell experiment carried on 51-C flight. NASA Activities 16(2):11-12, February 1985.

Shuttle mission to include blood test. The Washington Post January 14, 1985.

Dintenfass, L., P. Osman, and B. Maguire. Measurement of aggregation of red cells in space--A project for the NASA Space Shuttle. Journal of Electrical and Electronics Engineering, Australia 4:118-125, 1984.

Mission Operation Report No. E-420-51-C-12. Washington, D.C.: Headquarters Administration Division, NASA HQ, 1985.

STS 51-D

Launch Date: April 12, 1985

Landing Date: April 19, 1985

Relevant Payloads: AFE, SSIP

Experiments:

Flight: 51-D (was 51-E)

Experiment Title: Statoliths in Corn Root Caps (SE82-03)

Principal Investigator: Sean M. Amberg
Affiliation: Seward High School, Seward, NE
Country: U.S.

Science Advisor: Harold Papazian, Martin Marietta Aerospace, Denver, CO

Sponsor: SSIP, OSF, NASA HQ; Martin Marietta Aerospace, Denver, CO

Developer: Martin Marietta Aerospace, Denver, CO

Management and Integration: Man-Systems Div., NASA JSC

Experiment Location: middeck

Species Studied: corn

Objectives of Experiment: The object of this student experiment was to study the effects of microgravity on the gravity sensing mechanism (statoliths) of corn.

Description: Corn plants with capped roots and without capped roots were flown. The changes in the statoliths in the root caps were examined by electron microscopy postflight.

Results: To be included (if available) in next edition.

References:

Bowie, M.L. Space Shuttle Student Involvement Program (Experiment Status/Update). Washington, D.C.: NASA, March 15, 1985.

Flight: STS 51-D (was 51-E)

Experiment Title: American Flight Echocardiograph (AFE)

Principal Investigator: Michael W. Bungo
Affiliation: Medical Sciences Div., NASA JSC
Country: U.S.

Sponsor: Life Sciences Div., OSSA, NASA HQ

Developer: Medical Sciences Div., NASA JSC

Management and Integration: Shuttle Payload Engineering Div., OSSA, NASA HQ

Experiment Location: middeck

Species Studied: human

Objectives of Experiment: This experiment gathered human data on cardiovascular deconditioning.

Description: Daily echocardiograph (an ultrasonic scanner of the cardiovascular system) readings were taken from four crew members.

Results: Inflight echocardiograph data showed that both heart rate and mean blood pressure increased by 20%, whereas heart size decreased (i.e., a 35% decrease in right ventricular size) during spaceflight. Stroke volume index and left ventricular diastolic volume index increased the first day of the mission and then decreased to below normal for the rest of the flight. Cardiac index increased 85% the first day inflight, followed by normal preflight levels for the rest of the flight, and then a 59% increase postflight. After landing, normal cardiovascular functioning returned in about a week.

References:

Life Sciences Division, Office of Space Science and Applications, NASA Headquarters. Life Sciences Accomplishments. NASA TM-88177. Washington, D.C.: NASA, 1985, pages 18-19..

Life Sciences Advisory Committee. Report #4. Life Sciences Div., OSSA, NASA HQ, July 18-19, 1985, pages 8-9.

Shuttle mission 51-D--prelaunch profile. NASA Activities 16(3):10, March 1985.

Flight: 51-D (was 51-E)

Experiment Title: The Effect of Weightlessness on the Aging of Brain Cells (SE83-03)

Principal Investigator: Andrew I. Fras
Affiliation: Binghamton High School, Binghamton, NY
Country: U.S.

Science Advisor: G. June Marshall, U Southern California Orthopedic Hospital, Los Angeles, CA

Sponsor: SSIP, OSF, NASA HQ; U Southern California Orthopedic Hospital, Los Angeles, CA

Developer: U Southern California Orthopedic Hospital, Los Angeles, CA

Management and Integration: Man-Systems Div., NASA JSC

Experiment Location: middeck

Species Studied: housefly

Objectives of Experiment: The object of this student experiment was to study the relationship between microgravity and aging. Disuse atrophy during spaceflight appears to be similar to some effects of aging. Brain deterioration due to microgravity would represent a serious threat to astronaut health.

Description: Approximately 300 houseflies were flown in a Fly Enclosure Module. Postflight studies were done to determine if there is an increased accumulation of age pigment in and deterioration of the fly brain cells.

Results: To be included (if available) in next edition.

References:

Bowie, M.L. Space Shuttle Student Involvement Program (Experiment Status/Update). Washington, D.C.: NASA, March 15, 1985.

Shuttle Mission 51-D--Pre-Launch Profile. NASA Activities 16(3):10-11, March 1985.

STS 51-B

Launch Date: April 29, 1985

Landing Date: May 6, 1985

Relevant Payloads: Spacelab 3 (NASA)

Experiments:

Flight: Spacelab 3

Experiment Title: Dynamic Environment Measurement System (DEMS)

Principal Investigator: Paul Callahan; Christopher Schatte
Affiliation: Life Sciences Flight Experiments Project Office, NASA ARC
Country: U.S.

Sponsor: Life Sciences Flight Experiments Project Office, NASA ARC

Developer: Life Sciences Flight Experiments Project Office, NASA ARC

Management and Integration: Spacelab Payloads Project Office, NASA MSFC; Shuttle Payload Engineering Div., OSSA, NASA HQ

Experiment Location: Spacelab

Species Studied: none

Objectives of Experiment: The objective was to monitor environmental conditions in the Research Animal Holding Facility during the ascent and descent phases of the flight for interpretation of experimental data.

Description: The Dynamic Environment Measurement System recorded acoustic noise, vibration, and acceleration on magnetic tapes during launch, reentry, and landing.

Results: The DEMS unit performed nominally during the mission. No anomalies or operational problems were reported by the crew when changing recording tapes or activating the unit. Data are being reduced to verify performance of the unit and to correlate environmental stresses with reactions of the animals and performance of the hardware.

References:

Ames Research Center Life Sciences Payload, Spacelab 3, April 29, 1985, 60 Day Report. Moffett Field, CA: NASA Ames Research Center, July 26, 1985.

Spacelab 3. Marshall Space Flight Center, AL: NASA, 1984.

Flight: Spacelab 3

Experiment Title: Autogenic Feedback Training (AFT)

Principal Investigator: Patricia S. Cowings
Affiliation: Neurosciences Branch, Life Sciences Div., NASA ARC
Country: U.S.

Sponsor: Life Sciences Flight Experiments Project Office, NASA ARC

Developer: Life Sciences Flight Experiments Project Office, NASA ARC

Management and Integration: Spacelab Payloads Project Office, NASA MSFC; Shuttle Payload Engineering Div., OSSA, NASA HQ

Experiment Location: middeck

Species Studied: human

Objectives of Experiment: The objectives were to test the effectiveness of AFT as a countermeasure for Space Adaptation Syndrome (SAS), to predict inflight susceptibility based on preflight data, and to determine similarities between SAS and motion sickness on Earth.

Description: Two crew members who constituted the test group received preflight training in the recognition and control of motion sickness symptoms. The training consisted of the use of biofeedback techniques to counteract these symptoms while wearing electronic monitors for recording physiological data (sweat, pulse, heart rate, and respiration rate). During spaceflight, the test subjects wore the monitors in an undergarment and an accelerometer on the head to measure head and body movements. Data were recorded continuously over the first five days of the mission. Subjective reports of symptoms were also recorded. Controls consisted of two crew members who wore the physiological monitors but who did not receive autogenic feedback training.

Results: The performance of one of the test subjects was about average. This subject, who had shown significant improvement in ground-based tests, exhibited a low heart rate and little sweating, which were indicative of a lack of stress. The second test subject did not fare as well and showed less ability to control his physiological responses; this subject experienced one motion sickness episode. Results obtained to date were considered encouraging.

References:

Spacelab 3. Marshall Space Flight Center, AL: NASA, 1984.

Flight: Spacelab 3

Experiment Title: Urine Monitoring Investigation (UMI)

Principal Investigator: Carolyn S. Leach
Affiliation: Medical Sciences Div., NASA JSC
Country: U.S.

Sponsor: Medical Sciences Div., NASA JSC

Developer: Medical Sciences Div., NASA JSC

Management and Integration: Spacelab Payloads Project Office, NASA MSFC; Shuttle Payload Engineering Div., OSSA, NASA HQ

Experiment Location: middeck

Species Studied: human

Objectives of Experiment: The object was to test the Urine Monitoring System for its use in future missions. This system was developed to monitor crew water intake and urine output, in order to study fluid balance changes due to weightlessness.

Description: The Urine Monitoring System was installed near the waste collection system for collecting and measuring urine samples. Urine samples from one crew member were stored for postflight urinalyses.

Results: This test identified several problems in the Urine Collection System. The problems are currently being resolved for modification for future tests.

References:

Johnson, F.S., Jr. (NASA HQ, Public Affairs). Preliminary results from STS 51-B Spacelab 3 mission. NASA Correspondence Control #E851651. May 15, 1985.

Spacelab 3. Marshall Space Flight Center, AL: NASA, 1984.

Flight: Spacelab 3

Experiment Title: Biotelemetry System (BTS)

Principal Investigator: Christopher Schatte
Affiliation: Life Sciences Flight Experiments Project Office, NASA ARC
Country: U.S.

Sponsor: Life Sciences Flight Experiments Project Office, NASA ARC

Developer: Life Sciences Flight Experiments Project Office, NASA ARC

Management and Integration: Spacelab Payloads Project Office, NASA MSFC; Shuttle Payload Engineering Div., OSSA, NASA HQ

Experiment Location: Spacelab

Species Studied: rat

Objectives of Experiment: The objective was to test the Biotelemetry System in rats.

Description: The Biotelemetry System monitors deep body temperature, electrocardiogram, and heart rate in animals that have had wireless sensors surgically implanted prior to launch. The signals from the sensors are sent to an onboard microcomputer. The sensors were implanted in four rats housed in the Research Animal Holding Facility (RAHF).

Results: The BTS performed well and the data obtained were of high reliability and accuracy. Implanted rats appeared to tolerate the implants well. Heart rate counts were of such a quality that one rat was monitored for stress indications. Minor problems that were encountered were attributed to data links and not to the BTS hardware.

References:

Ames Research Center Life Sciences Payload, Spacelab 3, April 29, 1985, 60 Day Report. Moffett Field, CA: NASA Ames Research Center, July 26, 1985.

O'Toole, T.O. Shuttle begins science flight: minor but annoying glitches crop up after launching. The Washington Post, April 30, 1985, p. A7, cols. 1-6.

Spacelab 3. Marshall Space Flight Center, AL: NASA, 1984.

Flight: Spacelab 3

Experiment Title: Research Animal Holding Facilities (RAHF--Rodent, Primate)

Principal Investigator: Christopher Schatte
Affiliation: Life Sciences Flight Experiments Project Office, NASA ARC
Country: U.S.

Sponsor: Life Sciences Flight Experiments Project Office, NASA ARC

Developer: Life Sciences Flight Experiments Project Office, NASA ARC

Management and Integration: Spacelab Payloads Project Office, NASA MSFC; Shuttle Payload Engineering Div., OSSA, NASA HQ

Experiment Location: Spacelab

Species Studied: rat; squirrel monkey, Saimiri sciureus

Objectives of Experiment: The objectives were to evaluate the environmental conditions of the RAHF to determine its safety and adequacy for housing animals during spaceflight and to study physiological, behavioral, and morphological changes of animals exposed to microgravity.

Description: The experiment tested two RAHFs, one with two squirrel monkeys and the other with 24 rats. Environmental conditions (temperature, humidity, water pressure, etc.) inside the RAHFs were monitored electronically. The animals were watched for physiological and behavioral changes during spaceflight.

Results: All rats and monkeys were maintained in a healthy condition during the flight, demonstrating that research can be conducted safely on these species in space. The rats (as in previous flights) did not appear to experience space motion sickness. Among the many physiological parameters measured in the rats, most notable was the marked loss of muscle mass and increased fragility of long bones. These changes appear to be related to microgravity and not stress-induced by the RAHF. Other rat findings included suppressed interferon production by spleen cells, defective release of growth hormone, possible dissociation of circadian pacemakers, changes in hepatic lipid and carbohydrate metabolism, hypersensitivity of marrow cells to erythropoietin, and reduction in the number of spermatagonial cells in the testes. One monkey exhibited some of the same space sickness symptoms (lethargy, loss of appetite, but no observed vomiting) as humans for the first 4 days of the mission. This

monkey then recovered completely, as observed in humans with space adaptation syndrome. The second monkey adapted more rapidly to space and showed no symptoms of motion sickness. Both the rats and the monkeys showed normal behavior, indicating a positive adjustment to spaceflight.

References:

Callahan P.X., C. Schatte, G. Bowman, R.E. Grindeland, G.A. Funk, W.A. Lenck, and W.E. Berry. Ames Research Center Life Sciences Payload: Overview of Results of a Spaceflight of 24 Rats and 2 Monkeys. AIAA 24th Aerospace Sciences Meeting, January 6-9, 1986, Reno, Nevada, AIAA Paper 86-0583.

Fast, T., R. Grindeland, M. Ruder, M. Vasques, P. Lundgren, S. Scibetta, J. Tremor, P. Buckendahl, L. Keil, O. Chee, T. Reilly, B. Dalton, and P. Callahan. Rat maintenance in the Research Animal Holding Facility (RAHF) during the flight of Spacelab 3. The Physiologist 28(4):375, August 1985. [abstract]

Fuller, C.A. Early adaptation to altered gravitational environments in the squirrel monkey. The Physiologist 28(4): 377, August 1985. [abstract]

Johnson, F.S., Jr. (Public Affairs, NASA HQ). Preliminary results from STS 51-B Spacelab 3 mission. NASA Correspondence Control #E851651. May 15, 1985.

Schatte, C., R. Grindeland, P. Callahan, W. Berry, G. Funk, and W. Lencki. Animal studies on Spacelab-3. In: Proceedings of the 2nd International Conference on Space Physiology, Toulouse, France, November 20-22, 1985 (ESA SP-237). Noordwijk, The Netherlands: European Space Agency, pp. 197-202, 1986.

Spacelab 3. Marshall Space Flight Center, AL: NASA, 1984.

Spacelab-3 Bioscience Mission Results. In: Proceedings of the Seventh Annual Meeting of the IUPS Commission on Gravitational Physiology. The Physiologist 28(6,Suppl.): S-187-S-236, 1985.

STS 51-G

Launch Date: June 17, 1985

Landing Date: June 24, 1985

Relevant Payloads: FPE and FEE (France), GAS

Experiments:

Flight: STS 51-G

Experiment Title: French Postural Experiment (FPE)

Principal Investigator: A. Berthoz
Affiliation: Centre National de Recherche Scientifique (CNRS), Paris
Country: France

Sponsor: Centre National d'Etudes Spatiales (CNES) (cooperative agreement with Life Sciences Div., OSSA, NASA HQ)

Developer: CNES, France

Management and Integration: Flight Projects Engineering Office, NASA JSC; Shuttle Payload Engineering Div., OSSA, NASA HQ

Experiment Location: middeck

Species Studied: human

Objectives of Experiment: The objective was to obtain data on sensorimotor adaptation (muscle tone, posture, orientation, and movement) to microgravity.

