



**National Aeronautics and Space Administration  
and  
National Science Foundation**

**Biomedical Polar Research  
Workshop Minutes**

**Washington, DC  
October 11-12, 1990**



## NASA/NSF Biomedical Polar Research Workshop

On October 11-12, 1990, the National Aeronautics and Space Administration (NASA) and the National Science Foundation (NSF) conducted a workshop to discuss potential areas of biomedical research to be conducted jointly in the arctic and antarctic. This workshop was held as part of an ongoing science planning effort undertaken by the NASA Life Sciences Biomedical Programs and the NSF Polar Programs to utilize the remote environment of manned polar bases as analogs for the space environment. With the President's recent commitment to a U.S. presence on Mars by 2019 (via Space Station and a lunar colony), NASA Life Sciences is developing research programs that focus on the long-term health effects of the space environment. Certain biomedical research areas are becoming increasingly important to the programs and missions envisioned for the 1990s and the early 21st century. Therefore, NASA is interested in using the polar regions as analogs to space in order to conduct focused research on specific biomedical issues related to their space exploration program. In addition, NSF has had a long history of research activities in the arctic and antarctic. In the Long-Range Science Plan of the Polar Programs, NSF identifies research in human behavior and medicine as an important part of its core research effort.

The workshop was conducted to provide a background of NASA and NSF goals, an overview of previous and current biomedical research, and a discussion about areas of potential future joint activities. The objectives of the joint research were defined as follows:

- To develop an understanding of the physiological, psychological, and behavioral alterations and adaptations to extreme environments of the polar regions;
- To ensure the health, well-being, and performance of humans in these environments; and
- To promote the application of biomedical research to improve the quality of life in all environments.

Dr. Chester Pierce, Harvard University, Cambridge, Massachusetts, Chairman of the workshop, welcomed the attendees (attachment 1) and provided a brief overview of the agenda (attachment 2) for the workshop. Dr. Polly Penhale, Manager, NSF Polar Biology and Medicine, then presented a brief overview of current NSF activities in the antarctic which was followed by presentations by a number of NSF Principal Investigators on their work in the antarctic. Dr. Elliot Dick, University of Wisconsin Medical School, Madison, spoke about his epidemiological research on the cyclical nature of the spread of colds and flu and the effectiveness of several countermeasures currently in development to minimize their spread (attachment 3). Dr. Kerr Boyce, U.S. Naval Hospital, San Diego, California, discussed an eight-year historical survey of naval medical interventions at McMurdo Station and the medical capabilities of the station (attachment 4). Dr. Albert Harrison, University of California at Davis, presented a review of recent behavioral research on men and women in isolation and

confinement including topics such as state of consciousness, stress, health, small group dynamics, personnel selection, crew training, and environmental engineering (attachment 5). Dr. Lester Reed, Naval Medical Research Institute, Bethesda, Maryland, described his research on the changes observed in thyroid and hormone production in extreme environments (attachment 6). Dr. Jeffrey Johnson, East Carolina University, Greenville, North Carolina, discussed the importance of structural approaches to the study of groups in isolated and extreme environments, drawing similarities to groups in space (attachment 7). Dr. Lawrence Palinkas, University of California at San Diego, discussed the psychological impacts of isolation and confinement. And Dr. Noel Broadbent, Director, NSF Arctic Social Sciences, presented cultural perspectives of survival in the extreme environments of the arctic.

Dr. Janis Stoklosa, Manager, NASA Life Sciences Biomedical Programs, then presented an overview of NASA's Biomedical Programs including goals, objectives, methodological approaches and key space research areas (attachment 8). She further discussed rationale for using the polar regions as analogs for extended duration missions and provided NASA proposed biomedical research areas for studies in these regions. Dr. Mary Connors, Ames Research Center, Moffett Field, California, who was not able to attend, provided material on crew factor issues including human, automation, and telecommunication systems; strategic behavior and workload; sleep, fatigue, and circadian rhythms; and virtual reality and spatial instrumentation (attachment 9). Ms. Karen Gaiser, Lockheed Engineering and Sciences Company, Washington, D.C., discussed microbiological factors with regard to the transmission of infectious disease and environmental (i.e., air and water) control (attachment 10). She also discussed NASA's interest in nutritional needs in extreme environments. Dr. Charles Czeisler, Harvard Medical School, Cambridge, Massachusetts, discussed the importance of circadian rhythms and his investigations using bright light to reset the human biological clock to provide health benefits and performance enhancement in operational situations. Dr. Richard Meehan, University of Colorado Health Sciences Center, Denver, presented a review of prior space immunology studies and relevant stress immunology studies (attachment 11). Dr. Frederick Hagerman, Ohio University, Athens, described both the physiological and psychological value of exercise during long-term exposure to space (attachment 12). And Dr. Jack Stuster, Anacapa Sciences, Inc., Santa Barbara, California, discussed habitability issues and requirements of long-term isolation and confinement (attachment 13).

On the second day of the workshop, participants broke into two groups, i.e., human factors and human physiology, to identify specific issues of relevant research in these areas. The reports of these groups are as follows:

### **Group I Report: Human Factors**

The major theme identified as relevant to both NSF and NASA deals with human factors issues regarding activities in the polar regions. The significant topics within this theme are: screening, selection and training; stress and adaptation; cognition and performance; man-machine systems; habitat design; behavior measurement, performance assessment, and methods improvement; and group dynamics.

## Screening, Selection and Training

The purpose of this research is to identify individual characteristics which are most suitable to polar and space environments. Existing programs for the screening and selection of polar expeditions have been successful in "selecting out" individuals physically and psychologically unqualified for duty in extreme, isolated environments. However, these programs have been less successful at predicting individual or group patterns of adaptation and levels of performance in these environments. Research could identify characteristics of individuals least likely to be affected by the unique stressors associated with prolonged isolation in an extreme environment. Evaluation of existing behavioral and occupational screening techniques or development of new techniques for selecting personnel for duty in polar settings is also possible. For instance, the sensitivity and specificity of techniques that screen individuals at the group level rather than at the level of individual personalities could be explored. Polar environments also provide a laboratory for developing techniques that could identify personnel who can best perform under similar circumstances in space with the least risk to health and well-being. Research could also develop requirements and strategies for the training of crews to work together on long-duration missions in extreme environments. This could include a systematic investigation of the effects of crew size, structure, and organization in team building activities prior to deployment.

## Stress and Adaptation

The purpose of this research is to study the effects of extreme environments on individual and group mental health and to develop countermeasures to minimize or alleviate the identified negative effects. Survival in extreme environments demands that attention be given to individual and group mental health. Such attention could be directed to the prediction, measurement, and management of biopsychosocial processes of adaptation and adjustment. Research could address the individual, social, and environmental sources of stress in extreme environments, the consequences of these stressors on human health and performance, and the sociocultural and psychological characteristics of successful adaptation in these settings. For instance, a better understanding of the role and function of cultural attitudes, socialization, and adaptive knowledge is possible. Studies of the dynamics of family separation and reunification are also possible in the context of prolonged isolation in extreme environments.

It is important that studies address these issues from a multidisciplinary perspective. For instance, psychological symptoms such as depression, insomnia, hostility, and cognitive decrements could be influenced by social group dynamics, changes in endocrine function, changes in circadian rhythm, health-related behavior (e.g. nutrition, exercise), and the stress of prolonged isolation. These symptoms, in turn, could influence patterns of social relations, cognitive and task performance, immunocompetence, and general health and well-being. Moreover, the effect of these stressors on performance could be moderated by a host of psychological, social, and cultural factors.

