NASA

SPACE ENVIRONMENT WORKSHOPS FOR LIFE SCIENTISTS

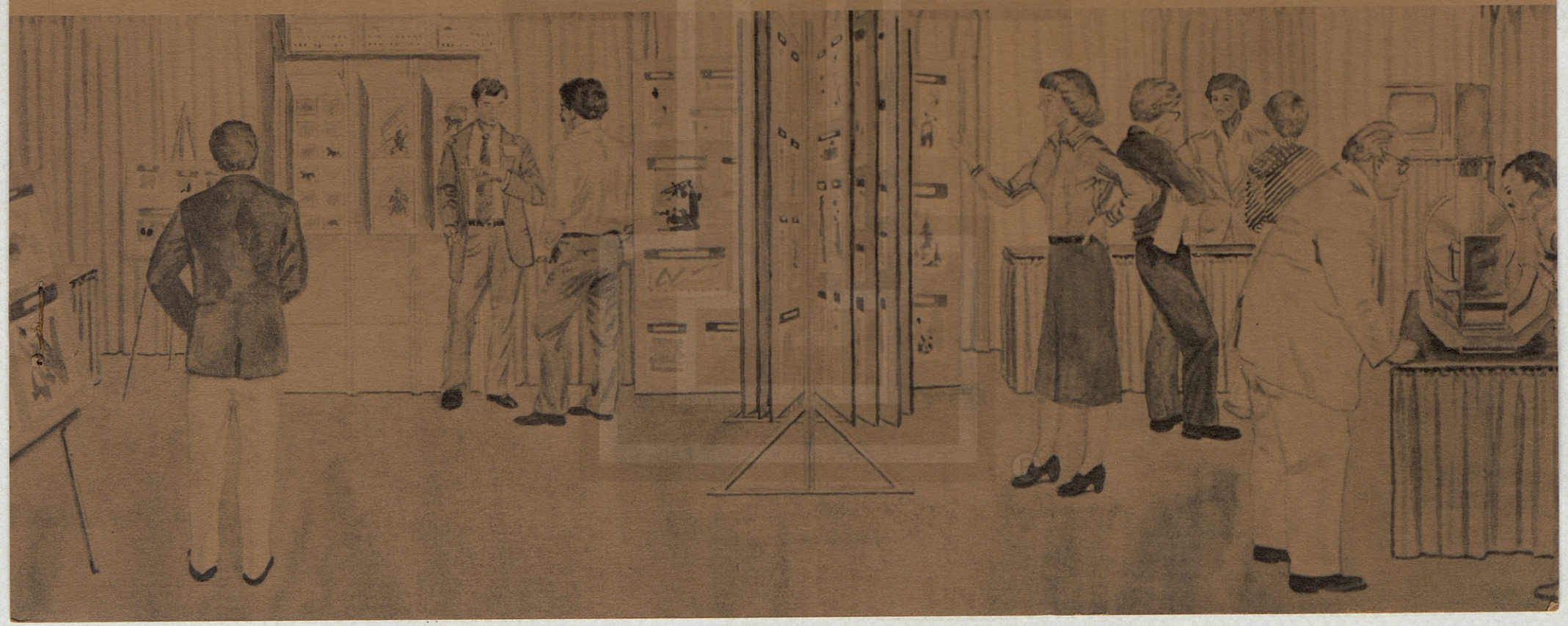
ANAHEIM, CALIFORNIA

FEDERATION OF AMERICAN SOCIETIES OF EXPERIMENTAL BIOLOGY

APRIL 13-18, 1980

AEROSPACE MEDICAL ASSOCIATION

MAY 12-15, 1980



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HOTLINE COMMUNICATION: LIFE SCIENCES SPACE EXPERIMENT/TECHNICAL AREAS; ABSTRACTS, ILLUSTRATIONS, AND SCIENTIST CONTACTS

WORKSHOP CHAIRMAN: JOHN A. MASON

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LIFE SCIENCES HOTLINE WORKSHOP

The NASA Space Environment Booth is organized as a communication center. The exhibit will give an opportunity for conferees at two Anaheim, California, scientific meetings (Federation of American Societies of Experimental Biology - April 13-18, 1980, and Aerospace Medical Association - May 12-15, 1980) to communicate one-on-one with the individual NASA scientist wherever he may be in the country via "hotline" telephones located in the exhibit booth. The NASA scientists thus contacted are the principal investigators or administrators involved in over 25 life science areas associated with Spacelab, the laboratory which will be carried in the Space Shuttle.

Thus, after a conferee has reviewed the display posters, which describe current life sciences space activities, he may begin a direct dialog on a person-to-person basis with the NASA person responsible for the area of science within which he has questions.

The NASA contact has at his finger-tips, the telephone listings of his personal network of backup scientists, with whom he can put the conferee in direct communication if required on special questions.

The exhibit/workshop is aimed at informing interested scientists about the NASA life sciences space activities with an ultimate goal of better utilization of spaceflight to address life sciences questions.

The communications concept:

When a conferee has need for further information regarding any of the areas presented in the exhibit posters, he/she simply lifts the hotline telephone and dials 972-4950. The appropriate NASA code is then given to the operator along with the telephone number listed on the bottom of the page describing his particular area of interest. In this way, the conferee can speak to the NASA individual responsible for the scientific area of interest.

The exhibit personnel in Anaheim will be available to discuss general aspects of the Shuttle/Spacelab program, and specific aspects, including the NASA Principal Investigator Interface; Spacelab 1, U.S.-Life Sciences Experiments; Environmental Parameters of Space; and other areas.

Supporting the hotline is an integrated display section presented by Astronaut Shannon W. Lucid. Dr. Lucid is a biochemist.

The display is a complete presentation which leads the viewer from take-off and landing, through a 3-dimensional model of the Shuttle Orbiter and closer, into the system-view of the laboratory in which the experiments will take place.

The exhibit contains early mockups of the rat and monkey cages which fit into the Spacelab. In attendance will be personnel who will explain the equipment and its experimental use.

Motion pictures will be exhibited, showing zero-g experiments from Skylab and other experimental demonstrations.

The NASA exhibit personnel includes:

In Anaheim

Michael A. Berry*
Patricia S. Cowings**
David D. Feller**
William E. Feddersen
John E. Greenleaf**
Daniel C. Holley**
Shannon W. Lucid
Emily Morey-Holton**
Henry A. Leon**
Robert W. Mah**
John A. Mason
William B. Toscano**
Bill A. Williams

Via Hotline

Steven I. Altchuler
Charles M. Barnes
Michael A. Berry*
Gary H. Bowman
Nitza M. Cintron
Patricia S. Cowings**
Nancy G. Daunton
Lucky A. Goebel
Danielle J. Goldwater
John E. Greenleaf**
Robert E. Heyer
Jerry L. Homick
Robert L. Johnson
Ryborn R. Kirby
Jeffrey L. Lacy
Henry A. Leon**
Gary W. McCollum
Dennis R. Morrison
Dolores B. O'Hara
Michael A. Reynolds
Millard F. Reschke
Malcolm C. Smith, Jr.
Kenneth A. Souza
Gerald R. Taylor
Charles M. Winget

*May be either at Anaheim meeting or Johnson Space Center
**May be either at Anaheim meeting or Ames Research Center

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NASA-S-80-10233

PREVENTIVE METHOD FOR ZERO-G SICKNESS

AUTOGENIC-FEEDBACK TRAINING FOR VESTIBULAR SYMPTOMATOLOGY

OVERVIEW

OBJECTIVES

- DETERMINE ABILITY OF TREATMENT GROUPS TO SUPPRESS MOTION SICKNESS
- DETERMINE APPLICABILITY TO LARGE POPULATION
- EXAMINE INDIVIDUAL VARIABILITY IN PERFORMANCE
- DETERMINE TRANSFER TO OTHER STIMULUS CONDITIONS
- DETERMINE RETENTION AND RELEARNING PROPERTIES
- ESTABLISH PRACTICAL APPLICATION TO PRE-FLIGHT TRAINING
- APPLY TRAINING AS A PREVENTATIVE METHOD FOR ZERO-GRAVITY SICKNESS
- EVALUATE TREATMENT IN-FLIGHT EXPERIMENTS

TREATMENT COMPONENTS

BIOFEEDBACK:

- SENSORY FEEDBACK OF ON-GOING PHYSIOLOGICAL ACTIVITY
- OPERANT CONDITIONING
- PRACTICE

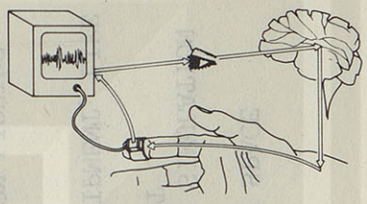
AUTOGENIC THERAPY:

- IDEOMOTOR ACTION
- SELF-SUGGESTION EXERCISES
- PASSIVE CONCENTRATION
- REPETITION

AUTOGENIC-FEEDBACK TRAINING:

- DIRECTED ATTENTION TRAINING
- MULTIPLE MODALITY FEEDBACK
- MULTIPLE RESPONSE CONDITIONING
- ELIMINATION OF DEPENDENCE ON FEEDBACK
- INTRODUCTION OF ENVIRONMENTAL "DISTRACTIONS"

THE BIOFEEDBACK LOOP



INTRODUCTION

- AUTOGENIC-FEEDBACK TRAINING IS PROPOSED AS A THERAPY FOR ZERO GRAVITY SICKNESS
- PREVIOUS STUDIES HAVE SHOWN THIS METHOD ENABLES HUMANS TO SUPPRESS THEIR OWN MOTION SICKNESS SYMPTOMS THROUGH LEARNED AUTONOMIC CONTROL
- THE HYPOTHESES OF THE PRESENT STUDY WERE:
  - LEARNED SYMPTOM SUPPRESSION TRANSFERS ACROSS OPPOSITE DIRECTIONS OF CORIOLIS ACCELERATION
  - EFFECTIVENESS OF TREATMENT IS NOT DIRECTLY RELATED TO INITIAL SUSCEPTIBILITY TO CORIOLIS SICKNESS
  - BIDIRECTIONAL AUTONOMIC CONDITIONING >=< UNIDIRECTIONAL CONDITIONING
  - A STANDARDIZED TRAINING PROGRAM IS APPLICABLE
  - * PERFORMANCE OF AN ALTERNATIVE COGNITIVE TASK DOES NOT EFFECT CORIOLIS TEST RESULTS

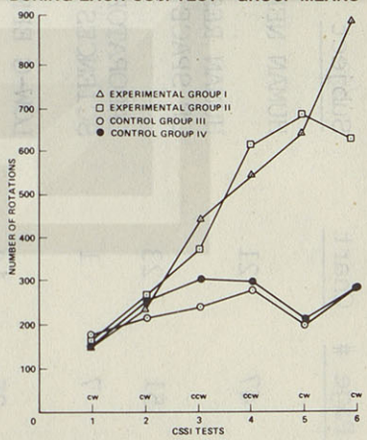
* DATA ON THIS CONTROL CONDITION WERE INCOMPLETE AT TIME OF ABSTRACT SUBMISSION

METHODS

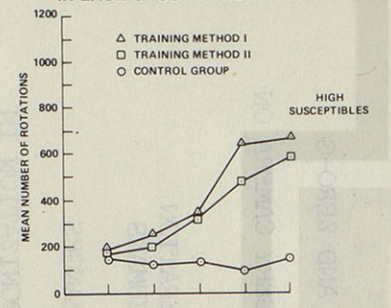
- TWENTY-FOUR MEN (AGES 18 TO 30) WERE ASSIGNED TO FOUR EQUAL GROUPS – MATCHED FOR INITIAL SUSCEPTIBILITY TO CORIOLIS SICKNESS
- AUTONOMIC RESPONSES CONDITIONED WERE:
  - HEART RATE
  - RESPIRATION RATE
  - GALVANIC SKIN RESPONSE
  - BLOOD VOLUME PULSE OF FACE AND HANDS
  - ACTIVITY OF EXTERNAL INTERCOSTAL MUSCLE
- A ROTATING CHAIR WAS USED TO INDUCE MOTION SICKNESS SYMPTOMS
- THE CORIOLIS SICKNESS SUSCEPTIBILITY INDEX (CSSI) INDICATED MALAISE LEVELS
- ALL SUBJECTS WERE GIVEN SIX CSSI TESTS, FIVE DAYS APART
  - TESTS 1 AND 2 WERE CLOCKWISE
  - TESTS 3 AND 4 WERE COUNTERCLOCKWISE
  - TESTS 5 AND 6 WERE CLOCKWISE
- TREATMENT GROUPS I AND II RECEIVED TRAINING BEFORE CSSI TESTS 3, 4 AND 5
- CONTROL GROUP III RECEIVED NO TREATMENT

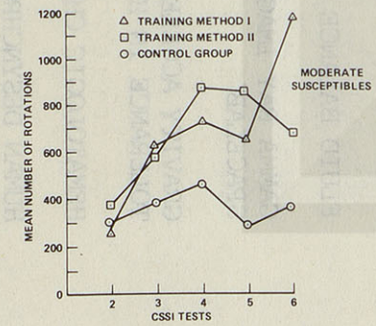
CONTROL GROUP IV (SIX SUBJECTS) RECEIVED "SHAM" TRAINING

NUMBER OF ROTATIONS ACHIEVED DURING EACH CSSI TEST - GROUP MEANS



MEAN NUMBER OF ROTATIONS FOR HIGH AND MODERATE SUSCEPTIBLES IN EACH GROUP ACROSS TESTS





CORIOLIS SICKNESS SUSCEPTIBILITY BASED ON NUMBER OF ROTATIONS ACHIEVED DURING CSSI TEST 1

SPEED, (rpm)	NUMBER OF ROTATIONS PER STEP	EXPERIMENTAL GROUP I (BIDIRECTIONAL)	EXPERIMENTAL GROUP II (UNIDIRECTIONAL)	CONTROL GROUP III (TEST ONLY)	CONTROL GROUP IV	CATEGORY
4	0 30					
6	31 70					HIGH
10	71 120					
12	121 180					
14	181 250					MODERATE
16	251 330					
18	331 420					
20	421 520					
22	521 630					LOW
24	631 750					
26	751 880					
28	881 1020					
30	1021 1170					

* SUBJECTS CAPABLE OF TOTAL SYMPTOM SUPPRESSION (ACHIEVED 1170 ROTATIONS) AFTER TRAINING

* SUBJECTS CAPABLE OF SIGNIFICANT SYMPTOM SUPPRESSION (p 0.05) AFTER TRAINING

RANDOMIZED BLOCKS DESIGN FOR ANALYSIS OF VARIANCE

SOURCE	F	p	SIGNIFICANCE
GROUPS	F = 3.95	p 0.05	*
BLOCKS	F = 8.06	p 0.025	*
TESTS	F = 7.044	p 0.0005	*
GROUPS X BLOCKS	F = 0.243	p 0.05	N/S
GROUPS X TESTS	F = 3.28	p 0.001	*
BLOCKS X TESTS	F = 1.33	p 0.05	N/S

PLANNED COMPARISONS (t-TESTS, ONE-TAILED)

CSSI =3				CSSI =5			
GROUPS	t_{10}	t	SIG	GROUPS	t_{10}	t	SIG
I X III	t = 0.876	p > 0.05	N/S	I X III	t = 2.39	p 0.025	*
I X IV	t = 0.980	p > 0.05	N/S	I X IV	t = 2.29	p 0.025	*
II X III	t = 0.608	p > 0.05	N/S	II X III	t = 2.21	p 0.05	*
II X IV	t = 0.940	p > 0.05	N/S	II X IV	t = 2.16	p 0.05	*
I X II	t = 0.177	p > 0.05	N/S	I X II	t = -0.202	p > 0.05	N/S
III X IV	t = 0.960	p > 0.05	N/S	III X IV	t = 0.077	p > 0.05	N/S

CONCLUSIONS

- LEARNED CONTROL OF SYMPTOM SUPPRESSION DOES TRANSFER ACROSS OPPOSITE DIRECTIONS OF CORIOLIS ACCELERATION
- INITIAL SUSCEPTIBILITY OF MOTION SICKNESS IS APPARENTLY UNRELATED TO EFFECTIVENESS OF TRAINING
- BIDIRECTIONAL AND UNIDIRECTIONAL CONDITIONING OF AUTONOMIC RESPONSES ARE EQUALLY EFFECTIVE
- A STANDARDIZED TRAINING SCHEDULE IS APPLICABLE

PRACTICING AN ALTERNATIVE COGNITIVE TASK DURING CSSI TESTS DOES NOT IMPROVE PERFORMANCE SIGNIFICANTLY

BIOFEEDBACK

AUTOGENIC-FEEDBACK TRAINING FOR VESTIBULAR SYMPTOMATOLOGY. Patricia S. Cowings and William B. Toscano, NASA-Ames Research Center, Moffett Field, CA 94035.

The overall objective of this research is directed toward developing an effective and efficient method for training human subjects to volitionally control their own physiological reactions to motion sickness provoking conditions. The eventual application of this work will be the prevention or alleviation of the debilitating effects of zero-gravity sickness syndrome in the passengers and crew on actual Space Shuttle missions.

The preventive method is referred to as autogenic feedback training, a combined application of biofeedback and autogenic therapy. Autogenic therapy employs self-suggestion exercises designed to induce specific somatic sensations which are highly correlated with specific physiologic responses. Practice of these exercises results in a tendency for parasympathic dominance within the organism which precludes the emergence of physiological (i.e.; symptomatic) reactions to stress. Biofeedback employees operant conditioning paradigm wherein the subject is presented with immediate sensory information or "feedback" about the ongoing activity level of some physiological response (e.g. his own heart rate on a meter). By rewarding appropriate changes in activity levels (e.g. heart rate decreases), the subject can eventually be taught to control the reinforcement-contingent variable. (By combining biofeedback and autogenic therapy, it is possible to significantly enhance the degree of learned autonomic control. Self-suggestion exercises increase the initial probability of making a correct response and immediate feedback informs the subject that he is responding appropriately.) The result is faster leaving, with large magnitude response chances that are repeatable over time. Additionally, this method can readily permit learned control of multiple autonomic responses simultaneously.

NASA-S-80-10211

2

BIOLOGICAL APPLICATIONS IN SPACE

SEPARATIONS

ELECTROPHORESIS

CELLS

- MOVING CELLS THROUGH IN FLUID BUFFER SYSTEMS
- THERMAL CONVECTION CAUSES MIXING
- ELECTROPHORETIC SEPARATION IS LIMITED IN RESOLUTION

PROTEINS

- THROUGHPUT AT AN ACCEPTABLE RESOLUTION IS LIMITED

OTHER PREPARATIVE TECHNIQUES

- QUANTUM CURRENT DISTRIBUTION IS HAMPERED BY GRAVITY INDUCED PHENOMENA

APPROACH

STEPS

- ESTABLISH CORRELATION BETWEEN CELL SURFACE CHANGE AND CELL SYNTHESIS FUNCTIONS
- QUANTITATIVELY TEST SURFACE CHANGE OR SUMMULATIONS
- STANDARDIZE ASSAYS FOR CELL FUNCTION
- EVALUATE VARIOUS SEPARATION
- PRODUCT IMPROVEMENT IN RESOLUTION AND THROUGHPUT
- SELECT CANDIDATE CELLS
- DEVELOP FLIGHT EXPERIMENTS
  - APOLLO 16
  - APOLLO 17
  - SP-1 LAB
  - APOLLO SOYUZ TEST PROJECT

PROTEINS

- TEST GROUND BASED PURIFICATION TECHNIQUES
- DEMONSTRATE LIMITATIONS IMPOSED BY GRAVITY
- PRODUCT ADVANTAGES OF SEPARATION UNDER MICRO GRAVITY CONDITIONS
- SELECT CANDIDATE PROTEINS
- DEVELOP FLIGHT DEMONSTRATION EXPERIMENT

GOALS

- DEMONSTRATION FLIGHT EXPERIMENTS TO QUANTITATE ADVANTAGES, RESOLUTION AND THROUGHPUT IMPROVEMENTS FOR SELECTED CELLS OR PROTEINS OF MEDICAL IMPORTANCE

BIOSYNTHESIS CELL CULTURE

PROBLEM AREAS

- CURRENT TECHNOLOGY LIMITED TO MONOLAYERS
- DEGENERATION INTERFERES WITH SUSPENDED SYSTEMS
- REPLICATION OF CHANGING TO PRODUCE CELLS
- O_2 OR CO_2 BUBBLES CAUSE TRAUMA

APPROACH

- IDENTIFY PRINCIPLES OF CELL CULTURE UNDER LOW GRAVITY CONDITIONS
- DEFINE ZERO-G TECHNICAL ADVANTAGES OF CELL CULTURE SYSTEMS UNDER MICRO GRAVITY CONDITIONS
- COMPARE GROUND BASED CELL CULTURE TECHNIQUES
  - CELL GROWTH
  - PRODUCT SYNTHESIS AND RELEASE
  - DEFINE OPTIMAL SECURE CONDITIONS
- DEVELOP MODEL CULTURE SYSTEM
  - EXAMINE CULTURE CONDITIONS AND ALTERNATE FEATURES
  - ILLUSTRATE SPECIFIC ADVANTAGES IN CELL CULTURE AND PRODUCT RECOVERY
  - DETERMINE CONSTRAINTS
  - SELECT CANDIDATE CELLS AND PRODUCTS

GOAL

- IDENTIFY ADVANTAGES AND DISADVANTAGES OF CELL CULTURE SYNTHESIS UNDER MICROGRAVITY CONDITIONS
- TO DEMONSTRATE THE FEASIBILITY OF COMMERCIAL CELL CULTURE IN SPACE

BIODYNAMICS

INTEREST AREAS

- HOW CELL PHYSIOLOGY INVOLVES GRAVITY
  - CELL GRAVITY SENSORS
  - CHROMOSOME LEVEL DAMAGE
  - METABOLITE DIFFUSION
- SELECTED CELLS APPEAR TO HAVE INCREASED GROWTH RATES UNDER MICROGRAVITY CONDITIONS
- SPACE VACUUM, RADIATION SPECTRUM AND CONTAMINANTS MAY PROVIDE SPECIFIC ADVANTAGES FOR CELL AND MOLECULAR BIOLOGY RESEARCH METHODS
  - RADIATION SYNTHESIS
  - FREEZE FRACTURE TECHNIQUES
  - ELECTRON MICROSCOPY

RESEARCH EMPHASIS

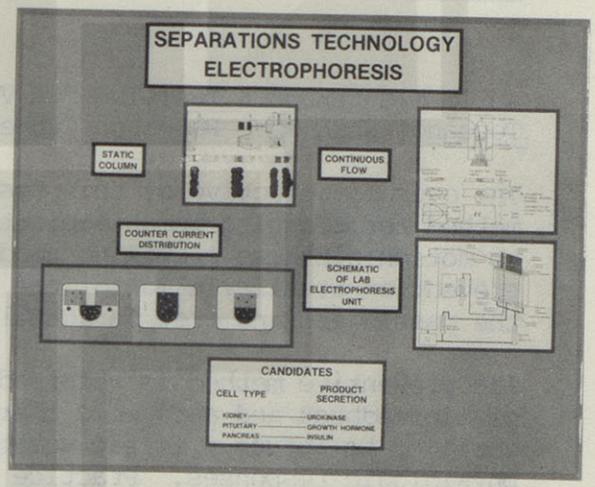
- DISAGGREGATION CELLS
  - SHEAR FORCES CAN SIGNIFICANTLY EFFECT CELL OVERALL STRUCTURE AND GAS TRANSFER THROUGH THE MEMBRANE
- CELL MICROENVIRONMENT
  - CELLS CREATE THEIR OWN MICROENVIRONMENT WHICH MIGHT BE SIGNIFICANTLY ALTERED IN ZERO-G WITH IMPROVEMENTS IN SUPPLY OF FUEL AND WASTE PRODUCT REMOVAL. CELLULAR METABOLISM COULD BE ENHANCED
- GAS TRANSFER IN MEDIA
  - GAS BUBBLE FORMATION AND SHEDDING PROBLEMS IN INFLUENCE OF GRAVITY
  - BUBBLES DO NOT RISE, COALESCENCE IS REDUCED
- MACROPHAGE DEPENDENCE
  - MOST CELLS APPEAR CONSIDERABLE DEPENDENCY TO FIXED OR SPECIFIC PROTEINS FOR ATTACHMENT TO TISSUE BED
  - CELLULAR METABOLISM MAY BE ALTERED IN MICROGRAVITY
  - CELLS BOUND DEVOTE MORE ENERGY FOR GROWTH ON BIOSYNTHESIS

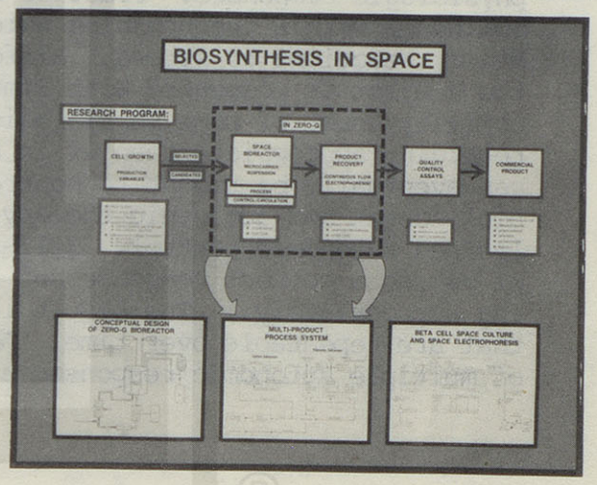
GOALS

- VALIDATE CHANGES IN CELL BIOLOGY RELATED TO SPACE ENVIRONMENT
- IDENTIFY UNIQUE EXPERIMENTS, APPROACHES, AND RESEARCH METHODS

NASA-S-80-10224

2a





WEIGHTLESSNESS, EFFECTS OF

BIOMEDICAL APPLICATIONS. Dennis R. Morrison, NASA-Johnson Space Center, Houston, TX 77058.