Description: Muscle movement and the role of vision during postural control, and modifications of the optokinetic nystagmus and the vestibulo-ocular reflex were monitored in crew members, using tape recorders, photography, and biomechanical sensors.

Results: Key results include: (a) the tonic activity responsible for upright standing posture is delivered by the flexor muscle of the ankle joint in microgravity, while it is mainly due to the action of the extensor muscle on Earth; (b) a preponderant role of vision on general body tilt angle starting from the second day of microgravity was observed; (c) significant modifications of vertical and horizontal optokinetic nystagmus were observed at the beginning of the flight and on return to Earth; and (d) there was a strong decrease in vestibulo-ocular reflex gain during active head motion in microgravity, in both the horizontal and vertical planes.

References:

Mission Operation Report No. E-420-51-G-17. Washington, D.C.: Headquarters Administration Div., NASA HQ, 1985.

Clement, G., T. Vieville, F. Lestienne, and A. Berthoz. Preliminary results of the 'Equilibrium and Vertigo' experiment performed during STS 51-G shuttle flight. In: Proc. of the 2nd Intl. Conf. on Space Physiology, Toulouse, France, Nov. 20-22, 1985 (ESA SP-237). Noordwijk, The Netherlands: ESA, pp. 129-135, 1986.

Flight: STS 51-G

Experiment Title: Growth of Lettuce Seeds (G-0034)

Principal Investigator: David Bowden
Affiliation: El Paso/Ysleta Schools, TX
Country: U.S.

Sponsor: GAS Program, OSF, NASA HQ; El Paso/Ysleta Schools, TX; Richard N. Azar, El Paso, TX

Developer: El Paso/Ysleta Schools, TX; hardware: Farah Manufacturing, El Paso; El Paso Natural Gas; Whaller Specialties; Falco Machine & Tool Co.; El Paso Electric Co.

Management and Integration: Special Payloads Div., NASA GSFC

Experiment Location: GAS adapter beam in cargo bay

Species Studied: lettuce, Lactuca sativa

Objectives of Experiment: The object was to observe the ability of lettuce to germinate in microgravity.

Description: Lettuce seeds were allowed to germinate in space. The resulting seedlings were analyzed postflight for general degree of health, root structure, and amount of biomass produced.

Results: To be included (if available) in next edition.

References:

Prouty, C.R. (ed.). 1984 Get Away Special Experimenter's Symposium. NASA CP-2324. Washington, D.C.: NASA, 1984.

Flight: STS 51-G

Experiment Title: Seed Germination (G-0034)

Principal Investigator: Gisele Bryant
Affiliation: El Paso/Ysleta Schools, TX
Country: U.S.

Sponsor: GAS Program, OSF, NASA HQ; El Paso/Ysleta Schools, TX; Richard N. Azar, El Paso, TX

Developer: El Paso/Ysleta Schools, TX; hardware: Farah Manufacturing, El Paso; El Paso Natural Gas; Whaller Specialties; Falco Machine & Tool Co.; El Paso Electric Co.

Management and Integration: Special Payloads Div., NASA GSFC

Experiment Location: GAS adapter beam in cargo bay

Species Studied: barley

Objectives of Experiment: The object was to study genetic changes in barley germinated in microgravity.

Description: Barley seeds were allowed to germinate in space. The seedlings were examined for genetic changes postflight, and a genetic study of the next generation was planned.

Results: To be included (if available) in next edition.

References:

Prouty, C.R. (ed.). 1984 Get Away Special Experimenter's Symposium. NASA CP-2324. Washington, D.C.: NASA, 1984.

Flight: STS 51-G

Experiment Title: Growth of Brine Shrimp (G-0034)

Principal Investigator: Donald R. Cake
Affiliation: El Paso/Ysleta Schools, TX
Country: U.S.

Sponsor: GAS Program, OSF, NASA HQ; El Paso/Ysleta Schools, TX; Richard N. Azar, El Paso, TX

Developer: El Paso/Ysleta Schools, TX; hardware: Farah Manufacturing, El Paso; El Paso Natural Gas; Whaller Specialties; Falco Machine & Tool Co.; El Paso Electric Co.

Management and Integration: Special Payloads Div., NASA GSFC

Experiment Location: GAS adapter beam in cargo bay

Species Studied: brine shrimp, Artemia

Objectives of Experiment: The experiment was designed to observe the effects of microgravity on the growth of brine shrimp.

Description: Brine shrimp were injected into a hatching chamber at 0, 24, 48, and 60 hours of the flight. Postflight analyses of growth and development of the shrimp were performed.

Results: To be included (if available) in next edition.

References:

Prouty, C.R. (ed.). 1984 Get Away Special Experimenter's Symposium. NASA CP-2324. Washington, D.C.: NASA, 1984.

Flight: STS 51-G

Experiment Title: Germination of Turnip Seeds (G-0034)

Principal Investigator: Priscillo Campos (G-0034)
Affiliation: El Paso/Ysleta Schools, TX
Country: U.S.

Sponsor: GAS Program, OSF, NASA HQ; El Paso/Ysleta Schools, TX; Richard N. Azar, El Paso, TX

Developer: El Paso/Ysleta Schools, TX; hardware: Farah Manufacturing, El Paso; El Paso Natural Gas; Whaller Specialties; Falco Machine & Tool Co.; El Paso Electric Co.

Management and Integration: Special Payloads Div., NASA GSFC

Experiment Location: GAS adapter beam in cargo bay

Species Studied: turnip

Objectives of Experiment: The experiment was designed to determine the germination rate, biomass, and cell structure of turnips grown in microgravity.

Description: Two hundred turnip seeds were allowed to germinate on wet paper towels in space for 5 days, after which they were preserved for postflight analyses.

Results: To be included (if available) in next edition.

References:

Prouty, C.R. (ed.). 1984 Get Away Special Experimenter's Symposium. NASA CP-2324. Washington, D.C.: NASA, 1984.

Flight: STS 51-G

Experiment Title: Planaria Regeneration (G-0034)

Principal Investigator: Monica Chavez
Affiliation: El Paso/Ysleta Schools, TX
Country: U.S.

Sponsor: GAS Program, OSF, NASA HQ; El Paso/Ysleta Schools, TX; Richard N. Azar, El Paso, TX

Developer: El Paso/Ysleta Schools, TX; hardware: Farah Manufacturing, El Paso; El Paso Natural Gas; Whaller Specialties; Falco Machine & Tool Co.; El Paso Electric Co.

Management and Integration: Special Payloads Div., NASA GSFC

Experiment Location: GAS adapter beam in cargo bay

Species Studied: brown planaria, Dugesia tigrina

Objectives of Experiment: The object was to study the effect of microgravity on cell regeneration in planaria.

Description: The 15 brown planaria were flown in a growth chamber for 5 days and then preserved for postflight analyses.

Results: To be included (if available) in next edition.

References:

Prouty, C.R. (ed.). 1984 Get Away Special Experimenter's Symposium. NASA CP-2324. Washington, D.C.: NASA, 1984.

Flight: STS 51-G

Experiment Title: Effectiveness of Antibiotics on Bacteria (G-0034)

Principal Investigator: Karen Herman
Affiliation: El Paso/Ysleta Schools, TX
Country: U.S.

Sponsor: GAS Program, OSF, NASA HQ; El Paso/Ysleta Schools, TX; Richard N. Azar, El Paso, TX

Developer: El Paso/Ysleta Schools, TX; hardware: Farah Manufacturing, El Paso; El Paso Natural Gas; Whaller Specialties; Falco Machine & Tool Co.; El Paso Electric Co.

Management and Integration: Special Payloads Div., NASA GSFC

Experiment Location: GAS adapter beam in cargo bay

Species Studied: bacteria (species unspecified)

Objectives of Experiment: The object was to compare the effectiveness of antibiotics on bacteria in microgravity versus normal gravity, which could have an impact on the health of humans during space travel.

Description: Lyophilized bacteria were injected into a nutrient solution and then sprayed onto agar. Two antibiotic discs were then attached to the agar surface. A photograph was taken of the agar plate 20 hours later for examination of the degree of bacterial growth postflight.

Results: To be included (if available) in next edition.

References:

Prouty, C.R. (ed.). 1984 Get Away Special Experimenter's Symposium. NASA CP-2324. Washington, D.C.: NASA, 1984.

Flight: STS 51-G

Experiment Title: Observing Growth of Soil Mold (G-0034)

Principal Investigator: Rebecca Lopez
Affiliation: El Paso/Ysleta Schools, TX
Country: U.S.

Sponsor: GAS Program, OSF, NASA HQ; El Paso/Ysleta Schools, TX; Richard N. Azar, El Paso, TX

Developer: El Paso/Ysleta Schools, TX; hardware: Farah Manufacturing, El Paso; El Paso Natural Gas; Whaller Specialties; Falco Machine & Tool Co.; El Paso Electric Co.

Management and Integration: Special Payloads Div., NASA GSFC

Experiment Location: GAS adapter beam in cargo bay

Species Studied: mold, *Mucor rouxii*

Objectives of Experiment: The experiment was designed to study the growth of soil mold in microgravity under both anaerobic and aerobic conditions, in order to learn more about the life cycle.

Description: Soil mold cultures were grown in two Plexiglas chambers, one with aerobic conditions and the other anaerobic. Photographs of the mold growth patterns were taken about 35 hours after introduction of the mold into the growth chambers.

Results: To be included (if available) in next edition.

References:

Prouty, C.R. (ed.). *1984 Get Away Special Experimenter's Symposium*. NASA CP-2324. Washington, D.C.: NASA, 1984.

Flight: STS 51-G

Experiment Title: Postflight Examination of Plant Genetic Structure (G-0034)

Principal Investigator: James Martinez
Affiliation: El Paso/Ysleta Schools, TX
Country: U.S.

Sponsor: GAS Program, OSF, NASA HQ; El Paso/Ysleta Schools, TX; Richard N. Azar, El Paso, TX

Developer: El Paso/Ysleta Schools, TX; hardware: Farah Manufacturing, El Paso; El Paso Natural Gas; Whaller Specialties; Falco Machine & Tool Co.; El Paso Electric Co.

Management and Integration: Special Payloads Div., NASA GSFC

Experiment Location: GAS adapter beam in cargo bay

Species Studied: plants (unspecified species) flown on STS 51-G

Objectives of Experiment: This was a postflight study of the genetics of the plants flown on STS 51-G.

Description: No additional plant species were included in this experiment, which was conducted postflight on the plants flown by the other El Paso/Ysleta, TX students as a Get Away Special (G-0034) on STS 51-G.

Results: To be included (if available) in next edition.

References:

Prouty, C.R. (ed.). 1984 Get Away Special Experimenter's Symposium. NASA CP-2324. Washington, D.C.: NASA, 1984.

Flight: STS 51-G

Experiment Title: French Echocardiograph Experiment (FEE)

Principal Investigator: L. Pourcelot
Affiliation: U Tours
Country: France

Sponsor: Centre National d'Etudes Spatiales (CNES) (cooperative agreement with Life Sciences Div., OSSA, NASA HQ)

Developer: CNES, France

Management and Integration: Flight Projects Engineering Office, NASA JSC; Shuttle Payload Engineering Div., OSSA, NASA HQ

Experiment Location: middeck

Species Studied: human

Objectives of Experiment: The objective was to obtain data on cardiovascular adaptation to microgravity.

Description: Cardiovascular data were collected on two of the crew using the French echocardiograph, a noninvasive ultrasonic device for imaging the heart and determining blood flow rates in major arteries.

Results: The results of the cardiovascular examination in weightlessness showed a decrease of cardiac output stroke volume and left ventricular diastolic volume; a decrease in cerebral circulatory resistance; and variations in peripheral resistance and vascular stiffness of the lower limbs, which are in accordance with orthostatic disturbances during the recovery period.

References:

Mission Operation Report No. E-420-51-G-17. Washington, D.C.: Headquarters Administration Div., NASA HQ, 1985.

Pourcelot, L., Ph. Arbeille, J.-M. Pottier, F. Patat, M. Berson, A. Roncin, Ch. le Toullee, A. Guell, and C. Gharib. Cardiovascular examination during STS 51G mission June 1985. In: Proceedings of the 2nd International Conference on Space Physiology, Toulouse, France, November 20-22, 1985 (ESA SP-237). Noordwijk, The Netherlands: European Space Agency, pp. 13-17, 1986.

Flight: STS 51-G

Experiment Title: Symbiotic Growth of Chlorella and Kefir in Microgravity (G-0034)

Principal Investigator: Rudy Santini
Affiliation: El Paso/Ysleta Schools, TX
Country: U.S.

Sponsor: GAS Program, OSF, NASA HQ; El Paso/Ysleta Schools, TX; Richard N. Azar, El Paso, TX

Developer: El Paso/Ysleta Schools, TX; hardware: Farah Manufacturing, El Paso; El Paso Natural Gas; Whaller Specialties; Falco Machine & Tool Co.; El Paso Electric Co.

Management and Integration: Special Payloads Div., NASA GSFC

Experiment Location: GAS adapter beam in cargo bay

Species Studied: green algae, Chlorella; yeast, Kefir

Objectives of Experiment: The object was to form a closed ecological life support system consisting of a symbiotic relationship between Kefir (contributing carbon) and Chlorella (producing oxygen from the yeast substrate).

Description: Nutrients were supplied to the Chlorella and Kefir cultures during the mission. After 112 hours growth, the cultures were preserved for postflight analyses.

Results: To be included (if available) in next edition.

References:

Prouty, C.R. (ed.). 1984 Get Away Special Experimenter's Symposium. NASA CP-2324. Washington, D.C.: NASA, 1984.

STS 51-F

Launch Date: July 29, 1985

Landing Date: August 6, 1985

Relevant Payloads: Spacelab 2 (NASA)

Experiments:

Flight: Spacelab 2 (51-F)

Experiment Title: Gravity-Influenced Lignification in Higher Plants

Principal Investigator: Joe R. Cowles
Affiliation: U Houston, Houston, TX
Country: U.S.

Sponsor: Life Sciences Div., OSSA, NASA HQ

Developer: U Houston; Lockheed and NASA ARC (Plant Growth Units)

Management and Integration: Spacelab Payloads Project Office, NASA MSFC; Shuttle Payload Engineering Div., OSSA, NASA HQ

Experiment Location: middeck

Species Studied: mung bean, Vigna radiata; oat, Avena sativa; pine, Pinus elliotti

Objectives of Experiment: The object was to study the effects of microgravity on growth and lignification in oats, pine seedlings and mung beans. Lignin is the compound in plant cell walls that gives plants strength and rigidity. Gravity is thought to be the controlling factor in lignification, and previous data showed reduced lignin content in mung beans flown on STS-3 compared with ground controls.