Research could identify and define specific operational procedures and policies to minimize and mitigate the adverse psychological effects of living and working under

isolation and confinement. Proposed methods and techniques to sustain individual and group performance and well-being, as well as avoiding interpersonal conflict, could include preventive strategies which might serve polar expeditioners, their families, and their home-based colleagues. Such efforts could involve the individual or group during any phase of the mission from selection and training through successful re-entry to home. In addition, research is needed to investigate the effectiveness of group "buddy" methods or organizational procedures pertaining to personal hygiene, outside communication, and food preparation and consumption in minimizing problems such as depression, nostalgia, sleep disturbances, and headaches.

### Cognition and Performance

The purpose of this research is to investigate the impact of extreme environments on cognition and performance. Accounts of men and women in isolation and confinement yield many reports of cognitive impairment, including: mild confusion, problems of maintaining concentration on the task at hand, distorted time perception, and reduced attentiveness to external stimuli. Additional research could identify the antecedents to and consequences of cognitive state and devise countermeasures for adverse consequences. Among the important research areas are vigilance, problem-solving, time perception, and automaticity or mindlessness. Such research could address the role of cognitive state in group, as well as individual, problem-solving, decision-making, and performance.

### Man-Machine Systems

The purpose of this research is to study human-machine interfaces in the context of a hostile, isolated environment. Machines will serve essential life support functions, provide data useful for decision-making purposes, occasionally reach and implement decisions, and play an integral role in work and in the advancement of science in polar and space environments. Because a significant number of serious errors and problems have resulted from human-machine interfaces, several questions arise regarding the integration of human and machine activity, especially the activities of "intelligent" machines to contribute to or execute decisions. Such issues include the allocation of tasks to humans and machines, perceived control, trust and distrust of machine activity, manual override, and skill degradation. Particularly complex are problems of telescience, telemedicine, and other activities that require coordination of groups of people and machines that are at disparate locations. Research is needed to identify requirements for combining human, automation, and telecommunications systems into an integrated, synergistic, and fully-functioning overall system capable of supporting extended polar and space missions.

### Habitat Design

The purpose of this research is to identify habitat designs which enhance human performance and productivity, essential in isolated and confined environments. Research could identify potential design features and systematically evaluate the effectiveness of those features in sustaining human performance for long durations under conditions of isolation and confinement. These features could include free-

volume requirements, food system, habitat aesthetics, privacy, lighting, noise abatement, and recreational opportunities.

### Behavior Measurement, Performance Assessment, and Methods Improvement

The purpose of this research is to develop more efficient and descriptive behavior measurements, performance assessments, and research methodologies that are particularly relevant to studies in extreme and isolated environments. This research could focus on new or improved data collection and analytical methods, research protocols, and measures of important theoretical concepts. This could include an improved means for the measurement of psychosocial variables used to determine individual and group morale, cognitive and physical performance, productivity, social support, and psychological health and well-being; the "real time" assessment of mental and physical workloads of personnel in order to predict and minimize the overloading of specific capabilities and guide the reallocation of assigned tasks; and the development and application of existing and statistical techniques particularly suited to social and behavioral science research involving small sample sizes.

### Group Dynamics

The purpose of this research is to examine small group dynamics in extreme environments with small group defined as a group consisting of no more than ten people. As the crews of isolated polar research stations and extended space missions become more socially and culturally heterogeneous, it is important to understand how this complexity will affect individual and group performance. Also of interest are studies that advance our understanding of the role of leadership, task differentiation, variations in workloads, the development of organizational culture, the role and function of culturally-determined attitudes and behavior, and the role of personality in facilitating group problem-solving, performance, morale, and productivity in extreme environments. Studies that incorporate longitudinal research designs that can better investigate processes of group formation, adaptation, and conflict are also potential research areas.

### **Group II Report: Human Physiology**

One of the themes of the potential research deals with the type and extent of physiological alterations and adaptations experienced in extreme environments. The subcategories within this theme are: circadian rhythms, epidemiology of infectious illness, and energy balance and thermoregulation.

### Circadian Rhythms

The purpose of this research is to study the daily cycling of hormonal, physiological, and cognitive parameters and to study how these cycles may be altered by changes in lighting, activity, and wakefulness, all common to both spaceflight and polar residence. Specifically, extended experimental protocols could include the natural laboratory of polar environments, controlling external lighting and temperature, to investigate daily variation in body temperature, and hypothalamic, pineal, and pituitary regulation. In addition, performance tasks, thermoregulation, and hormonal and immunologic

responses could be measured to understand the significance of these circadian patterns. Specific interventions of light exposure or sleep deprivation could also be imposed to better understand these cycles.

### Epidemiology of Infectious Illness

The purpose of this research is to investigate the effects of various space-simulated environments on the ability of the human host to respond to immune insult through infection. This research could include studies of the susceptibility of persons exposed to long periods of group isolation and/or studies of circumstances where natural rhythms of sleep and wakefulness are perturbed.

The unique polar environment could allow longitudinal studies to identify which aspects of human immune effector cell function are modulated by the neuroendocrine-mediated influence of changing circadian rhythms or the combined stresses of polar isolation. Projects could focus on identifying markers of reduced immune competence and the mechanism of stress-induced immune dysregulation.

Potential studies could include appropriate control groups and determine if measured immune variables predict susceptibility to infectious disease or reactivation of viral infection. The effectiveness of countermeasures including the prevention of microbial transmission, anti-viral chemotherapy or biologic response modifiers could also be included.

There is a probability that mid-isolation outbreaks of infectious disease in space and polar environments could occur spontaneously or following resupply of inanimate objects. Such outbreaks have been reported many times in isolated populations but do not have solid etiologic documentation. Since these outbreaks are sporadic and unpredictable, the medical records of several isolated populations, especially of polar regions, could be reviewed. Populations could then be studied prospectively by remote methods such as satellite communications and on-site epidemiological and microbiological investigations.

### Energy Balance and Thermoregulation

The purpose of this research is to determine the importance of exercise and nutrition in blunting the negative physiological responses often accompanying long-term exposure to confinement, as well as their effectiveness as positive interventions for the relief of boredom, a state that has already been experienced in isolated polar regions and will most likely be a part of any space flight or station experience of long duration. It is suggested that human exercise, nutrition, and thermoregulation studies, conducted either individually or in combination, be developed so that energy input and output could be studied under extreme isolated conditions.

This research could provide information for determining the caloric intake and nutritional requirements of polar crews. Space flight experience has shown that astronauts require a greater caloric intake than expected. This experience has also been noted in certain workers in the antarctic, such as divers and heavy vehicle operators. Studies investigating carbohydrate, protein, fat, vitamin, electrolyte, and



trace metal intake and utilization could lead to an understanding of specific nutrient requirements for long-term polar residents and space travelers. Diet regimens could be developed and evaluated to determine effects on performance efficiency, behavioral patterns, endocrine level, and body mass.

Physiological studies could emphasize musculoskeletal, cardiovascular, and respiratory responses to exercise with a special emphasis on factors affecting compliance to exercise in an isolated environment. Methodologies which include whole body, organ, cellular, and molecular investigation are possible. Thermoregulation is also a potential experimental focus and could be studied in conjunction with both energy input and output.