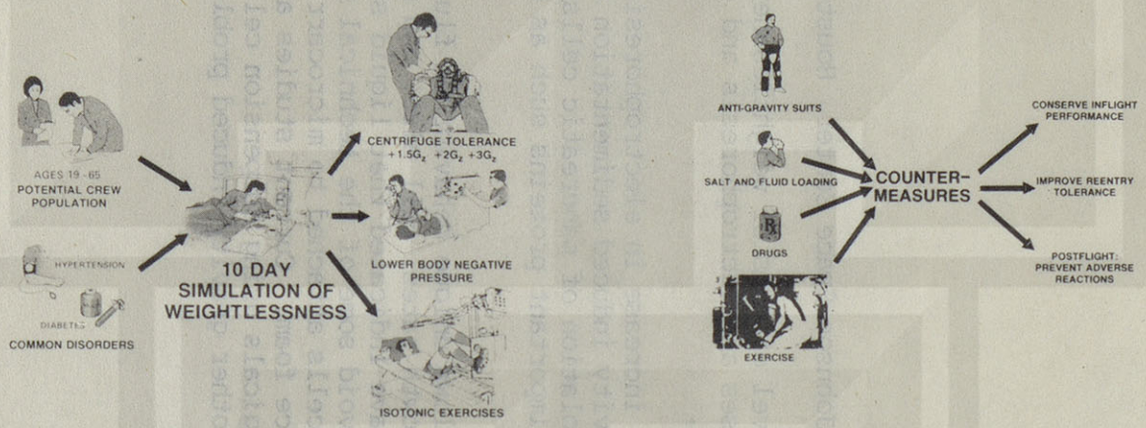
The Space Bioprocessing Program is exploring the novel effects of weightlessness (no buoyancy or sedimentation or convection) on such processes as electrophoresis and suspension cell culture which may have industrial applications.

Separations: Studies have shown that a substantial increase in electrophoresis resolution and/or throughput is possible in the absence of gravity induced sedimentation or thermal convection. Current research is emphasizing the isolation of pancreatic cells, pituitary cells, kidney cells, and purification of medically important proteins such as antihemaphilic factor (AHF).

Suspension Culture Biosynthesis: Weightlessness allows unique behavior of fluids and suspensions. Some cells have demonstated increased growth rates, cell size, and metabolism under weightless conditions. Preliminary studies have indicated that liquid suspension cell cultures, under microgravity conditions, may avoid some of the technical problems of current ground-based biosynthesis systems. Living cells attached to microcarriers would not sediment nor would oxygen bubbles rise to produce foam. Current studies are exploring new possibilities for synthesizing high value biologicals using suspension cell culture systems which are not plagued by sedimentation nor other gravity induced problems.

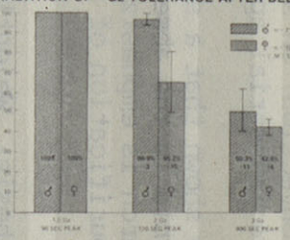
NASA-S-80-10229

3 CARDIOVASCULAR CHANGES RESULTING FROM BED REST



INSIDE OF CENTRIFUGE CAB.
SUBJECT BEING PREPARED FOR ACCELERATION TEST.

DEGRADATION OF +Gz TOLERANCE AFTER BEDREST



U.S. AND U.S.S.R. BIOMEDICAL SCIENTISTS HAVE WORKED TOGETHER TO STANDARDIZE METHODS OF GROUND-BASED SPACE SIMULATION RESEARCH, AND TO COMPARE TWO METHODS OF WEIGHTLESSNESS SIMULATION: HORIZONTAL AND -6 HEAD DOWN BEDREST. SIMILAR STUDIES WITH 20 MEN, AGES 35 TO 40 WERE CARRIED OUT IN THE SOVIET UNION (MAY 1978) AND IN THE AMES "HUMAN RESEARCH FACILITY" (JULY-AUGUST 79) INVOLVING BOTH ARC AND JSC INVESTIGATORS. EXCHANGE OF U.S. AND U.S.S.R. SCIENTISTS DURING BOTH STUDIES ALLOWED FIRST-HAND COMPARISON OF RESEARCH TECHNIQUES AND EXPERIMENTAL CONDITIONS BETWEEN NATIONS. PRELIMINARY RESULTS INDICATING A GREATER DECONDITIONING EFFECT FOR -6 HEAD DOWN BEDREST WERE PRESENTED AT THE U.S. - U.S.S.R. JOINT WORKING GROUP MEETING AT JSC, OCT. 1979.

FEMALE SUBJECT DURING BED REST PERIOD
IN FLIGHT SIMULATOR PERFORMANCE TEST.

FEMALE SUBJECT DURING POST BED REST
SUPINE BICYCLE ERGOMETRY.

LOWER BODY NEGATIVE PRESSURE TEST WITH MALE SUBJECT
UNDERGOING ECHOCARDIOGRAPHY DURING U.S. / U.S.S.R. STUDY.

RE-ENTRY FORCES, TOLERANCE

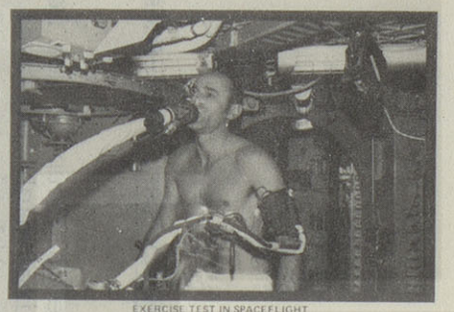
CARDIOVASCULAR CHANGES RESULTING FROM BED REST. Danielle J. Goldwater, NASA-Ames Research Center, Moffett Field, CA 94035.

Traditionally, astronauts were selected from a fairly homogeneous group of men meeting strict test pilot standards of physical fitness. They maintained high levels of aerobic conditioning and near ideal body weights through conscientious athletic training and diet. During the Shuttle era, Spacelab crewmembers will be drawn from the general scientific community including individuals of both sexes and a much wider age range. In addition, the reusuable Space Shuttle must re-enter the Earth's atmosphere in a way that imposes different "G" forces than previously experienced with space flight. Following a period of weightlessness such stresses will cause blood to be drawn away from the brain toward the feet and lower body, increasing the possibility of fainting or blackout during re-entry and exposure to earth's gravity. It is not known whether women, with their lower circulating blood volumes, and older people drawn from a more sedentary population predisposed to develop hypertension, coronary artery disease, diabetes, etc., will be more susceptible to these re-entry stresses than previously selected astronauts. To determine the effects of age and sex on tolerance to re-entry forces following a period of simulated weightlessness, men and women aged 35 to 65 are being studied at NASA-Ames Research Center. Information from these studies will be used to devise optimal medical selection criteria for future Shuttle passengers.

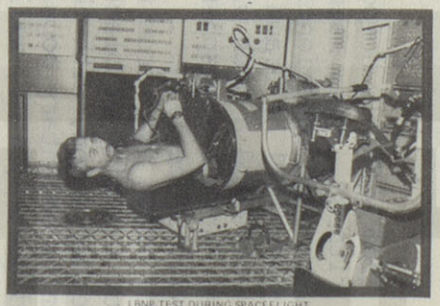
NASA-S-80-10210

4 CARDIOVASCULAR PHYSIOLOGY

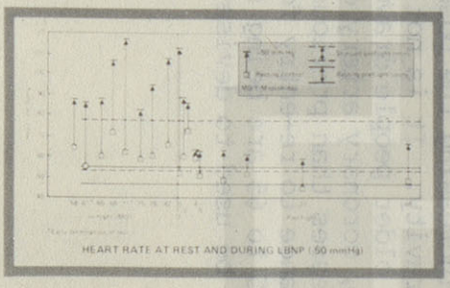
EXERCISE TEST IN SPACELAB MOCKUP



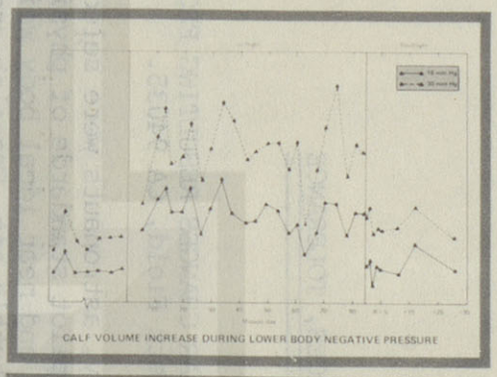
EXERCISE TEST IN SPACEFLIGHT



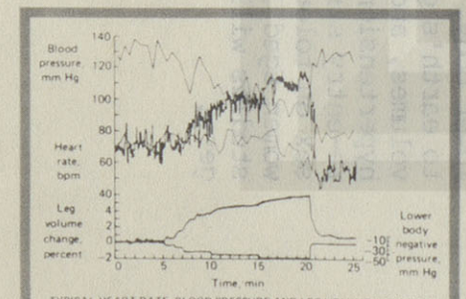
LBNP TEST DURING SPACEFLIGHT



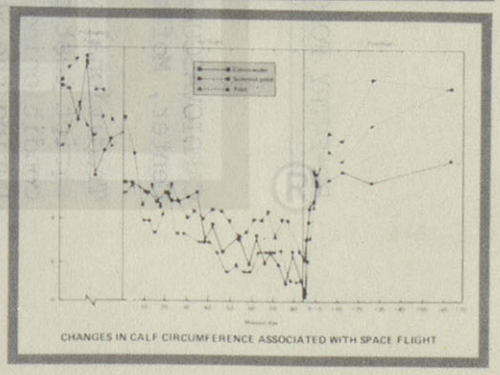
HEART RATE AT REST AND DURING LBNP (50 mmHg)



CALF VOLUME INCREASE DURING LOWER BODY NEGATIVE PRESSURE



TYPICAL HEART RATE, BLOOD PRESSURE AND LEG VOLUME RESPONSES TO LBNP DURING FLIGHT



CHANGES IN CALF CIRCUMFERENCE ASSOCIATED WITH SPACE FLIGHT

CARDIOVASCULAR, EFFECTS OF WEIGHTLESSNESS

CARDIOVASCULAR PHYSIOLOGY. Robert L. Johnson, NASA-Johnson Space Center, Houston, TX 77058.

The changes in cardiovascular function observed during weightlessness appear to be due largely to adaptive changes involving other body systems rather than to primary changes in the heart or blood vessels. Among the more visible events initiating cardiovascular changes are alterations in fluid volume and distribution, and changes in concentrations of electrolytes and vasoactive hormones, coupled with losses of tissue and muscle mass.

The hypothesis derived from the Skylab studies includes a rapid transfer of intravascular fluid from the lower to the upper body, probably beginning at the onset of exposure to weightlessness. Much of this transferred fluid must be accommodated by recruitment and distention of pulmonary vessels and dilation of central veins. Alterations in cardiac dynamics secondary to all increased preload would be expected. A headward migration of extravascular fluids via venous and lymphatic channels follows at a slower pace. Adaptive vascular changes adjust intravascular volume to altered regional blood volumes. Inflight exercise, other activities, and flight conditions other than weightlessness modify these processes of adaptation to an unknown degree. Re-exposure to Earth's gravity abruptly reverses the direction of these changes.

While degradation of orthostatic tolerance appears to be of little consequence during flight, it carries the potential for troublesome problems upon re-exposure to gravitational stress. Varying degrees of orthostatic intolerance, transient in duration, have been demonstrable by orthostatic testing after all space flights of more than a few days in duration.

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NASA-S-80-10203

5 MAJOR SPACEFLIGHT CELL BIOLOGY STUDIES

BACTERIOPHAGE INDUCTION SYSTEMS TESTED IN SPACE

SYSTEM	FLIGHT	RESULTS
Escherichia coli K 12	Most Sputniks All 6 Vostoks Voskhod 1 & 2 COSMOS 110 ZOND 5 and 7	Number of phages inflight exceeded ground controls Excess proportional to length of mission Simulated launch vibrations plus ^{60}Co irradiation gave increases higher than irradiation alone No increases from launch vibration alone or after ^{60}Co irradiation
Salmonella typhimurium BS 5 (P 22/ - P 22)	Biosatellite II	Increased cell density following 4h in flight Space flown cells more resistant to ^{85}Sr irradiation (inflight 265-1648 rads) as indicated by decreased phage production
Escherichia coli C 60 (λ)	Biosatellite II	No postflight differences in growth when exposed to ^{85}Sr - inflight. Flight terminated early, no opportunity for phage production

MAJOR SPACEFLIGHT STUDIES WITH GROWING CELLS

FLIGHT	DEVICE	TEST SYSTEM	RESULTS
Sputnik 5 Vostok 1 & 2	Bioelements	Clostridium butyricum	Gas production rate same in flight as for ground controls
Biosatellite II	Experiment P 1039	Paramyxa carolinensis (Amoeba)	Trend - towards higher division rate during flight - No change in survival, food assimilation, growth, etc
Gemini 6 & 12 Biosatellite II	Experiment P 1047	Rana pipiens Frog eggs in 2 cell stage	No difference between flight and ground control specimens. Authors recommend repeat with inflight fertilization
Skylab 3 ASTP COSMOS 782	Experiment MA 161	Fundulus heteroclitus (Killifish)	Dependence of hatched fry on visual cues suggestive of absence of vestibular input No other differences resulting from flight
SKYLAB 3	Experiment SO 15	Wistar 38 human embryonic lung tissue culture	No differences in growth curves, mitotic indices, cell migration rates, cell size, nuclear size and location, nucleolus size, etc
Soyuz 16 ASTP	"Biorhythm I"	Streptomyces levoris	No differences in cyclic spore formation inflight No biological indications of HZE damage

CELL STUDIES WITH COSMIC HZE* PARTICLES

EXPERIMENT	FLIGHT	SPECIES	RESULTS
BIOSTACK (Becker)	Apollo 16 and 17 ASTP	Bacillus subtilis spores Artemia salina cysts	Swelling during growth of first vegetative cells from "hit" spores Those "hit" by HZE showed reduction in larval emergence and hatching incidence of developmental anomalies increased
BIOBLOCK (Benavolenskiy)	COSMOS 613	Saccharomyces cerevisiae 139 B	Of 1045 colonies, 169 hits with $Z \geq 8$ and 12 hits with $Z \geq 5$ over 2 months 1.3% of cells demonstrated "radiation damage" compared with 0.15% normally 2×10^4 cells damaged per particle

*HZE - Heavy (high atomic number) high energy particles

INFLIGHT CELL STUDIES WITH ULTRAVIOLET IRRADIATION

FLIGHT	EVENT	TEST SYSTEM	RESULTS
6 sounding rockets 4 balloon flights 3 orbital satellites	Exposed To Direct UV irradiation	T 1 Coliphage Pseudomonas fluorescens Tobacco Mosaic Virus	Contrasts that UV between 200 and 300 nm is major cause of inflight inactivation
Apollo 16		Escherichia coli T 7 bacteriophage	Flight specimens more sensitive to UV than ground controls although shape of dose response curves similar
	Exposed To Direct UV plus Components of 254, 280 and 300 nm	Rhodotorula rubra Saccharomyces cerevisiae Chaetomium globosum Trichophyton rosearum	No evidence of synergism between inflight UV irradiation and reduced gravity
		Bacillus subtilis	No change in survival rate at 1 atm. Combined UV and vacuum resulted in greater loss of viability than UV alone. (Spores simulated to UV by vacuum)
		Bacillus thuringiensis Aeromonas proteolytica	No change in survival rates. No change in ability to produce toxins

SPACEFLIGHT STUDIES WITH VARIOUS RADIATION SOURCES

SOURCE	SYSTEM	FLIGHT	RESULTS
^{60}Co gamma (preflight and postflight)	Hydrogenomonas eutrophe Z 1 Saccharomyces ellipsoidea (diploid) Zygosaccharomyces bailii (haploid)	COSMOS 368	No measurable loss of viability or change in radiosensitivity
32p beta (inflight)	Neurospora crassa conidia	Gemini XI	Neither survival rate or mutation frequency altered for dry cells. Better survival and lower mutation frequency for agar suspended cells
^{85}Sr gamma (inflight)	Neurospora crassa conidia	Biosatellite II	No inflight effect on dry cells

CELL BIOLOGY IN ZERO-G

CELL BIOLOGY. Gerald R. Taylor, NASA-Johnson Space Center, Houston, TX 77058.

Whereas a large variety of cell biology studies have been conducted in space, consistent space-mediated alterations have not been identified. Although individual studies often produced equivocal data, evaluation of the aggregate results indicates that cell systems are generally no less stable in space than they are in the Earth-based laboratory. Of course the conditions to which cell systems are exposed in space are usually less well controlled (and less controllable), often leading to more variable and erratic results.

It has not yet been demonstrated that the space flight environment could be used to affect unique or hitherto unknown cell changes. On the contrary, cell systems appear to remain sufficiently stable to permit experimentation with models which require a fixed cell line. Therefore, taken as a unit, the cell biology studies conducted during the preceding two decades should definitely be considered a success. It is now possible to prepare cell biology experiments for the Space Shuttle era with a reasonable probability that the cells will not react engimatically to the unique environment encountered within the spacecraft.

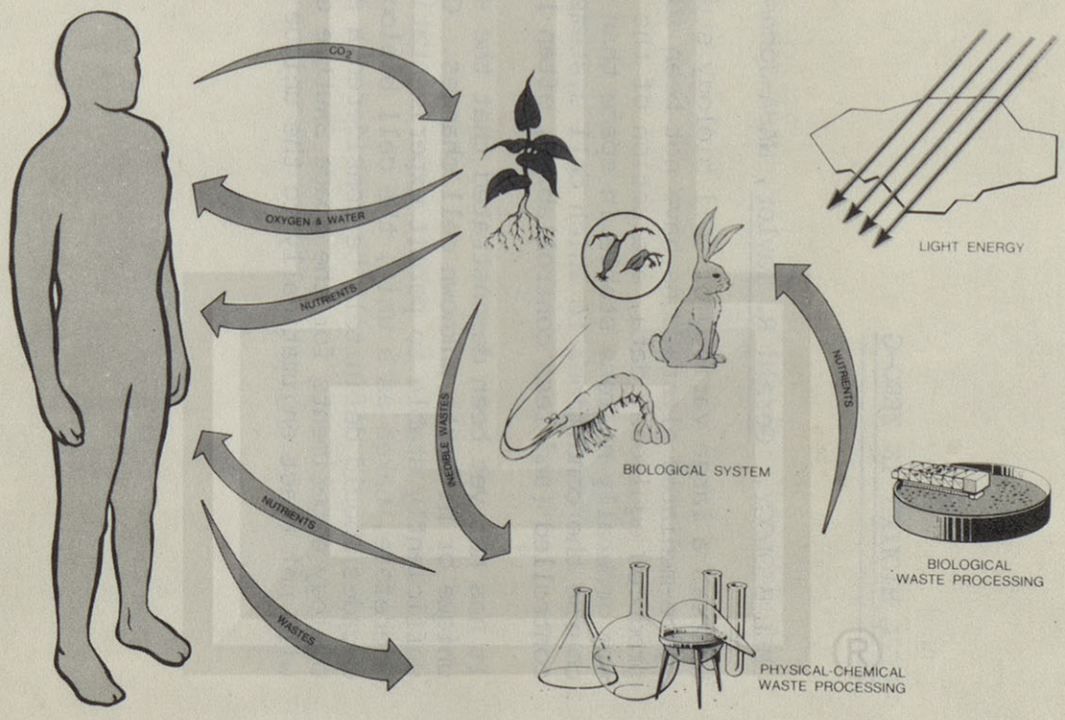
NASA-S-80-10207

6 HUMAN REQMTS FOR CONTROLLED ECOLOGICAL LIFE SUPPORT

- NUTRITION
- ATMOSPHERE
- THERMAL ENVIRONMENT
- WATER
- MECHANICAL FORCES & FACTORS
- PHYSIOLOGICAL INTERACTIONS
- HEALTH AND SAFETY

- FOOD PROCESSING
- HABITABILITY
- PERSONAL HYGIENE
- WORK/PRODUCTIVITY
- EAT/REST/SLEEP
- RECREATION/EXERCISE
- SOCIOLOGICAL FACTORS

REGENERATIVE SYSTEMS



HUMAN NEEDS IN SPACE

CELSS HUMAN REQUIREMENTS. Malcolm C. Smith, Jr., NASA-Johnson Space Center, Houston, TX 77058

The objective of the Controlled Ecologic Life Support System (CELSS) Program is to collect, evaluate, develop, and/or refine criteria and methods for assuring physical, physiological and psychological well being of isolated human populations in future space facilities and habitats. The initial phase is in progress. It includes formulation of a research strategy to meet known and anticipated human requirements in a system which emphasizes regenerative processes as alternatives to storage and resupply of air, water, and food and to storage of metabolic wastes.