Description: This was a modification of an experiment flown by Cowles (see Annals of Botany 54 (Suppl. 3):33-48, 1984) on STS-3 in March 1982. Two plant growth units (PGUs) containing 4- and 10-day-old pine seedlings, mung bean seeds, and oat seeds were flown on Spacelab 2. Each PGU consisted of six minigrowth chambers inside an airtight unit, in which light, temperature, air circulation, and atmospheric composition could be monitored. The effect of oxygen concentration on lignification was not examined in this experiment, because the STS-3 study indicated no significant differences in atmospheric carbon dioxide or oxygen levels between flight seedlings and ground controls. Gas samples of the PGU atmospheres were obtained, and photographs of the plants were taken. Control samples of each of the three plant species were grown on the ground for comparison with the plants subjected to microgravity.

Results: Preliminary results indicated that the mung beans and oat seeds germinated well and the pine seedlings grew well in space. Some reduced growth (15-20%) of the mung beans was observed in microgravity. About 29% of the mung bean roots and about 40% of the oat roots grew above the supporting medium in the PGUs in microgravity, indicating some root disorientation.

References:

Clifton, K.S. (ed.). Spacelab Mission 2 Experiment Descriptions. NASA TM-78198. Marshall Space Flight Center, AL: NASA MSFC, 1978.

Cowles, J.R. Gravity-Influenced Lignification in Higher Plants: Experiment 2, Spacelab 2. 90-Day Report. November 1985.

Cowles, J., G. Jahns, R. LeMay, and R. Omran. Growth characteristies of plants grown in microgravity on Spacelab 2. Plant Physiology 80(4, Suppl.): 9, 1986.

Cowles, J., R. LeMay, R. Omran, and G. Jahns. Cell wall related synthesis in plant seedlings grown in the microgravity environment of the space shuttle. Plant Physiology 80(4, Suppl.): 9, 1986.

Flight: Spacelab 2 (51-F)

Experiment Title: Vitamin D Metabolites and Bone Demineralization

Principal Investigator: Heinrich K. Schnoes
Affiliation: U WI, Madison, WI
Country: U.S.

Sponsor: Life Sciences Div., OSSA, NASA HQ

Developer: U WI, Madison, WI

Management and Integration: Spacelab Payloads Project Office, NASA MSFC; Shuttle Payload Engineering Div., OSSA, NASA HQ

Experiment Location: middeck

Species Studied: human

Objectives of Experiment: The objective was to increase understanding of the molecular basis of bone demineralization and mineral imbalance previously observed during spaceflight. In particular, the relationship of calcium imbalance to vitamin D metabolites was studied because these metabolites are important in calcium and phosphate balance.

Description: Prior to the flight, improved methods for the analysis of vitamin D metabolites were developed. Baseline data on vitamin D metabolites in blood plasma were obtained from rats, chickens, and monkeys subjected to simulated weightlessness and given diets with varying vitamin D levels. Baseline data on vitamin D metabolites were also obtained from normal humans, bed-rest patients, and patients with bone, liver, or kidney diseases prior to the flight. The flight experiment involved the collection of blood samples from crew members early in the mission and then toward the end, as well as pre- and postflight. The plasma was separated and frozen during the flight for postflight analyses.

Results: Levels of 1,25-dihydroxyvitamin D, a key vitamin D metabolite, were elevated early in flight (mission day 1,2) in all four subjects compared with preflight levels. The elevated levels remained approximately within the normal range, however. By day 6 of the flight, the levels had returned to normal.

References:

Clifton, K.S. (ed.). Spacelab Mission 2 Experiment Descriptions. NASA TM-78198. Marshall Space Flight Center, AL: NASA MSFC, 1978.

Post Launch Mission Operation Report No. M-977-51-F-03. Washington, D.C.: Headquarters Administration Div., NASA HQ, September 30, 1985.

STS 51-J

Launch Date: October 3, 1985

Landing Date: October 7, 1985

Relevant Payloads: BIOS

Experiment:

Flight: STS 51-J

Experiment Title: BIOS

Principal Investigator: S.L. Bonting
Affiliation: U Nijmegen (currently at NASA ARC)
Country: The Netherlands

Sponsor: Government of The Netherlands

Developer: U Nijmegen, The Netherlands

Management and Integration: Shuttle Payload Engineering Div., NASA HQ

Experiment Location: middeck

Species Studied: protein (myoglobin)

Objectives of Experiment: This was a repeat of part of the Biostack experiment flown by Bücker on Spacelab 1, which assessed the effects of HZE (high charge and energy) particles on proteins.

Description: Thin films of myogolobin on agarose with nuclear track detectors in between were flown. Postflight analyses involved wetting the films prior to examination, in order to enhance detection of possible HZE damage. The films from Spacelab 1 were examined in the dry state and no evidence of damage from cosmic radiation was detected.

Results: A report is available through Dr. W.J. De Grip at the U of Nijmegen in The Netherlands (telephone: 9-011-31-80-514259).

References:

Shuttle Payload Engineering Div., NASA HQ.

STS 61-A

Launch Date: October 30, 1985
Landing Date: November 6, 1985
Relevant Payloads: Spacelab D-1 (Federal Republic of Germany)
Experiments:

Flight: Spacelab D-1 (61-A)

Experiment Title: Body Impedance Measurement (BIM 300)

Principal Investigator: F. Baisch
Affiliation: DFVLR, Cologne
Country: Federal Republic of Germany

Sponsor: DFVLR, Federal Republic of Germany

Developer: DFVLR, Federal Republic of Germany

Management and Integration: DFVLR, Federal Republic of Germany

Experiment Location: Spacelab

Species Studied: human

Objectives of Experiment: This study was designed to obtain data on the cardiovascular adaptation to microgravity.

Description: Cardiovascular data, including heart rate, respiratory rate, and time course of body fluid shifts, were obtained on crew members using electrocardiography and electrical impedance (whole body and thoracic).

Results: To be included (if available) in next edition.

References:

Mission Operation Report No. M-989-61-A-D1. Washington, D.C.: Headquarters Administration Div., NASA HQ, 1985.

Sahm, P.R. and R. Jansen (eds.). Scientific Goals of the German Spacelab Mission D-1. Cologne, FRG: DFVLR, 1985, pages 214-217.

Flight: Spacelab D-1 (61-A)

Experiment Title: Effects of Low Gravity on Mammalian Cell Polarization at the Ultrastructural Level (BR 48 F)

Principal Investigator: M. Bouteille
Affiliation: U Paris
Country: France

Sponsor: CNES, France

Developer: U Paris, France

Management and Integration: DFVLR, Federal Republic of Germany

Experiment Location: Spacelab

Species Studied: mammal (plasma cells, species unspecified)

Objectives of Experiment: The ultrastructural distribution of cell components due to microgravity were observed.

Description: Highly polarized, suspended mammalian plasma cells were observed.

Results: To be included (if available) in next edition.

References:

DFVLR. PROJEKTPLAN D1 Teil I. Document Reference Code D1-PM-PL-001-PM. September 6, 1983.

Mission Operation Report No. 989-61-A-D1. Washington, D.C.: Headquarters Administration Div., NASA HQ, 1985.

Sahm, P.R. and R. Jansen (eds.). Scientific Goals of the German Spacelab Mission D-1. Cologne, FRG: DFVLR, 1985, pages 158-159.

Flight: Spacelab D-1 (61-A)

Experiment Title: Dosimetric Mapping Inside BIORACK (BR 19 D)

Principal Investigator: Horst Bücker
Affiliation: DFVLR, Cologne
Country: Federal Republic of Germany

Sponsor: DFVLR, Federal Republic of Germany; ESA (BIORACK)

Developer: DFVLR, Federal Republic of Germany

Management and Integration: DFVLR, Federal Republic of Germany

Experiment Location: Spacelab

Species Studied: none

Objectives of Experiment: The object was to obtain data on the radiation levels in BIORACK (a research facility on Spacelab D-1).

Description: Radiation detectors of various types were placed in areas of BIORACK.

Results: To be included (if available) in next edition.

References:

DFVLR. PROJEKTPLAN D1 Teil I. Document Reference Code D1-PM-PL-001-PM. September 6, 1983.

Mission Operation Report No. 989-61-A-D1. Washington, D.C.: Headquarters Administration Div., NASA HQ, 1985.

Sahm, P.R. and R. Jansen (eds.). Scientific Goals of the German Spacelab Mission D-1. Cologne, FRG: DFVLR, 1985, pages 170-173.

Flight: Spacelab D-1 (61-A)

Experiment Title: Embryogenesis and Organogenesis of Carausius morosus under Spaceflight Conditions (BR 18 D)

Principal Investigator: Horst Bücker
Affiliation: DFVLR, Cologne
Country: Federal Republic of Germany

Sponsor: DFVLR, Federal Republic of Germany; ESA (BIORACK)

Developer: DFVLR, Federal Republic of Germany

Management and Integration: DFVLR, Federal Republic of Germany

Experiment Location: Spacelab

Species Studied: stick insect, Carausius morosus

Objectives of Experiment: The object was to study the sensitivity of stick insect embryos to the combined effects of radiation (from HZE particles) and microgravity during spaceflight.

Description: The effects of spaceflight were observed in stick insect embryos in five developmental stages. The postflight observations on the eggs included the male to female ratio, hatching frequency, growth, incidence of abnormalities in the newly hatched insects and abnormalities in the progeny.

Results: To be included (if available) in next edition.

References:

DFVLR. PROJEKTPLAN D1 Teil I. Document Reference Code D1-PM-PL-001-PM. September 6, 1983.

Mission Operation Report No. 989-61-A-D1. Washington, D.C.: Headquarters Administration Div., NASA HQ, 1985.

Sahm, P.R. and R. Jansen (eds.). Scientific Goals of the German Spacelab Mission D-1. Cologne, FRG: DFVLR, 1985, pages 182-184.

Flight: Spacelab D-1 (61-A)

Experiment Title: Effects of Zero Gravity on the Interactions between Cells, Cells and Viruses, Cells and Informational Macromolecules (BR 07 I)

Principal Investigator: O. Ciferri
Affiliation: U Pavia
Country: Italy

Sponsor: Italian Government; ESA (BIORACK)

Developer: U Pavia, Italy

Management and Integration: DFVLR, Federal Republic of Germany

Location of Experiment: Spacelab

Species Studied: bacteria; viruses

Objectives of Experiment: The object was to study the changes in the bacterial cell wall due to microgravity.

Description: Conjugation, phage infection, and DNA transformation were studied in bacteria.

Results: To be included (if available) in next edition.

References:

DFVLR. PROJEKTPLAN D1 Teil I. Document Reference Code D1-PM-PL-001-PM. September 6, 1983.

Mission Operation Report No. 989-61-A-D1. Washington, D.C.: Headquarters Administration Div., NASA HQ, 1985.

Sahm, P.R. and R. Jansen (eds.). Scientific Goals of the German Spacelab Mission D-1. Cologne, FRG: DFVLR, 1985, pages 166-167.

Flight: Spacelab D-1 (61-A)

Experiment Title: Human Lymphocyte Activation in Weightlessness (BR 32 CH)

Principal Investigator: Augusto Cogoli
Affiliation: Eidgenossische Technische Hochschule (ETH), Zurich
Country: Switzerland

Sponsor: Swiss National Science Foundation; Swiss Institute of Technology; ESA (BIORACK)

Developer: ETH, Zurich, Switzerland

Management and Integration: DFVLR, Federal Republic of Germany

Experiment Location: Spacelab

Species Studied: human

Objectives of Experiment: Changes in human lymphocyte activation due to spaceflight were monitored, in order to see if microgravity depresses the immune system, as indicated in some previous space missions (see Spacelab 1).

Description: Samples of whole blood were taken from four crew members preflight, during, and postflight. The blood was exposed to the mitogen Concanavalin A and preserved for later study. Lymphocyte cultures from blood donated from a noncrew member were exposed to a mitogen (Concanavalin A) on the D-1 mission and also preserved for study. The samples were tested for degree of lymphocyte activation. Mitogens generally activate lymphocytes in normal blood samples.

Results: To be included (if available) in next edition.

References:

DFVLR. PROJEKTPLAN D1 Teil I. Document Reference Code D1-PM-PL-001-PM. September 6, 1983.

Mission Operation Report No. 989-61-A-D1. Washington, D.C.: Headquarters Administration Div., NASA HQ, 1985.

Sahm, P.R. and R. Jansen (eds.). Scientific Goals of the German Spacelab Mission D-1. Cologne, FRG: DFVLR, 1985, pages 155-157.

Flight: Spacelab D-1 (61-A)

Experiment Title: Tonometer (TOM 00)

Principal Investigator: J. Draeger
Affiliation: U Hamburg
Country: Federal Republic of Germany

Sponsor: DFVLR, Federal Republic of Germany

Developer: U Hamburg, Federal Republic of Germany

Management and Integration: DFVLR, Federal Republic of Germany

Experiment Location: Spacelab

Species Studied: human

Objectives of Experiment: Eye pressure changes due to microgravity were investigated. The fluid shift to the upper body during adaptation to microgravity may cause an increase in the intraocular pressure. This may pose a potential danger to certain crew members who may be at risk for developing glaucoma.

Description: A tonometer (designed for use in microgravity) was used to monitor changes in the aqueous humor and volume of the inner eye of two subjects during the mission. Measurements were also obtained pre- and postflight.

Results: To be included (if available) in next edition.

References:

DFVLR. PROJEKTPLAN D1 Teil I. Document Reference Code D1-PM-PL-001-PM. September 6, 1983.

Mission Operation Report No. 989-61-A-D1. Washington, D.C.: Headquarters Administration Div., NASA HQ, 1985.

Sahm, P.R. and R. Jansen (eds.). Scientific Goals of the German Spacelab Mission D-1. Cologne, FRG: DFVLR, 1985, pages 211-213.

Flight: Spacelab D-1 (61-A)

Experiment Title: Gesture and Speech in Microgravity (LAN 200 GPS 00)

Principal Investigator: A.D. Friederici
Affiliation: MPI, Nijmegen
Country: The Netherlands

Sponsor: Government of The Netherlands

Developer: MPI, Nijmegen, The Netherlands

Management and Integration: DFVLR, Federal Republic of Germany

Experiment Location: Spacelab

Species Studied: human

Objectives of Experiment: The object was to study the communication aspects of human cognitive behavior in microgravity. This study was concerned with the effect of microgravity on the relationship between speech and gesture.

Description: Crew members were presented with visual displays of various geometric shapes, which they were asked to verbally describe and perform previously learned gestures. The verbal descriptions and gestures were performed both separately and together by each subject. The subjects were unable to see their own gestures during the task, and they each performed the tasks in both microgravity and 1-g, thus serving as their own controls. In addition, a separate control group was tested on Earth, in order to account for any learning effects.

Results: To be included (if available) in next edition.

References:

Mission Operation Report No. M-989-61-A-D1. Washington, D.C.: Headquarters Administration Div., NASA HQ, 1985.

Sahm, P.R. and R. Jansen (eds.). Scientific Goals of the German Spacelab Mission D-1. Cologne, FRG: DFVLR, 1985, pages 221-222.