# **Attachment 1**



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# **Attachment 2**





**NASA/NSF  
ANTARCTIC BIOMEDICAL SCIENCE WORKING GROUP  
OCTOBER 11-12, 1990**

**1825 Eye St., NW, Suite 1100  
Washington, D.C.**

**Thursday, October 11, 1990**

8:00	WELCOMING REMARKS	F. Sulzman/J. Stoklosa C. Roberts/P. Penhale
8:15	CHAIRMAN'S REMARKS	C. Pierce
8:30	NSF OVERVIEW	P. Penhale
9:00	EPIDEMIOLOGICAL RESEARCH IN ANTARCTICA	E. Dick
9:30	U.S. NAVY MEDICAL SUPPORT	K. Boyce
9:55	HUMAN EXPERIENCES IN ANTARCTICA	A. Harrison
10:20	BREAK	
10:30	CLINICAL RESEARCH IN ANTARCTICA	L. Reed
10:55	GROUP DYNAMICS IN ISOLATED ENVIRONMENTS	J. Johnson
11:20	ADAPTATION AND ADJUSTMENT IN ANTARCTICA	L. Palinkas
11:45	CULTURAL PERSPECTIVES ON SURVIVAL IN EXTREME ENVIRONMENTS	N. Broadbent
12:10	LUNCH	
1:00	NASA OVERVIEW	J. Stoklosa
1:30	MAN SYSTEMS AND HUMAN FACTORS MODELING	B. Woolford/J. Stoklosa
1:55	PSYCHOLOGICAL ISSUES OF SPACEFLIGHT	A. Holland/J. Stoklosa
2:20	SPACE HUMAN FACTORS/ CREW COMMUNICATION	M. Connors/A. Harrison
2:45	ENVIRONMENTAL FACTORS/ MICROBIOLOGY	D. Pierson/K. Gaiser
3:10	BREAK	

**NASA/NSF  
ANTARCTIC BIOMEDICAL SCIENCE WORKING GROUP  
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**Thursday, October 11, 1990 (cont.)**

3:25	IMMUNOLOGICAL ISSUES RELATED TO SPACEFLIGHT	R. Meehan
3:50	CIRCADIAN RHYTHMS	C. Czeisler
4:15	MOTIVATING EXERCISE TRAINING FOR ISOLATED ENVIRONMENTS	F. Hagerman
4:40	COMPARISON OF ANALOG ENVIRONMENTS/HABITABILITY	J. Stuster
5:05	ADJOURN	
6:00	RECEPTION	
8:00	International Club of Washington 1800 K St., NW Washington, D.C. 20006	

**NASA/NSF  
ANTARCTIC BIOMEDICAL SCIENCE WORKING GROUP  
OCTOBER 11-12, 1990**

**Friday, October 12, 1990**

8:00           BREAK OUT INTO WRITING GROUPS

- PSYCHOLOGY/HUMAN FACTORS
- ENVIRONMENTAL FACTORS
- PHYSIOLOGICAL ISSUES

10:15           BREAK

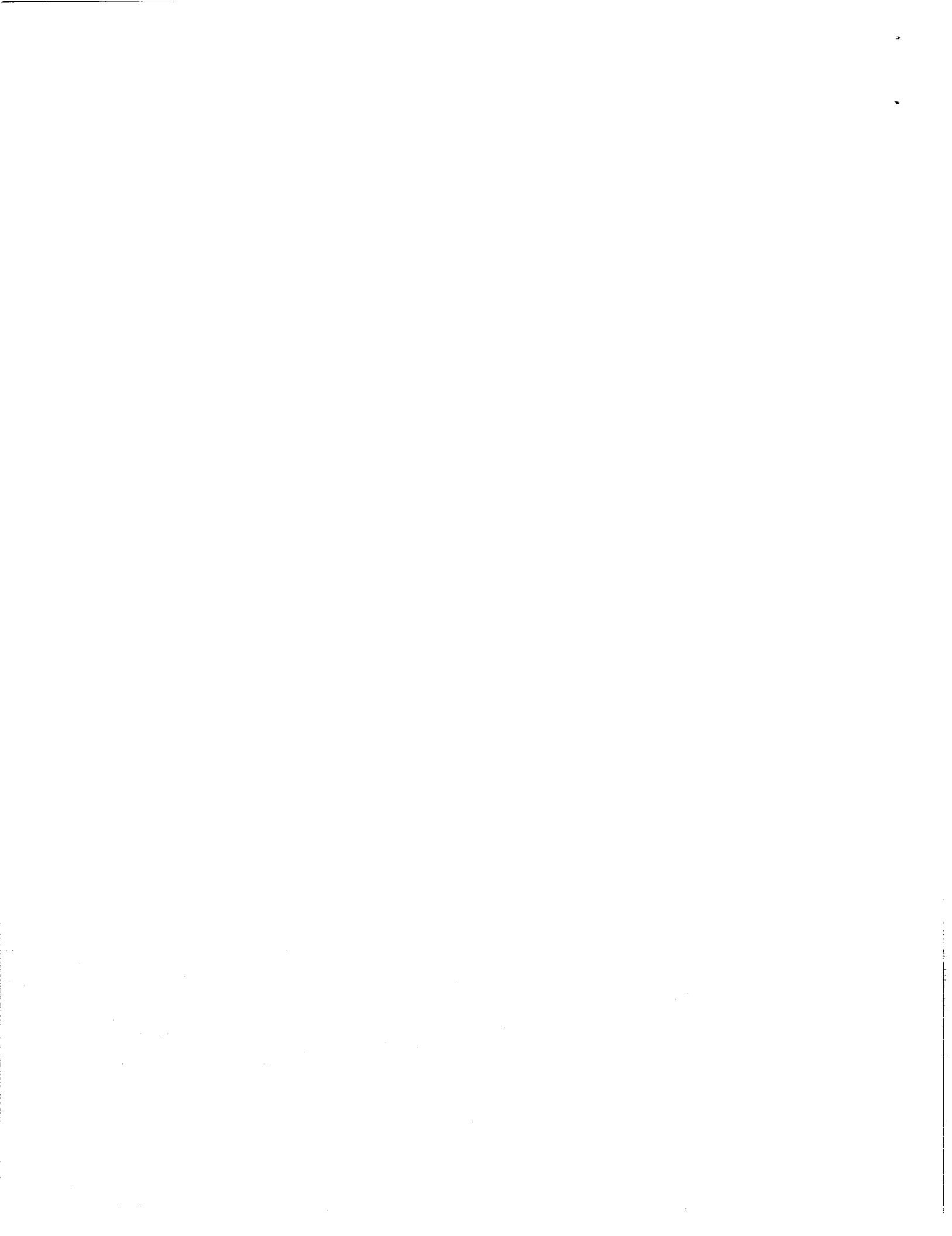
12:00           LUNCH

1:00            GROUP SUMMARY PRESENTATIONS

3:00            ADJOURN



# **Attachment 3**



N93-16800

Talk on October 11, 1990 at the NASA/NSF Antarctic Biomedical Science Working Group in Washington, D.C.