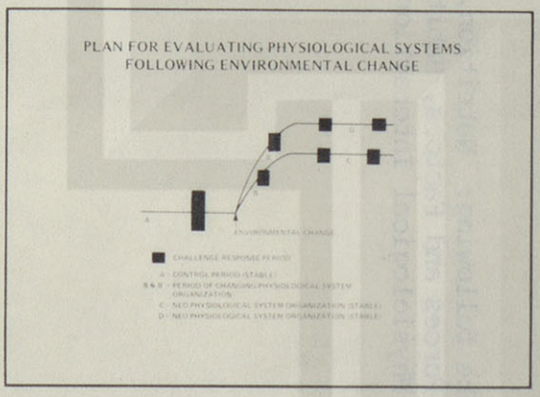
Areas of investigation include the following: Nutrition, Food Processing, Water, Atmosphere, Thermal Environment, Mechanical Forces and Factors, Habitability, Personal Hygiene, Health Care, Sociological Factors, and Physiological Interactions.

NASA-S-80-10221

7 CIRCADIAN RHYTHMS

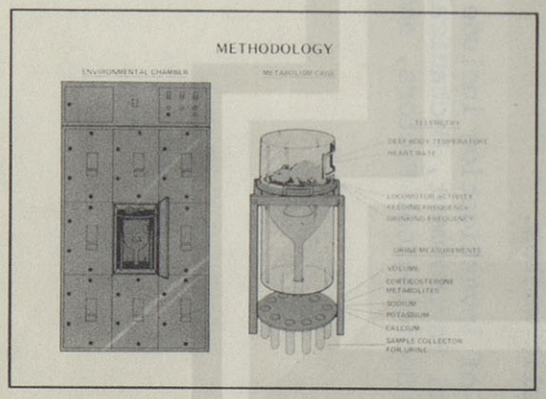
Rationale and Goals

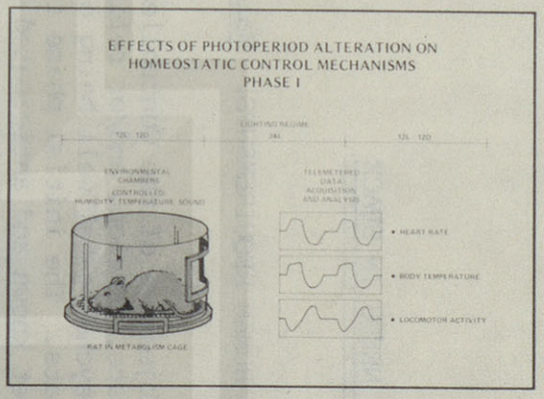
- Changes in the organization of physiological systems have been used to evaluate the condition of the organism during space flight
- The physiological "COSTS" of such changes have not been adequately determined
- Therefore, the proposed animal experiments are designed to quantitate the stress response (E.G., homeostatic competence) during the periods of physiological system change



Statement of Problem

- Under normal environmental conditions (I.E., 1 GZ, light/dark) animals function *optimally* in terms of their ability to resist an external stress
- When the environmental conditions are altered (E.G., changed photoperiod, simulated space flight), the ability to resist an external stress (E.G., cold) is impaired





Questions being asked of this animal model

- How long does it take for adaptation to a new set of environmental conditions?
- Is the response to a homeostatic challenge the same following all environmental stresses?
- What is homeostatic competence in the space environment?
- What is the physiological baseline under normal conditions?
- What is the time course of physiological changes following environmental alterations?
- What is the homeostatic competence before, during and after environmental alterations?

HUMAN DESYNCHRONIZATION IN SPACE TRAVEL

CIRCADIAN RHYTHMS. Charles M. Winget, NASA-Ames Research Center, Moffett Field, CA 94035.

Time requirements for successful research work aboard Space Shuttle will frequently cause a conflict between physiological, psychological, and performance rhythms. Mostly this takes the form of work being moved into night hours and sleep into day hours. Although the consequences of such conflicts are still largely unknown, it is thought that they may be considerable. The present research at Ames Research Center is concerned with some of these consequences, i.e. the reactions of circadian rhythms in performance, body temperature, cardiovascular system, and self-rated alertness. Research emphasis is on oscillating physiological baselines and temporal dysrhythmias, such as circadian internal desynchronization of neuroendocrine, metabolic, renal, and cardiovascular control mechanisms in humans. Basic physiological mechanisms of the endogenously controlled temporal events in subhuman primates and other animal models are studied. Rhythm desynchronization of personnel in the Space Shuttle and in earth orbital laboratories and of translongitudinal travelers is of foremost importance. Biochemical, biotelemetry and biophysical techniques are used to collect the data. For additional information refer to: C. M. Winget, The Rhesus Monkey, G. H. Bourne, ed. (Academic Press, New York, 1975), pp. 277-299; and C. M. Winget, et al., J. Occup. Med., 20, 204 (1978).

NASA-S-80-10220

8 THE JOINT U.S./U.S.S.R. BIOLOGICAL SATELLITE PROGRAM

TYPES OF U.S. EXPERIMENTS FLOWN ON SOVIET SPACECRAFT

- ANIMALS
  - MUSCULOSKELETAL SYSTEM
  - HEMATOLOGY
  - METABOLISM
  - ENDOCRINOLOGY
  - IMMUNOLOGY
  - REPRODUCTION AND EMBRYOLOGY
  - RADIATION EFFECTS
- PLANTS
  - GROWTH AND DEVELOPMENT
  - BIOCHEMISTRY
- BIRDS
  - EMBRYOLOGY
- INSECTS
  - GROWTH AND DEVELOPMENT
  - AGING
  - RADIATION EFFECTS
  - BEHAVIOR
- FISH
  - GROWTH AND DEVELOPMENT
  - VESTIBULAR SYSTEM
  - BEHAVIOR
- RADIATION DOSIMETRY

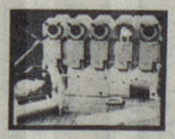
SIGNIFICANT BIOLOGICAL CHANGES ATTRIBUTED TO SPACEFLIGHT

- DECREASED BONE GROWTH RATE
- DECREASED BONE STRENGTH
- INCREASED RBC HEMOLYSIS
- INCREASED LIVER GLYCOGEN AND ALTERED LEVELS OF ENZYMES INVOLVED IN FAT AND ENERGY METABOLISM
- MUSCLE ATROPHY
- INCREASE IN SIZE AND FUNCTION OF ADRENALS
- DECREASE IN ANIMAL COORDINATION AND PERFORMANCE IMMEDIATELY POSTFLIGHT

KOSMOS-936 FLIGHT HARDWARE

KOSMOS SPACECRAFT, AS IT IS MOUNTED SPHERE WITH BIOLOGICAL MODULE AND BAT TENNA BIOPACK ATTACHED. PLANTS AND ANIMALS ARE HOUSED IN SPHERE. OTHER MODULES SUPPLY POWER, WATER, AND ENVIRONMENTAL CONTROL. LAUNCHED BY A SOLID-FUEL ROCKET

REMOVED INTO THE ORBITAL MODULE OF THE KOSMOS 936 BIOSATELLITE. THE ITEM WEIGHS 10.5 KG. THE TOP 10 ROW OF TWO LEVELS FIXED HOLDING RATS. THE ITEM BELOW IT IS ONE OF FOUR STATIONARY RAT HOLDING UNITS



KOSMOS 936 RAT HOLDING UNITS, SIMILAR TO UNITS FLOWN ON TRIPS PREVIOUS SOVIET BIOSATELLITES. PROVIDES FOOD, WATER, WASTE MANAGEMENT, AND AN EARTHLIKE ATMOSPHERE FOR FIVE RATS.

KOSMOS 936 CENTRIFUGE. TWO SUCH UNITS WERE OPERATED CONTINUOUSLY DURING THE 18.5 DAY FLIGHT PROVIDING WITH 1 G GRAVITY (1 G) AND LIFE SUPPORT FOR FIVE RATS EACH

KOSMOS-936 GROUND OPERATIONS

PREFLIGHT FAMILIARIZATION AND TRAINING

A U.S. SCIENTIST DEMONSTRATES THE PROCEDURES FOR LIVER EXTRACTION AND PROCESSING WHICH ARE TO BE CARRIED OUT POSTFLIGHT BY SOVIET SPECIALISTS.

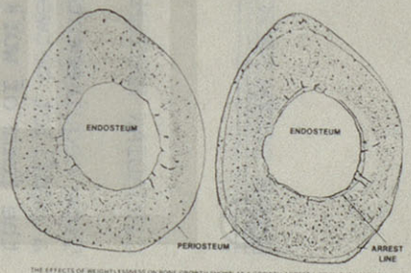
RECOVERY SITE OPERATIONS

VERY SOON AFTER TOUCHDOWN A MOBILE LABORATORY IS SET UP NEAR THE SPACECRAFT. SOME OF THE ANIMALS ARE SACRIFICED IMMEDIATELY AND TISSUE PREPARED FOR TRANSPORT BACK TO MOSCOW.

POSTFLIGHT OPERATIONS

CONTROL ANIMALS AND REMAINDER OF FLIGHT ANIMALS ARE SACRIFICED AT SPECIFIED TIMES DURING THE MONTH FOLLOWING. RECOVERY SPECIMENS ARE PROCESSED AT LABORATORIES IN MOSCOW AND ARE DIVIDED AMONG INVESTIGATORS FROM NINE COUNTRIES.

KOSMOS-936 EXPERIMENT TO ASSESS CHANGES IN BONE GROWTH



THE EFFECTS OF WEIGHTLESSNESS ON BONE GROWTH SHOWN AS A GROWTH ARREST LINE IN THE LAYERS OF ENDOSTEUM AND PERIOSTEUM, FOLLOWING 25 DAYS OF POSTFLIGHT RECOVERY. THE LEFT FIGURE IS A PHOTOMICROGRAPH OF A CONTROL RAT WITH NORMAL GROWTH. THE RIGHT FIGURE SHOWS THE ARREST LINE IN THE BONE OF A RAT THAT EXPERIENCED 18.5 DAYS OF ZERO G IN KOSMOS 936. SURPRISINGLY, RATS ON THE CENTRIFUGE SHOWED A DECREASE IN BONE GROWTH SIMILAR TO THE ZERO G RATS, BUT WITHOUT COMPARABLE DECREASE IN BONE BREAKING STRENGTH.

SOVIET/US SPACE COOPERATION

COSMOS EXPERIMENTS. Kenneth A. Souza, NASA-Ames Research Center, Moffett Field, CA 94035.

In 1974 the Soviet Union offered to fly U.S. biological experiments aboard a series of their unmanned satellites. The first in the series was Cosmos 782, launched from the USSR in November 1975 and orbited for 19.5 days. This satellite carried a payload of rats, plants, insects, fish, tissue cultures, microorganisms and radiation dosimeters. Besides the U.S. and USSR, five countries participated in this mission contributing over 100 experiments designed to study the effects of space flight on a wide range of biological species and to investigate with animals problems observed in astronauts and cosmonauts during manned space flight. Two more soviet unmanned biological satellites have flown with U.S. experiments; Cosmos 936 and Cosmos 1129, launched in 1977 and 1979, respectively. The payloads, experiment complement, and flight duration of these latter two missions was similar to those of Cosmos 782.

To date, 32 U.S. biological and radiation physics experiments have flown on the 3 US/USSR biological satellite missions and plans are underway for a mission with sub-human primates scheduled for 1981. Over 100 U.S. scientists from 18 universities and three governmental agencies have participated. Their efforts have contributed substantially to a better understanding of how space flight affects a wide range of biological species and the manner in which organisms attempt to adapt to less than one-g. Reports of these studies have appeared in a variety of scientific journals and presented at numerous national and international scientific journals.

NASA-S-80-10226

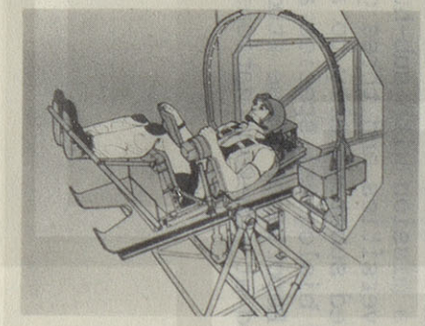
9 CENTRIFUGATION STUDIES

OBJECTIVES

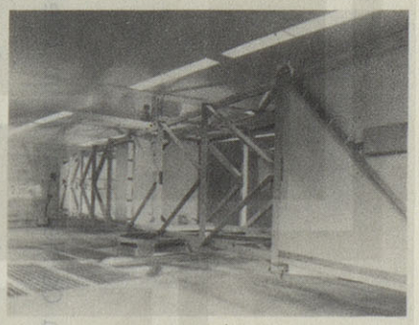
TO DETERMINE THE EFFECT OF:

a) ACUTE BLOOD WITHDRAWL
b) INFUSION OF BLOOD, AND
c) ORAL REHYDRATION

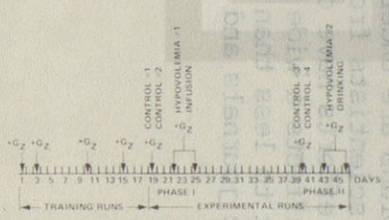
ON GZ (HEAD-TO-FOOT) ACCELERATION TOLERANCE IN NORMAL, HEALTHY, YOUNG MEN



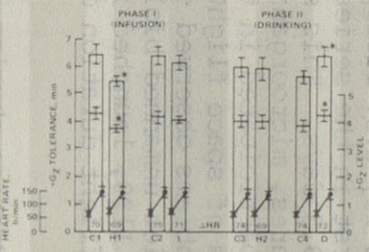
TEST SUBJECT'S ORIENTATION WITHIN CENTRIFUGE CAB



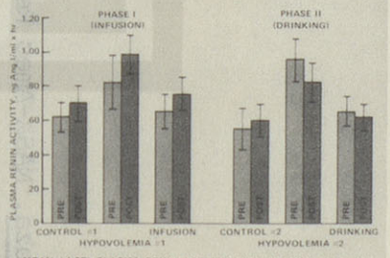
AMES RESEARCH CENTER'S 20G CENTRIFUGE



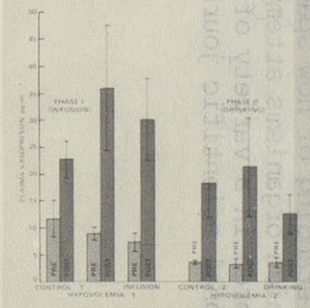
EXPERIMENTAL PROTOCOL



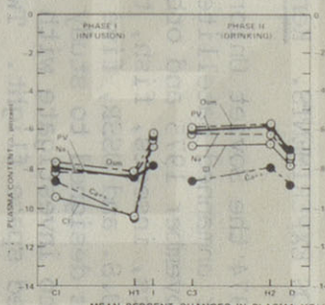
MEAN (±SE) +G_z ACCELERATION TOLERANCE AND PRE- AND POST-ACCELERATION HEART RATES IN PHASE I AND PHASE II

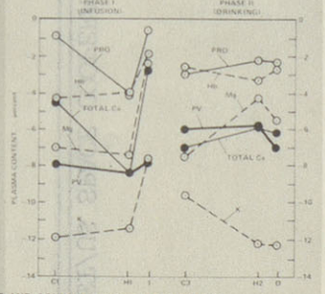


MEAN (±SE) PLASMA RENIN ACTIVITY DURING ACCELERATION IN PHASE I AND PHASE II



MEAN (±SE) PLASMA VASOPRESSIN CONCENTRATIONS DURING ACCELERATION IN PHASE I AND PHASE II





MEAN PERCENT CHANGES IN PLASMA VOLUME AND CONTENTS DURING ACCELERATION IN PHASE I AND PHASE II

CONCLUSION

ORAL REHYDRATION IS AS EFFECTIVE AS BLOOD REPLACEMENT IN RESTORING +G_z ACCELERATION TOLERANCE DECREMENTS DUE TO HYPOVOLEMIA

GRAVITY ACCELERATION TOLERANCE IN HUMANS

EFFECT OF HYPOVOLEMIA, INFUSION, AND ORAL REHYDRATION ON PLASMA ELECTROLYTES, ADH, RENIN ACTIVITY, AND +G TOLERANCE. John E. Greenleaf, P. J. Brock, R. F. Haines, S. A. Rositano, L. D. Montgomery, and L. C. Keil NASA-Ames Research Center, Moffett Field, CA 94035.

The purpose of this study was to determine the effect of (a) blood withdrawal, (b) blood infusion, and (c) oral fluid intake on plasma volume and electrolyte shifts and $+G_z$ tolerance at an acceleration rate of 0.5 G/min. Six healthy men, 21 to 27 years old, were centrifuged after the withdrawal of 400 ml of blood (hypovolemia) from each man; they were centrifuged again following blood infusion (Phase I). Three weeks later the men were accelerated after similar hypovolemia and again after consuming 800 ml of an isotonic (0.9%) NaCl drink (Phase II). Phase I hypovolemia resulted in a reduction in tolerance in all subjects from a mean ($\pm$S.E.) control level of 6.42$\pm$0.35 min to 5.45$\pm$0.17 min (-15.1%, $p<0.05$). Both infusion and drinking returned tolerances essentially to control levels (infusion = 6.13$\pm$0.23 min; drinking = 6.38$\pm$0.34 min). In all acceleration runs there was an obligatory shift (loss) of plasma volume and electrolytes, especially potassium, regardless of the experimental treatments. Compared with their respective control values, neither hypovolemia, infusion, nor drinking influences the 5.8 to 8.4% losses of plasma volume during acceleration. There were significant ($p<0.05$) increases in plasma vasopressin levels during every acceleration experiment from 12 to 35 pg/ml that were not influenced appreciably by infusion or drinking. In Phases I and II hypovolemia elevated ($p<0.05$) plasma renin activity, while infusion and drinking lowered PRA to control levels. There were no significant changes in post-acceleration PRA when compared with their respective pre-acceleration activities. During acceleration, calf blood flow decreased to 3 to 4 ml/(min . 100 ml tissue) from resting levels of 6 to 9 ml/(min . 100 ml). It is concluded that oral rehydration is as effective as blood replacement in restoring $+G_z$ acceleration tolerance decrements due to hypovolemia.

NASA-S-80-10218

10 ALTERED BONE TURNOVER DURING FLIGHT

THE EFFECT OF SPACEFLIGHT ON BONE TURNOVER WAS STUDIED ON GROWING RATS DURING 19-DAY SPACEFLIGHTS ABOARD COSMOS 782 AND COSMOS 936. PERIOSTEAL BONE FORMATION RATE AT THE TIBIO FIBULAR JUNCTION WAS REDUCED 47% and 43%, RESPECTIVELY, AS COMPARED WITH GROUND CONTROLS ($P < 0.001$ IN BOTH CASES). INHIBITION OF BONE FORMATION WAS ACCOMPANIED BY AN ARREST LINE AT THE PERIOSTEUM SUGGESTING THAT FORMATION CEASES DURING FLIGHT. THE PERIOSTEAL BONE FORMATION RATE RETURNED TO OR EXCEEDED NORMAL VALUES 25 DAYS AFTER FLIGHT. SPACEFLIGHT DID NOT APPEAR TO ALTER ENDOSTEAL BONE PARAMETERS: NO SIGNIFICANT CHANGES OCCURRED IN NET FORMATION RATE, OSTEOBLAST NUMBER, MEDULLARY AREA, OR OSTEOCLAST NUMBER, EITHER IMMEDIATELY AFTER FLIGHT OR 25 DAYS POST-FLIGHT. SIMILARLY, NO CHANGES WERE SEEN IN THE LONGITUDINAL GROWTH OF THE TIBIA, FEMUR, OR HUMERUS. LACUNARCANALICULAR DIAMETER WAS ONLY SLIGHTLY INCREASED IN THE HUMERUS AFTER SPACEFLIGHT (COSMOS 782) AND NOT CHANGED IN THE FEMUR (COSMOS 936). ALSO, NO CHANGES WERE DETECTED IN VASCULAR VOLUME IN EITHER FEMUR OR HUMERUS. THE RESULTS SUGGEST THAT NEAR WEIGHTLESSNESS DURING ORBITAL SPACE FLIGHT RESULTS IN REDUCED BONE FORMATION AT THE PERIOSTEUM BUT NOT AT THE ENDOSTEUM OR THE GROWTH PLATE AND THAT MECHANICAL UNLOADING OF BONE DURING SPACEFLIGHT DOES NOT ENHANCE RESORPTION AT THE ENDOSTEUM. (SUPPORTED IN PART BY NASA CONTRACTS RA186988 AND RA366876)

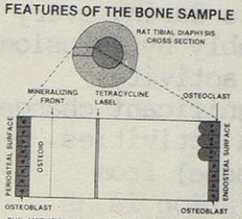
INTRODUCTION

CALCIUM HOMEOSTASIS APPEARS TO BE MODIFIED DURING SPACEFLIGHT. METABOLIC STUDIES OF SKYLAB ASTRONAUTS INDICATE THAT URINARY CALCIUM INCREASES WHILE IN SPACE. FURTHERMORE, AFTER AN 84 DAY FLIGHT THERE WAS A SIGNIFICANT DECREASE IN THE DENSITY OF THE OS CALCIS. SINCE MECHANICAL FORCES IMPOSED BY MUSCLE UTILIZATION AND GRAVITY ARE THOUGHT TO INFLUENCE BONE TURNOVER, PROLONGED RECUMBANCY AND/OR PROLONGED WEIGHTLESSNESS COULD RESULT IN OSTEOPOROSIS. TO BETTER UNDERSTAND THE EFFECT OF SPACEFLIGHT ON BONE, THE FOLLOWING PARAMETERS: BONE FORMATION AND RESORPTION, BONE LENGTH, BONE DENSITY, PORE SIZE DISTRIBUTION, ARREST LINE, LENGTH, AND DIFFERENTIATED BONE CELL NUMBER (OSTEOBLAST AND OSTEOCLAST) WERE EVALUATED IN GROWING RATS BOTH IMMEDIATELY AND 25 DAYS AFTER 19 DAY ORBITAL SPACEFLIGHTS ABOARD THE SOVIET BIOLOGICAL SATELLITES 782 AND 936.