Flight: Spacelab D-1 (61-A)

Experiment Title: Spatial Description in Space (LAN 200 SDS 00)

Principal Investigator: A.D. Friederici
Affiliation: MPI, Nijmegen
Country: The Netherlands

Sponsor: Government of The Netherlands

Developer: MPI, Nijmegen, The Netherlands

Management and Integration: DFVLR, Federal Republic of Germany

Experiment Location: Spacelab

Species Studied: human

Objectives of Experiment: The object was to study human cognitive behavior in microgravity. Specifically, the study was concerned with the influence of perceptual cues (vestibular, retinal, and visual background information) on a subject's communication about spatial arrangements.

Description: Crew members performed a series of tasks, in which they verbally described various drawings of figures in different spatial relationships. The tasks were also performed on Earth in normal gravity for comparison.

Results: To be included (if available) in next edition.

References:

Mission Operation Report No. M-989-61-A-D1. Washington, D.C.: Headquarters Administration Div., NASA HQ, 1985.

Sahm, P.R. and R. Jansen (eds.). Scientific Goals of the German Spacelab Mission D-1. Cologne, FRG: DFVLR, 1985, pages 222-223.

Flight: Spacelab D-1 (61-A)

Experiment Title: Geotropism (BOT 02)

Principal Investigator: J. Gross
Affiliation: U Tubingen
Country: Federal Republic of Germany

Sponsor: DFVLR, Federal Republic of Germany

Developer: U Tubingen, Federal Republic of Germany

Management and Integration: DFVLR, Federal Republic of Germany

Experiment Location: Spacelab

Species Studied: corn

Objectives of Experiment: The object was to study the effect of microgravity on the transport of the growth hormone auxin in corn. Specifically, the study was to determine if directed hormone transport is induced by a gravitational field.

Description: Corn seeds were allowed to germinate in space. The transport of the growth hormone auxin in the resulting 4-day-old corn seedlings was monitored using radioactively labelled hormone.

Results: To be included (if available) in next edition.

References:

DFVLR. PROJEKTPLAN D1 Teil I. Document Reference Code D1-PM-PL-001-PM. September 6, 1983.

Mission Operation Report M-989-61-A-D1. Washington, D.C.: Headquarters Administration Div., NASA HQ, 1985.

Sahm, P.R. and R. Jansen (eds.). Scientific Goals of the German Spacelab Mission D-1. Cologne, FRG: DFVLR, 1985, pages 190-191.

Flight: Spacelab D-1 (61-A)

Experiment Title: Reaction Time (JUF 250)

Principal Investigators: M. Hoschek/J. Hund
Affiliation: Birkenweg 1a, 6109 Muehltal 1 (address)
Country: Federal Republic of Germany

Sponsor: DFVLR, Federal Republic of Germany

Developer: Not Available

Management and Integration: DFVLR, Federal Republic of Germany

Experiment Location: Spacelab

Species Studied: human

Objectives of Experiment: The object was to measure human reactions in microgravity. This is a student experiment.

Description: To be included (if available) in next edition.

Results: To be included (if available) in next edition.

References:

Mission Operation Report No. M-989-61-A-D1. Washington, D.C.: Headquarters Administration Div., NASA HQ, 1985.

Sahm, P.R. and R. Jansen (eds.). Scientific Goals of the German Spacelab Mission D-1. Cologne, FRG: DFVLR, 1985, page 238.

Flight: Spacelab D-1 (61-A)

Experiment Title: Central Venous Pressure (ZVD 00)

Principal Investigator: K. Kirsch
Affiliation: Free U Berlin
Country: Federal Republic of Germany

Sponsor: DFVLR, Federal Republic of Germany

Developer: Free U Berlin, Federal Republic of Germany

Management and Integration: DFVLR, Federal Republic of Germany

Experiment Location: Spacelab

Species Studied: human

Objectives of Experiment: The object was to study blood displacement to the upper half of the body due to microgravity.

Description: Venous pressure was monitored in crew members during spaceflight.

Results: To be included (if available) in next edition.

References:

DFVLR. PROJEKTPLAN D1 Teil I. Document Reference Code D1-PM-PL-001-PM. September 6, 1983.

Mission Operation Report No. 989-61-A-D1. Washington, D.C.: Headquarters Administration Div., NASA HQ, 1985.

Sahm, P.R. and R. Jansen (eds.). Scientific Goals of the German Spacelab Mission D-1. Cologne, FRG: DFVLR, 1985, pages 209-211.

Flight: Spacelab D-1 (61-A)

Experiment Title: The Involvement of Gravitational Forces in the Shaping of the Topological Distribution of Cytoplasmic Determinants in the Drosophila melanogaster Egg (BR 15 E)

Principal Investigator: R. Marco
Affiliation: U Autonoma Madrid
Country: Spain

Sponsor: Spanish Government; ESA (BIORACK)

Developer: U Autonoma Madrid, Spain

Management and Integration: DFVLR, Federal Republic of Germany

Location of Experiment: Spacelab

Species Studied: fruit fly, Drosophila melanogaster

Objectives of Experiment: The study examined the effects of microgravity on the development of the fruit fly egg. Previous flight experiments with Drosophila have shown some developmental anomalies. This study was designed to determine if these anomalies were due to the near-weightlessness of space.

Description: Eggs produced during different stages of the D-1 mission were collected and fixed for later study of the morphology of the embryos. Eggs collected at the beginning of the flight were predicted to have normal development, because most of the oogenesis in the females was completed prior to launch. Eggs collected at the end of the flight were predicted to show abnormalities, because they would have been formed in microgravity. Eggs were also collected from females in 1-g centrifuges on the flight as a control group. The flies exposed to centrifugation were predicted to show normal development.

Results: To be included (if available) in next edition.

References:

DFVLR. PROJEKTPLAN D1 Teil I. Document Reference Code D1-PM-PL-001-PM. September 6, 1983.

Mission Operation Report No. 989-61-A-D1. Washington, D.C.: Headquarters Administration Div., NASA HQ, 1985.

Sahm, P.R. and R. Jansen (eds.). Scientific Goals of the German Spacelab Mission D-1. Cologne, FRG: DFVLR, 1985, page 181.

Flight: Spacelab D-1 (61-A)

Experiment Title: Growth and Differentiation (Sporulation) of *Bacillus subtilis* in Space (BR 28 D)

Principal Investigator: H.D. Mennigmann
Affiliation: U Frankfurt
Country: Federal Republic of Germany

Sponsor: DFVLR, Federal Republic of Germany; ESA (BIORACK)

Developer: U Frankfurt, Federal Republic of Germany

Management and Integration: DFVLR, Federal Republic of Germany

Experiment Location: Spacelab

Species Studied: bacteria, *Bacillus subtilis*

Objectives of Experiment: The effects of microgravity on *Bacillus subtilis* were investigated.

Description: Growth and spore formation were monitored in *B. subtilis* during spaceflight. The bacteria were in microgravity and in a 1-g centrifuge on the flight. The growth rate was measured by a photometer, and the spore formation at different stages was measured by examining samples with an electron microscope postflight.

Results: To be included (if available) in next edition.

References:

DFVLR. PROJEKTPLAN D1 Teil I. Document Reference Code D1-PM-PL-001-PM. September 6, 1983.

Mission Operation Report No. 989-61-A-D1. Washington, D.C.: Headquarters Administration Div., NASA HQ, 1985.

Sahm, P.R. and R. Jansen (eds.). *Scientific Goals of the German Spacelab Mission D-1*. Cologne, FRG: DFVLR, 1985, pages 163-165.

Flight: Spacelab D-1 (61-A)

Experiment Title: The Circadian Rhythm of Photoaccumulation in the Unicellular Green Alga Chlamydomonas reinhardii under Conditions Free of Earth Gravity (BR 27 D)

Principal Investigator: D. Mergenhagen
Affiliation: U Hamburg
Country: Federal Republic of Germany

Sponsor: DFVLR, Federal Republic of Germany; ESA (BIORACK)

Developer: U Hamburg, Federal Republic of Germany

Management and Integration: DFVLR, Federal Republic of Germany

Experiment Location: Spacelab

Species Studied: green alga (unicellular), Chlamydomonas reinhardii

Objectives of Experiment: The object of the study was to determine if the circadian rhythm of Chlamydomonas reinhardii occurs in space.

Description: Chlamydomonas cells tend to accumulate near light in the daytime and away from light at night on Earth. The photoaccumulation of algae in cell suspensions was recorded by a photocell under conditions of 100 minutes dark, 20 minutes light. Under these conditions on Earth, Chlamydomonas follows its normal accumulation pattern as if there was a normal day-night cycle.

Results: To be included (if available) in next edition.

References:

DFVLR. PROJEKTPLAN D1 Teil I. Document Reference Code D1-PM-PL-001-PM. September 6, 1983.

Mission Operation Report No. 989-61-A-D1. Washington, D.C.: Headquarters Administration Div., NASA HQ, 1985.

Sahm, P.R. and R. Jansen (eds.). Scientific Goals of the German Spacelab Mission D-1. Cologne, FRG: DFVLR, 1985, pages 160-162.

Flight: Spacelab D-1 (61-A)

Experiment Title: Frog Statolith Experiment--STATEX (STA 00)

Principal Investigator: J. Neubert
Affiliation: DFVLR, Cologne
Country: Federal Republic of Germany

Sponsor: DFVLR, Federal Republic of Germany

Developer: DFVLR, Federal Republic of Germany

Management and Integration: DFVLR, Federal Republic of Germany

Experiment Location: Spacelab

Species Studied: South African frog, Xenopus laevis

Objectives of Experiment: The object of this experiment was to study the effects of gravitational forces on embryogenesis and organ development of the vestibular system of the South African frog, in order to determine the formation and function of the gravity sensing system of vertebrates.

Description: The effects of weightlessness on the early stages--fertilized eggs, embryos, and tadpoles--were recorded. A second group in the same stages was also subjected to 1-g centrifugation for comparison. The early frog stages were protected from the acceleration and vibration of the launch and landing by cooling the animal environment to 10°C to lower metabolic functions temporarily. After landing, the statolith organs (macula organs) of some of the animals were examined by electron microscopy; others were used in studies of reproduction and behavior.

Results: To be included (if available) in next edition.

References:

DFVLR. PROJEKTPLAN D1 Teil I. Document Reference Code D1-PM-PL-001-PM. September 6, 1983.

Mission Operation Report No. 989-61-A-D1. Washington, D.C.: Headquarters Administration Div., NASA HQ, 1985.

Sahm, P.R. and R. Jansen (eds.). Scientific Goals of the German Spacelab Mission D-1. Cologne, FRG: DFVLR, 1985, pages 176-178.

Flight: Spacelab D-1 (61-A)

Experiment Title: The Development of Statocyte Polarity and its Influence on Geotropic Response in Lentil Seedling Roots (BR 39 F)

Principal Investigator: G. Perbal
Affiliation: U Paris
Country: France

Sponsor: CNES, France; ESA (BIORACK)

Developer: U Paris, France

Management and Integration: DFVLR, Federal Republic of Germany

Experiment Location: Spacelab

Species Studied: lentil, Lens

Objectives of Experiment: The effect of graviperception on the growth of lentil roots and the relationship between statocytes and the endoplasmic reticulum in the geotropic response were studied.

Description: Lentil seeds were flown on Spacelab in small plant growth chambers and allowed to germinate in space. A group of seedlings was cultivated in a 1-g centrifuge for comparison. The effects of microgravity on cell division and differentiation were examined. Another set of seedlings was cultivated in microgravity and then placed in a 1-g centrifuge for 3 hours; the roots were examined for presence of geotropic curvature.

Results: To be included (if available) in next edition.

References:

DFVLR. PROJEKTPLAN D1 Teil I. Document Reference Code D1-PM-PL-001-PM. September 6, 1983.

Mission Operation Report No. 989-61-A-D1. Washington, D.C.: Headquarters Administration Div., NASA HQ, 1985.

Sahm, P.R. and R. Jansen (eds.). Scientific Goals of the German Spacelab Mission D-1. Cologne, FRG: DFVLR, 1985, pages 194-196.

Flight: Spacelab D-1 (61-A)

Experiment Title: Effects of Space Environmental Factors on Cell Proliferation (BR 21 F)

Principal Investigator: H. Planel
Affiliation: U Toulouse
Country: France

Sponsor: CNES, France; ESA (BIORACK)

Developer: U Toulouse, Federal Republic of Germany

Management and Integration: DFVLR, Federal Republic of Germany

Experiment Location: Spacelab

Species Studied: Paramecium

Objectives of Experiment: The effects of spaceflight on reproduction and structure of Paramecium were studied.

Description: The rate of cell division and structural changes due to microgravity were observed in Paramecium.

Results: To be included (if available) in next edition.

References:

DFVLR. PROJEKTPLAN D1 Teil I. Document Reference Code D1-PM-PL-001-PM. September 6, 1983.

Mission Operation Report No. 989-61-A-D1. Washington, D.C.: Headquarters Administration Div., NASA HQ, 1985.

Sahm, P.R. and R. Jansen (eds.). Scientific Goals of the German Spacelab Mission D-1. Cologne, FRG: DFVLR, 1985, pages 157-158.

Flight: Spacelab D-1 (61-A)

Experiment Title: Mass Discrimination (ROS 230)

Principal Investigator: Helen E. Ross
Affiliation: U Stirling
Country: Scotland

Sponsor: Medical Research Council, Scotland

Developer: U Stirling, Scotland

Management and Integration: DFVLR, Federal Republic of Germany

Experiment Location: Spacelab

Species Studied: human

Objectives of Experiment: This study was designed to investigate the effects of spaceflight on human cognitive behavior, regarding the sensory aspects of weight and mass discrimination. The experiment was first performed by Ross on Spacelab 1, and the D-1 version was done to confirm and improve the reliability of the previous results.

Description: Mass discrimination during spaceflight was measured by testing each crew member's ability to distinguish the heavier of paired balls composed of epoxy resin with an inner lead ring. The 3 cm diameter balls ranged in mass from 50-64 g (in 2-g increments). Pairs of 80 different combinations of masses were given to the subjects in random order. The subject was to determine the relative mass of each ball by holding it in his hand and shaking it twice. The shaking was done at two different speeds in order to test the effects of acceleration on mass discrimination. Weight discrimination data were obtained (using the same protocol) from the crew on Earth both pre- and postflight. In addition, the reactions of the subjects were recorded on film in order to analyze the movements made during the tasks.

Results: To be included (if available) in next edition.

References:

Mission Operation Report No. M-989-61-A-D1. Washington, D.C.: Headquarters Administration Div., NASA HQ, 1985.

Sahm, P.R. and R. Jansen (eds.). Scientific Goals of the German Spacelab Mission D-1. Cologne, FRG: DFVLR, 1985, pages 219-220.

Flight: Spacelab D-1 (61-A)

Experiment Title: Cell Cycle and Protoplasmic Streaming of the Slime Mold *Physarum* in Weightlessness (BR 16 D)

Principal Investigator: V. Sobick
Affiliation: DFVLR, Cologne
Country: Federal Republic of Germany

Sponsor: DFVLR, Federal Republic of Germany; ESA (BIORACK)

Developer: DFVLR, Federal Republic of Germany

Management and Integration: DFVLR, Federal Republic of Germany

Experiment Location: Spacelab

Species Studied: slime mold, *Physarum*

Objectives of Experiment: The object was to study the effects of weightlessness on protoplasmic streaming and cell cycle in the slime mold. Prior experiments on a clinostat suggested that the cell contraction and protoplasmic streaming may be gravity sensitive.