## EPIDEMIOLOGIC RESEARCH IN ANTARCTICA

Including derivative work on virus transmission and transmission interruption using the Antarctic Hut model

### Introduction

In any civilization, regardless of its state of industrialization, literacy, and standard of living, disease of the respiratory tract - 90% caused by viruses - is overwhelmingly its most common health affliction. Our laboratory has been studying the epidemiology and transmission of respiratory viruses since the early 1960's. The first studies were in a University of Wisconsin housing village, Eagle Heights, where it was demonstrated that these viruses pass through even small populations as very "mixed cultures"; within one 12-unit apartment building, half a dozen different viruses could spread simultaneously. Surprisingly, however, an individual virus often did not transmit easily. Within a single family, only about 50% of the susceptibles became infected with a single virus type, and the virus often did not move to a neighboring apartment and very seldom to the apartments at the other end of the building. Subsequently, we studied a second grade school population and found, as well, that several viruses moved simultaneously and slowly through this population.

We were very surprised that the viruses did not spread more readily, but making definite conclusions about means of spread was hampered by the distinct possibility that the several viruses in these open populations were, in themselves, interfering with person-to-person transmission. (If one is infected with one virus, it is often difficult to be infected with a second virus, and sometimes this antiviral protection can last for a week or more.)

We then turned to human volunteer transmission studies wherein we infected one or more individuals with a specific virus and then placed these infected persons (donors) in rooms with other individuals (recipients) who had no antibody to this virus. The donors and recipients engaged in various interactive behaviors, e.g., playing cards, singing, working with TV games, etc. Much to our amazement, virus transmission was nearly impossible even with hours of exposure; transmission was really only readily accomplished when married couples were the donor-recipient pair. Even here, transmission occurred in only one-third of the couples. (A 1976 Reprint [#1] describing our married couple study is enclosed.)

These studies with volunteers were consonant with our prior epidemiologic studies. We felt that all our results suggested strongly that respiratory viruses often disseminated with difficulty and therefore might be kept from spreading by use of increased personal sanitation. We attempted to test this hypothesis using the married couples as a transmission model and iodinated

facial tissues as the sanitary agent. Unfortunately, the married couple model proved to be so uncertain a transmission vehicle that it could not serve its purpose as a transmission model.

In the spring of 1975, I had the great good fortune to meet Dr. Harold Muchmore of the Oklahoma State Medical School who was also a pre-eminent Antarctic epidemiologist. He explained to me how the personnel at McMurdo station, especially during the winter fly-in (Winfly) period, could serve as an isolated population where few viruses were present and their natural progress could be followed in detail within a group of approximately 200. At Winfly 1975, using Dr. Muchmore's NSF logistics support and our NASA grants (much of the human volunteer work had actually been supported by NASA), a young Oklahoma State medical student and I went to McMurdo to determine the feasibility of assaying the epidemiology of the respiratory viruses in the population. We found the Antarcticans to be very well motivated and it was actually possible to carry out a fairly thorough epidemiologic study during Winfly 1975. A by-product of that investigation was our first inkling that the winter-over (WO) population was not especially susceptible to respiratory disease. We returned to the United States very enthusiastic about the possibility of doing definitive studies of interpersonal virus transmission at McMurdo Station and, possibly, interrupting transmission in the population.

Before I launch into a description of our work at McMurdo Station and the derivative development of a human volunteer transmission model, The Antarctic Hut, it may be useful to introduce the audience to the jumble of respiratory viruses.

Slide 1 - The respiratory viruses. This illustration depicts the seven different virus groups which cause respiratory infections. Each of these groups has subsidiary members which are antigenically distinct; none of these 135+ viruses yields any cross immunity to one another. Each of the viruses is able to cause everything from a common cold to severe influenza and pneumonia. However, influenza viruses are much more likely to cause severe illnesses than are the coronaviruses or the rhinoviruses. The latter two viruses are usually called the "common cold viruses" with the rhinoviruses far in predominance. Herpes simplex was not listed; it also can cause colds and a rather severe sore throat. It is the same organism which can cause sexually transmitted diseases and has done so in epidemic form over the past 15 years or so.

Slide 2 - Epidemic curve of viruses in a 25-family population. In order to illustrate how viruses move in clusters through a small population, depicted is an epidemic curve for the academic year 1964-65 in 25 families we studied at Eagle Heights, the UW student housing village. All 25 families were housed in one three-building group of 12-unit apartments. The population was approximately 100, with half of them children of school and pre-school age. This 1964-65 epidemic curve is very typical of any year, with the parainfluenza viruses in late fall, followed by winter with a mixture of several viruses (influenza, parainfluenza 1, respiratory syncytial virus, etc.) and spring with a rhinovirus outbreak. A somewhat similar distribution will be seen each year in nearly any population in developed countries, at least in the northern hemisphere.



Slide 3 - Respiratory viruses in a single Eagle Heights building. This slide illustrates the 15 viruses which infected 12 families within a single Eagle Heights building over 1963-65. You will note that there are several viruses which were not listed in the previous 1964-65 slide; this illustrates the changing mix of viruses that passes through populations in sequential years.

These two foregoing slides also illustrate well the near impossibility of synthesizing a vaccine for protection against all the respiratory viruses and, as well, the similarly great difficulty in developing antiviral drugs for these varied and ubiquitous agents. Currently, we have only influenza vaccine which is not very effective, and, as an antiviral, amantadine which is a fair preventive against influenza A. Nothing else is available. The sheer technical difficulty of coping with 135+ viruses by conventional vaccine and antiviral drug techniques makes environmental control of virus transmission probably the only practical method for eliminating virus infections in any population, including those projected for planetary colonies.

### Epidemiology in Antarctica

Slide 4 - Antarctic research seasons at McMurdo. During our McMurdo studies (1976-80), 50-70 persons wintered over, and, at the beginning of Winfly, approximately 150 new persons from the United States and New Zealand joined the WO party. The duration of Winfly is approximately five weeks and is succeeded in early October by the vanguard of the summer researchers. During the Austral summer there are frequent flights between McMurdo Station and Christchurch, New Zealand, so the population is no longer very isolated.

Slide 5 - Map of McMurdo Station. McMurdo Station is a substantial village with: a major dormitory (Building 155) which houses most of the Winfly residents and contains the kitchen and mess hall, a modern dispensary and small hospital (Building 142), an electricity generating plant (Building 136), a firehouse (Building 182), the biology laboratory (Building 56), which contained our virus units, other dormitories (Buildings 125 and 137), and NSF headquarters (Building 167). During the summer research season, this complex of buildings can house and occupy up to 1,000 individuals.

Slides 6-17 - These were all McMurdo Station scenery slides which are familiar to most of you, and, therefore, add little to the scientific narrative. They are not included.

Slide 18 - The evening meal at the Building 155 mess hall. About 90% of the population took all three meals in this dining area; the remainder ate at separate kitchens in the firehouse or at the power plant, or, occasionally, in their individual housing quarters.

Slide 19 - The mess line at the Building 155 dining facility. Since 90% of the population ate at the Building 155 mess facility, this was a very convenient place to conduct surveillance for respiratory disease. The men were asked about their colds every day, and those who had colds were cultured in the

dispensary across from the mess hall. The resultant nasal washings were inoculated within hours into cell culture in the nearby biology building. We equipped its microbiology laboratory for virus work without difficulty. The biology building was very uncrowded during Winfly with good microbiological facilities including research microscopes. (I presume that the new microbiology building under construction will have an excellent virus facility able to handle the virology envisioned with the NASA/NSF Antarctic analog program.)