METHODS

COSMOS 782 WAS LAUNCHED ON 11/25/75 AND RECOVERED 12/15/75 WHILE COSMOS 936 WAS FLOWN FROM 8/3/77 TO 8/22/77. THE ANIMALS RECEIVED TETRACYCLINE PRIOR TO LAUNCH TO LABEL BONE MINERALIZING SURFACES. HALF OF THE RATS WERE SACRIFICED AT THE END OF THE FLIGHT PERIOD WHILE THE REMAINING ANIMALS RECEIVED A SECOND INJECTION OF TETRACYCLINE AND WERE KILLED 25 DAYS POSTFLIGHT. THE FLIGHT CONTROL GROUP WAS MAINTAINED ABOARD AN IDENTICAL EARTH BASED SPACECRAFT AND EXPOSED AS CLOSELY AS POSSIBLE TO FLIGHT CONDITIONS (INCLUDING ACCELERATION, NOISE, SHOCK AND VIBRATION OF LAUNCH AND RE-ENTRY). BONE FORMATION AND MEDULLARY AREA, DIFFERENTIAL CELL COUNTS (COSMOS 936 ONLY), FORMING SURFACES AND RESORBING SURFACES (COSMOS 936 ONLY) WERE MEASURED IN THE LEFT TIBIA AT THE TIBIA-FIBULA JUNCTION BY QUANTITATIVE MORPHOMETRY. PORE SIZE DISTRIBUTION AND BONE DENSITY WERE MEASURED IN THE LEFT HUMERUS (COSMOS 782) AND LEFT FEMUR (COSMOS 936). BONE LENGTH WAS MEASURED USING PRECISION CALIPERS AND THE LONGITUDINAL GROWTH RATE CALCULATED FOR THE FLIGHT AND POSTFLIGHT PERIODS.

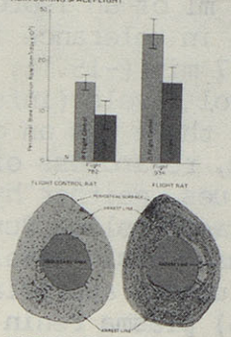
FEATURES OF THE BONE SAMPLE



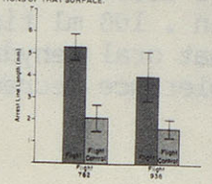
THE METHOD USED TO MEASURE BONE FORMATION AND RESORPTION RELIES ON THE FACT THAT AT THE TIBIAL DIAPHYSIS THE PERIOSTEAL CIRCUMFERENCE ENLARGES BY BONE FORMATION AND THE ENDOSTEAL CIRCUMFERENCE ENLARGES BY RESORPTION. TETRACYCLINE IS GIVEN PRIOR TO SPACEFLIGHT TO MARK ALL PERIOSTEAL BONE FORMED DURING THE EXPERIMENTAL PERIOD. BONE RESORPTION IS DETERMINED BY THE CHANGE IN MEDULLARY AREA AND BY MEASUREMENT OF TOTAL ENDOSTEAL FORMATION DURING THE EXPERIMENTAL PERIOD.

RESULTS

PERIOSTEAL BONE FORMATION WAS INHIBITED IN THE TIBIA DURING SPACEFLIGHT.



THE DECREASE IN BONE FORMATION AT THE PERIOSTEUM DURING SPACEFLIGHT WAS ACCOMPANIED BY A SIMULTANEOUS INCREASE IN LENGTH OF AN ARREST LINE AT THE PERIOSTEUM, SUGGESTING THAT BONE FORMATION CEASED ALONG CORRESPONDING PORTIONS OF THAT SURFACE.



EFFECT OF SPACEFLIGHT ON BONE FORMATION

THE BONE FORMATION DEFECT IN THE FLIGHT RATS WAS CORRECTED IN THE POSTFLIGHT PERIOD: ALL OF THE FLIGHT RATS PRODUCED MORE BONE AT THE PERIOSTEUM IN THE POSTFLIGHT PERIOD THAN DURING SPACEFLIGHT.

SELECTED BONE PARAMETERS WHICH REFLECT BONE TURNOVER WERE MEASURED FOLLOWING SPACEFLIGHT AND THE RESULTS ARE SUMMARIZED IN TABLE 1. THE EFFECT OF SPACEFLIGHT APPEARED TO BE LIMITED TO INHIBITION OF BONE FORMATION AT THE PERIOSTEAL SURFACE. THERE WERE NO CHANGES IN PARAMETERS RELATED TO LONGITUDINAL BONE GROWTH OR IN BONE TURNOVER AT THE ENDOSTEUM.

TABLE 1: THE EFFECT OF SPACEFLIGHT ON SELECTED BONE PARAMETERS

PARAMETER	COSMOS 782	COSMOS 936
FORMATION		
TIBIA PERIOSTEAL BONE FORMATION RATE	47%* $P < 0.001$	43% $p < 0.001$
TIBIA PERIOSTEAL BONE APPOSITION RATE	41% $p < 0.001$	37% $p < 0.001$
TIBIA ARREST LINE LENGTH	+192% $p < 0.001$	+368% $p < 0.001$
TIBIA ENDOSTEAL BONE FORMATION RATE		27% NS**
TIBIA ENDOSTEAL FORMING SURFACE LENGTH		+75% NS
TIBIA ENDOSTEAL OSTEOBLASTS		+21% NS
RESORPTION		
TIBIA MEDULLARY AREA	+12% NS	6% NS
TIBIA ENDOSTEAL RESORBING SURFACE		+6% NS
TIBIA ENDOSTEAL OSTEOCLASTS		NO CHANGE
VASCULAR CANALICULAR VOLUME	HUMERUS +21% NS	FEMUR 7% NS
GROWTH		
TIBIA LONGITUDINAL GROWTH RATE	+12% NS	+16% NS
LONGITUDINAL GROWTH RATE	HUMERUS +22% NS	FEMUR 2% NS
OSTEOCYTE ACTIVITY		
LACUNAR CANALICULAR VOLUME	HUMERUS 2% NS	FEMUR 1% NS
MINERALIZATION		
DENSITY	HUMERUS 1% NS	FEMUR 2% NS

* FLIGHT GROUP WAS COMPARED TO FLIGHT CONTROLS
** NS = $p > 0.05$
* THERE WAS LESS THAN 1 OSTEOCLAST/MM SURFACE IN ALL GROUPS

SUMMARY

1) BONE FORMATION WAS INHIBITED AT THE PERIOSTEUM DURING SPACEFLIGHT.
2) NO CHANGES WERE OBSERVED IN ENDOSTEAL BONE TURNOVER OR IN LONGITUDINAL GROWTH.
3) THE DEFECT IN PERIOSTEAL BONE FORMATION WAS CORRECTED DURING THE POSTFLIGHT PERIOD.

NASA-S-80-10219

10a EFFECT OF SPACEFLIGHT ON BONE STRENGTH

THE EFFECT OF SPACEFLIGHT ON WHOLE BONE MECHANICAL PROPERTIES OF STATIONARY AND CENTRIFUGED RATS BOTH IMMEDIATELY FOLLOWING AND 25 DAYS AFTER AN 18.5 DAY FLIGHT ABOARD COSMOS 936 WAS DETERMINED. THE LEFT FEMUR WAS USED FOR MEASUREMENT OF MECHANICAL PARAMETERS WHICH WERE DETERMINED BY A STANDARD TORSION TEST. ULTIMATE TORQUE, DEFORMATION TO FAILURE, ENERGY, AND STIFFNESS WERE MEASURED. AFTER 18.5 DAYS OF SPACEFLIGHT, A SIGNIFICANT DECREASE IN BONE TORSION STRENGTH, INCLUDING TORQUE (17.5 ± 4.4 vs 26.1 ± 6.9 10^3 CM-DYNES), STIFFNESS (2.97 ± 0.22 vs 4.15 ± 0.39 10^3 CM-DYNES/RADIAN), AND ENERGY (18.0 ± 8 vs 26.1 ± 3 10^3 ERG RADIANS) WAS OBSERVED. INFLIGHT CENTRIFUGATION APPEARED TO PREVENT THESE CHANGES. ALL SIGNIFICANT DIFFERENCES PRODUCED BY SPACEFLIGHT ON BONE STRENGTH RECOVERED 25 DAYS POSTFLIGHT. THE DECREASE IN BONE STRENGTH APPEARS PRIMARILY DUE TO CHANGES IN BONE GEOMETRY SINCE BODY WEIGHTS OF RATS AND LENGTHS OF THE LEFT FEMORA REVEALED NO CONSISTENT EFFECT OF FLIGHT. HOWEVER, THE PRESENCE OF A SIGNIFICANT BONE GROWTH ARREST LINE IN BONES FROM FLIGHT RATS MUST ALSO BE CONSIDERED. (SUPPORTED IN PART BY NASA CONTRACTS RA190850 AND RA366876)

INTRODUCTION

SPACEFLIGHT RESULTS IN ALTERED CALCIUM HOMEOSTASIS IN ANIMALS AND HUMANS. URINARY CALCIUM WAS INCREASED IN SKYLAB ASTRONAUTS, WHEREAS, AFTER AN 84 DAY FLIGHT THE DENSITY OF THE OS CALCIS WAS DECREASED. FURTHERMORE, WHEN GROWING RATS WERE ORBITED FOR 19 DAYS ABOARD COSMOS 782 THE PERIOSTEAL BONE FORMATION RATE IN THE TIBIA DIAPHYSIS WAS REDUCED 47%. THIS LATER CHANGE OR SOME OTHER EFFECT OF SPACE FLIGHT COULD ALTER BONE MECHANICAL PROPERTIES. TO TEST THE POSSIBILITY THAT SPACE FLIGHT HAS A DELETERIOUS EFFECT ON BONE MECHANICAL PROPERTIES, WE DETERMINED FEMUR BREAKING STRENGTH BY TORSIONAL LOADING IN RATS THAT HAD BEEN FLOWN FOR 19 DAYS ABOARD COSMOS 936.

METHODS

COSMOS 936 WAS LAUNCHED IN THE SOVIET UNION ON 8/3/79 AND RECOVERED 8/22/79. ANIMAL CARE, PREFLIGHT, AND POSTFLIGHT ACTIVITIES WERE PERFORMED BY THE SOVIETS. THE FLIGHT ANIMALS WERE DIVIDED INTO TWO GROUPS: 1) RATS SUBJECTED TO NEAR WEIGHTLESSNESS (FLIGHT STATIONARY) AND 2) RATS CENTRIFUGED AT 1 x g (FLIGHT CENTRIFUGED). HALF OF THE RATS WERE SACRIFICED AT THE END OF THE 19 DAY FLIGHT WHILE THE REMAINING ANIMALS WERE KILLED 25 DAYS POSTFLIGHT. THE FLIGHT CONTROL GROUP WAS MAINTAINED ABOARD AN IDENTICAL EARTH BASED SPACECRAFT AND EXPOSED AS CLOSELY AS POSSIBLE TO FLIGHT CONDITIONS (INCLUDING ACCELERATION, NOISE, SHOCK AND VIBRATION OF LAUNCH AND REENTRY).

BONE MECHANICAL PARAMETERS WERE EVALUATED IN THE LEFT FEMUR WITH THE STANDARD TORSION TEST MACHINE DESIGNED BY BURSTEIN AND FRANKEL. THE FEMUR WAS MAINTAINED IN MOISTENED CONDITION AT ALL TIMES. THE ENDS OF THE FEMUR WERE EMBEDDED IN EPOXY RESIN PRIOR TO TESTING. THE TORQUE ANGULAR DISPLACEMENT CURVE WHICH RESULTED WAS RECORDED ON A STORAGE OSCILLOSCOPE AND REDUCED TO OBTAIN ULTIMATE TORQUE, DEFORMATION TO FAILURE, STRAIN ENERGY AND STIFFNESS.

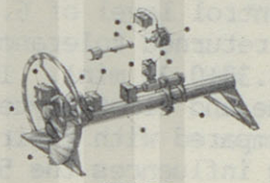
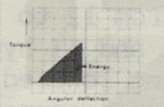
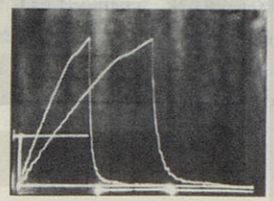


FIG. 4. THE COMPONENTS OF A STANDARD TORSION TESTING MACHINE ARE:
A: FRAME; B: TAIL STOCK; C: PENDULUM; D: DOG CLUTCH IN PENDULUM; E: DOG CLUTCH ON ROTATING SHAFT; F: ROTATING GRIPS; G: ANGULAR DEFORMATION TRANSDUCER; H: STATIONARY GRIPS; I: TORQUE TRANSDUCERS; J: SELF CALIBRATION SYSTEM; *TWO SIZES SHOWN.

TYPICAL CURVE FOR TORSIONAL FAILURE TESTING

Figure 6



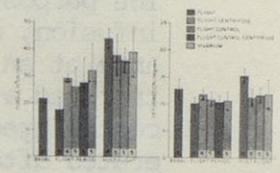


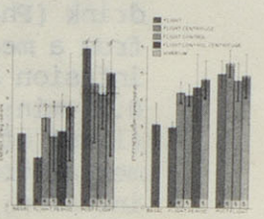
RESULTS

SPACEFLIGHT RESULTED IN A SIGNIFICANT DECREASE IN MECHANICAL PERFORMANCE: FEMURS FROM THE FLIGHT RATS WERE LESS STIFF THAN THE FLIGHT CONTROLS, AND FAILED UNDER TORSION AT A LOWER TORQUE AND ENERGY OF ABSORPTION. IN CONTRAST TO THE FLIGHT RATS, FEMURS FROM ANIMALS THAT HAD BEEN CENTRIFUGED AT 1 X g DURING SPACEFLIGHT SHOWED NO DECREASE IN BONE STRENGTH.

THE DEFECT IN BONE MECHANICAL PROPERTIES WAS CORRECTED DURING THE POSTFLIGHT PERIOD. AFTER 25 DAYS OF RECOVERY ALL OF THE PARAMETERS ASSOCIATED WITH FEMUR STRENGTH HAD INCREASED IN THE FLIGHT ANIMALS, EITHER UP TO OR IN EXCESS OF THE CONTROL VALUES.

EFFECT OF SPACE FLIGHT ON FEMUR BREAKING STRENGTH FLIGHT 936





DISCUSSION

THE CAUSE OF THE DECREASE IN BONE BREAKING STRENGTH DURING SPACEFLIGHT HAS NOT BEEN DETERMINED. BECAUSE OSTEOCLASTIC RESORPTION AS WELL AS OSTEOCYTE ACTIVITY HAD NOT BEEN ALTERED IT CAN BE ASSUMED THAT THE CHANGES IN THE MECHANICAL PROPERTIES OF THE FEMUR ARE ATTRIBUTABLE SOLELY TO THE BONE FORMED DURING SPACEFLIGHT. THE FEMURS FAILED AT THE DIAPHYSIS, A REGION WHERE MOST OF THE BONE BEING FORMED WAS AT THE PERIOSTEAL SURFACE. AS A RESULT, THE NEWLY FORMED BONE WOULD HAVE EXPERIENCED THE GREATEST SHEAR FORCES DURING THE STRENGTH TESTING. THE MECHANICAL BEHAVIOR OF BONE IS DEPENDENT UPON THE MATERIAL PROPERTIES AS WELL AS GEOMETRY (AMOUNT AND DISTRIBUTION) OF THE STRUCTURE. BONE FORMATION WAS INHIBITED DURING SPACEFLIGHT AT THE TIBIA DIAPHYSIS, SUCH THAT THERE WAS A DECREASE IN THE CROSS SECTIONAL AREA. THIS RESULT IS CONSISTENT WITH THE HYPOTHESIS THAT ALTERED BONE GEOMETRY (REDUCED RADIUS) WAS AT LEAST PARTIALLY RESPONSIBLE FOR THE REDUCTION IN FEMUR MECHANICAL PROPERTIES.

IN SUMMARY

1) THE MECHANICAL PROPERTIES OF THE FEMUR WERE ALTERED DURING SPACEFLIGHT IN GROWING RATS SUCH THAT BONE BREAKING STRENGTH WAS REDUCED.
2) THE DEFECT IN BONE MECHANICAL PROPERTIES WAS CORRECTED FOLLOWING FLIGHT AND COULD BE PREVENTED DURING FLIGHT BY CENTRIFUGATION OF THE RATS AT 1 X g.
3) ALTERED BONE GEOMETRY DUE TO INHIBITION OF BONE FORMATION AT THE PERIOSTEAL SURFACE PROVIDES THE MOST LIKELY EXPLANATION FOR THE DECREASE IN BONE STRENGTH DURING SPACE FLIGHT.

BONE FORMATION ARRESTED BY SPACE FLIGHT

EFFECT OF SPACE FLIGHT ON BONE. Emily R. Morey-Holton, NASA-Ames Research Center, Moffett Field, CA 94035.

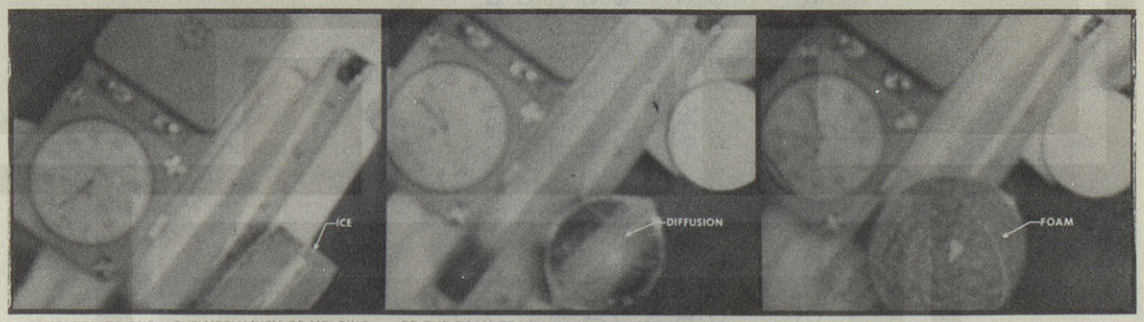
The effect of space flight on bone was studied on growing rats both immediately following and 25 days after about 19 days of flight aboard Cosmos 782 or 936. Periosteal bone formation at the tibiofibular junction was reduced 47% and 43%, respectively, as compared with ground controls. Inhibition of bone formation was accompanied by an arrest line at the periosteum suggesting that formation ceases during flight. Centrifugation did not correct the defect. In contrast, whole bone mechanical properties of stationary and centrifuged rats from Cosmos 936 showed that the significant decrease in bone torsional strength induced by space flight was corrected by inflight centrifugation. All significant differences produced by space flight on bone recovered by 25 days postflight.

NASA-S-80-10209

11 ENVIRONMENTAL PARAMETERS OF SPACE

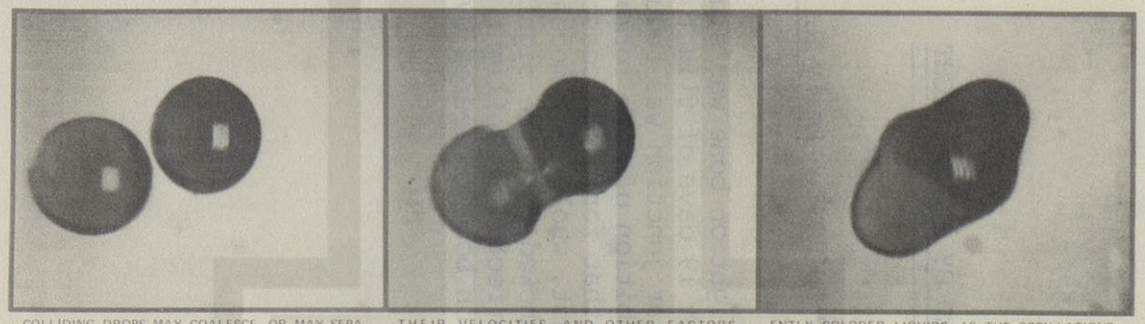
OUR FUTURE HOLDS THE OPPORTUNITY TO PERFORM RESEARCH IN SPACE. BUT ALL OUR INTUITIONS ABOUT RESEARCH WERE DEVELOPED BY EXPERIENCE IN A 1-g ENVIRONMENT. AN EFFORT HAS BEGUN TO CHARACTERIZE LABORATORY PROCESSES AND PROPERTIES IN THE ZERO-g ENVIRONMENT.

ICE MELTING, DIFFUSION AND FOAM



COMPARED TO ONE-g, THE MECHANISM OF MELTING IS MUCH DIFFERENT IN LOW-g. THE LIQUID DOES NOT DRAIN AWAY FROM THE ICE, BUT SURROUNDS IT. THIS INSULATING LAYER OF LIQUID INFLUENCES THE RATE OF HEAT CONDUCTION TO THE ICE. AFTER THE ICE WAS MELTED, AIR WAS INJECTED INTO THE DROP. A FOAM WAS FORMED. THE VOLUME OF THE FOAM GRADUALLY INCREASED AS AIR WAS ADDED UNTIL IT REACHED A STATIC DIAMETER AND NO FURTHER INCREASE IN SIZE WAS OBSERVED. ON THE SURFACE OF THE FOAM, BUBBLES WERE OBSERVED ERUPTING AND SMALL DROPS FLYING AWAY SO AIR WAS ADDED. DIFFUSION BY ITSELF IS DIFFICULT TO OBSERVE ON EARTH BECAUSE THE FORCE OF GRAVITY PRODUCES CIRCULATION WITH THE FLUID. IT DOES NOT SHOW HERE, BUT AFTER 515 HOURS THE DIFFUSION FRONT HAD A PARABOLIC SHAPE, WITH A SIGNIFICANT LAG IN DIFFUSION AT THE CONTAINER WALL.