Description: The slime mold *Physarum* was observed during spaceflight using a photo diode/microscope to record the pattern of light changes caused by the cell contractions and a 16 mm camera to record the speed and direction of the protoplasmic streaming.

Results: To be included (if available) in next edition.

References:

DFVLR. PROJEKTPLAN D1 Teil I. Document Reference Code D1-PM-PL-001-PM. September 6, 1983.

Mission Operation Report No. 989-61-A-D1. Washington, D.C.: Headquarters Administration Div., NASA HQ, 1985.

Sahm, P.R. and R. Jansen (eds.). *Scientific Goals of the German Spacelab Mission D-1*. Cologne, FRG: DFVLR, 1985, pages 168-170.

Flight: Spacelab D-1 (61-A)

Experiment Title: Differentiation (BOT 03)

Principal Investigator: R.R. Theimer
Affiliation: U Munchen
Country: Federal Republic of Germany

Sponsor: DFVLR, Federal Republic of Germany

Development: U Munchen, Federal Republic of Germany

Management and Integration: DFVLR, Federal Republic of Germany

Experiment Location: Spacelab

Species Studied: plant (species not specified)

Objectives of Experiment: This experiment was to investigate the differentiation and function of gravity perception organs of plants in microgravity.

Description: The differentiation of gravity perception organs was studied during the regeneration of whole plants from totipotent somatic cell cultures.

Results: To be included (if available) in next edition.

References:

DFVLR. PROJEKTPLAN D1 Teil I. Document Reference Code D1-PM-PL-001-PM. September 6, 1983.

Mission Operation Report No. 989-61-A-D1. Washington, D.C.: Headquarters Administration Div., NASA HQ, 1985.

Sahm, P.R. and R. Jansen (eds.). Scientific Goals of the German Spacelab Mission D-1. Cologne, FRG: DFVLR, 1985, pages 190-192.

Flight: Spacelab D-1 (61-A)

Experiment Title: Study on Antibacterial Activity of Antibiotics in Space Conditions (BR 58 F)

Principal Investigator: R. Tixador
Affiliation: U Toulouse
Country: France

Sponsor: CNES, France; ESA (BIORACK)

Developer: U Toulouse, France

Management and Integration: DFVLR, Federal Republic of Germany

Experiment Location: Spacelab

Species Studied: bacteria, E. coli

Objectives of Experiment: The possibility that bacterial resistance to certain antibiotics may increase in space due to microgravity or cosmic radiation was studied. This increased resistance might represent a medical hazard for the crew. An increase in resistance to antibiotics may be due to the thickness and structure of the bacterial cell wall in space.

Description: The antibacterial effects of Colistin and Kanamycin were tested in E. coli. The effects of these antibiotics on the bacterial ultrastructure were examined postflight.

Results: To be included (if available) in next edition.

References:

DFVLR. PROJEKTPLAN D1 Teil I. Document Reference Code D1-PM-PL-001-PM. September 6, 1983.

Mission Operation Report No. 989-61-A-D1. Washington, D.C.: Headquarters Administration Div., NASA HQ, 1985.

Sahm, P.R. and R. Jansen (eds.). Scientific Goals of the German Spacelab Mission D-1. Cologne, FRG: DFVLR, 1985, pages 162-163.

Flight: Spacelab D-1 (61-A)

Experiment Title: Role of Gravity in Determination of the Dorsoventral Axis in Developing Embryos of the Amphibian, Xenopus laevis (BR 52 NL)

Principal Investigator: G.A. Ubbels
Affiliation: U Utrecht
Country: The Netherlands

Sponsor: Government of The Netherlands; ESA (BIORACK)

Developer: U Utrecht, The Netherlands

Management and Integration: DFVLR, Federal Republic of Germany

Experiment Location: Spacelab

Species Studied: South African frog, Xenopus laevis

Objectives of Experiment: The effect of weightlessness on the establishment of the dorsoventral axis was studied.

Description: Egg fertilization and development of the South African frog were observed due to microgravity and after exposure to 1-g centrifugation.

Results: To be included (if available) in next edition.

References:

Ubbels, G.A. et al. The role of gravity in the establishment of the dorso-ventral axis in the developing amphibian embryo. In: Proceedings of a Workshop on Space Biology, Cologne, Germany, March 9-11, 1983. ESA SP-206, May 1983, pages 77-82.

DFVLR. PROJEKTPLAN D1 Teil I. Document Reference Code D1-PM-PL-001-PM. September 6, 1983.

Mission Operation Report No. 989-61-A-D1. Washington, D.C.: Headquarters Administration Div., NASA HQ, 1985.

Sahm, P.R. and R. Jansen (eds.). Scientific Goals of the German Spacelab Mission D-1. Cologne, FRG: DFVLR, 1985, pages 179-180.

Flight: Spacelab D-1 (61-A)

Experiment Title: Graviperception (BOT 01)

Principal Investigator: D. Volkmann
Affiliation: U Bonn
Country: Federal Republic of Germany

Sponsor: DFVLR, Federal Republic of Germany

Developer: U Bonn, Federal Republic of Germany

Management and Integration: DFVLR, Federal Republic of Germany

Experiment Location: Spacelab

Species Studied: garden cress, Lepidium sativum

Objectives of Experiment: The object was to study the effects of microgravity on the roots and structure of the gravity perceptive cells (statocytes) of garden cress.

Description: Garden cress plants were grown from seed during spaceflight. The root growth patterns were recorded photographically, and the statocyte structure was analyzed by electron microscopy postflight.

Results: To be included (if available) in next edition.

References:

DFVLR. PROJEKTPLAN D1 Teil I. Document Reference Code D1-PM-PL-001-PM. September 6, 1983.

Mission Operation Report No. M-989-61-A-D1. Washington, D.C.: Headquarters Administration Div., NASA HQ, 1985.

Sahm, P.R. and R. Jansen (eds.). Scientific Goals of the German Spacelab Mission D-1. Cologne, FRG: DFVLR, 1985, pages 188-190.

Flight: Spacelab D-1 (61-A)

Experiment Title: Vestibular Research (VS ES 201)

Principal Investigator: R. von Baumgarten
Affiliation: U Mainz
Country: Federal Republic of Germany

Sponsor: DFVLR, Federal Republic of Germany; ESA (sled)

Developer: U Mainz, Federal Republic of Germany

Management and Integration: DFVLR, Federal Republic of Germany

Experiment Location: Spacelab

Species Studied: human

Objectives of Experiment: The object of the experiment was to measure the physiological responses of crew members to differing optokinetic stimulation patterns, in order to increase knowledge about space sickness. This experiment was also to confirm previous Spacelab 1 results on the vestibular system.

Description: The experiments included the production of caloric nystagmus by cooling or heating the ears beyond body temperature, measurement of the minimum threshold of detection of acceleration, monitoring of vestibulo-ocular reflexes, tests of eye movements and sensations on a dynamic tilting device, and neck receptor tests to study the influence of neck position receptors on human spatial orientation. The neck receptor study involved the subject's head being enclosed in a helmet that was attached to the floor, followed by the rest of the body being moved in different positions without feedback from the semicircular canals. Eye movements and the awareness of body position were recorded. The subjects were also tested pre- and postflight.

Results: To be included (if available) in next edition.

References:

DFVLR. PROJEKTPLAN D1 Teil I. Document Reference Code D1-PM-PL-001-PM. September 6, 1983.

Mission Operation Report No. 989-61-A-D1. Washington, D.C.: Headquarters Administration Div., NASA HQ, 1985.

Sahm, P.R. and R. Jansen (eds.). Scientific Goals of the German Spacelab Mission D-1. Cologne, FRG: DFVLR, 1985, pages 200-205.

Flight: Spacelab D-1 (61-A)

Experiment Title: Vestibular Research (VS NS 102)

Principal Investigator: Laurence R. Young
Affiliation: MIT; Cambridge, MA
Country: U.S.

Sponsor: Life Sciences Div., OSSA, NASA HQ; ESA (sled)

Developer: MIT, Cambridge, MA

Management and Integration: DFVLR, Federal Republic of Germany

Experiment Location: Spacelab

Species Studied: human

Objectives of Experiment: This experiment was designed to better understand the mechanism of space motion sickness by measuring the perception of linear acceleration. Prior experiments were performed on Spacelab 1.

Description: A number of reactions of crew members to acceleration and visual phenomena were studied. The ESA Vestibular Sled (a motor-driven seat) was used to exert linear accelerations. The perception of these accelerations (detection time, detection threshold, and compensatory eye movements) was measured using a joystick and electrooculography. Eye torsion was measured using marked contact lenses and recorded with a camera. A rotating dome was used to produce illusions of self-rotation, and the reactions were recorded on film.

Results: To be included (if available) in next edition.

References:

DFVLR. PROJEKTPLAN D1 Teil I. Document Reference Code D1-PM-PL-001-PM. September 6, 1983.

Mission Operation Report No. 989-61-A-D1. Washington, D.C.: Headquarters Administration Div., NASA HQ, 1985.

Sahm, P.R. and R. Jansen (eds.). Scientific Goals of the German Spacelab Mission D-1. Cologne, FRG: DFVLR, 1985, pages 205-206.

STS 61-B

Launch Date: November 26, 1985

Landing Date: December 3, 1985

Relevant Payloads: MORELOS (Mexico)

Experiments:

Flight: STS 61-B

Experiment Title: Transportation of Nutrients in a Weightlessness Environment

Principal Investigator: Ivan Ortega
Affiliation: Instituto de Fisica, Laboratorio de Cuernavaca, UNAM
Country: Mexico

Sponsor: Secretaria de Communicaciones y Transportes de Mexico

Developer: Ivan Ortega; Secretaria de Communicaciones y Transportes de Mexico

Management and Integration: Unidad de Proyectos Especiales, Secretaria de Communicaciones y Transportes de Mexico; Spacelab and Middeck Integration Office, NASA JSC

Experiment Location: middeck

Species Studied: bean, Phaseolus vulgaris

Objectives of Experiment: The objective was to determine the effects of a weightless environment on nutrient transport in bean plants.

Description: Ten plant specimens were planted in containers that allowed chemical dyes to be released inflight for absorption by the plants. At selected intervals, each plant was sectioned and the segments were retained for postflight analysis to determine the rate and extent of absorption of the dyes.

Results: To be included (if available) in next edition.

References:

Morelos Payload Specialist Experiments (MPSE), Launch Site Support Plan, Payload Integration Plan (JSC-21031) Annex 8, KSC, FL: NASA, September 1985.

Morelos Payload Specialists Experiments, Payload Integration Plan, Houston, TX: NASA, November 1985.

Flight: STS 61-B

Experiment Title: Effects of Weightlessness and Light on Seed Germination

Principal Investigator: Alphonso Jose Vilches Peluyera
Affiliation: Instituto National del Consumidor, Mexico City
Country: Mexico

Sponsor: Secretaria de Communicaciones y Transportes de Mexico

Developer: Alphonso Jose Vilches Peluyera; Secretaria de Communicaciones y Transportes de Mexico

Management and Integration: Unidad de Proyectos Especiales, Secretaria de Communicaciones y Transportes de Mexico; Spacelab and Middeck Integration Office, NASA JSC

Experiment Location: middeck

Species Studied: amaranth, Amaranthus hypocondriacus; lentil, Lens esculenta; wheat, Triticum aestivum

Objectives of Experiment: The objective was to determine the effects of weightlessness and light on germination of amaranth, lentil, and wheat seeds.

Description: Seeds of the three species were planted in orbit on the second day of flight in two identical containers. One container was exposed to illumination and the other to darkness. Photographs of the resulting seedlings were taken every 24 hours. One day prior to landing, the seedlings were fixed with glutaraldehyde. A histological examination was performed postflight to determine the presence and location of starch granules.

Results: To be included (if available) in next edition.

References:

Morelos Payload Specialist Experiments (MPSE), Launch Site Support Plan, Payload Integration Plan (JSC-21031) Annex 8, KSC, FL: NASA, September 1985.

Morelos Payload Specialists Experiments, Payload Integration Plan, Houston, TX: NASA, November 1985.

Flight: STS 61-B

Experiment Title: Electropuncture in Space

Principal Investigator: Fernando Ramirez y Escalano
Affiliation: Consultant
Country: Mexico

Sponsor: Secretaria de Communicaciones y Transportes de Mexico

Developer: Fernando Ramirez y Escalano; Secretaria de Communicaciones y Transportes de Mexico

Management and Integration: Unidad de Proyectos Especiales, Secretaria de Communicaciones y Transportes de Mexico; Spacelab and Middeck Integration Office, NASA JSC

Experiment Location: middeck

Species Studied: human

Objectives of Experiment: The objective was to validate theories of electropuncture, which propose that disequilibria in the behavior of human organs can be monitored and stimulated using a low intensity electric dc current in specified zones.

Description: The experiment was performed through the measurement of the conductance in a predetermined zone. The functional disequilibrium or equilibrium of an organ is indicated by setting the electric probes on the skin near various organs of a crew member, taking the measurement, and determining if it falls into a certain range. Low intensity currents were applied to improve the functional state of the organ.

Results: To be included (if available) in next edition.

References:

Morelos Payload Specialist Experiments (MPSE), Launch Site Support Plan, Payload Integration Plan (JSC-21031) Annex 8, KSC, FL: NASA, September 1985.

Morelos Payload Specialists Experiments, Payload Integration Plan, Houston, TX: NASA, November 1985.

Flight: STS 61-B

Experiment Title: Effects of Spatial Environment on the Reproduction and Growing of Bacteria

Principal Investigator: Silvia Estrada Flores (student)
Affiliation: University Center, Mexico City
Country: Mexico

Science Advisor: Dr. Amelia Cardenus, University Center, Mexico City

Sponsor: Secretaria de Communicaciones y Transportes de Mexico

Developer: Silvia Estrada Flores; Secretaria de Communicaciones y Transportes de Mexico

Management and Integration: Unidad de Proyectos Especiales, Secretaria de Communicaciones y Transportes de Mexico; Spacelab and Middeck Integration Office, NASA JSC

Experiment Location: middeck

Species Studied: Escherichia coli; phage lambda CII-68; phage lambda

Objectives of Experiment: The objective was to determine the effects of weightlessness on the reproduction and growing of bacteria and bacteriophages.

Description: During the flight, cultures of E. coli bacteria were mixed with different bacteriophages that attack E. coli. The cultures were subsequently observed and photographed.

Results: To be included (if available) in next edition.

References:

Morelos Payload Specialist Experiments (MPSE), Launch Site Support Plan, Payload Integration Plan (JSC-21031) Annex 8, KSC, FL: NASA, September, 1985.

Morelos Payload Specialists Experiments, Payload Integration Plan, Houston, TX: NASA, November 1985.