Slide 20 - Dr. Adrian Mandel interviewing a Navy man in the Building 155 mess line. This is a close-up of our interviewing process in the McMurdo mess line. I wish to call particular attention to Dr. Mandel. For about 15 years (1965-80), our research was partially funded from NASA/AMES, and Dr. Mandel was my project officer. He went with us during Winfly of 1976 and 1977. He is, by training, a bacteriologist and performed an outstanding and quite heroic job in those two years. He was then in his late 50's and uncomplainingly put in the terribly long hours required. He was outstanding with the McMurdo personnel, had superb aseptic technique in the laboratory and was as skilled at veni-puncture as anyone whom I have met. We were very grateful to NASA for permitting him to join us for those two very important years. I understand that he has just retired from his position at Ames; I'm sorry that I wasn't able to add my accolades at his retirement celebration.

Slide 21 - The epidemic curve of respiratory virus disease at McMurdo Station, Winfly 1976. To the best of my knowledge, this is the first successful epidemiologic and etiologic surveillance of an isolated population using modern virologic techniques. (A Reprint [#2] describing this investigation is enclosed.) Respiratory illnesses, as usual, move very slowly. Counting five indigenous colds reported by the WO population (we have never isolated viruses from colds reported by the winter-over personnel at the beginning of winter fly-in, so we are somewhat suspicious of the authenticity of these indigenous colds) as well as 31 colds brought in by the newcomers at the beginning of Winfly, the 200 person population started with a total of 36 colds. These initial colds gave rise to only 52 subsequent colds over the five-week Winfly period. About 1% of the population reported new colds each day. In mid-September, the colds peaked at 30 in 200 men.

Interestingly, there were really two epidemic curves, one for the new (summer) population and the other for those who had wintered-over. This is best illustrated on Figure 5 on p. 327 in Reprint #2. The newcomers began with about 20% of the population infected, and at the end of Winfly this had diminished to 5%. Conversely, the WO men started out at 5% and ended up at 10-15%. The curve in the WO population is certainly explainable in that these men were just being exposed to a new group of viruses, but that in the summer men does not seem to be obviously explicable. At the end of Winfly, the major virus isolated, McMurdo 88 (McM 88), had plenty of susceptibles left to infect in the summer men; only 19 of 78 summer men without McM 88 antibody became infected (see table 5 on p. 330 in Reprint #2).

In great contrast to our expectations, there was no severe outbreak of disease in the WO personnel.

Only two virus types were isolated, both of them non-typable rhinoviruses. For reasons we do not understand, only McM 88 was transmitted widely, accounting for 25 of the 88 colds. At the time of the greatest number of colds, mid-September, around 15 of the 30 were associated definitely with McM 88.

(Should it interest the reader, at the end of Reprint #2, under Conclusions and Extrapolations (pp. 338-339), I have summarized what I feel to be the significance of this McMurdo investigation and have tried to place it in the context of our other work, including our subsequent "Antarctic Hut" experiments.)

Slide 22 - Epidemic curve during Winfly, 1977. Our overall findings in 1977 were very similar to those of 1976, including a very slow rate of virus spread and no difference between the WO and summer men in incidence or severity of illness. (A Preprint #3 of a publication which will appear in the March, 1991 issue of the American Journal of Epidemiology is enclosed.) There were also two interesting new observations: (1) although rhinoviruses were present as well, adenovirus type 21 (Ad21) was predominant. This virus often causes epidemics of rather severe influenza-like illness in susceptible military populations. At McMurdo, the Ad21 patients were rather severely ill with influenza-like symptoms, but the spread of this agent through the population was extremely slow. This was especially peculiar in that the hallmark of Ad21 illness is a lasting, severe cough, which should hasten spread. This characteristic cough was present in this population. We do not know why the Ad21 did not spread rapidly; perhaps there were not enough initial cases (only 3) or the population was too dispersed. The ventilation is excellent in Building 155, the major housing and dining quarters. The presence of antibody in the population did not account for the slow spread, as approximately 89% of the population had no Ad21 antibody. (2) Those individuals who had jobs which kept them outdoors in unheated (-30° C.) circumstances, day after day, had a high rate of Ad21 infections. They had an attack rate of 57%, compared with 8% in those men who worked in indoor environments. The difference was statistically highly significant (< 0.001). This unusual circumstance is described by Dr. Shult on pages 11 and 12 of Preprint #3 and is discussed on pages 15 and 16. While there were possible confounding factors in this unusual outbreak, this observation needs to be examined in a more controlled circumstance. It would be interesting to move our Antarctic Hut model down to McMurdo Station and use as recipients some of the frigid outdoor workers and compare, in the same experiment, some of the men with indoor jobs. Maybe it is not a good idea to become chilled when cold viruses are circulating! The effect of chilling on colds has been examined by prior investigators in human volunteer models, and nothing positive has emerged. However, those experiments did not subject the volunteers to anything like the severe environment to which these men were subjected at McMurdo Station. Most of these very cold men were equipment operators in unheated cabs working out at Williams Field, or the fuel suppliers who also spent much time outside.

Slide 23 - Building 137, a small dormitory. This demonstrates the external structure of a small dormitory, which is very similar to the dormitory building next door, Building 125, in which we did the following intensive epidemiologic study.

Slide 24 - Rate of colds and of McMurdo 88 colds in four McMurdo Station buildings. (This is Figure 7 on p. 332 of Reprint #2.) Note that the occupants of two small buildings (125 and 136) have much higher illness attack rates, both of colds in general and of McM 88 in particular, than the residents of Building 155. We studied Building 136 and 125 intensively, but Building 125 was more of a viral "pure culture" and made for easier analysis. (In Reprint #2, illness and virus movement in Buildings 136 and 125 are depicted on Figures 8 and 9.) We do not know positively why the attack rates were higher in the two smaller dormitories, but the population was much less dense in Building 155, and, as well, Building 155 had an extremely good ventilation system, using a significant portion of outside air. Buildings 136 and 125 recirculated the air.

Slide 25 - Dissemination of Rhinovirus McMurdo 88 in Building 125. Fourteen men lived in Building 125, all of them employees of Holmes and Narver, the civilian contractor at McMurdo Station. They slept in nine small bunk rooms and, as well, had a small day room where many evenings were spent playing cards or engaging in other convivialities. The great majority of these men were skilled tradesmen and very gregarious. Of the 14 occupants, only one, Person K, had antibody to McM 88 (surprisingly, he became infected). All but two of the colds were diagnosable in that we obtained acute and convalescent serum specimens appropriate for measuring seroconversion to McM 88. There were, in all, five McM 88 infections in the building, one of them (subject AA) being subclinical. The cold in subject V was a severe incoming cold, and the subsequent McM 88 colds were of varying severity, but all were typical cold-like illnesses. (See Reprint #2, figure 6, p. 329 for cold severity of each McM 88 case; a mild cold is less than 7, moderate 7-12, severe, greater than 12.) The last McM 88 cold was in subject K, whose cold began on September 13. At this time, there were four active McM 88 infections among these 14 men, but no further infections were reported. Five individuals reported no colds, and they did not seroconvert to McM 88, indicating that they were probably not subclinically infected with this virus. This attack rate within this family-like population was much like that in the normal families we had studied in Wisconsin - around 50%.

The low attack rate among the Building 125 population was of particular interest, because we watched all the possible "cold-spreading" circumstances in which these men lived. It seemed astounding that dissemination was so low.