LIQUID DROP COALESCENCE



COLLIDING DROPS MAY COALESCE, OR MAY SEPARATE AGAIN, OR MAY FORM MANY SMALL DROPLETS, DEPENDING UPON THE SIZE OF THE DROPS, THEIR VELOCITIES, AND OTHER FACTORS. IMMEDIATELY FOLLOWING COALESCENCE THERE IS A SHARP BOUNDARY BETWEEN THE TWO DIFFERENTLY COLORED LIQUIDS. AS THE OSCILLATIONS CONTINUED THE TWO COLORS CAN BE OBSERVED TO SLOWLY MIX.

LIQUID DYNAMICS

IF A FREE-FLOATING DROP IS ROTATED IN A LOW-g ENVIRONMENT, SURFACE TENSION FORCES CAN BALANCE CENTRIFUGAL FORCES TO ESTABLISH AN EQUILIBRIUM INTERFACE SHAPE. THESE ROTATING DROPS CAN BE STABLE IN EITHER A TOROIDAL OR PEANUT SHAPE CONFIGURATION. BEYOND A CRITICAL RATE OF ROTATION, THE DROP WILL BREAK APART.

LOW-G EFFECTS ON LIQUIDS

ENVIRONMENTAL PARAMETERS OF SPACE. Michael A. Reynolds, NASA-Johnson Space Center, Houston, TX 77058.

Many potential users of Space Shuttle whose research could benefit from near zero-g environment are not equipped with the required intuitive and quantitative understanding of the near zero-g environment necessary to design their experiment.

With this in mind we will give a qualitative presentation of some physical phenomena emphasizing behavior of liquids. A brief summary of some of the effects of low-gravitational acceleration on liquids are:

a. Surface tension forces tend to control the behavior of a drop of liquid, forming it into a sphere if it is not in contact with another material.

b. Rotating drops can be stable in either a toroidal or peanut shape configuration.

c. Colliding drops may coalesce, or may separate again, or may form many small droplets, depending upon the sizes of the drops, their velocities, and other factors.

d. Immiscible liquids separate at a very low rate at zero-g.

e. The stability of foams was demonstrated in Skylab.

NASA-S-80-10223

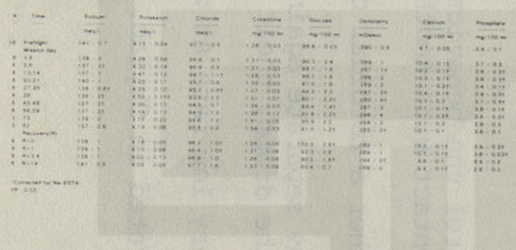
12 FLUID AND ELECTROLYTE BALANCE

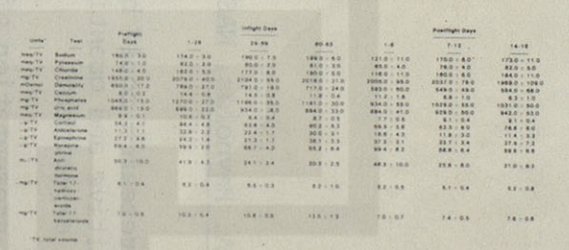
SUMMARY

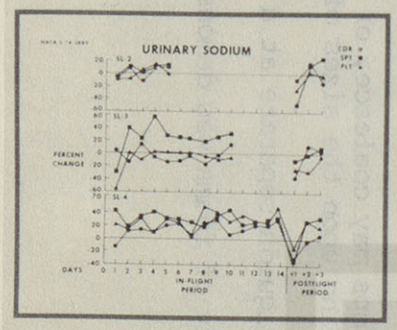
BIOCHEMICAL INVESTIGATIONS UNDERTAKEN AS PART OF THE SKYLAB PROGRAM PROVIDED THE FIRST COMPREHENSIVE INSIGHT INTO THE BIOCHEMICAL ALTERATIONS IN MAN THAT ARE ELICITED AS A RESULT OF THE STRESSES OF PROLONGED SPACE FLIGHT. THROUGH A SERIES OF ANALYTICAL DETERMINATIONS AND BIOCHEMICAL MEASUREMENTS ON BLOOD AND URINE OF ALL CREWMEMBERS OF THE SKYLAB MISSION A NUMBER OF PREVIOUSLY PREDICTED BIOCHEMICAL CHANGES WERE SUBSTANTIATED AND, IN ADDITION, VARIOUS UNSTABLE PHYSIOLOGICAL STATES WERE IDENTIFIED. THE MOST ACUTE AND CONSISTENT AMONG THESE CHANGES WHICH SIGNIFICANTLY IMPACTS THE OVERALL HOMEOSTATIC BALANCE IN MAN IS THE ALTERATION OF FLUID AND ELECTROLYTE METABOLISM. ALTHOUGH TRANSIENT IN NATURE UPON RETURN TO EARTH, IT IS UNCLEAR AT THIS TIME WHAT LONG-TERM CONSEQUENCES THIS IMBALANCE MIGHT HAVE ON OTHER PROCESSES AFTER FLIGHT HAS CONTINUED FOR GREATER EXTENDED PERIODS OF TIME.

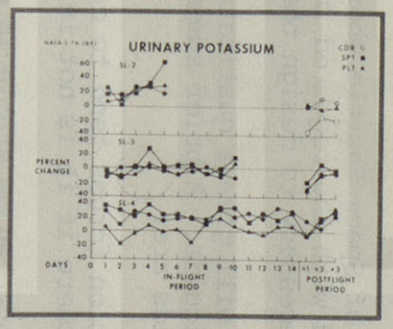
RESULTS

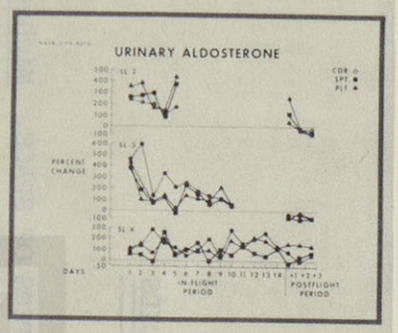
INCREASES WERE SEEN IN OSMOLALITY AND IN THE CIRCULATING LEVEL OF SODIUM, POTASSIUM, PHOSPHORUS, GLUCOSE, URIC ACID, CHOLESTEROL, AND CREATININE. CHANGES ARE ALSO SEEN IN THE CIRCULATING LEVEL OF ADRENOCORTICOTROPHIC HORMONE, CORTISOL, ANGIOTENSIN I, ALDOSTERONE, INSULIN, AND THYROXINE. ANALYSIS OF URINE SAMPLES POOLED OVER PERIODS OF 24 HRS REVEALED AN ACCELERATED RATE OF EXCRETION OF CORTISOL, CATECHOLAMINES, ANTIDIURETIC HORMONE, AND ALDOSTERONE AS WELL AS SODIUM, POTASSIUM, CALCIUM, PHOSPHORUS, CHLORIDE, AND MAGNESIUM. THE COMPUTED BALANCE OF SODIUM AND POTASSIUM WAS NEGATIVE INFLIGHT, CONSISTENT WITH THE INCREASE IN URINARY POTASSIUM WAS THE CONCOMITANT INCREASE OF ALDOSTERONE OUTPUT IN ALL CREWMEN; HOWEVER, A MORE ANOMALOUS FINDING WAS THAT A LOSS OF SODIUM ALSO OCCURRED. IT MAY BE THAT THESE CHANGES ARE ATTRIBUTABLE TO ALTERATIONS IN THE RENAL TUBULE PROXIMAL TO THE SITE OF ALDOSTERONE ACTION WHICH RESULT IN AN INCREASED EXCRETION OF SODIUM.





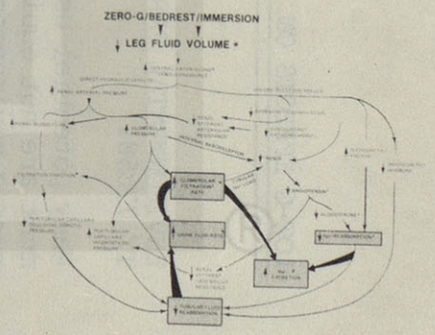






HYPOTHESIS

THE CHANGES THAT ARE REPORTED ARE CONSISTENT WITH THE HYPOTHESIS THAT AN INCREASE IN THORACIC BLOOD VOLUME OCCURS AFTER INSERTION INTO WEIGHTLESS FLIGHT WHICH ACTS UPON THE STRETCH RECEPTORS IN THE WALLS OF THE GREAT VESSELS AND IN THE ATRIA. THIS STIMULUS IS INTERPRETED AS AN EXPANSION OF BLOOD VOLUME WHICH THEN CAUSES A LOSS OF WATER AND OF ELECTROLYTES, PARTICULARLY SODIUM. THIS FLUID LOSS, PERHAPS IN CONJUNCTION WITH OTHER FACTORS, LEADS ULTIMATELY TO A REDUCTION OF BLOOD VOLUME AND AN INCREASED SECRETION OF RENIN AND OF ALDOSTERONE. FLUID BALANCE IS THUS RE-ESTABLISHED AT A NEW LEVEL APPROPRIATE TO THE NULL GRAVITY CONDITION. THE NEW HOMEOSTATIC SET POINT WHICH IS ACHIEVED IN THE METABOLISM OF ELECTROLYTES AND WATER EXERTS A COST ON THE ORGANISM WHICH IS REFLECTED IN ELEVATED LEVELS OF CORTISOL AND OTHER ENDOCRINOLOGIC PARAMETERS. THESE PARAMETERS CLEARLY INDICATE THAT THE SPACE FLIGHT CREWMEN HAD BEEN SEVERLY STRESSED BY THEIR EXPOSURE TO WEIGHTLESSNESS AND IT REMAINS THE SUBJECT OF FUTURE RESEARCH TO DETERMINE WHETHER THE DEPLETION OF THE BIOCHEMICAL RESERVES IS OPERATIONALLY TOLERABLE OVER A PROLONGED PERIOD OF TIME.



FACTORS AFFECTING URINARY FLUID AND SODIUM FOLLOWING FLUID REDISTRIBUTION IN ZERO-G, BEDREST OR IMMERSION

FLUID BALANCE AND ZERO-G

FLUID AND ELECTROLYTE BALANCE. Nitza M. Cintron, NASA-Johnson Space Center, Houston, TX 77058.

Biochemical investigations undertaken as part of the Skylab Program provided the first comprehensive insight into the biochemical alterations in man that are elicited as a result of the stresses of prolonged space flight. Through a series of analytical determinations and biochemical measurements on blood and urine of all crewmembers of the Skylab mission a number of previously predicted biochemical changes were substantiated and, in addition, various unstable physiological states were identified. The most acute and consistent among these changes which significantly impacts the overall homeostatic balance in man is the alteration in fluid and electrolyte metabolism. Increases were seen in osmolality and in the circulating level of sodium, potassium, phosphorus, glucose, uric acid, cholesterol, and creatinine. Changes were also seen in the circulating level of adrenocorticotrophic hormone, cortisol, angiotensin I, aldosterone, insulin, and thyroxine. Analysis of urine samples pooled over periods of 24 hr revealed an accelerated rate of excretion of cortisol, catecholamines, antidiuretic hormone, and aldosterone as well as sodium, potassium, calcium, phosphorus, chloride, and magnesium.

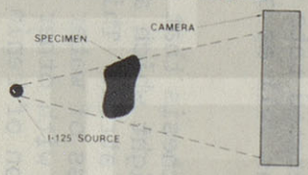
The changes that are reported consistent with the hypothesis that an increase in thoracic blood volume occurs after insertion into weightless flight which acts upon the stretch receptors in the walls of the great vessels and in the atria. This stimulus is interpreted as an expansion of blood volume which then causes a loss of water and electrolytes, particularly sodium. This fluid loss, perhaps in conjunction with other factors, leads ultimately to a reduction of blood volume and an increase secretion of renin and of aldosterone. Fluid balance is thus re-established at a new level appropriate to the null gravity condition. The new homeostatic set point which is achieved in the metabolism of electrolytes and water exerts a cost on the organism which is reflected in elevated levels of cortisol and other endocrinologic parameters.

NASA-S-80-10230

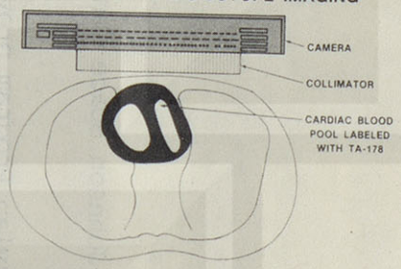
13 GAMMA CAMERA FOR BIOLOGICAL STUDIES IN SPACE

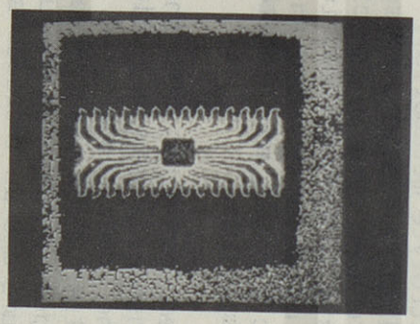
A MULTIWIRE PROPORTIONAL COUNTER CAMERA UNDER DEVELOPMENT AT THE JOHNSON SPACE CENTER WILL PROVIDE A TOOL WITH WIDE APPLICATION IN BIOMEDICAL RESEARCH. TWO FORMS OF IMAGING WILL BE POSSIBLE – RADIOGRAPHIC IMAGING OF TRANSMITTED X-RAYS AND IMAGING OF INJECTED RADIOISOTOPE DISTRIBUTIONS.

RADIOGRAPHIC IMAGING

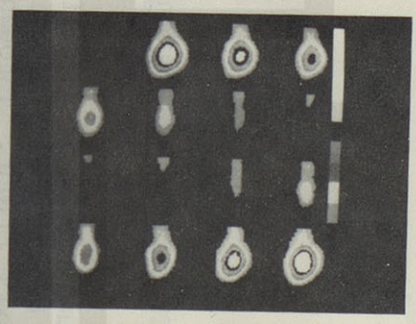


INJECTED RADIOISOTOPE IMAGING

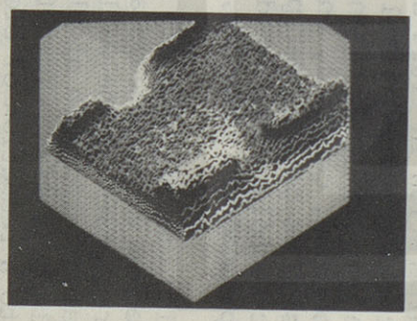




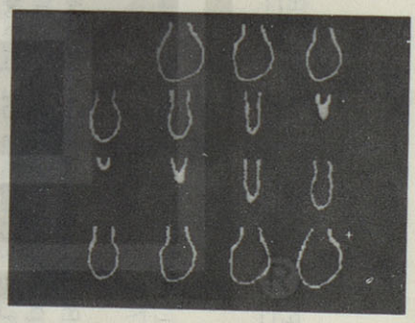
INTEGRATED CIRCUIT RADIOGRAPH



16 FRAME CARDIAC PHANTOM STUDY
VENTRICULAR VOLUME RANGE 0-140 ml



RAT FEMUR RADIOGRAPH 1 mm HOLE
PERPENDICULAR TO BONE SHAFT



VENTRICULAR WALL LOCATION

GAMMA RAY IMAGERY CAMERA ON SPACELAB

GAMMA RAY IMAGING CAMERA FOR BIOMEDICAL APPLICATIONS ON SPACELAB. Jeffrey L. Lacy, NASA-Johnson Space Center, Houston, TX 77058.

A gamma ray imaging camera is currently being developed at the Johnson Space Center (JSC) for biomedical applications. This device is based on technology developed at JSC for high energy astrophysics research. As well as having significant image quality advantages over commercially available camera, this device can be made compatible with space usage. It thus has the potential to provide a wide range of radiological and nuclear medicine diagnostics to a multi-user community of Spacelab investigators.

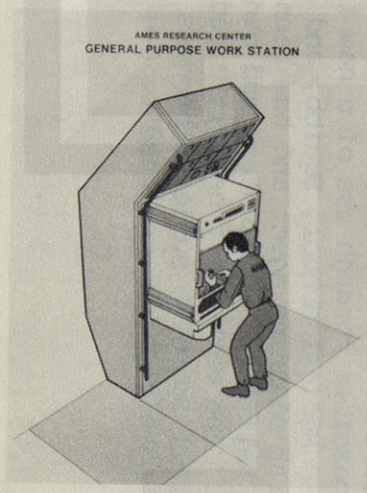
X-ray transmission studies such as bone densitometry and tissue fluid content determination can be performed using sealed radioactive sources such as I-125 and Am-241. Injected radioisotope imaging will be possible through use of a new isotope, Ta-178, being developed in a joint effort among Harvard Medical School, Squibb, and JSC. This isotope shows great promise as a cardiovascular scanning agent and has been employed for both lung and liver imaging. It has a short half-life (10 minutes) and can be supplied from a long-lived generator (22-day half-life). The very short half-life reduces subject radiation dose to the point that studies on normal Spacelab subjects becomes feasible. Thus, very direct and detailed measurements of physiological response to 0-g should be possible using nuclear medicine techniques.

LACY
Hotline # 525-5457, 5176

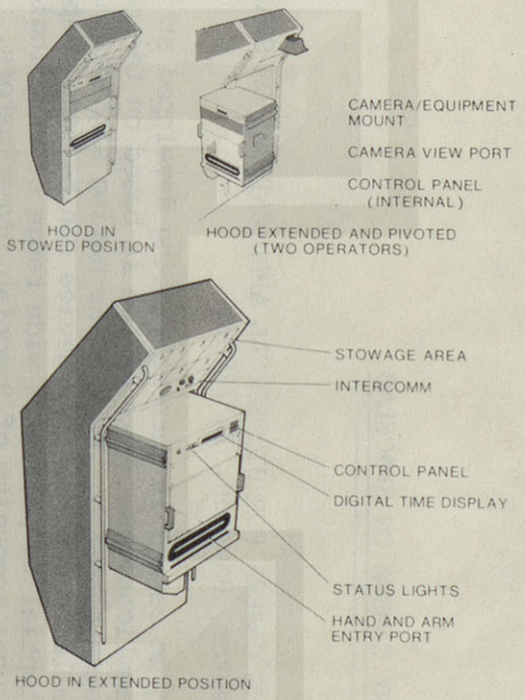
NASA-S-80-10231

14 (GPWS) FOR LIFE SCIENCES SPACELAB

AS PART OF THE LIFE SCIENCES FLIGHT EXPERIMENTS PROGRAM (LSFEP) NASA WILL PROVIDE STANDARD, FLIGHT-CERTIFIED LABORATORY EQUIPMENT NEEDED TO CONDUCT MANY OF THE LIFE SCIENCE EXPERIMENTS ON-BOARD SHUTTLE/SPACELAB MISSIONS. AMES RESEARCH CENTER IS THE NASA LEAD CENTER FOR NON-HUMAN FLIGHT EXPERIMENT MANAGEMENT, AND IS RESPONSIBLE FOR SEVERAL MAJOR ITEMS OF SPACE HARDWARE. ONE SUCH PIECE OF HARDWARE IS THE GENERAL PURPOSE WORK STATION.



GENERAL PURPOSE WORK STATION



THE GENERAL PURPOSE WORK STATION (GPWS) IS BEING DEVELOPED TO SERVE AS A WORK AREA IN WHICH CERTAIN EQUIPMENT, CHEMICALS, MATERIALS AND HAND TOOLS CAN BE SAFELY USED IN THE SPACELAB. LAMINAR AIRFLOW AND APPROPRIATE FILTERS ARE THE PRIMARY MEANS BY WHICH GASES, LIQUIDS AND SOLID MATERIALS ARE CONTROLLED. A PULL-OUT AND PIVOT FEATURE OF THE WORK STATION HOOD ALLOWS 2 CREW MEMBERS SIMULTANEOUS ACCESS TO THE 30'' WIDE x 24'' DEEP x 28'' HIGH WORK SPACE. THE GPWS IS DESIGNED AS A MULTI-USE FACILITY WHICH WILL BE FLOWN AS NECESSARY IN SUPPORT OF ANY LIFE SCIENCES EXPERIMENTS WHICH FLY ON SPACELAB AND AS A ''STATIC'' WORKBENCH TO SUPPORT ANY OTHER EXPERIMENTS.

WORK STATION, GENERAL PURPOSE: FOR SPACELAB LIFE SCIENCES EXPERIMENTS

GENERAL PURPOSE WORK STATION FOR LIFE SCIENCES SPACELAB. Lucky A. Goebel, NASA-Ames Research Center, Moffett Field, CA 94035.

As part of the Life Sciences Flight Experiments Program (LSFEP), NASA will provide standard flight-certified laboratory equipment needed to conduct many of the life science experiments onboard Shuttle/Spacelab missions.

Of the standard flight-certified laboratory equipment, the General Purpose Work Station (GPWS) is one of the major units currently under development. As liquids, gases, and solid particles are introduced into the work area, the laminar air flow entrains them and causes them to move to the bottom of the work area. Liquids will be absorbed by pads located at the entry points of the air ducts. Small particles and gaseous vapors will be purged from the air stream by a network of filters. To ensure proper cleansing of the air, it may be repeatedly circulated in a closed-loop mode. When properly scrubbed, the air may then be expelled into the Spacelab environment without posing a hazard to the crew.

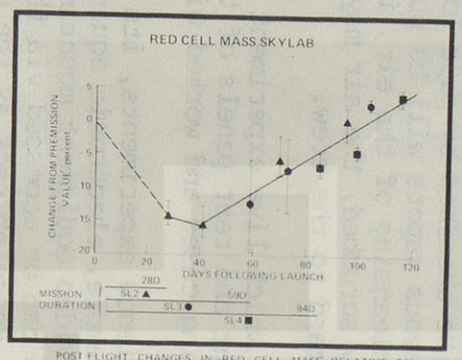
The GPWS is the only support hardware under development in which live experiment animals may be handled without risk of escape. By closing the front and rear panels of the work station, the animals may be safely removed from their holding cases and worked with.

Although the GPWS is being developed primarily for life science experiments, its use need not be restricted to this particular discipline. As an example, electronic equipment repair may be accomplished at the work station. Photography and video equipment mountings are being provided. Finally, the data systems of the Spacelab can be accessed via the remote acquisition unit (RAU) which will be installed in the same Spacelab rack as the GPWS.