STS 61-C

Launch Date: January 12, 1986

Landing Date: January 18, 1986

Relevant Payloads: GAS, SSIP

Flight: STS 61-C

Experiment Title: Gypsy Moths and American Dog Ticks: Space Partners (G-470)

Principal Investigator: Dora K. Hayes
Affiliation: Livestock Insects Laboratory, Agricultural Environmental Quality Institute (AEQI), Agricultural Research Service (ARS), US Department of Agriculture (USDA), Beltsville, MD
Country: U.S.

Sponsor: GAS Program, OSF, NASA HQ; Animal and Plant Health Inspection Service (APHIS) and ARS, USDA; NASA GSFC

Developer: Livestock Insects Laboratory, AEQI, ARS, USDA

Management and Integration: Special Payloads Div., NASA GSFC

Experiment Location: GAS adapter beam in cargo bay

Species Studied: gypsy moth, Lymantria dispar L.; American dog tick, Dermacentor variabilis Say.

Objectives of Experiment: The goal was to determine the effects of weightlessness on the gypsy moth and dog tick life cycles; specifically, the effects on termination of hibernation or the diapause stage in gypsy moth eggs, and on ovipositions and subsequent hatch in dog ticks in diapause. The results may lead to new means of controlling these insect pests in that if the long diapause could be shortened, greater numbers of sterile males could be produced in the laboratory for release in the wild.

Description: Thirty egg masses containing 300-700 gypsy moth eggs each and engorged American dog ticks in diapause were individually rolled in monofilament nylon mesh tied to a large sheet of coarse-mesh cotton screen and rolled around a temperature-recording device in a humidity-controlled atmosphere. Laboratory-reared dog ticks and laboratory-reared and wild gypsy moth eggs were utilized. Ground control groups were monitored.

Results: To be included (if available) in next edition.

References:

Prelaunch Flight Operation Report No. M-989-61-C. Washington, D.C.: Headquarters Administration Div., NASA HQ, 1985.

Space Shuttle Mission 61-C Press Kit, December 1985.

Press Release for GAS-Can Experiment #G-470, December 20, 1985.

Prouty, C.R. (ed.) 1984 Get Away Special Experimenter's Symposium. NASA CP-2324. Washington, D.C.: NASA, 1984.

Flight: STS 61-C

Experiment Title: Comparative and Morphological Study of the Radish Root System (G-007)

Principal Investigator: Guy A. Smith (student); Konrad Dannenberg
Affiliation: Johnson Environmental and Energy Center, University of Alabama Huntsville; Alabama Space and Rocket Center, Huntsville, AL
Country: U.S.

Sponsor: GAS Program, OSF, NASA HQ; Alabama Space and Rocket Center, Huntsville, AL; cosponsors: American Institute of Aeronautics and Astronautics; Alabama A&M; University of Alabama Huntsville

Developer: Alabama Space and Rocket Center, Huntsville, AL; Marshall Amateur Radio Club, Huntsville, AL; University of Alabama Huntsville

Management and Integration: Special Payloads Div., NASA GSFC

Experiment Location: GAS bridge in cargo bay

Species Studied: radish, Raphanus sativus

Objectives of Experiment: This experiment was a morphological and anatomical study of the effects of microgravity on the primary root system of germinating radish seeds.

Description: This experiment was flown earlier on flight STS 41-G and was reflown on STS 61-C. The seeds were placed on filter paper on the ground. A pump activated in orbit sent water and nutrients to the radish seeds to stimulate germination. After 3 days of flight, a pump applied a formaldehyde/alcohol solution to arrest further growth.

Results: After 3 days of growth in microgravity, the seeds produced shoots approximately 1/2 inch long, which indicated a growth rate somewhat greater than that seen in normal gravity. This result may have been due to conditions of elevated temperature during the time of the flight.

References:

Prelaunch Flight Operation Report No. M-989-61-C. Washington, D.C.: Headquarters Administration Div., NASA HQ, 1985.

Space Shuttle Mission 61-C Press Kit, December 1985.

Thomas, L.R. and F.L. Mosier (eds.). 1985 Get Away Special Experimenter's Symposium. NASA CP-2401. Washington, D.C.: NASA, 1985.

Flight: STS 61-C

Experiment Title: Measurement of Auxin Levels and Starch Grains in Plant Roots (SE82-19)

Principal Investigator: Chia-Lien Wang
Affiliation: Richfield High School, Waco, TX (currently student at Stanford University)
Country: U.S.

Science Advisor: Randy Moore, Baylor University

Sponsor: SSIP, OSF, NASA HQ; Baylor University

Developer: Baylor University

Management and Integration: Man-Systems Div., NASA JSC

Experiment Location: middeck

Species Studied: corn, *Zea mays*

Objectives of Experiment: The objectives were to study the growth and development of corn roots and regeneration of the root cap in decapped roots under microgravity conditions. (Auxin levels were not measured, as is suggested by the experiment title, since the experimental objectives were altered during experiment development.)

Description: Corn seedlings were grown during the flight. The root caps were removed from some seedlings approximately 11 hrs before launch. These seedlings and their comparable ground controls were fixed 5 days after decapping (that is, approximately 5 days after Shuttle launch and 1 day before landing).

Results: Roots that grew in space grew slower and were shorter and thinner than those that grew on the ground. There was no regeneration of root caps in space-grown plants, whereas by the 4th day the caps on the control roots had completely regenerated. Initial observations of cell structure suggested that cytokinesis was altered or disrupted in some way in space.

References:

Bowie, M.L. *Space Shuttle Student Involvement Program (Experiment Status/Update)*. Washington, D.C.: NASA, March 15, 1985.

Moore, R., C.-L. Wang, W.M. Fondren, and C.E. McClelen. Botanical research aboard the space shuttle: dynamics of root growth in microgravity. *Plant Physiology* 80(4, Suppl.): 26, 1986.

Flight: STS 61-C

Experiment Title: Brine Shrimp *Artemia* Experiment (G-332)

Principal Investigator: Angela White
Affiliation: Booker T. Washington High School, Houston, TX
Country: U.S.

Sponsor: GAS Program, OSF, NASA HQ; Booker T. Washington High School, Houston, TX

Developer: Bryan Ignatov, Booker T. Washington High School, Houston, TX

Management and Integration: Special Payloads Div., NASA GSFC

Experiment Location: GAS bridge in cargo bay

Species Studied: brine shrimp, *Artemia*

Objectives of Experiment: The objective was to determine the behavioral and physiological effects of microgravity on brine shrimp eggs hatched in space.

Description: The experiment was activated by injecting the eggs into a temperature-controlled, light-cycled growth chamber. Photographic cycles for documentation were carried out.

Results: To be included (if available) in next edition.

References:

Prelaunch Flight Operation Report No. M-989-61-C. Washington, D.C.: Headquarters Administration Div., NASA HQ, 1985.

Space Shuttle Mission 61-C Press Kit, December 1985.

Appendices

Appendix A

Detailed Supplementary Objective (DSO) Summaries

Introduction

The medical DSO's are preliminary studies (i.e., pilot studies) flown on the middeck area of the Shuttle and performed on the crew in order to study various aspects of human adaptation to microgravity. Many of the DSO's are designed either to take a brief look at a specific physiological effect or to pilot test a countermeasure for a medical problem, prior to the initiation of more detailed and more costly experiments. The majority of the DSO's described below examine certain aspects of space motion sickness or cardiovascular deconditioning, which are two of the most significant physiological changes affecting human health in microgravity. The DSO summaries are brief, because final reports are not available for many of them. For further information on DSO results, contact Dr. Michael W. Bungo, M.D. at the Space Biomedical Research Institute (SBRI), NASA JSC. The DSO's are handled through the SBRI. The summaries are arranged by the DSO number and cover STS-1 through STS 51-J. The launch and landing dates of these Shuttle missions are as follows:

STS-1	April 12-14, 1981
STS-2	November 12-14, 1981
STS-3	March 22-30, 1982
STS-4	June 27 - July 4, 1982
STS-5	November 11-16, 1982
STS-6	April 4-9, 1983
STS-7	June 18-24, 1983
STS-8	August 30 - September 5, 1983
STS-9 (Spacelab 1)	November 28 - December 8, 1983
STS 41-B	February 3-11, 1984
STS 41-C	April 6-13, 1984
STS 41-D	August 30 - September 5, 1984
STS 41-G	October 5-13, 1984
STS 51-A	November 8-16, 1984
STS 51-C	January 24-27, 1985
STS 51-D	April 12-19, 1985
STS 51-B (Spacelab 3)	April 29 - May 6, 1985
STS 51-G	June 17-24, 1985
STS 51-F (Spacelab 2)	July 29 - August 6, 1985
STS 51-I	August 27 - September 3, 1985
STS 51-J	October 3-7, 1985
STS 61-A	October 30 - November 6, 1985
STS 61-B	November 26 - December 3, 1985
STS 61-C	January 12-18, 1986

Summaries

DSO 401

Title: Validation of Predictive Tests and Countermeasures for Space Motion Sickness

Principal Investigator: Jerry L. Homick
Affiliation: Medical Sciences Div., NASA JSC

Flights: Every Shuttle

This DSO, variations of which are repeated on every Shuttle, involves the ongoing collection of data on the prediction and prevention (countermeasures) of space motion sickness. Past spaceflight experience has shown that up to half of the crew may develop motion sickness, which can interfere with crew performance. The inflight data are supplemented pre- and postflight on crew members. The data collected include questionnaires on prior motion sickness experience, preflight induced motion sickness testing with the Coriolis Sickness Susceptibility Index (CSSI), symptoms checklist/tape recording, and responses to various antimotion sickness drugs. A combination of oral scopolamine and Dexedrine has been effective in reducing motion sickness symptoms in certain crew members. The preflight CSSI test was not a good predictor of motion sickness during spaceflight; therefore, this test was replaced with the Off-Vertical Rotation (OVR) test on STS-11. The data collection on this DSO is continuing and further results will be available later.

DSO 402

Title: Cardiovascular Deconditioning and Countermeasures Assessment/Biochemistry and Endocrinology

Principal Investigator: Michael W. Bungo; Philip C. Johnson, Jr. (STS-4); Carolyn S. Leach
Affiliation: Medical Sciences Div., NASA JSC

Flights: Every Shuttle

This DSO was initiated on all Shuttles in order to obtain data from crew members on cardiovascular changes due to microgravity (deconditioning) and on various prevention methods (countermeasures). Both pre- and postflight cardiovascular data were also obtained. Deconditioning produces an increase in heart rate, a decrease in systolic blood pressure, a decrease in pulse pressure, and a variable effect on diastolic blood pressure. Biochemistry tests on blood and urine were performed on two crew members on STS-2 pre- and postflight. Postflight decreases were

observed in blood levels of triglycerides, magnesium, sodium, potassium, and AST and in urine levels of sodium, magnesium, potassium, and chloride. Postflight increases were found for blood glucose, cholesterol, BUN, uric acid, bilirubin, calcium, alkaline phosphatase, CPK, angiotensin I, aldosterone, insulin, T3, T4, HGH, ACTH, LDH, and osmolarity. Postflight increases in urine cortisol, aldosterone, epinephrine, and norepinephrine levels were noted.

A Cardiovascular Index of Deconditioning (CID) was developed. The CID equals the change in heart rate while the subject is standing postflight compared to preflight minus the change in systolic blood pressure standing postflight compared to preflight plus the change in diastolic blood pressure standing postflight compared to preflight. The Stand test produces orthostatic provocation: heart rate and blood pressure are measured in the supine followed by the standing positions. These tests were used to measure the efficacy of various countermeasures. The oral administration of isotonic saline consumed in the 4 hours before reentry was found to be a very effective countermeasure against orthostatic intolerance. The heart rate response was reduced and the fall in average blood pressure was reversed by the saline method. This countermeasure has become a standard operating procedure on Shuttle missions.

DSO 403

Title: Head and Eye Motion (Ascent and Entry)

Principal Investigator: William E. Thornton
Affiliation: Astronaut Office, NASA JSC

Flights: STS-5, 6, 7, and 8

Data on head and eye motion were obtained in order to study changes in vestibular functioning in microgravity. Head motion was measured with a head-mounted gyro and a seat-mounted potentiometer. Eye motion was measured with horizontal electrooculograms (EOG's) during launch and reentry, as well as in simulations of launch and reentry. No abnormalities were observed in either crew members who had space motion sickness or in those who experienced no motion sickness.

DSO 404

Title: On-Orbit Head and Eye Tracking Tasks

Principal Investigator: William E. Thornton
Affiliation: Astronaut Office, NASA JSC

Flights: STS-5, 6, 7, and 8

Data were obtained on the vestibular system in relation to developing countermeasures for motion sickness. Head and eye tracking of visual targets were measured in space using tests equivalent to the electro-nystagmogram. Pre- and postflight studies were also performed on crew members. The measurements included gaze, head turns, pursuit tracking, vestibulocervico-ocular reflex, and vestibular and peripheral visual suppression. The data indicate that there are no disordered end organs (vestibular organs affected by fluid shifts and other changes due to microgravity) and no decreased central nervous system pressure.

DSO 405

Title: Acceleration Detection Sensitivity

Principal Investigator: William E. Thornton
Affiliation: Astronaut Office, NASA JSC

Flights: STS-5, 7, and 8

This DSO was designed to study the development of space motion sickness, with respect to whether microgravity changes the gain of the otolith organs (that detect linear acceleration). The equipment consisted of a longitudinal whole body oscillator with four springs and a harness. The results were affected by extraneous angular oscillations that interfered with the ability of the subjects to detect linear acceleration. The equipment required some design changes.

DSO 406

Title: Kinesthetic Ability

Principal Investigator: William E. Thornton
Affiliation: Astronaut Office, NASA JSC

Flights: STS-5, 7, and 8

This DSO was initiated to measure possible changes in the neuromuscular system in microgravity. The test consisted of the ability to reproduce a fixed position without visual reference by marking a point moving an arm or leg and then trying to reach the same point again.

DSO 407

Title: Leg Volume "Stocking"/Photographic Documentation of Body Fluid Shift

Principal Investigator: William E. Thornton
Affiliation: Astronaut Office, NASA JSC

Flights: STS-6, 7, and 8

Measurements of lower to upper body fluid shift in microgravity were made using multiplanar photogrammetry of the head in three positions and the legs in five positions. Stocking plethysmograph data were also obtained.

DSO 408

Title: Near Vision Acuity (STS 41-B)/Contrast Sensitivity Measurements (STS 41-C - 51-C)

Principal Investigator: James M. Vanderploeg; Arthur P. Ginsburg
Affiliation: Space Biomedical Research Institute, NASA JSC; U.S. Air Force, Aviation Vision Lab, Visual Display Systems Branch, Human Engineering Div.

Flights: STS-5, 6, 7, 8, 41-B, 41-C, 41-D, 41-G, and 51-C

The DSO was developed to document changes in near vision acuity in microgravity, which was reported by STS-4 crew members. The DSO involved use of a Krimsky Rule to measure near vision accommodation inflight, pre-, and postflight. No significant effects on near accommodation point were found. Contrast sensitivity (CS) measurements using special vision charts became the main focus of the DSO on STS-13 (41-C). Some statistically significant changes in CS were found and further CS experiments were planned for later flights.