When we returned to Wisconsin, I found a 1976 publication by members of Great Britain's famous Common Cold Unit at Salisbury which set me to thinking about the men in Building 125. The English had obtained nearly 100% transmission of Rhinovirus type 2 among human volunteers in British Antarctica. The colds were also very severe. These Antarctic colds were compared with simultaneously-induced Rhinovirus 2 colds back in England, and the latter colds were much milder and did not spread at all. These investigators ascribed the severe colds and high transmission in Antarctica to a special sensitivity to respiratory viruses among the Antarctic volunteers who had wintered over. Since we had not found any particular susceptibility among the WO men at McMurdo, I suspected that the high transmission in the Antarctic was due to crowding, poor ventilation and the severe illnesses in the persons inoculated with Rhinovirus type 2. (Our discussion of this outbreak in British Antarc-

tica can be found on pp. 334-336 in Reprint #2.) We surmised that, had we had several severe colds in the Building 125 population, there might have been a high rate of spread under these crowded and poorly ventilated circumstances. The contrast in the observations in Building 125 and those of the Common Cold Unit among British Antarcticans prompted our subsequent "Antarctic Hut" experiments, which will be described after the next section.

### An Experiment at McMurdo Station, Antarctica in the Interruption of Respiratory Virus Transmission

We did not carry on surveillance in Antarctica during 1978; instead, we worked with the S.C. Johnson Company of Racine, Wisconsin (Johnson's Wax) to develop a virucidal facial tissue which would be at least suitable for experimental virus-interruption purposes in a small population such as that at McMurdo during Winfly. They devised a quite satisfactory product which was lightly perfumed and dark brown in color. The tissues were actually made through the remodeling of some rooms in the S.C. Johnson plant in Auckland, New Zealand. The only real disadvantage to these tissues was that the iodine would sublime within a few hours, so about a dozen tissues were sealed in literally thousands of clear plastic containers. The tissues were all ready for an interruption trial in Winfly 1979.

Extensive orientation of the personnel for the Winfly 1979 trial was carried out. I flew down just before the base was closed for the winter and told the 1979 WO personnel of our plans and enlisted the help of the WO physician. During the six months overwintering stint, our laboratory had regular conversations with members of the WO party. Before Winfly 1979, the summer personnel were also thoroughly informed. We gave several talks at Port Hueneme, at Christchurch and at McMurdo. Accordingly, the entire population understood (I think!) what we were trying to do and how we were going to do it.

Slide 26 - Handing out the virucidal tissues ("Killer Kleenexes") in the chow line. Mr. David Breshnahan, the NSF representative at McMurdo, receives his tissues eagerly. Each day in the chow line we handed out packets of tissues to all persons dining in the Building 155 mess and, as well, distributed larger packets at strategic places over the base. (Each morning, a couple of people from our group loaded the bed of a truck with large tissue packets and picked up the day-old packets all over the base and left new ones. It was a very cold "paper route.") The tissues were supposed to be used systematically every hour for clearing the nasal passages and wiping the hands and face. This was a voluntary effort, but the individuals were urged on by their superiors in Holmes and Narver or in the Navy. Those individuals who had respiratory disease used only the iodine tissues for nasal sanitation, covering coughs and sneezes, and wiping the hands and face.

Slide 27 - The epidemic curve for the population of 233 men during Winfly, 1979. We permitted the usual outbreak to begin and respiratory illness proceeded until September 10 at a normal, or slightly above normal, incidence of infection. At the evening meal of September 10, we began to hand out the

tissues as described in the previous paragraph. In the days immediately thereafter there was actually a little rise in incidence for two or three days after the tissues were given out (incubation period?) and then a sharp diminution of both incidence and prevalence occurred. The incidence per day was 4.3 through September 15 and 1.7 for the remainder of Winfly; the difference was highly significant ( $X^2 = 33$ ,  $P = < 0.001$ ).

Slide 28 - Incidence and prevalence of respiratory disease in 69 WO 1979 personnel. The drop in incidence and prevalence was especially marked in the WO personnel, particularly when compared with a normal Winfly curve for the WO personnel as is depicted on the next slide.

Slide 29 - Normal WO epidemic curve (Winfly 1976). The WO personnel "catch" their colds from the newly arrived summer personnel and the incidence and prevalence curves slowly rise until a steady state is reached in mid-September. The precipitous drop in Winfly 1979 is decidedly aberrant (slide 28).

This was an historically controlled interruption trial, with all the frailties such trials are subject to. Although the decrease in respiratory illness was significant, obvious and sharp, the controls were the normal years of 1975, 1976 and 1977. You have seen the latter two years; the curve for 1975 was similar. Nonetheless, the events of 1979 could have just been a normal epidemic curve of the particular viruses present that year which were Influenza B, several parainfluenza viruses and some rhinoviruses - not exactly a pure culture! We, nor any of our consultants, could devise a way in which the 1979 Winfly population itself could be split into control and test groups. The difficulty rested in that the purpose of the experiment could only be to stop base-wide cold transmission, done by smothering the viruses in those persons ill using the virucidal tissues for that purpose. When smothered and killed at the source, the viruses could not infect another individual. If we had split the population in half and used placebo and test tissues, all that could have occurred would have been a halving of the number of people on base who would have been smothering their colds. Only when individuals are protecting themselves is a control group possible in a single population. In theory, we could have arranged somehow an isolation of two populations at McMurdo, but that would have been nearly impossible, and, also, different viruses would almost surely have circulated in each population.

If the sharply diminishing disease rates in 1979 are genuinely a result of virucidal tissue use, almost surely this was due to the presence of influenza virus in the population. It got everybody's attention! We identified influenza in the population shortly after beginning the tissue handouts and realized full well the potential disaster which faced us in this closed population. The medical officer for that year and the base commander called a meeting of all supervisory personnel, and the medical officer and I explained the circumstances. The only available method for stanching this possible influenza epidemic was careful and thorough use of the virucidal tissues. Accordingly, their use was made mandatory and a bulletin so stating was issued. Everyone at McMurdo understood the possible serious outcome of widespread influenza, and use of the tissues became epidemic! The Executive Meeting occurred and the all-hands memorandum was issued, if I recall correctly, on September 13, and in a couple of days, the number of new cases entering

the dispensary dropped markedly. The diminution was even greater than depicted in the slides, as the data in the figures represent date of onset, not date of dispensary admission. The latter was a couple of days later than the time of onset. It became extremely apparent around September 17 that influenza was falling rapidly, and the tissues received the credit whether deserved or not. To those of us at McMurdo during this time, the sudden diminution of serious illness did seem like something of a miracle. In gratitude, and with considerable humor, plaques and medals were made for our group and were presented, as a complete surprise, at the base-wide award ceremony at the end of Winfly. I considered bringing these mementos to our October 11-12 meeting, as the citations were so clever and humorous. There was no little mutual gratitude involved; our group was most grateful to the base personnel for taking the problem seriously and pursuing the appropriate preventive measure so assiduously. Likewise, I believe the McMurdo personnel may have been somewhat grateful to us for possibly aborting an outbreak of serious and potentially fatal illness. Maybe we did!

When we returned to Wisconsin from McMurdo, we reported our results to S.C. Johnson in Racine, and also to Kimberly-Clark, the makers of Kleenex tissue and other similar products. The two companies and the University of Wisconsin began negotiations to develop a practical version of the "Killer Kleenex."