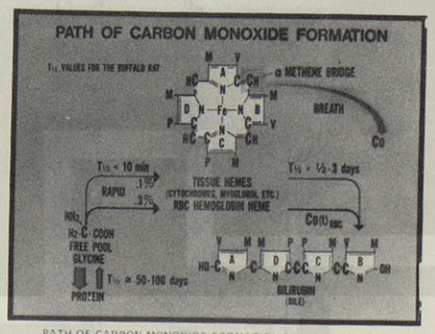
GOEBEL
Hotline # 448-5767

NASA-S-80-10232

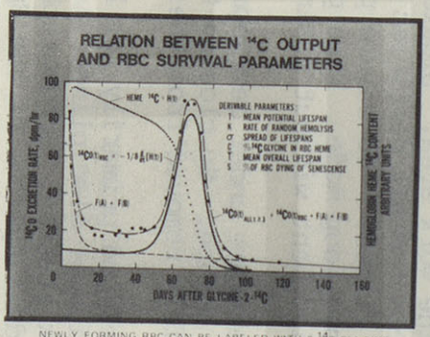
15 RED CELL MASS CHANGES CAUSED BY SPACEFLIGHT



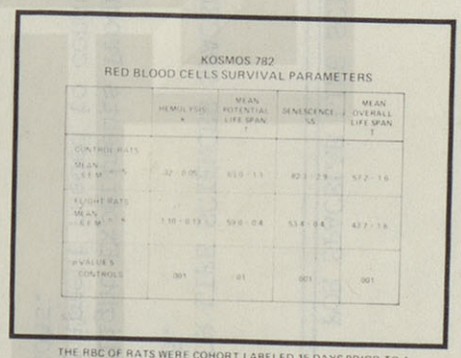
POST FLIGHT CHANGES IN RED CELL MASS RELATIVE TO PREFLIGHT VALUES. THE GREATEST CHANGE WAS FOUND IN THE SHORTEST FLIGHT. THIS AND OTHER DATA SUGGEST THAT THE DECREASE OCCURRED EARLY INTO THE FLIGHT AND THAT ADAPTATION AND RECOVERY WERE ALREADY INITIATED BY THE END OF THE LONGER FLIGHTS.



PATH OF CARBON MONOXIDE FORMATION FROM GLYCINE. THE 2-CARBON OF GLYCINE IS THE UNIQUE SOURCE FOR THE ALPHA METHENE BRIDGE CARBON OF HEME. THIS CARBON COMES OFF AS CARBON MONOXIDE IN THE BREATH FOLLOWING HEMOLYSIS AND HEME DEGRADATION.



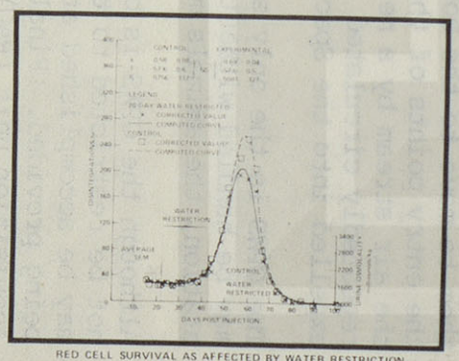
NEWLY FORMING RBC CAN BE LABELED WITH 2 ^{14}C GLYCINE. AFTER APPLYING CORRECTIONS FOR CYTOCHROME HEME ^{14}CO AND THE RECYCLING OF GLYCINE, THAT THE MICE OF THESE RBC'S CAN BE FOLLOWED BY QUANTITATING THE OUTPUT OF ^{14}CO IN THE BREATH.



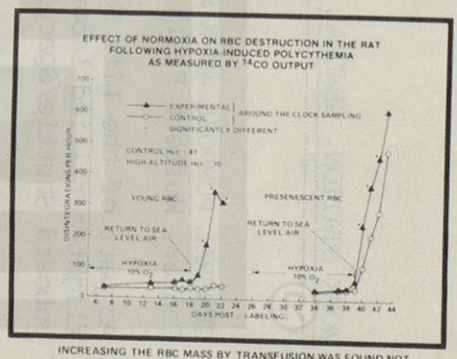
KOSMOS 782
RED BLOOD CELLS SURVIVAL PARAMETERS

	HEMOLYSIS	MEAN POTENTIAL LIFE SPAN	SENESCENCE	MEAN OVERALL LIFE SPAN
CONTROL RATS MEAN, SEM	.32/.005	610/11	821/29	572/16
FLIGHT RATS MEAN, SEM	1.16/.013	590/04	534/04	427/16
P VALUE VS CONTROLS	.001	.01	.001	.001

THE RBC OF RATS WERE COHORT LABELED 15 DAYS PRIOR TO A SPACE FLIGHT LASTING 19.5 DAYS. UPON RETURN TO EARTH, RBC SURVIVAL PARAMETERS WERE DETERMINED BASED ON THE OUTPUT OF ^{14}CO. THE MAIN EFFECT OF SPACE FLIGHT WAS A THREE FOLD INCREASE IN RANDOM HEMOLYSIS WHICH INCREASED THE PERCENT OF RBC DYING OF SENESCENCE AND SHORTENED THE OVERALL LIFESPAN. THIS WAS REPEATED IN A LATER FLIGHT WHICH ALSO DEMONSTRATED THAT ARTIFICIAL GRAVITY CAN ATTENUATE THE EFFECT.



RED CELL SURVIVAL AS AFFECTED BY WATER RESTRICTION. WATER RESTRICTION (33% OF NORMAL) FOR 20 DAYS, WHICH ALSO LEADS TO A CONSIDERABLE DECREASE IN FOOD INTAKE, HAS NO AFFECT ON RANDOM HEMOLYSIS OR MEAN POTENTIAL LIFESPAN. THIS LARGELY ELIMINATES DEHYDRATION OR DECREASED FOOD INTAKE AS CAUSATIVE FACTORS IN THE HEMOLYSIS OF SPACE FLIGHT.



INCREASING THE RBC MASS BY TRANSFUSION WAS FOUND NOT TO EFFECT HEMOLYSIS OF ENDOGENOUS RBC. HOWEVER, IF RATS LABELED WITH 2 ^{14}C GLYCINE ARE MADE POLYCYTHEMIC BY BEING SUBJECTED TO HYPOXIA, THERE IS A RAPID DESTRUCTION OF YOUNG AND OLD RBC UP ON TO SEA LEVEL AIR. THUS, THE EXISTENCE OF A HEMOLYTIC MECHANISM WHICH CONTRIBUTES TO THE ADJUSTMENT OF RBC MASS IS VERIFIED.

HEMATOLOGIC CHANGES

RED CELL MASS CHANGES CAUSED BY SPACE FLIGHT. Henry A. Leon, NASA-Ames Research Center, Moffett Field, CA 94035.

With few exceptions the loss of a variable quantity of red cell mass has been a consistent occurrence in humans subjected to space flight.

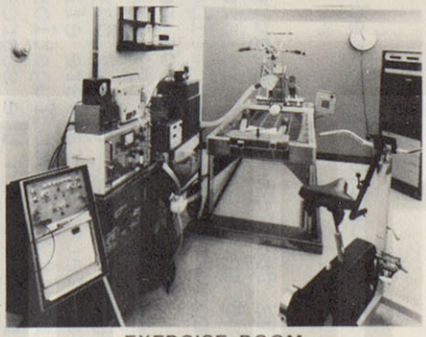
This is best illustrated by the results from Skylab (Figure 1) which shows that red cell mass is reduced early in the flight and therefore is related to some early event. Both increased destruction and decreased production may contribute to the loss. Red cells can be labeled with 2-^{14}C glycine (Figure 2) and a number of red cell survival parameters can be quantitated by analyzing the out-pattern of ^{14}CO (Figure 3). Using this technique it was found that in rats subjected to space flight (18-19 days), red cell hemolysis was increased three-fold and other survival parameters were effected (Figure 4). A subsequent flight demonstrated that artificial gravity (centrifugation at 1XG) could attenuate the hemolytic action of weightless space flight. In the search for a mechanism for this hemolysis it has been found that subjecting rats to vibration, confinement, food or water restriction (Figure 5) has no effect on the red cell survival parameters in question. We have demonstrated, however, that in post-hypoxic polycythemic rats hemolysis is increased considerably (Figure 6) verifying the existence of a hemolytic mechanism in otherwise normal rats.

NASA-S-80-10225

16 HUMAN RESEARCH FACILITY

LBNP TEST ROOM

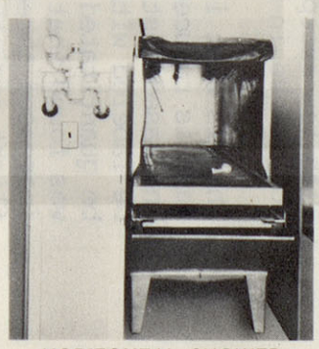
NURSES WORK STATION



EXERCISE ROOM

SUBJECTS LOUNGE

SUBJECTS ROOM



HORIZONTAL SHOWER

HUMAN RESEARCH SIMULATION OF SPACE FLIGHT

HUMAN RESEARCH FACILITY. Dolores B. O'Hara, NASA-Ames Research Center, Moffett Field, CA 94035.

The Human Research Facility (HRF) of the Ames Research Center is designed specifically for conducting ground studies simulating space flight conditions in humans. These predominantly include bedrest to simulate weightlessness and confinement. The HRF is located on the first floor of Building N-239, for Life Sciences Research. Contained within this 4,100 square feet: an experimental testing area and a subject resident area.

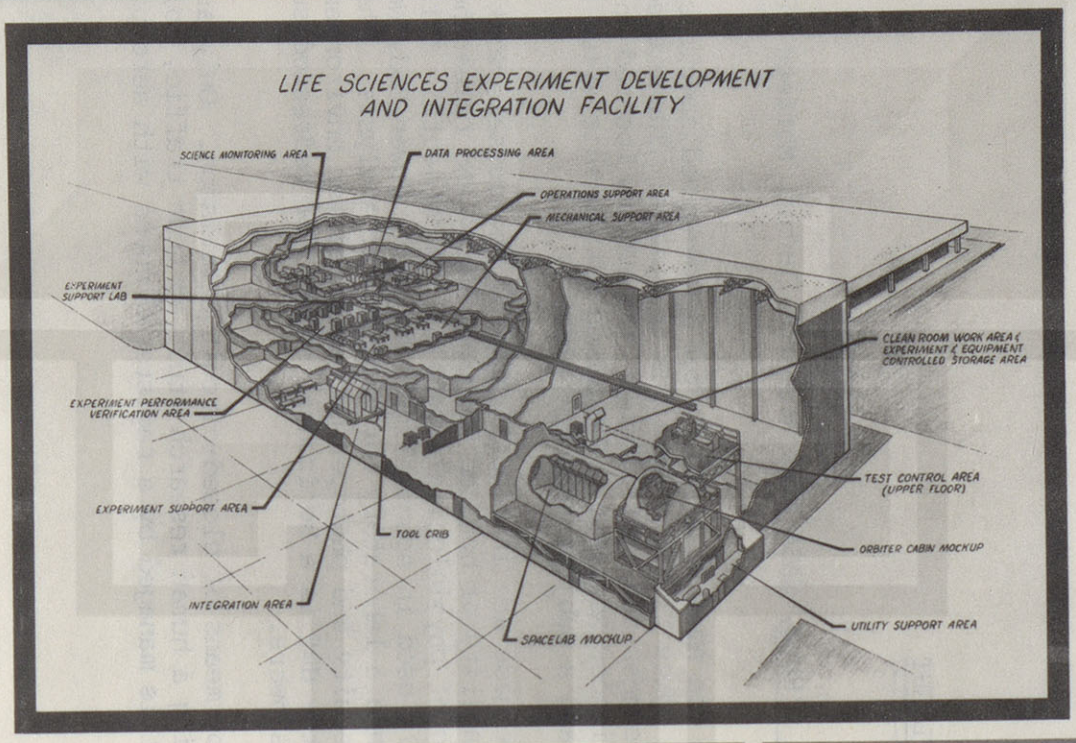
The HRF has a 12 bed capacity and the beds are in visual range of the nurse's work station. The subject testing area has the capability of housing both Facility- and researcher-supplied hardware for displaying and recording of physiological signals from subjects. This test area uses all test equipment routinely used in space flight including lower Body Negative Pressure, exercise ergometry, etc., and a laboratory for biochemical analysis. The HRF is temperature controlled and light intensity and photoperiod regulated for environmental control purposes. An integral part of the HRF is a horizontal shower for bedrested subjects in addition to three bathrooms with showers.

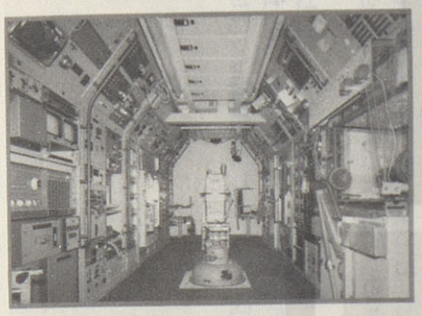
Access to the Facility is monitored by means of closed-circuit television. Only authorized personnel are permitted to enter during a human research study so that traffic, noise and disruption are kept to a minimum. It is managed by a registered nurse with aerospace medicine experience.

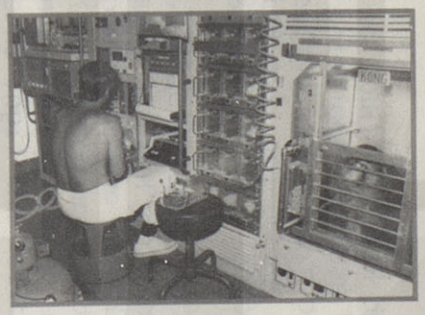
NASA-S-80-10228

17

JSC LIFE SCIENCES INTEGRATION FACILITY







EXPERIMENT INTEGRATION FACILITY

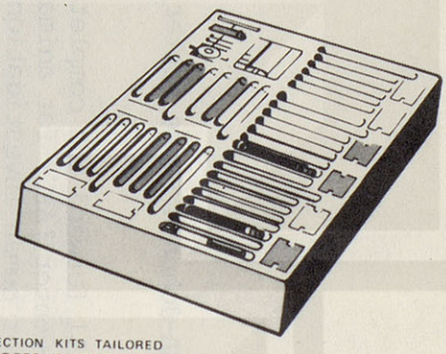
LIFE SCIENCES INTEGRATION FACILITY. Gary W. McCollum, NASA-Johnson Space Center, Houston, TX 77058.

After the investigator has developed his experiment, he will forward the completed hardware to the appropriate development center. (To Ames Research Center (ARC) for animal and biological investigations; or to Johnson Space Center (JSC) for human investigations.) The development center will undertake checkout and investigation process, including evaluation of system compatibility, system thermal balancing, system EMI evaluation, and weight, balance and CG analysis. Upon completion, LSLE equipment will be forwarded to JSC Life Sciences Integration Facility (labs for experiment-to-rack-integration, rack-to-floor-section-integration, floor-section-to-high-fidelity-Spacelab-mockup-integration and interfaces with mockup of Orbiter aft flight deck and mid-deck) where the total payload will be assembled and combined with additional LSLE and flight equipment. Flight equipment includes racks, data system interface units, power units, etc. Final hardware and interface tests will be performed along with discipline oriented payload specialist training, final science verification testing and preparation for shipment to Kennedy Space Center.

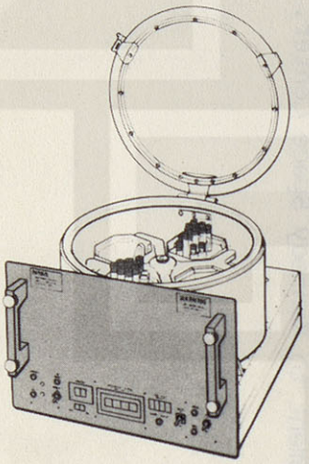
NASA-S-80-10205

18 LIFE SCIENCES LABORATORY EQUIPMENT (LSLE)

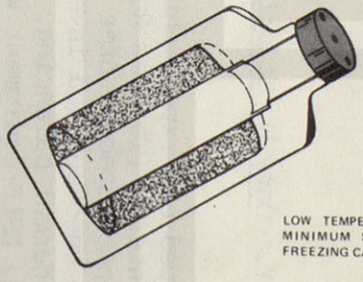
THE LIFE SCIENCE LABORATORY EQUIPMENT (LSLE) IS AN INVENTORY OF FLIGHT EXPERIMENT EQUIPMENT WHICH HAS A HIGH OR MULTIPLE USAGE RATE. THESE ITEMS WILL BE AVAILABLE FOR LIFE SCIENCE INVESTIGATOR ON THE SPACE SHUTTLE MISSION, TO DEVELOP THEIR EXPERIMENT IN THEIR LABORATORY AND FOR NASA FLIGHT CREW PERSONNEL TO PERFORM THE EXPERIMENT IN FLIGHT. CURRENTLY 56 ITEMS HAVE BEEN IDENTIFIED AS LSLE. THESE PICTORIALS ARE TYPICAL HIGH REQUEST EXPERIMENT HARDWARE.



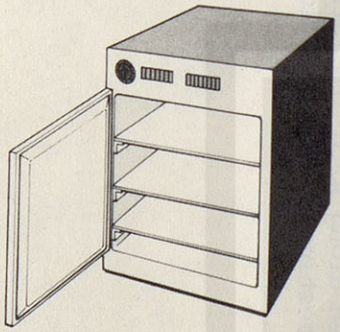
BLOOD COLLECTION KITS TAILORED TO EXPERIMENT REQUIREMENTS.



ONE CENTRIFUGE FOR SPECIMEN SEPARATION WITH CAPABILITIES OF 0 TO 1600 G AND 0 TO 4000 G.

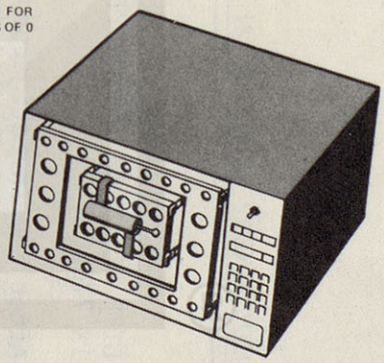


LOW TEMPERATURE FREEZERS. FOR MINIMUM SIZE SPECIMENS. WITH A FREEZING CAPABILITY TO -195 C.



REFRIGERATES 2.5 FT CU VOLUME AND 3 C TO 20 C REFRIGERATING RANGES.

TWO MASS MEASURING DEVICES FOR LIQUIDS OR SOLIDS WITH RANGES OF 0 TO 10Kg AND 10 TO 100 Kg.



FURTHER DESCRIPTION OF THE LSLE MAY BE OBTAINED FROM THE LSLE MANAGER OF THE LIFE SCIENCE PROJECT DIVISION, NASA JOHNSON SPACE CENTER, HOUSTON, TEXAS 77058 (713) 483-4164.

LABORATORY EQUIPMENT, LIFE SCIENCES

LIFE SCIENCES LABORATORY EQUIPMENT (LSLE). Ryborn R. Kirby, NASA-Johnson Space Center, Houston, TX 77058

The Life Sciences Experiments Program will provide flight-worthy general-purpose Life Science Laboratory Equipment (LSLE) to support investigators who have approved experiments for Shuttle Spacelab missions. This LSLE will be developed after analysis of all experiment proposals, to identify common equipment which can be used to support more than one experiment, and used on more than one mission. After the experimenter has been selected, available LSLE equipment will be identified and provided to the investigator for incorporation in his experiment development.

LSLE is comprised of scientific equipment and supplies, utilized by the life scientist investigator, whenever possible, to reduce the need for new equipment development, to limit overall program cost, and to reduce development lead time.

Inventory of space-qualified LSLE items is maintained by NASA for selection and integration into the various flight laboratory designs. After each laboratory flight, the LSLE items will be recovered, recertified, and returned to storage for reuse in subsequent flight laboratories.

NASA-S-80-10208

19 NASA PRINCIPAL INVESTIGATORS FLIGHT OPPORTUNITIES

NASA-S-78-12685

NASA LIFE SCIENCES PROGRAM

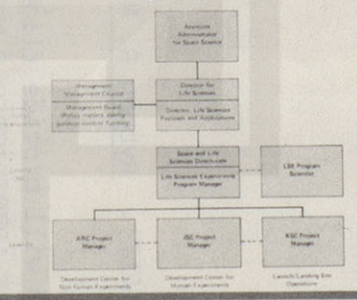
BASIC OBJECTIVES

- INSURE HUMAN HEALTH, SAFETY, WELL BEING AND EFFECTIVE PERFORMANCE IN SPACE FLIGHT
- UTILIZE THE SPACE ENVIRONMENT TO FURTHER KNOWLEDGE IN EARTH MEDICINE AND BIOLOGY
- UTILIZE SPACE TECHNOLOGY AND THE SPACE ENVIRONMENT FOR APPLICATION TO TERRESTRIAL MEDICAL AND BIOLOGICAL PROBLEMS
- TO UNDERSTAND THE ORIGIN AND DISTRIBUTION OF LIFE IN THE UNIVERSE

LIFE SCIENCES PAYLOADS

- LIFE SCIENCES FLIGHT EXPERIMENTS PROGRAM (LSFEP)
  - OBJECTIVE
    - TO ESTABLISH AN STS FLIGHT PROGRAM FOR THE CONDUCT OF LIFE SCIENCES RESEARCH AND DEVELOPMENT IN SPACE
  - SPECIFIC FUNCTIONS/RESPONSIBILITIES
    - FLIGHT PLANNING
    - EXPERIMENT SOLICITATION/SELECTION
    - PAYLOAD DEVELOPMENT
    - PRE-, IN-, AND POSTFLIGHT MISSION OPERATIONS
    - PI SUPPORT
    - POSTFLIGHT RESEARCH, DATA ANALYSIS, AND REPORTING

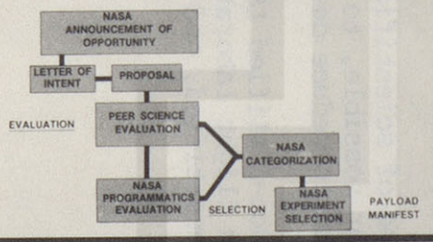
LIFE SCIENCES FLIGHT EXPERIMENTS PROGRAM
ORGANIZATION



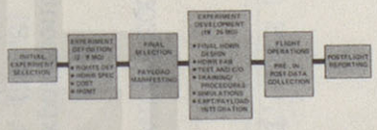
NASA-S-78-12671

NASA LIFE SCIENCE PAYLOAD PROGRAM

EXPERIMENT SOLICITATION AND SELECTION PROCESS



LIFE SCIENCES PAYLOADS
EXPERIMENTS DEVELOPMENT PROCESS



LIFE SCIENCES PAYLOADS

- LIFE SCIENCES LABORATORY EQUIPMENT (LSLE) PROGRAM
  - OBJECTIVE
    - TO ESTABLISH AN INVENTORY OF COMMONLY USED LIFE SCIENCES LABORATORY EQUIPMENT FOR MULTI-EXPERIMENT, MULTI-FLIGHT USE
  - APPROACH
    - INVENTORY DEVELOPED ON AN "AS NEEDED" BASIS
    - ITEMS "SPEC'D" TO COVER AS BROAD A RANGE OF EXPERIMENT REQUIREMENTS/NEEDS AS FEASIBLE
    - ALL HARDWARE DEVELOPED/PROCURED THROUGH EXPERIMENT CONTRACTS WILL BE CONSIDERED FOR POTENTIAL LSLE USE
  - EXAMPLES
    - MICROCOMPUTER
    - BLOOD COLLECTION AND WORK KITS
    - BLOOD PRESSURE MEASUREMENT SYSTEM
    - LOWER BODY NEGATIVE PRESSURE DEVICE
    - ANIMAL HOLDING FACILITIES
    - GENERAL PURPOSE WORKBENCH
    - REFRIGERATORS
    - FREEZERS

LIFE SCIENCES PAYLOADS

- AO OSS-1-78
  - ANNOUNCEMENT COVERS FLIGHT OPPORTUNITIES IN 1984 THROUGH 1986
    - LIFE SCIENCES DEDICATED FLIGHTS
    - MINILABS
    - CARRY-ON OPPORTUNITIES
  - MORE THAN 600 LETTERS OF INTENT RECEIVED
  - 370 PROPOSALS RECEIVED
    - 128 HUMAN
    - 160 ANIMAL
    - 35 PLANT
    - 47 OTHER (MICROORGANISMS, CELL CULTURES, ETC)
  - CURRENT STATUS
    - SCIENTIFIC PEER REVIEW - 9/78
    - 87 PROPOSALS SELECTED FOR DEFINITION (12/79 - 10/80)
    - SELECTION FOR DEVELOPMENT SCHEDULED 1/81
    - INITIAL PAYLOAD SELECTION SCHEDULED 4/81

OPPORTUNITY TO FLY NEW EXPERIMENTS OFFERED

NASA PRINCIPAL INVESTIGATORS INTERFACES FLIGHT OPPORTUNITIES/ADVANCED MISSIONS. William E. Feddersen, NASA-Johnson Space Center, Houston, TX 77058.