DSO 409

Title: Microbial Screening Test Report

Principal Investigator: Duane L. Pierson
Affiliation: Medical Sciences Div., NASA JSC

Flights: STS-6, 7, and 8

Measurements of bacterial and fungal airborne contaminants were made on the Shuttle mid- and flight decks using a centrifugal microbial monitor. The number of airborne contaminants increased during the missions. It was concluded

that inflight microbial monitoring is important, particularly on missions containing experimental animals.

DSO 410

Title: Audiometry

Principal Investigator: William E. Thornton
Affiliation: Astronaut Office, NASA JSC

Flights: STS-6, 7, and 8

Audiometry measurements were made, using T/M (tympanic membrane) compliance with a pneumatic otoscope. Preflight and inflight data were obtained; however, the results were difficult to analyze due to the lack of noise level measurements on the Shuttle. Any changes in hearing threshold in microgravity were thought to be related to middle ear changes. Audio evoked potentials were thought to be superior measurements.

DSO 411

Title: Simple Mass Measurement

Principal Investigator: William E. Thornton
Affiliation: Astronaut Office, NASA JSC

Flights: STS-8

The purpose of this study was to test the instrumentation needed to measure the body mass of humans in microgravity. The technique is based on manual linear acceleration using a beam balance with an attached net to hold the subject to be weighed. The major problem with this system was the time required for the mass measurement. An improved instrument (which uses electronics) is under development.

DSO 412

Title: Treadmill Operation

Principal Investigator: William E. Thornton
Affiliation: Astronaut Office, NASA JSC

Flights: STS-7 and 8

Documentation of the Shuttle treadmill operation was attempted using 16 mm cine film. Additional film of different points on the treadmill needs to be taken before analysis of

treadmill operation is possible.

DSO 413

Title: Cell Attachment in Microgravity

Principal Investigator: Dennis R. Morrison
Affiliation: Biomedical Applications Branch, NASA JSC

Flights: STS-7

This DSO tested the ability of kidney cells to attach to microcarrier beads in microgravity for cell culture studies. The cells would contact the beads only during random collisions in microgravity, and it was necessary to determine whether there would be enough collisions for the cells to attach and use the beads as a substrate. The cells were contained in plastic bags, and a ground control group of cells and beads was maintained. The results indicated that the cells were able to attach to the beads in microgravity, although fewer cells were attached to each bead compared to the controls.

DSO 414

Title: Ophthalmoscopy

Principal Investigator: Ellen L. Shulman
Affiliation: NASA JSC

Flights: STS-7 and 8

Ophthalmoscopy was performed on two crew members on the third day of the flight. The test was used to measure a possible increase in intracranial pressure, which may occur in response to the fluid shift during adaptation to microgravity. No evidence of increased cranial pressure was found; however, this would have been more likely to appear on the first 2 days of the mission.

DSO 415

Title: Tissue Pressure Tonometry

Principal Investigator: William E. Thornton
Affiliation: Astronaut Office, NASA JSC

Flights: STS-7 and 8

Tonometry data were recorded to document fluid shifts, atrophy, and loss of muscle tone in microgravity compared to pre-

and postflight data.

DSO 416

Title: Ambulatory Monitoring with and without Skeletal Loading

Principal Investigator: William E. Thornton
Affiliation: Astronaut Office, NASA JSC

Flights: STS-7 and 8

Physiological monitoring was provided to record data on changes related to space motion sickness. The recorded data include bowel sounds, heart rate, blood pressure, skin temperature, and skin reflectance. Bowel sounds were found to be a useful measure of treatment effectiveness.

DSO 417

Title: Inflight Countermeasures for SAS

Principal Investigator: William E. Thornton
Affiliation: Astronaut Office, NASA JSC

Flights: STS-7 and 8

Various types of countermeasures for space motion sickness (SAS or Space Adaptation Syndrome) were evaluated. Physical treatments, such as a cervical loading device for the spinal column and a leg-truncal loading device, were not effective in one subject with motion sickness. The antimotion sickness drugs were much more effective in stopping the vomiting and other adverse gastrointestinal symptoms.

DSO 418

Title: Eye Hand Coordination

Principal Investigator: William E. Thornton
Affiliation: Astronaut Office, NASA JSC

Flights: STS-8

This DSO was performed in an effort to determine if sensory signals are involved in the development of space motion sickness. A 5-minute task to measure eye hand coordination was performed by all crew members pre- and postflight and early, mid, and late in the STS-8 mission. The task consisted of the subject following with a colored marker a black spot on moving graph paper. The

degree to which the subjects made errors in following the black spot pattern was then evaluated. Preliminary results did not indicate any gross differences in the errors made under the various conditions.

DSO 421

Title: Animal Enclosure Module Inflight Test

Principal Investigator: Dan Weber (student investigator); Malcolm C. Smith, Jr. (technical monitor)
Affiliation: Hunter College High School, New York, NY (currently at Cornell U, Ithaca, NY); NASA JSC

Flights: STS-8

The Animal Enclosure Module (AEM) was flown with six Specific Pathogen Free (SPF) male albino rats of the Lewis Wistar strain on STS-8. A control group of three rats was maintained. The purpose of this DSO was to test the ability of the AEM to maintain healthy rats in space with no dangers to crew safety, because this was the first time a cage of animals was flown in the crew compartment in the U.S. The AEM was developed by General Dynamics/Convair Division for an SSIP experiment, "Effects of Weightlessness on Arthritis" on STS 41-B. The major safety concerns involved microbial, particulate, and odor contamination of the crew atmosphere. Contamination was to be avoided by the use of germ-free rats, microbial filters on the intake and exhaust areas of the AEM, and airtight seals around certain areas of the AEM.

The rats flown in the AEM were 56 days old and weighed an average of 275 g at the launch date. All six rats were healthy at the end of the flight. The flight rats consumed less food and did not gain weight at the rates expected compared to ground controls. This was due to the AEM food delivery system in which the food was attached to the cage sides. The ground control cages had a more conventional food system. The water supply of half the flight rats was depleted before the end of the mission, and the water for the rest of the rats was nearly gone. Minor changes in the food and water systems were recommended. In addition, the air flow rate through the AEM needed to be increased in order to improve the removal of the cage waste products.

DSO 422

Title: Anatomical Observation

Principal Investigator: William E. Thornton

Affiliation: Astronaut Office, NASA JSC

Flights: STS-8

Examination of gross anatomical changes in the crew due to microgravity were made using palpation, ascultation, and percussion. The use of physical observation was useful except for location of various internal organs.

DSO 423

Title: Study of Inflight Fluid Changes

Principal Investigator: William E. Thornton; Carolyn S. Leach
Affiliation: Astronaut Office, NASA JSC; Medical Sciences Div., NASA JSC

Flights: STS-8

This DSO was to extend the data collected on fluid changes in microgravity in DSO 407 on STS-6, 7, and 8. Fluid intake/output was studied by estimating fluid intake and using urine collection bags. The results indicate that there was up to a 4-liter fluid shift, and only moderate diuresis was observed at night. Hormonal studies on the urine were also conducted.

DSO 424

Title: Evoked Potentials

Principal Investigator: William E. Thornton
Affiliation: Astronaut Office, NASA JSC

Flights: STS-8

Auditory evoked potentials were studied pre- and postflight on STS-8. All crew members received the pre- and postflight tests, and inflight studies were performed on two normal subjects and two subjects before and after developing space motion sickness. Visual evoked potential studies were done preflight and inflight. No significant changes were noted in either the auditory or visual evoked potentials.

DSO 425

Title: Intraocular Pressure

Principal Investigator: Sam L. Pool
Affiliation: Medical Sciences Div., NASA JSC

Flights: STS-8

Increased pressure in the eye may occur in microgravity, due to characteristic body fluid shifts. This eye pressure change could be related to space motion sickness. This DSO examined changes in intraocular pressure with a battery powered applanation tonometer. One subject was tested before, during, and after STS-8. No significant differences in intraocular pressure were observed.

DSO 427

Title: Soft Contact Lens Application Test

Principal Investigator: William E. Thornton; L.R. Young
Affiliation: Astronaut Office, NASA JSC

Flights: STS-8

Improved methods of applying a specially marked contact lens to the eye for use in ocular motion experiments were tested. The major problem with the contact lens was that it did not remain in place well in microgravity. The use of sterile water on the eye at frequent intervals may be a solution to this problem.

DSO 432

Title: Engineering Test of Carry-on Incubator and Cell Attachment in Microgravity

Principal Investigator: Dennis R. Morrison; Augusto Cogoli
Affiliation: Biomedical Applications Branch, NASA JSC; Swiss Federal Institute of Technology, Zurich, Switzerland

Flights: STS-8

The purpose of this DSO was to improve methods of handling cells for use in cell biology experiments in microgravity. The STS-7 cell attachment study (DSO 413) was done at cabin temperature. The use of an incubator improved the condition of the cells on STS-8. The degree of cell attachment to microcarrier beads in microgravity was evaluated as in DSO 413, using inflight microphotography and postflight electron microscopy to count the number of beads with attached cells. More of the cells attached to beads in microgavity than in ground control samples. After the initial attachment in the first 14 hours, both division rates were similar for flight and ground control samples.

DSO 433

Title: Preflight Postflight Parallel Swing Tests

Principal Investigator: Donald E. Parker; Millard F. Reschke and Jerry L. Homick; A.P. Arrott and B.K Lichtenberg
Affiliation: Miami U, Oxford, OH; Medical Sciences Div., NASA JSC; Payload System, Inc., Wellesley, MA

Flights: STS-8 and 41-B

This study investigated changes in self-motion perception in microgravity pre- and postflight. Motion sickness and disorientation in space may be the result of changes in vestibular responses of the otolith receptors, which respond to gravitational forces and linear movement. The parallel swing apparatus reduces visual and skin receptor cues for motion, so that the motion cues to the otolith receptors may be examined separately. The apparatus was used to measure perception of roll around the head x-axis motion and linear translation along the head y-axis. One subject from the STS-8 mission was tested pre- and postflight. At 2.5 hours postflight, the subject perceived roll motion as linear translation. The perception returned to the normal preflight level 36 hours postflight. Similar results were obtained from STS-11 subjects. In addition, data on the effects of microgravity on eye movements were collected with an infrared sensitive video camera in the dark. The eye movements postflight differed significantly from preflight. The changes in eye movements and perception of movement after exposure to microgravity support the otolith reinterpretation hypothesis, that the brain interprets signals from the otolith receptors as linear translation in microgravity.

DSO 437

Title: Inflight Microbiological Sampling

Principal Investigator: Duane L. Pierson; K.K. Gaiser
Affiliation: Medical Sciences Div., NASA JSC

Flights: STS 51-B (Spacelab 3)

Data were collected on microorganisms from the cabin and Spacelab areas, the animal cages, the rats and monkeys, and the crew (ear, nose, throat, and feces).

DSO 439

Title: Documentation of the Action of Metoclopramide

Principal Investigator: William E. Thornton
Affiliation: Astronaut Office, NASA JSC

Flights: STS 41-D, 41-G, 51-C, and 51-B (Spacelab 3)

The symptoms of space motion sickness were studied with respect to bowel sounds. It was observed on prior Shuttles that subjects affected with space motion sickness had no bowel sounds, indicating temporary intestinal paralysis. After recovery from symptoms of space motion sickness, the normal bowel sounds returned. The motion sickness symptoms in microgravity are different from those at 1-g. Tape recordings of bowel sounds were made inflight and postflight using portable recorders mounted on a waist belt. Data were collected from subjects with and without space motion sickness. Some of the subjects with motion sickness took metoclopramide, which stimulates intestinal motility. Bowel sounds were also recorded in these subjects.

DSO 440

Title: Crew Visual Performance Testing

Principal Investigator: Louis V. Genco; H.L. Task
Affiliation: U.S. Air Force, Wright-Patterson Air Force Base, OH

Flights: STS 41-D, 41-G, and 51-C

Visual performance parameters in microgravity were measured. A Visual Function Tester, which produces illumination stimulus patches focused at optical infinity, was used. Although complete results were obtained from a limited number of subjects, some general conclusions could be made. Visual acuity decreased slightly and most of the crew also experienced a decrease in resolution. Regarding vertical phorias, the right eyes of the subjects looked higher than the left eyes. No significant changes in lateral phorias, cyclophoria, peripheral flicker, or foveal flicker were observed. Stereopsis was significantly improved in microgravity. All visual performance parameters returned to normal postflight.

DSO 441

Title: Blood Pressure Monitoring During Reentry

Principal Investigator: William E. Thornton; Thomas P. Moore
Affiliation: Astronaut Office, NASA JSC; Medical Sciences Div., NASA JSC

Flights: STS-8, 41-D, 41-G, 51-C, 51-D, 51-B (Spacelab 3), and 51-F (Spacelab 2)

The purpose of this study was to gather data on blood pressure and heart rate in order to determine whether orthostatic tolerance is a significant problem after space travel. The subjects were monitored using a portable apparatus. Reentry orthostatic hypotension was not detected in the subjects tested.

DSO 442

Title: A Preventive Treatment for Zero-Gravity Sickness

Principal Investigator: Patricia S. Cowings
Affiliation: Neurosciences Branch, Life Sciences Div., NASA ARC

Flights: STS 51-C

This was a pilot study for an experiment flown on Spacelab 3 (51-B), involving the use of autogenic feedback training (biofeedback) to prevent or minimize space motion sickness symptoms. The DSO was aimed at working out the logistics for the use of the physiological monitoring equipment, which was incorporated into a garment, and other experimental procedures.

DSO 446

Title: Leg Plethysmography

Principal Investigator: Thomas P. Moore; William E. Thornton
Affiliation: Medical Sciences Div., NASA JSC; Astronaut Office, NASA JSC

Flights: STS 51-B and 51-J

This DSO was initiated to establish the time course of leg volume changes related to fluid shifts during spaceflight, reentry, and landing, particularly the change from horizontal to vertical posture. The changes in leg volume were measured by stocking plethysmographs preflight, inflight, and postflight. Each measurement consisted of leg volume readings in both the standing and the supine positions. Inflight measurements were made on the first day, near the middle, and near the end of the mission.

DSO 449

Title: Preflight Postflight Parallel Swing Tests

Principal Investigator: Donald E. Parker; Millard F. Reschke; A.P. Arrott and B.K. Lichtenberg
Affiliation: Miami U, Oxford, OH; Medical Sciences Div., NASA

JSC; Payload System, Inc., Wellesley, MA

Flights: STS 51-D

This was a continuation of DSO 433 performed on STS-8 and 11 to investigate changes in human perception of self-motion and eye movements in microgravity. The Miami University Parallel Swing apparatus consisted of a four-pole pendulum able to produce linear or roll motion. The subject was restrained in a styrofoam body mold inside an aluminum cylinder. Pure roll, pure linear, and a combination of roll and linear motion was produced in the study. Similar results to STS-8 and 11 were obtained on 51-D. In addition, the crew members reported difficulties in movement perception immediately postflight during readaptation to 1-g. Predicted increases in eye movement amplitude were not observed on 51-D. The investigators concluded that preflight prophylactic adaptation training may be valuable for use with astronauts.