We had sufficient tissues remaining to perform another experiment in Winfly 1980. However, in 1980 we had great difficulties in arranging for good orientation sessions of the new men, and we did not have the help of an influenza epidemic. We did achieve considerable diminution of disease, but the curve was nothing like 1979. One of the reasons for difficulties in Winfly 1980 is the outbreak depicted on the next slide.

Slide 30 - A sharp outbreak of cold-like illnesses at Scott Base during mid-Winfly. As most of you know, Scott Base is around 2-1/2 miles down the road from the much larger American base at McMurdo. The New Zealanders at Scott Base and the Americans at McMurdo had much contact with one another, particularly on a social basis. Actually, during our years in Antarctica, we carried on epidemiologic studies at Scott Base along with those at McMurdo, and found that very little illness occurred at Scott Base during Winfly, and we never found McMurdo viruses at Scott Base. Typical is the complete absence of illness at Scott Base during the first couple of weeks of 1980. However, coincident with an end-of-season WO party at Scott Base, was a very substantial outbreak of illness involving eleven of the twelve residents. The circumstances of this outbreak were unusual. The main entertainment at the party was an excellent American orchestra from McMurdo. The leader, who was also the major vocalist and a saxophonist, had a severe cold, as did a couple of his sidemen. While the index case for this sharp outbreak occurred the day prior to the WO party, it seems very likely that the major source of the outbreak was the vibrating larynx of the band leader with the severe cold. (Frustratingly, we have been unable to establish the etiology of this outbreak, even though excellent specimens were furnished by all those ill and were placed in cell culture on the same day. We have not as yet, however, tried serodiagnosis of viruses which will not propagate in cell culture, such as the coronaviruses.) There are a couple of other similar outbreaks recorded in the scientific literature, one in which a band leader disseminated rubella

to his audience in Honolulu (Marks et al. Saturday Night Fever: A common-source outbreak of rubella among adults in Hawaii. Am J Epidemiol 114:574-83 [1981]) and the other in an airplane at Homer, Alaska where a single individual with severe influenza disseminated her illness to 72% of her fellow passengers (Moser, et al. An outbreak of influenza aboard a commercial airliner. Am J Epidemiol, 110:1-6 [1979]). These three outbreaks demonstrate rather clearly the environment in which rapid dissemination of respiratory illnesses can occur either on earth or within a space capsule or a planetary colony.

### Development of the Antarctic Hut Transmission Model

As stated above, upon our return from Antarctica in 1980, negotiations were resumed with Johnson's Wax and Kimberly-Clark. I talked to the executives and scientific personnel of the two companies, bringing them up to date on our 1980 results which weren't all that good. They were not, however, deterred at all. At this time, the theoretical method for respiratory virus transmission probably had a great deal to do with their eagerness. As a result of some work in the late 1970's from the University of Virginia, it seemed that the most likely way of transmission, at least of rhinovirus infections, was through hand contact. If this were so, a virucidal tissue should very effectively stop transmission. In actuality, the evidence was really not all that good, and I did try to point this out to the assemblage.

Notwithstanding my cautionary remarks, we began immediately the quest for a more practical virucidal facial tissue and a population in which to test it. At our first working meeting, the Kimberly-Clark chief chemist, Dr. Shafi Hussein, suggested that we try citric acid as a virucide to take advantage of most respiratory viruses' sensitivity to acid and of the capacity of citric acid to stick to wood fibers. We promptly tried this in our laboratory and found it to be excellent; one square inch of citric acid-treated tissue destroyed one million rhinoviruses in less than one minute. Subsequently, sodium lauryl sulfate and malic acid were added to deal more effectively with the enveloped viruses. The resultant facial tissue was completely non-toxic, highly virucidal, stable and did not impart any color to the fiber base.

We then discussed the population in which to test the effectiveness of the tissue. My experience with a variety of populations made me highly skeptical of testing the tissue in this trial phase in any population which could not be nearly completely controlled. I suggested that we try to create a human volunteer transmission model using the knowledge gleaned in Antarctica by both the British and ourselves. Dr. Hussein and his colleagues decided on the latter course and we began promptly. Our first experiment was only partially successful but our second succeeded beyond our wildest dreams. We placed five to ten men whom we had infected with Rhinovirus type 16 (donors) together with five other men who had no antibody to this virus (recipients) together in a single room for seven days, and all five susceptible persons were infected - as were four of seven individuals who were monitoring the experiment! These monitors were in the study unit approximately four hours per day. We did four confirmatory experiments to set the conditions necessary for the most efficient test of the virucidal tissues. These five experiments were placed together in a 1984 "model" publication which is enclosed (Reprint #4),



together with another volunteer paper of ours which was published simultaneously as a twin (Reprint #5) in the Journal of Infectious Diseases. These two papers were published together with two others which described unsuccessful efforts with interferon as an anti-rhinovirus drug. Accompanying these four papers was a Perspective written by Dr. Robert B. Couch, one of the editors for the Journal of Infectious Diseases and a long-time worker with various respiratory viruses. He discussed these four papers and others in the Perspective, including ours under a section entitled Environmental Control? on p. 170 of the accompanying reprint (Reprint #6). The essence of the five experiments in our "Model" paper (Reprint #5) is illustrated on slide 31.

Slide 31 - Relationship between the number of hours to which each recipient was exposed to one or more donors and his probability of becoming infected. Rather amazingly there was a direct straight line relationship between the amount of time a recipient was exposed to an infected donor and his probability of becoming infected. One Donor Hour of Exposure (DHE) is the exposure of one or more recipients to a single donor for one hour. If the recipient is exposed to two donors for one hour this is two DHE; if he is exposed to two donors for ten hours, this is twenty DHE. The rate of transmission, within reason, seems not to depend upon the number of recipients but upon the number of donors in the room.

We wished to work out an arrangement whereby it was possible for about 50% of the recipients to become infected and wished to do that in the shortest period of time possible, preferably one day. You will note by interpolation on the graph that this requires approximately 200 (DHE). This would have taken more than one day, as our eight donors over twelve hours would yield only 96 DHE. We then decided to change the volunteer arrangement in the model to permit more intensive exposure and hoped to get 50% transmission within one 12-hour day. We settled on an intensive exposure via a continuous 12-hour poker game (with lunch breaks) with eight donors and twelve recipients in the experiment room. This arrangement is demonstrated on Slide 32.

Slide 32 - The 12-hour poker game (Antarctic Hut) transmission model. The reader will note that there are four tables, each with two donors and three recipients seated around the periphery. At one end of the room is located a monitor's table where all the activities and signs of colds are recorded by two graduate students. These two individuals plus other members of our research team continuously observe operations. We selected low-stakes poker as our major interaction vehicle for four reasons: (1) By using cards and poker chips, there was a continuous shuffle of objects, potentially filled with rhinoviruses, to the various people around the table. (2) The character of the game caused somewhat boisterous behavior. (3) The face-to-face arrangement of the volunteers provided a good opportunity for airborne transmission. (4) At least in its basic elements, poker is a fairly easy game to learn, and it is sufficiently compelling - even with nickel and dime bets - to be played for many hours.

Slides 33 and 34 - View of the interaction room through the lens of a video camera. This is a typical poker game with the monitors taking down all movements and signs of illness. Note the happy, rather excited demeanor of the young experimenters.

As soon as we decided upon this 12-hour model, it was tested, and we obtained a 42% transmission rate in the first trial. Quite naturally, Kimberly-Clark was anxious for us to test their new virucidal facial tissues in this model, which we did. We got no transmission at all! This was quite astonishing to us and is depicted on the next slide.