The NASA Johnson Space Center is presently engaged in developing a series of physiological experiments selected for flight on Spacelab I. These experiments are part of an overall complement of life sciences experiments which include investigators from Europe and the United States. The role of Principal Investigator in the Space Shuttle Program has expanded greatly from previous manned space flight programs. The Investigator Working Group is composed of Principal Investigators who are responsible for establishing recommendations for time-sharing, selection of Payload Specialists, and resolving operational conflicts among experiments.

Flight opportunities are available on Spacelab in the early 1980's. (An Announcement of Opportunities for Life Sciences Experiments has been issued and responses were due by June 30, 1978. New Announcements of Opportunity will be initiated in 1980.) From these proposals experiments are selected for definition studies and later assignment to specific Spacelab missions. A series of Spacelab Mission simulations have been conducted at the Johnson Space Center in preparation for future life sciences Spacelab flights.

Advanced missions and future life sciences programs are being studied. They include such activities as orbiting space stations, large construction platforms, and space solar power stations.

NASA-S-80-10212

20 NEUROPHYSIOLOGICAL RESEARCH

PARABOLIC FLIGHT

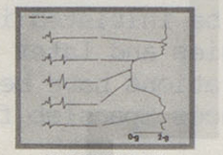
RESEARCH DESIGN AND PROTOCOL FOR MOTION SICKNESS TESTING ABOARD KC-135

MOTION SICKNESS TESTING USING HEADMOVEMENTS AND ROTATING CHAIR

NASA'S KC-135 USED IN PARABOLIC FLIGHT

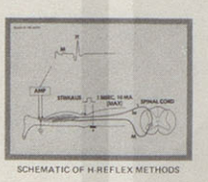
EVALUATION OF RIGHTING REFLEXES OF ANIMALS EXPOSED TO ZERO GRAVITY

PARABOLIC FLIGHT PROFILE OF KC-135



RELATIONSHIP OF H-WAVE RESPONSE TO PARABOLIC FLIGHT

H-REFLEX SUBJECT FLOATING DURING ZERO GRAVITY



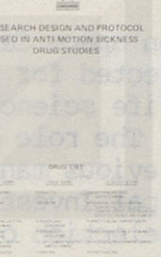
SCHEMATIC OF H-REFLEX METHODS

NASA-S-80-10213

20a JOHNSON SPACE CENTER

ANTIMOTION SICKNESS DRUG STUDIES

RESEARCH DESIGN AND PROTOCOL USED IN ANTI-MOTION SICKNESS DRUG STUDIES


DRUGS EVALUATED IN DRUG STUDY

SUBJECT PERFORMING HEADMOVEMENTS AS PART OF MOTION SICKNESS SUSCEPTIBILITY TEST

RESULTS OF DRUG STUDY

VESTIBULAR FUNCTION STUDIES

ROTATOR USED FOR MOTION SICKNESS STUDIES

POSTURAL ATAXIA STUDIES

VESTIBULAR SINGLE UNIT STUDIES

LINEAR ACCELERATION STUDIES

MAN'S ADAPTATION AND WEIGHTLESSNESS

NEUROPHYSIOLOGY. Millard F. Reschke, NASA-Johnson Space Center, Houston, TX 77058.

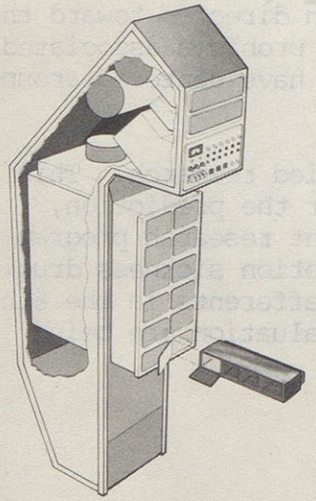
The Neurophysiology Research Program at the Johnson Space Center has been directed toward the issue of neurosensory adaptation to weightless space flight and observed problems associated with the unique inertial environment of space. Primary research efforts have centered around space motion sickness and man's adaptation to weightlessness.

Ground-based testing is currently being conducted in both basic and applied research. This research seeks to elucidate the causes of, and development of a means for the prediction, prevention and treatment of motion sickness. Key elements in this current research program includes testing and vestibular function during parabolic flight, anti-motion sickness drug evaluation, vestibulo-spinal testing and neural recordings from primary afferents in the 8th nerve. In addition, new and improved techniques of vestibular system evaluation are being developed.

NASA-S-80-10216

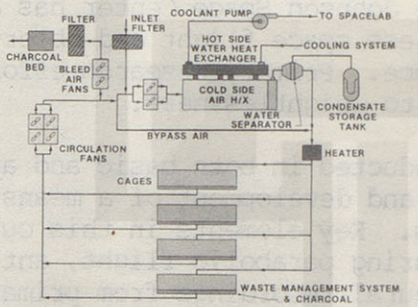
21 RESEARCH ANIMAL HOLDING FACILITY FOR SPACELAB

As a Part of the Life Sciences Flight Experiments Program (LSFEP) NASA will provide standard flight certified laboratory equipment needed to conduct many of the life science experiments onboard Shuttle/Spacelab missions. Ames Research Center is the NASA lead center for Non-human Flight Experiment Management.



RAHF DRAWING SHOWN WITH RESPECT TO THE FLOOR OF THE SPACELAB

ENVIRONMENTAL CONTROL SCHEMATIC



ENVIRONMENTAL CONTROL SYSTEM

The RAHF environmental control system provides basic life support functions of temperature control, humidity control, CO_2 removal, and O_2 supply. The system also provides the ventilation air flow required for zero-gravity entrainment of waste materials and evaporation of moisture from the waste management system. Active cooling and humidity control is provided by a thermoelectric unit.

SPECIFICATIONS

- *Temperature range (selective control)* — *70 to 27 C ± 1 C*
- *Humidity range* — *25 to 70%*
- *Minimum O_2 partial pressure* — *0.21 bars*
- *Maximum CO_2 partial pressure* — *0.008 bars*
- *Forced air flow through cages* — *180 cfm at 30 ft/min (9.2 m/min)*

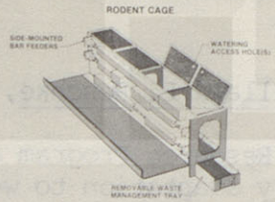
During Life Sciences investigations many different species of animals will need to be maintained in a healthful, appropriate environment. To accomplish this goal, Ames Research Center is developing a Research Animal Holding Facility (RAHF) to house the test animals while in space.

The Research Animal Holding Facility is modular in construction and will accommodate 24 laboratory rats or 144 mice or 4 squirrel monkeys. Environmental control, waste management, automatic dispensing of food and water, illumination control and appropriate interfaces required for biotelemetry are built into the RAHF. Parameters measured include, but are not limited to, temperature, humidity, food and water dispensed, day/night cycles, gross body movement and any information inherent in the biotelemetry signals.

NASA-S-80-10217

21a RESEARCH ANIMAL HOLDING FACILITY (CONT)

RODENT CAGE



BASELINE INSTRUMENTATION

Measurement	Channels	Range
Food intake	48	1.8 oz. increment
Water intake	24	2 oz. increment
Activity/motion	32	Laser sensitive
Ambient temp.	4	70-27 C
Ambient RH	4	25-70%
Sensors in flow	1	0-0.4 in. H_2O
Sensor in flow	1	0-0.4 in. H_2O
Hot side air flow	1	0-0.4 in. H_2O
Heater injection	1	On/off
Cooler injection	1	On/off
Condensate pump	1	On/off
Cage H_2O pressure	1	0-100 psig
Cabinet H_2O pressure	24	Event log
Leak H_2O sensor	18	Event log

RODENT CAGES

The baseline RAHF configuration provides a total of 12 cage dividers, each of which contains four cages, or four rodent cages. Any divider can be removed without disturbing the remaining dividers, and is large enough to allow each specimen unrestricted movement and is designed to ensure the specimen's physical safety.

Cage provisions

- [illegible]
- [illegible]
- [illegible]

ANIMAL HOLDING FACILITY FOR SPACELAB

RESEARCH ANIMAL HOLDING FACILITY FOR SPACELAB. Gary H. Bowman, NASA-Ames Research Center, Moffett Field, CA 94035.

As a part of the Life Sciences Flight Experiments Program (LSFEP), NASA will provide standard flight-certified laboratory equipment needed to conduct many of the life science experiments on-board the Shuttle/Spacelab missions. Ames Research Center is the NASA lead center for Non-Human Flight Experiments Management.

A flight-certified Research Animal Holding Facility (RAHF) being developed by Ames Research Center is modular in construction and will accommodate 24 laboratory rats or up to 144 mice or 4 squirrel monkeys. Each RAHF can stand alone and several RAHF's can be flown on a Spacelab mission; e.g. one RAHF could be used to house rats/mice while an adjacent RAHF could house squirrel monkeys in the same mission.

Waste management trays can be removed separately from the cages or individual cages can be removed without affecting the RAHF system or other cages. Light cycles are adjustable and can be selected for a group of animals. Nominal RAHF temperature is selectable in the range of 19°C to 27°C.

In addition to the measurement of temperature, humidity, food and water dispensed, day/night cycles and gross body movement, data can be obtained from animals implanted with appropriate biotelemetry units or from pictures of the animals in their cages.

BOWMAN
Hotline # 525-6273

NASA-S-80-10206

22

SKELETAL METABOLISM

THE PAST

SPACEFLIGHT CAUSES CHANGES IN CALCIUM METABOLISM

There is increased urinary and fecal calcium and a concommitant negative calcium balance during spaceflight. There is increased urinary hydroxyproline, indicating a loss of bone matrix

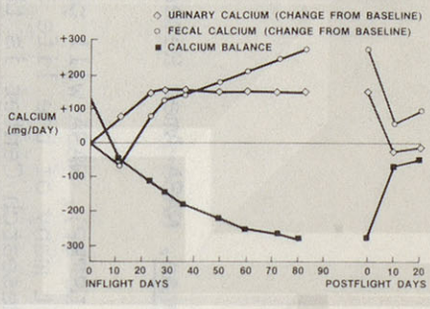
BED REST MODELS THE CHANGES IN SPACEFLIGHT

The same changes occur in bed rest as during spaceflight. Studies conducted on bed rest patients show the same patterns as those observed during spaceflight

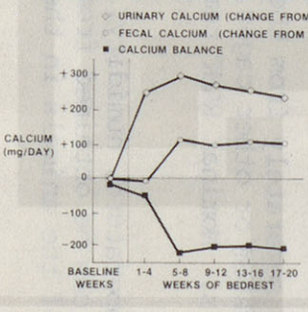
COUNTERMEASURES HAVE NOT BEEN SUCCESSFUL

Various countermeasures to prevent the calcium losses have been tested, but to no avail

CALCIUM CHANGES DURING SPACEFLIGHT



CALCIUM CHANGES DURING BEDREST



COUNTERMEASURES

γ-RAY COMPUTERIZED TOMOGRAPHY

THE PRESENT

BED REST EXPERIMENTS

Continued research is being conducted on bed rest patients to further understand the clinical changes

NEW MEASUREMENT TECHNIQUES

New techniques for measuring bone mineral content *in vivo*, such as monoenergetic γ-ray computerized tomography and dual energy X-ray computerized tomography, are being developed

DIFFERENT COUNTERMEASURES

Techniques such as oral administration of diphosphonates are being tested

MATHEMATICAL MODELING

Present knowledge of calcium metabolism is being integrated into a single mathematical model of whole-body calcium and bone metabolism

BASIC RESEARCH

Research into bone and calcium metabolism is being conducted to understand the basic processes involved

THE FUTURE

Research will need to be conducted to answer these and other questions:

BASIC BONE METABOLISM

What are the basic changes that take place in bone during spaceflight?

DURATION OF EXPOSURE

What is the maximum duration or frequency of spaceflight to which an individual can be exposed before irreparable bone damage occurs?

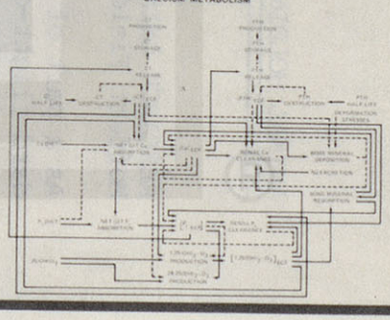
PATTERN OF BONE LOSS

What is the pattern of bone loss within the skeleton and within individual bones?

COUNTERMEASURES

What countermeasures can be, and should be, taken to prevent deleterious changes?

MATHEMATICAL MODEL OF CALCIUM METABOLISM



SKELETAL CHANGES IN SPACE FLIGHT

SKELETAL METABOLISM. Steven I. Altchuler, NASA-Johnson Space Center, Houston, TX 77058.

Previous research has demonstrated increased calciuria and fecal calcium excretion, and a concommitant negative calcium balance, after 3 months of space flight. Urinary hydroxyproline increased, indicating a loss of bone matrix. Similar changes were seen in bed-rest subjects, who also had a decrease in calcaneal radiographic density after 30 weeks of bed-rest. Countermeasures, including horizontal exercise, passive compression, and electromagnetic stimulation, have been tested to prevent the skeletal changes, but none have been effective. Research is underway to better understand the physiology of the skeletal changes and to develop effective countermeasures. Basic research into body calcium metabolism and and into normal bone function--at the subcellular, cellular, and organ levels--is being conducted. Bed-rest research is being conducted to understand the changes that occur simultaneously in the skeleton and related systems. New countermeasures are being tested in this milieu. Techniques to measure the bone changes more directly *in vivo* such as gamma-ray computerized tomography (CT) and dual-energy X-ray CT for bone densitometry are also under development. All the data from this research are being integrated into a comprehensive mathematical model of calcium and skeletal metabolism. This computer-implemented model is being used to predict changes in human experiments and will eventually become part of the whole-body algorithm under development at NASA. Future research will determine the precise changes that occur in the skeleton during space flight and will set a maximum exposure limit to which astronauts can be subjected before irreparable bone damage occurs. Additional work is needed to determine the parts of the skeleton most sensitive to space flight and to determine what countermeasures are feasible.

NASA-S-80-10204

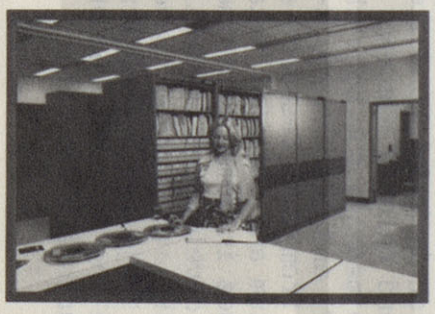
23 NATIONAL SPACE AND LIFE SCIENCES ARCHIVAL LIBRARY

BASIC RATIONALE OF ARCHIVAL LIBRARY

- FACT
- CONDITIONS
- INTERPRETATIONS
- OBJECTIVE - REPOSITORY OF FACT/CONDITIONS

POTENTIAL USES

- EVALUATE NEW METHODOLOGIES
- CONFIRMATORY EVIDENCE FOR SOME HYPOTHESIS
- ALTERNATE THEORETICAL INTERPRETATION
- ENGINEERING SYSTEMS ANALYSIS
- EVALUATION FOR FUTURE EXPERIMENTS
- EDUCATIONAL & HISTORICAL



CURRENT SUBJECT AREAS CONTAINED IN LIBRARY

- BIOINSTRUMENTATION
- CARDIOVASCULAR FUNCTIONS
- CELLULAR FUNCTION
- ENDOCRINE/ELECTROLYTE EFFECTS
- ENVIRONMENTAL FACTORS
- EXERCISE
- GASTROINTESTINAL FUNCTION
- HEMATOLOGY AND IMMUNOLOGY
- PSYCHOPHYSIOLOGICAL/BEHAVIORIAL FACTORS
- MEDICAL OPERATIONS
- NUTRITION
- MICROBIOLOGY AND VIROLOGY
- MUSCULOSKELETAL FUNCTION
- NEUROPHYSIOLOGICAL FUNCTION
- SENSORY SYSTEMS
- CREW OPERATIONAL FACTORS
- TEMPORAL FACTORS
- MISSION/PROGRAMS
- FLIGHT OPERATIONS
- BOTANY AND ZOOLOGY

SKYLAB EXPERIMENTAL DATA IN LIBRARY

M071 MINERAL BALANCE
M072 BONE DENSITOMETRY
M073 BIOASSY OF BODY FLUIDS
M074 SPECIMEN MASS MEASUREMENT
M078 BONE MINERAL MEASUREMENT
M092 INFLIGHT LOWER BODY NEGATIVE PRESSURE
M093 VECTORCARDIOGRAM
M111 CYTOGENETIC STUDIES OF BLOOD
M112 MAN'S IMMUNITY, IN VITRO ASPECTS
M113 BLOOD VOLUME AND RED CELL LIFE SPAN
M114 RED BLOOD CELL LIFE SPAN
M115 SPECIAL HEMATOLOGIC EFFECTS
M131 HUMAN VESTIBULAR FUNCTION
M133 SLEEP MONITORING
M151 TIME AND MOTION STUDY
M171 METABOLIC ACTIVITY
M172 BODY MASS MEASUREMENT
M191 BACTERIOLOGY AND MYCOLOGY
M192 VIROLOGY - RICKETTSIOLOGY
S015 ZERO-G EFFECTS ON HUMAN CELLS
S071 CIRCADIAN RHYTHM, POCKET MICE
S072 CIRCADIAN RHYTHM, VINEGAR GNATS
ESS EXPERIMENT SUPPORT SYSTEM
ED31 BACTERIA AND SPORES
ED32 IN VITRO IMMUNOLOGY
ED33 MICRO ORGANISMS IN VARYING "G"
ED41 MOTOR SENSORY PERFORMANCE
ED51 CHICK EMBRYOLOGY
ED52 WEB FORMATION
ED61/ED62 PLANT GROWTH/PLANT PHOTOTROPISM
ED63 CYTOPLASMIC STREAMING

OPERATIONAL DATA IN LIBRARY

- OPERATIONAL EQUIPMENT
  - INFLIGHT MEDICAL SUPPORT SYSTEM
  - OPERATIONAL BIOINSTRUMENTATION SYSTEM
  - FOOD SYSTEM
  - HEATING/SERVING TRAY
  - MEDICAL ACCESSORIES KIT
  - EXERCISE SYSTEM
  - INFLIGHT BLOOD COLLECTION SYSTEM
  - CO_2/DEWPOINT MONITOR
  - BIOMEDICAL STOWAGE CONTAINERS
  - FUNCTIONAL TEST SET
  - MEDICAL DATA SYSTEM
  - DATA ACQUISITION SYSTEM
  - SKYLAB MOBILE LABORATORIES
- OPERATIONAL TESTS
  - ENVIRONMENTAL MICROBIOLOGY
  - OPERATIONAL RADIATION MEASUREMENTS
  - PORTABLE CO_2/DEWPOINT MONITOR
  - WATER SAMPLE
  - IODINE MONITORING
  - CARBON MONOXIDE MONITOR
  - TASTE AND AROMA EVALUATION
  - FOOD PACKAGE
  - ATMOSPHERIC VOLATILE CONCENTRATOR
  - ACHILLES TENDON RESPONSE
  - GIRTH AND HEIGHT MEASUREMENTS AND CREW PROFILE PHOTOGRAPHS
  - URINE MASS MEASUREMENT BY BMMD
  - SWEAT SAMPLES
  - BLOOD FLOW IN LIMBS
  - STEREOPHOTOGRAMMETRY
  - GYPSY MOTHS
  - VISUAL LIGHT FLASH PHENOMENON
  - FISH DEMONSTRATION

ARCHIVAL LIBRARY, SPACE AND LIFE SCIENCES

SPACE LIFE SCIENCES ARCHIVAL LIBRARY. Robert E. Heyer, NASA-Johnson Space Center, Houston, TX 77058.

The Space Life Sciences Archival Library (SLSAL) was conceived and developed to disseminate all life sciences factual information relevant to the study of manned space flight to the biomedical scientific community, for the purpose of research and investigation. The SLSAL serves as the primary depository for life sciences biomedical and bioengineering information derived from manned space flight programs.

The library collection is multi-media in scope, reflecting the total complement of information and data media generated during a space program or manned mission. The collection has several types of information sources:

a. Life sciences data, raw and processed, obtained during space flight and related biomedical ground testing.

b. Technical and analytical information aiding in the production, support, and interpretation of life sciences data.

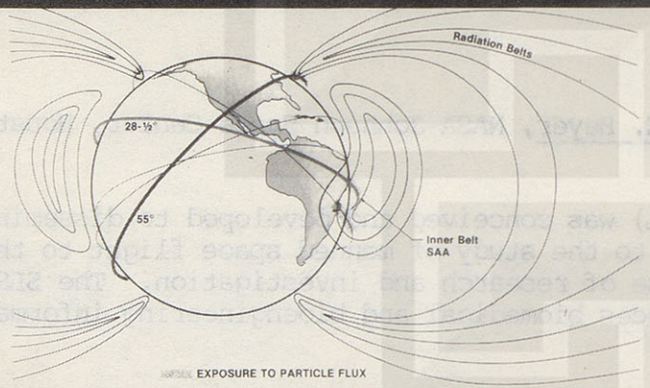
c. Written or published analyses and interpretations of life sciences data by a research scientist.