DSO 450

Title: Salivary Cortisol Levels During the Acute Phase of Space Flight

Principal Investigator: Nitza M. Cintron-Trevino
Affiliation: Medical Sciences Div., NASA JSC

Flights: STS 41-G

Saliva samples were collected preflight and inflight (four samples from each subject). Cortisol levels were then measured in the samples.

DSO 451

Title: Eye-Hand Coordination During SMS

Principal Investigator: William E. Thornton; Thomas P. Moore
Affiliation: Astronaut Office, NASA JSC; Medical Sciences Div., NASA JSC

Flights: STS 51-B, 51-J, and 61-C

The purpose of this DSO was to obtain data on the effects of space motion sickness (SMS) on the performance of crew members. This DSO was a follow-up study to the eye-hand tracking task performance tests carried out on STS-8 (DSO 418). None of the performance tests on STS-8 were made on crew members with SMS. In this DSO, a 5-minute eye-hand task was performed by crew members with and without SMS preflight, inflight, and postflight.

DSO 453

Title: Combined Blood Investigation

Principal Investigator: Carolyn S. Leach; William E. Thornton; H. Schneider, Nitza M. Cintron-Trevino, and R. Landry
Affiliation: Medical Sciences Div., NASA JSC; Astronaut Office, NASA JSC; Medical Sciences Div., NASA JSC

Flights: STS 51-B (Spacelab 3) and 51-F (Spacelab 2)

Blood samples were drawn from crew members before, during, and after the missions. The inflight samples were collected early, mid, and late in the missions. Various hormones and electrolytes were analyzed in the samples. Data on the changes in the levels of these compounds may be useful in studying fluid balance and space motion sickness to develop countermeasures.

DSO 455

Title: Clinical Characterization of Space Motion Sickness

Principal Investigator: William E. Thornton; James M. Vandenploeg
Affiliation: Astronaut Office, NASA JSC; Space Biomedical Research Institute, NASA JSC

Flights: STS 51-D, 51-G, 51-I, 51-J, 61-B, and 61-C

This DSO was developed to better define the time and nature of onset, progression, recovery, and the relationship of various treatments to the speed of recovery in space motion sickness (SMS). Data on eye movement, bowel sounds, and general signs and symptoms were obtained. The eye movement measurements included ocular alignment/skin deviation, ocular stability, visual acuity/spatial constancy, vestibulo-ocular reflex (VOR), electrooculogram (EOG), and others. Preflight training and baseline measurements were conducted, after which both inflight and postflight data on SMS were obtained.

DSO 456

Title: Medical Tests and Measurements for STS 51-D Payload Specialist

Principal Investigator: James M. Vanderploeg; William E. Thornton; Thomas Moore, Millard F. Reschke, Nitza M. Cintron-Trevino, Sam L. Pool, John B. Charles, and D. Inners; Donald E. Parker
Affiliation: Space Biomedical Research Institute, NASA JSC;

Astronaut Office, NASA JSC; Medical Sciences Div., NASA JSC; Miami U, Oxford, OH

Flights: STS 51-D

This DSO included all or part of DSO's 439, 441, 446, 449, 451, 455, 458, and 460. A battery of physiological tests was performed on one of the payload specialists on STS 51-D. The tests included blood pressure and heart rate monitoring, tape recordings of bowel sounds for studies of intestinal motility during space motion sickness, electroencephalograms, leg volume measurements, Sternberg tests, total body water studies, salivary monitoring after ingestion of acetaminophen tablets, and various dexterity and coordination tests (eye-hand tracking, hand-held computer test, and parallel swing-posture platform).

DSO 457

Title: Inflight Salivary Pharmacokinetics of Scopolamine and Dextroamphetamine

Principal Investigator: Nitza M. Cintron-Trevino and Lakshmi Putcha
Affiliation: Medical Sciences Div., NASA JSC

Flights: STS 61-B and 61-C

The objective of this DSO was to monitor changes in the salivary concentrations of the antimotion sickness drugs scopolamine and dextroamphetamine during spaceflight, in order to improve the therapy for space motion sickness. These two drugs are currently used together to treat motion sickness. Physiological changes due to microgravity may produce pharmacological changes in these drugs, thus affecting the treatment. The DSO protocol called for at least two preflight control phase performances of the study for collection of baseline data under normal gravity. In the study, a capsule containing 0.4 mg scopolamine and 10 mg dextroamphetamine was taken by the crew member with 100 ml water following an 8-10 hour fast. An additional 100 ml water were used to rinse the mouth after ingestion. Salivary samples, collected by a cottonball placed in the back of the mouth for 5 minutes, were taken at various intervals after ingestion. Samples collected inflight were stored in collection tubes for postflight analysis.

DSO 458

Title: Salivary Acetaminophen Pharmacokinetics

Principal Investigator: Nitza M. Cintron-Trevino and Lakshmi

Putcha
Affiliation: Medical Sciences Div., NASA JSC

Flights: STS 51-I, 61-B, and 61-C

This DSO was initiated to monitor changes in the salivary concentration of acetaminophen during spaceflight, similar to the drug monitoring in DSO 457. Participating crew members were required to collect control samples preflight to provide baseline data. During spaceflight, two 325 mg acetaminophen tablets were ingested with 100 ml water by the participating crew members following a fast of at least 8 hours. A thorough rinsing of the mouth with 100 ml of water was required postingestion. Samples of saliva, collected by saturating a cottonball in the mouth for 2-5 minutes, were collected at various intervals postingestion. The samples were stored in collection tubes for postflight analysis. Though no definite conclusions have yet been drawn and reported from the data collected, it has been established that the saliva kit was adequately designed, that salivary drug monitoring can be successfully performed during space missions, and that pharmacokinetic evaluation of acetaminophen can be accomplished using salivary data.

DSO 459

Title: Otolith Tilt-Translation Reinterpretation

Principal Investigator: Millard F. Reschke; Donald E. Parker
Affiliation: Medical Sciences Div., NASA JSC; Miami U, Oxford, OH

Flights: STS 61-C

The objectives of this DSO were to extend the data obtained in DSO 449, to validate and refine the otolith reinterpretation hypothesis, and to evaluate the use of preflight astronaut training for preadaptation to sensory rearrangement in microgravity to prevent space motion sickness. The otolith reinterpretation hypothesis is that, in microgravity, the brain reinterprets all otolith receptor information as linear motion (producing motion sickness in many individuals). In normal gravity, the brain interprets otolith information as either linear or head/body tilt motion. Preadaptation to this alteration in the perception of motion and collection of baseline data were achieved using a roll/tilt chair assembly and an After Image Ocular Counterrolling (AIOCR) Goggles assembly. The AIOCR tests inflight involved presentation of light flashes using a strobe at ten different head orientations. The crew members were also requested to document their perceived head motions after orbital insertion, during reeentry, and during descent. Postflight measurements were also required, in order to record

the duration of the changes in motion perception.

DSO 460

Title: Changes in Total Body Water During Spaceflight

Principal Investigator: Carolyn S. Leach, D. Inners, and John B. Charles
Affiliation: Medical Sciences Div., NASA JSC

Flights: STS 61-C

The purpose of this DSO was to measure changes in Total Body Water (TBW) as a result of exposure to microgravity. The hypothesis that TBW decreases by 1-1.5 liters during the first 3 days in microgravity was evaluated. TBW was measured by an isotope dilution method using ^{18}O-labeled water as a tracer. A known amount of the tracer-labeled water was ingested in the morning before breakfast. Saliva samples were then collected at 3 and 5 hours after tracer ingestion for postflight analysis of the amount of tracer. Three preflight, three inflight, and three postflight TBW measurements were required. Body mass was also measured in the pre- and postflight sessions.

DSO 461

Title: Leg Plethysmography

Principal Investigator: Thomas P. Moore; William E. Thornton
Affiliation: Medical Sciences Div., NASA JSC; Astronaut Office, NASA JSC

Flights: STS 61-B and 61-C

This DSO was a repeat of DSO 446.

DSO 462

Title: Noninvasive Estimation of Central Venous Pressure During Spaceflight

Principal Investigator: John B. Charles and Michael W. Bungo
Affiliation: Medical Sciences Div., NASA JSC

Flights: STS 61-C

This DSO was designed to measure the physiological adaptations to the headward fluid shift characteristic of microgravity by estimating the central venous pressure (CVP).

Participating crew members were required to participate in a 1 hour preflight training session during which they learned the noninvasive CVP measurement method and in one 20 minute preflight data collection session. A CVP 30 minute data collection session was held as soon as possible on flight day 1 and as often as possible throughout the flight. The CVP measurement method used involves monitoring the venous blood flow in a jugular or antecubital vein while varying the intrathoracic pressure until the venous flow is interrupted. Intrathoracic pressure is increased by imposing a slight, variable, end-expiratory airway resistance via a mouthpiece.

DSO 463

Title: Inflight Treadmill Stress Test

Principal Investigator: Michael W. Bungo and John B. Charles
Affiliation: Medical Sciences Div., NASA JSC

Flights: STS 61-C

The objective of this DSO was to document the frequency of cardiac rhythm abnormalities in the orbiter during spaceflight. A significant incidence of such abnormalities has been observed during extravehicular activity on Shuttle missions. Baseline responses to treadmill stress testing were recorded preflight. All participants were trained to use and maintain the experimental equipment prior to launch. During the last 24 hours inflight, the subject performed the treadmill electrocardiogram stress test and wore an activated Holter recorder while performing normal activities. During the stress test, the subject stood quietly on the treadmill for 5 minutes and then exercised at 70-85% of maximum heart rate for a period of 30 minutes. The Holter recorder was worn until postflight testing.

DSO 464

Title: Inflight Assessment of Renal Stone Risk Factor

Principal Investigator: Nitza M. Cintron-Trevino
Affiliation: Medical Sciences Div., NASA JSC

Flights: STS 61-C

The purpose of this DSO was to determine if spaceflight increases the risk of kidney stone formation and, if so, to formulate effective countermeasures. Excess excretion of calcium, which can eventually cause kidney stones and other problems, has been observed in microgravity. The determination involved collection of 24-hour urine samples from crew members

once preflight, twice inflight (early and later in the mission), and once postflight. The urine samples were saved for postflight analysis of oxalate, citrate, uric acid, calcium, phosphate, pH, sodium, potassium, magnesium, ammonium, sulfate, and total volume.

DSO 465

Title: Echocardiographic Evaluation of Cardiovascular Deconditioning

Principal Investigator: Michael W. Bungo and John B. Charles
Affiliation: Medical Sciences Div., NASA JSC

Flights: STS 61-C

This DSO was developed to utilize ultrasound examinations of the cardiovascular system (echocardiograms) to quantitate the adaptive changes occurring in spaceflight (cardiovascular deconditioning) and to develop appropriate countermeasures. Participating crew members were required to have a preflight echocardiogram and to participate in two preflight data collection sessions. Echocardiograms were also taken immediately after landing and at L+0, 1, 2, 3, 4, 5, 6, and 7 days postflight. No inflight data were recorded as part of this DSO. Blood pressures were measured at the same times as the echocardiograms. The ultrasound readings were taken while the subjects were in both the standing and supine positions.

References

Tandi M. Bagian, Space Biomedical Research Institute, NASA JSC.

Space Transportation System. Flight Tests and Supplementary Objectives Document. Rev G. JSC 16725. Houston, TX: NASA JSC, 1985.

Radiation Monitoring

Two researchers have collected radiation monitoring data, which have not been included in the experiment summaries. Steven E. Cash (U.S. Air Force Technical Applications Center (AFTAC), Patrick Air Force Base, FL) flew radiation monitoring equipment (RME) on STS-6, 8, 11, 41-C, 41-G, and 51-A. The equipment included a pocket neutron dosimeter and a Handheld Radiation Monitor, a type of gamma ray counter. Ferene Szabo (Central Research Institute for Physics, Budapest, Hungary) flew six Thermo Luminescent Dosimeters (TLDs) on STS 41-G. Pertinent results may be included if available in the next edition of this report.

Appendix B

Acronyms and Terms

AEM	Animal Enclosure Model
AFB	Air Force Base
ARC	Ames Research Center
BIORACK	A facility for performing animal and plant research on Spacelab (including experiment containers, incubators, refrigerators, centrifuges, etc.) built by ESA
CANEX	Canadian Payload Specialist Experiments
CNES	Centre National d'Etudes Spatiales
DFVLR	Deutsche Forschungs und Versuchsanstalt fuer Luft und Raumfahrt e.V. (German Aerospace Research Establishment)
DSO	Detailed Supplementary Objective
DTO	Development Test Objective
ESA	European Space Agency
GAS	Get Away Special
GSFC	Goddard Space Flight Center
HQ	Headquarters
HZE	High charge and energy galactic cosmic rays
JPL	Jet Propulsion Laboratory
JSC	Johnson Space Center
KSC	Kennedy Space Center
LaRC	Langley Research Center
LDEF	Long Duration Exposure Facility
MORELOS	Mexican Payload
MSFC	Marshall Space Flight Center
OSF	Office of Space Flight
OSS	Office of Space Science
OSSA	Office of Space Science and Applications
OSTA	Office of Space and Terrestrial Applications
PGU	Plant Growth Unit
RAHF	Research Animal Holding Facility
RME	Radiation Monitoring Equipment
SAS	Space Adaptation Syndrome
SASSE	Space Adaptation Syndrome Supplemental Experiments
SL	Spacelab
SLS-1	Space Life Sciences Laboratory-1 (Spacelab 4)
Space Sled	Linear accelerator for vestibular research on Spacelab (built by ESA)
SSIP	Shuttle Student Involvement Program
STS	Space Transportation System (Space Shuttle)
TLD	Thermo Luminescent Dosimeter

Appendix C

Addresses of Agencies Involved in Shuttle Experiments

NASA Centers

Ames Research Center
NASA
Moffett Field, CA 94035
(415)694-5000

George C. Marshall Space Flight Center
NASA
Marshall Space Flight Center, AL 35812
(205)453-2121

Goddard Space Flight Center
NASA
Greenbelt Rd.
Greenbelt, MD 20771
(301)344-7000

Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, CA 91109
(818)354-4321

John F. Kennedy Space Center
NASA
Kennedy Space Center, FL 32899
(305)867-7110

Langley Research Center
NASA
Hampton, VA 23665
(804)865-2000

Lyndon B. Johnson Space Center
NASA
Houston, TX 77058
(713)483-3111

NASA Headquarters
Washington, D.C. 20546
(202)453-1000

European Space Agencies (Partial List)

German Aerospace Research Establishment (DFVLR)
Washington Office
One Farragut Square South, NW
Washington, D.C. 20006
(202)737-0426

Deutsche Forshungs und Versuchsanstalt fuer
Luft und Raumfahrt e.V. (DFVLR)
P.O. Box 90 60 58
D-5000 Cologne 90
Federal Republic of Germany
49-22036011

European Space Agency
Agence Spatiale Europeenne
8-10, rue Mario-Nikis
F-75738 CEDEX 15
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33-142737654

European Space Agency, Technical Directorate
European Space Research and Technology Centre (ESTEC)
Noordwijk, The Netherlands
31-17196555

Principal Investigators Index

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Subject Index