The Archival Library services are available to all persons and are free. Some of the services include: reference, referral, duplication, and computer index searches. Written requests may be addressed as follows: National Aeronautics and Space Administration, Johnson Space Center, Code JM65/Attn: Archival Library, Houston, Texas 77058, or call (713) 483-2889. The hotline number is 525-2889.

HEYER
Hotline # 525-4731

NASA S 80 10201

24 RADIATION EXPOSURE VARIES WITH THE ORBITAL TRACK



The Inner Radiation Belt dips close to the Earth in the region of the South Atlantic Ocean (centered at 35° West Longitude, 35° South Latitude), giving rise to the "South Atlantic Anomaly", SAA. Within the SAA, electrons and protons dip close enough to the Earth to irradiate satellites in a 400 to 500 KM low Earth orbit during portions of their orbital tracks over that region of the Earth.

The Outer Radiation Belt dips close enough to the Earth in the region of both magnetic poles, so that satellites in a 400 to 500 KM high inclination low Earth orbit, such as 55°, will be irradiated during those portions of the orbit tracks in the vicinity of the poles.

The following points are significant:

- Irradiation is limited to discreet portions of the low Earth orbit (LEO) tracks that take spacecraft through either the polar horns or the SAA. Significant irradiation does not occur during other portions of those orbit tracks.
- The majority of 28-1/2° LEO orbital tracks in a 24 hour period miss the SAA entirely.
- All 28-1/2° LEO orbital tracks miss the polar horns entirely.
- Thus for the majority of a 24 hour period there is no radiation exposure in the 28-1/2° LEO orbits.
- Likewise, most 55° LEO orbit tracks in a 24 hour period miss the SAA entirely.
- But most 55° LEO orbit tracks pass through the polar horns from 1 to 4 times per revolution.
- Thus radiation exposure is a consideration on almost all 55° orbit tracks, although exposure will vary with passage through the SAA and/or polar horns.
- Since irradiation occurs only during that portion of an orbit track within the SAA or polar horns, a time plot of radiation intensity as the spacecraft proceeds along an orbit track, will show narrow "spikes" of radiation interspaced with time periods of zero radiation.
- These spikes show increased intensity as orbital altitude increases, since the orbit track passes through higher intensity regions of the polar horns and/or SAA.

NASA-S-80-10202

24a EXPERIENCE REPORT - RADIATION DOSE TO ASTRONAUTS

Mission	Mean Dose (Rad)
Mercury 9	0.027
Gemini 3	.020
Gemini 4	.045
Gemini 5	.177
Gemini 7	.150
Gemini 6	.025
Gemini 8	.010
Gemini 9	.018
Gemini 10	.840
Gemini 11	.025
Gemini 12	.015
Apollo 7	.16
Apollo 8	.16
Apollo 9	.20
Apollo 10	.48
Apollo 11	.18
Apollo 12	.58
Apollo 13	.24
Apollo 14	1.14
Apollo 15	.30
Apollo 16	.51
Apollo 17	.55
Skylab 2	2.43
Skylab 3	5.98
Skylab 4	11.73
Apollo-Soyuz	0.1

RADIATION: SPACE BIOLOGY

SPACE RADIATION BIOLOGY. Charles M. Barnes, NASA-Johnson Space Center, Houston, TX 77058.

Inherent in the NASA radiological health program are four major areas of concern: (1) Definition of the ambient space radiation environment; (2) investigation of the biological effects of the various radiation types, (3) investigation of possible interaction between weightlessness and radiation exposure, and (4) definition of acceptable dosimetry.

The ambient space radiation environment has been well characterized. Nevertheless, fluctuations are known to occur and more data regarding the nature of such changes are needed to evaluate risks to space crews.

NASA is emphasizing radiobiological research involving cosmic (HZE) particles. The operation of the BEVALAC at Lawrence Berkeley Laboratory, permits terrestrial experiments with HZE radiation and enables a rigorous experimental design.

Some experiments to investigate interaction between weightlessness and irradiation have been conducted in space. Results are somewhat equivocal and more well designed experiments are needed. It appears that no antagonism or synergism exists, and radiobiological data obtained at 1-g are currently considered applicable to space exposures.

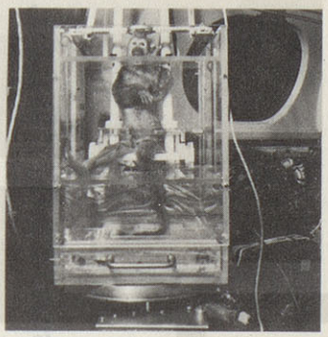
NASA-S-80-10227

25

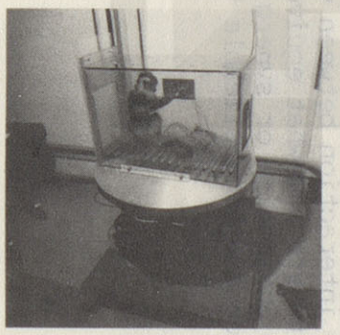
SQUIRREL MONKEY'S FOR SPACE STUDIES

ANIMALS BEING PLACED ON ROTATING PLATFORM FOR MOTION SICKNESS TESTING USING THE OBSERVATIONAL RATING SCALE TECHNIQUE

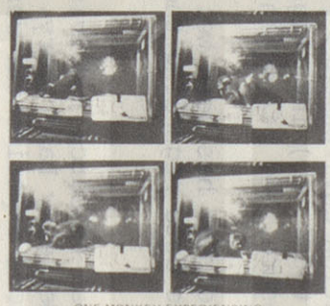
ANIMALS BEING PHOTOGRAPHED FOR SUBSEQUENT MOTION SICKNESS RESPONSE ANALYSIS



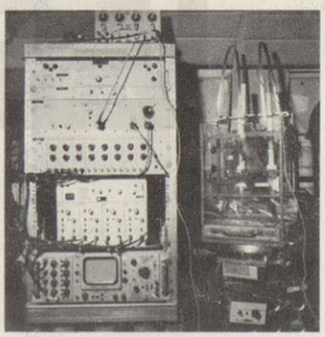
CHAIRED SQUIRREL MONKEY ACCELERATED BY RATE TABLE DURING PARABOLIC FLIGHT ONBOARD LEARJET



ANIMAL TRAINED TO LEVER PRESS TO CONTROL RATE OF ROTATION AND LEVEL OF SICKNESS EXPERIENCED



ONE MONKEY EXPERIENCING MOTION SICKNESS DURING PARABOLIC FLIGHTS



MONKEY AND FLIGHT INSTRUMENTATION USED IN RECORDING SQUIRREL MONKEY HORIZONTAL VOR

SQUIRREL MONKEYS BEING LOADED ON LEARJET PRIOR TO SERIES OF HYPO GRAVITY FLIGHTS

SQUIRREL MONKEY IN CAGE WITH SIMILAR DIMENSIONS TO THOSE OF THE RESEARCH ANIMAL HOLDING FACILITY SQUIRREL MONKEY CAGE, PRIOR TO HYPO-GRAVITY FLIGHTS IN LEARJET

SQUIRREL MONKEY IN SPACE EXPERIMENTS

SQUIRREL MONKEY AS A CANDIDATE FOR STUDIES OF SPACE SICKNESS AND VESTIBULAR FUNCTION IN SPACELAB. Nancy G. Daunton, L. O. Greene, Jr., and R. A. Fox, NASA-Ames Research Center, Moffett Field, CA 94035.

The squirrel monkey has become the primate of choice in many areas of life science research. Because of its small size and large brain/body ratio and the attendent behavioral, sensory and motor capabilities, this animal is particularly well-suited for use in studies to be performed in Spacelab.

In preparation for studies of the etiology of space sickness proposed for Spacelab, investigations of the squirrel monkey as a model for human motion and space sickness research are underway. The motion sickness response of squirrel monkeys in a number of sickness-inducing situations is being investigated. It has been shown that approximately 65% of animals (N=30) become sick to the point of vomiting when exposed to horizontal rotation at 25 RPM, while approximately 60% get sick during less than one-g parabolic flight. Approximately 35% become sick during vertical linear acceleration at 0.6 Hz. A "self-report" method of sickness assessment, based on operant behavioral techniques, is under development to study sickness levels comparable to the malaise and nausea found in humans. In preparation for studies investigating the changes in vestibular function resulting from exposure to zero-gravity in space, the vestibulo-ocular reflex (VOR) on the squirrel monkey is being investigated in the laboratory and in less than one-g parabolic flight.

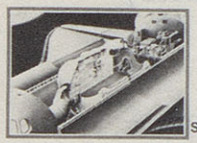
The results of these and other ground-based studies confirm the fact that the squirrel monkey is an appropriate animal for use in Spacelab experiments designed to investigate the etiology of space sickness and changes in vestibular function as induced by the absence of gravity.

DAUNTON
Hotline # 448-6245

NASA-S-80-10214

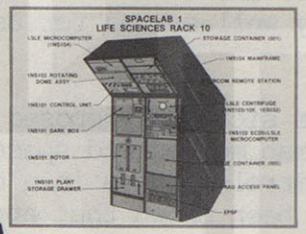
26 U. S. LIFE SCIENCES

- Spacelab 1, the First Shuttle Flight of the European Spacelab System, is a cooperative effort between NASA and the European Space Agency (ESA)
- Spacelab 1 is a shared payload which incorporates approximately 75 investigations in 5 discipline areas
- 7 U. S. experiments are under development
- Flight duration is 7 days
- Approximate launch date is October 1982



Spacelab 1 Configuration

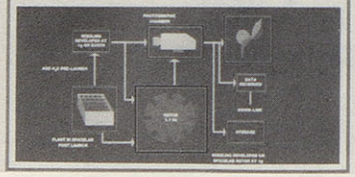
Spacelab Trainer at Marshall Space Flight Center



INS-101 - NUTATION OF HELIANTHUS ANNUS IN A MICROGRAVITY ENVIRONMENT

OBJECTIVES:

- TO DETERMINE QUANTITATIVELY, WHETHER NUTATION OCCURS UNDER WEIGHTLESSNESS
- TO MEASURE THE PERIOD, AMPLITUDE, ELLIPTICITY, AND DIRECTION OF NUTATION IF IT OCCURS
- TO EXERCISE NEW EXPERIMENTAL HARDWARE UNDER SPACEFLIGHT CONDITIONS

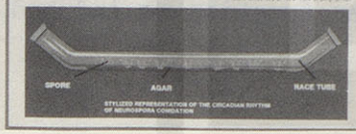


INS-007 - PRELIMINARY CHARACTERIZATION OF PERSISTING CIRCADIAN RHYTHMS DURING SPACEFLIGHT:

Neurospora as a model

OBJECTIVES:

- MEASUREMENT OF THE EFFECT OF THE MACRO-ENVIRONMENT OF SPACE AND THE MICRO-ENVIRONMENT OF THE SHUTTLE/SPACELAB ON THE TEMPORAL ORGANIZATION OF THE GROWTH AND DEVELOPMENT OF LIVING SYSTEMS
- TEST OF THE ENDOGENOUS CLOCK THEORY
- EXAMINATION OF POSSIBLE INFLUENCE OF ELECTROMAGNETIC RADIATION OF CIRCADIAN ORGANIZATION



STYLIZED REPRESENTATION OF THE CIRCADIAN RHYTHM OF NEUROSPORA CONIDIATION

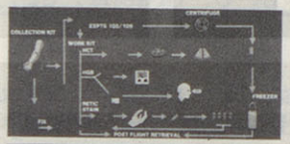
NASA-S-80-10215

26a EXPERIMENTS ON SPACELAB 1

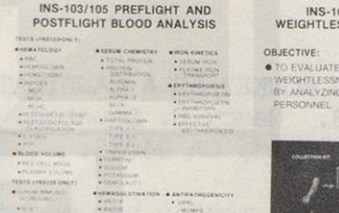
INS-103 - THE INFLUENCE OF SPACEFLIGHT ON ERYTHROKINETICS IN MAN

OBJECTIVE:

- TO GATHER NEW INFORMATION RELATIVE TO THE APPARENT SUPPRESSION OF ERYTHROPOIESIS AND ALTERATION OF ERYTHROKINETIC PROCESS WHICH MIGHT CONTRIBUTE TO THE ELUCIDATION OF THE MECHANISMS INVOLVED IN THE LOSS OF RED BLOOD CELL MASS DURING SPACEFLIGHT



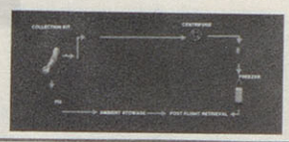
INS-103/105 PREFLIGHT AND POSTFLIGHT BLOOD ANALYSIS

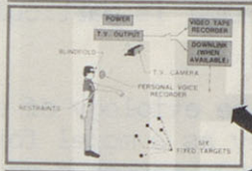


INS-105 - EFFECTS OF PROLONGED WEIGHTLESSNESS ON THE HUMORAL IMMUNE RESPONSE IN HUMANS

OBJECTIVE:

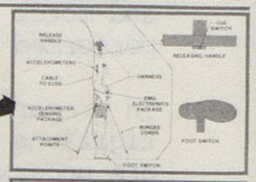
- TO EVALUATE THE EFFECT OF PROLONGED OR SUSTAINED WEIGHTLESSNESS ON THE IMMUNE RESPONSE IN HUMANS BY ANALYZING BLOOD SAMPLES FROM SPACE SHUTTLE PERSONNEL

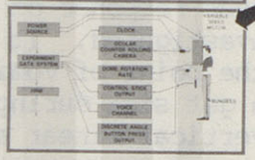




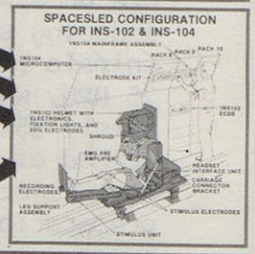
INS-102 - VESTIBULAR EXPERIMENTS IN SPACE

- OBJECTIVES:
  TO INVESTIGATE SPACE MOTION SICKNESS AND ANY ASSOCIATED CHANGES IN OTOLITH-MEDIATED RESPONSES OCCURRING DURING WEIGHTLESSNESS
- OTOLITH-SPINAL REFLEX MEASUREMENTS
- AWARENESS OF BODY POSITION
- PRECEPTION OF SELF MOTION AND OCULAR COUNTERROLLING INDUCED BY A ROTATING VISUAL FIELD
- PERCEPTION OF MOTION DURING LINEAR ACCELERATION
- MEASUREMENT OF EYE MOVEMENTS DURING LINEAR ACCELERATION
- MEASUREMENTS OF SUSCEPTIBILITY TO MOTION SICKNESS





SPACESLED CONFIGURATION FOR INS-102 & INS-104



INS-104 - ADAPTATION OF VESTIBULO-SPINAL REFLEX MECHANISMS DURING SPACEFLIGHT (H-REFLEX)

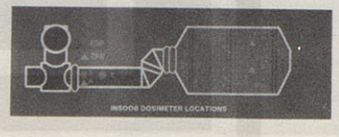
OBJECTIVE:

- TO DETERMINE THE EXTENT TO WHICH OTOLITH SUPPLIED INFORMATION IS USED TO MODIFY POSTURAL REFLEXES WHEN SUBJECT IS EXPERIENCING ACCELERATION THROUGHT ZERO-G

INS-006 - HZE-PARTICLE DOSIMETRY

OBJECTIVES:

- PASSIVE MAPPING OF THE EXPECTED HIGH-CHARGE AND ENERGY (HZE) PARTICLE RADIATION INSIDE THE SPACELAB
- ACQUISITION OF BASELINE DATA FOR EVALUATION OF RADIATION RISK FROM HZE PARTICLES TO MAN ON THE FUTURE SPACELAB MISSIONS
- CONTINUATION OF A PROGRAM OF DOCUMENTATION OF HZE-PARTICLE INSIDE MANNED SPACECRAFT (APOLLO AND SUBSEQUENT PROGRAMS)



INSIDE DOSIMETER LOCATIONS

ESA LIFE SCIENCE SL-1 EXPERIMENTS

EXPERIMENT NUMBER	TITLE	PRINCIPAL INVESTIGATOR	AFFILIATION
IES031	LYMPHOCYTE PROLIFERATION IN WEIGHTLESSNESS	COGOLI	ESA-SWITZERLAND
IES021	MASS DISCRIMINATION DURING WEIGHTLESSNESS	ROSS	ESA-SCOTLAND
IES029	MEASUREMENT OF INTRATHORACIC BLOOD PRESSURE	GAUER	ESA-GERMANY
IES027	ADVANCED BIOSTACK EXPERIMENT	BÜCKER	ESA-GERMANY
IES028	BALLISTOCARDIOGRAPHIC RESEARCH IN WEIGHTLESSNESS	SCANO	ESA-ITALY
IES029	MICROORGANISMS AND BIOMOLECULES IN SPACE HARD ENVIRONMENT	HORNECK	ESA-GERMANY
IES030	PERSONAL MINIATURE ELECTROPHYSIOLOGICAL TAPE RECORDER	GREEN	ESA-ENGLAND
IES032	COLLECTION OF BLOOD SAMPLES FOR THE DETERMINATION OF ADH, ALDOSTERONE AND OTHER HORMONES	GAUER	ESA-GERMANY
IES201	VESTIBULAR EXPERIMENTS ON THE SPACE SLED	VON BAUMGARTEN	ESA-GERMANY

EXPERIMENTS ON SPACELAB - UNITED STATES/EUROPEAN COOPERATION

U. S. LIFE SCIENCES EXPERIMENTS ON SPACELAB 1. Jerry L. Homick, NASA-Johnson Space Center, Houston, TX 77058.

Spacelab 1, the first Shuttle flight of the European Spacelab system, is a cooperative effort between NASA and the European Space Agency (ESA). ESA will provide the Spacelab and NASA the Shuttle/Orbiter, with both agencies sharing in sponsoring and implementing the experiments. Spacelab 1 is a multi-disciplinary mission comprised of approximately 75 separate investigations which have been categorized into five groups: (1) Atmospheric Physics and Earth Observations, (2) Space Plasma Physics, (3) Material Sciences and Technology, (4) Astronomy and Solar Physics, and (5) Life Sciences. Some of these experiments are contained in unpressurized pallets in the aft cargo bay of the Shuttle. The remainder including the life sciences experiments, are located in the pressurized laboratory module. Of the 17 life sciences experiments, 7 are being developed by scientists from the United States. These 7 experiments involve studies of radiation, plant circadian rhythms, plant mutation, vestibular system function, erythrokinetics, vestibulospinal reflexes and humoral immune responses. The latter four are human experiments. Spacelab 1 will be launched from the Kennedy Space Center in approximately October 1982. The planned mission duration is 7 days. Spacelab 1 is the first in a series of Spacelab missions which will include life sciences experiment payloads.

NASA-S-80-10222

27

FLIGHT MEDICINE

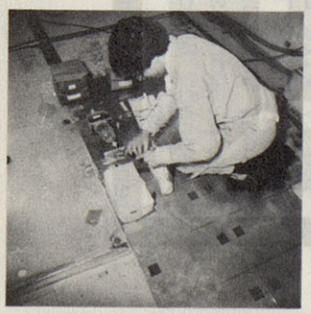
FLIGHT MEDICINE IS CONCERNED WITH THE HEALTH AND WELL-BEING OF THE FLIGHT CREW BOTH IN SPACE AND ON THE GROUND. A VARIETY OF AREAS INVOLVING APPLICATION OF MODERN MEDICAL TECHNIQUES TO THE ZERO GRAVITY ENVIRONMENT ARE BEING INVESTIGATED. SOME OF THE PRELIMINARY WORK IS BEING CONDUCTED IN THE NASA KC-135 ZERO-G SIMULATION AIRCRAFT AS SHOWN IN THE FOLLOWING ILLUSTRATIONS.

CPR – CARDIOPULMONARY RESUSCITATION REQUIRES CONTINUOUS TRAINING IN A GRAVITY ENVIRONMENT. A SPECIAL SHOE RESTRAINT METHOD OF HOLDING THE RESCUER IN PLACE IS BEING EVALUATED.

PERSONAL HYGIENE – EVALUATION OF THE PERSONAL HYGIENE STATION BY AN ASTRONAUT PHYSICIAN IS SHOWN.

EXAMINATION TECHNIQUE – SIMPLE THINGS LIKE TAKING A BLOOD PRESSURE REQUIRE RESTRAINTS FOR BOTH THE PATIENT AND THE EXAMINER. TRAINING IN SUCH TECHNIQUES IS REQUIRED FOR THE CREW.

PERSONAL RESCUE SPHERE – THE PRS IS PRESENTLY BEING EVALUATED AS AN ADJUNCT TO THE MEDICAL TREATMENT OF DECOMPRESSION SICKNESS. IT WILL ALLOW COMPRESSION THERAPY IN ADDITION TO 100% OXYGEN BY MASK.



MEDICAL KIT – FAMILIARIZATION WITH THE MEDICAL KIT (BLUE BAGS) AND USE OF ITS CONTENTS IS REQUIRED FOR THE CREW. EVALUATION OF TECHNIQUES SUCH AS IV INFUSION IS AN ON GOING PROCESS.

VISION – AN ADDITIONAL AREA OF INTEREST IS THE FUNCTIONING OF CONTACT LENSES IN THE WEIGHTLESS ENVIRONMENT. SOME PRELIMINARY WORK HAS BEEN CONDUCTED IN THE KC-135.

ZERO-G AND FLIGHT MEDICINE

ZERO-G AND FLIGHT MEDICINE. Michael A. Berry, NASA-Johnson Space Center, Houston, TX 77058.

The possibilities for new and innovative research in the zero-gravity environment are limited only by the imagination of the investigators. Opportunities exist in almost all scientific fields. Flight medicine is primarily concerned with the health and well-being of the flight crew both in space and on the ground. In addition to interest in several specialty areas, such as cardiovascular adaption, and space motion sickness, flight medicine is looking at the application of modern medical techniques and procedures to the weightless environment. One of the foremost lessons learned from all of the weightless activity of earlier space missions was that restraint of the individual within the work space was essential for efficient performance and minimal energy expenditure. This remains the case today, and must be considered when looking at any scientific procedure or technique.

Some of the areas that flight medicine is looking at are illustrated in the accompanying poster. Determining the most efficient and efficacious means of performing basic cardiopulmonary resuscitation while weightless is an important area of interest. Closely related to this is crew training with the inflight medical kit and medical checklist for both routine and emergency medical problems. Another area being investigated is the medical treatment of decompression sickness by adapting already available flight hardware.

BERRY
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