Slide 35 - Complete interruption of RV16 transmissions by a virucidal tissue. This delineates the overall results of four sequential trials of the virucidal tissues as compared with cotton handkerchiefs. The third experiment attained exactly the same result as the second, zero transmission, and the fourth experiment achieved a 75% transmission rate. (The interruption experiment is described in enclosed in Reprint #7.) For good reason, Kimberly-Clark was ecstatic, as were we, and they immediately began to manufacture the facial tissues for test market under the trade name AVERT. Unfortunately, probably because they were very expensive, the test markets were unsuccessful. After considerable internal debate, the AVERT project has been put on hold and we have about 10,000 boxes on campus. We hope that these can be used in the future to define their role in preventing infections under various experimental and natural circumstances. Note that we don't know whether the AVERT tissues were better than regular tissues; we know only that virucidal tissues stopped RV16 transmission among poker-playing male UW students.

### Mechanisms of RV16 Transmission Experiments

We carried out four final Antarctic Hut experiments in this series in order to delineate the mechanism of transmission. As indicated in the above paragraphs, the prevailing view was that colds were primarily transmitted by direct contact. It seemed likely to us that we should be able to settle this issue by some careful Antarctic Hut experiments.

Slide 36 - Four experiments to determine how Rhinovirus 16 is transmitted. Experiments A, B and C were typical 12-hour, 8 donor, 12 recipient poker game experiments, but, in each, six of the 12 recipients wore either a large collar or an arm brace which prevented them from touching their hands to their faces. (See Reprint #8.) This stopped hand transmission as a possible route. The other six individuals could pick their noses, rub their eyes or do whatever they wished. The collars and braces were designed so as not to interfere with poker playing. You will note on this slide that in Experiments A, B and C the transmission rates varied from 42% to 92%, and, overall, the restrained recipients had a 56% attack rate and the unrestrained (control) recipients had a 67% attack rate. The difference between 67% and 56% was not significant. The results of Experiments A, B and C suggest that eliminating hand-to-face contact did not impede transmission from the donors to the recipients.

Experiment D was really an extension of Experiment C. Our 12-hour experiments usually end at around 11:00 or 12:00 PM. At the end of Experiment C, 12 additional recipients were placed immediately in an identical room across the hall from the interaction room used for Experiments A, B and C. Into the room with these 12 new recipients were placed all the tables, chairs, poker chips, pencils, cards, etc. used in Experiment C. As it turned out, the transmis-

sion rate in Experiment C was 42%, so it is known that these donors had, somehow, transmitted their colds to the Experiment C recipients. These transferred fomites had been handled for 12 hours by eight men with fairly severe colds. The new recipients, whom we called "fomite recipients" began to play poker with this very decidedly "used" equipment. At first, they were reluctant even to handle the cards, but we patiently explained again the purpose of the experiment and persuaded them to touch their hands to their nostrils and eyes every 15 minutes to assure good hand-to-nostril contact. After a little reluctance the fomite recipients entered into their games with vigor. Meanwhile, we began a new poker game back in the Experiment C interaction room. This game, which began shortly after 12:00 midnight, contained eight donors playing with new decks of cards, i.e., everyone in the game had a "good" RV16 cold. Each hour the cards, poker chips, pencils and other easily transported items were interchanged between the donor poker game and the fomite recipient poker game. Thus, the fomite recipients had an hourly supply of freshly contaminated fomites. Both games continued for 12 hours. The reader will note that half the cards used by the Experiment D (fomite) recipients had been used by eight sick donors for 18 hours.

Much to our amazement, none of the fomite recipients shed rhinovirus type 16 nor did they develop any symptoms. Obviously, the fomites used in the fomite-only poker room were, theoretically at least, contaminated to a far greater extent than would ordinarily be the case. The donors' hands were cultured for RV16 in Experiment D and the recipients' were cultured in Experiments C and D. No virus was recovered from the recipients' hands, and amounts from 47-1600 TCID<sub>50</sub> were recovered from the Experiment D donors.

The reader will note that in these four experiments, we blocked hand transmission in Experiments A, B and C and airborne transmission in Experiment D. In the first three experiments the collars and arm splints made hand contact impossible, and in Experiment D interception by two brick walls made airborne transmission impossible.

Slide 37 - LANCET editorial on our Antarctic Hut research. The last slide is the best of all in that it is the listing of the editorials of the February 8, 1988 edition of The Lancet. The editorial on the "splints" is directed at this last series of experiments. As well, our other work including the transmission model, is reviewed. The editorial was a complete surprise and is enclosed (Reprint #9).

One additional experiment in this series was performed and is described in the 1988 publication: "Near Disappearance of Rhinovirus Along a Fomite Transmission Chain" (Reprint #10). In this work which was chiefly performed by Dr. Jennings and Ms. Mink, we sought to determine why, in our preceding experiments, so little virus had passed by fomite from the donor's nose to the recipient's hands. For this experiment we used a three donor/three recipient poker game where the amount of virus in the nasal washing, on the finger tips of the left hand and right hand, on the cards and poker chips, and on the recipient's upper lip and external nares, was determined. The three donors entered the experiment with approximately 1 million tissue culture infective doses per ml of nasal washing, and they deposited from 320-32,000 TCID<sub>50</sub>'s of RV16 on the finger tips of their left and right hands. On the cards and chips

(the fomites) the amount of virus was very small, none in approximately 1/3 of the cases and was usually no higher than 32 TCID<sub>50</sub> per fomite. By the time the virus got to the three recipients, the great majority of samples from the right and left hands as well as the upper lip and external nares were negative (14 of 18 samples). Of the four that were positive, two of them had 13 TCID<sub>50</sub> and two 100 TCID<sub>50</sub>. (These data can be found on Table 2 of Reprint #10).

We did find that when mucus was wet on any fomite that the virus was easily transmitted to a recipient's hand. Evidently, in our poker games there is very little wet mucus left, despite gross initial contamination. This "Near Disappearance..." paper was selected for comment by one of the co-editors, Dr. Mark S. Klempner, in the 1990 Yearbook of Infectious Diseases (pp. 128-29). The reader will enjoy Dr. Klempner's remarks! (Reprint [#11])

We are now embarked on an investigation with the American Filtrona Corporation to determine whether their new high capacity, fine pore filters will remove rhinoviruses from the air. If so, we shall try to stop transmission by filtering the air.

### CONCLUSIONS

These many pages, figures and reprints have covered many years of research in open populations such as families and school rooms, in an isolated Antarctic station and, finally, in a series of human volunteer experiments based on the prior epidemiologic investigations. We have found that a variety of different viruses spread slowly among the various populations and in the volunteer groups. Using a virucidal tissue, we have been able to completely stop rhinovirus 16 transmission in volunteers, and possibly greatly impede virus transmission in an Antarctic population. We have also presented evidence that most rhinovirus transmission is through aerosolized particles. We hope that we are on the threshold of effectively blocking transmission through the air through the filtering capacity of high technology filter units. Perhaps a combination of air filtration and careful nasal sanitation with virucidal tissues will effectively control virus transmission in isolated space colonies and in ordinary earth-bound populations.

### Viruses Causing Respiratory Disease in Man

Agents	No. of Antigenic Types Causing Respiratory Disease	Years of Discovery	Type of Clinical Illness
Influenza	2	1933-7	Influenza, Pneumonia, Colds
Parainfluenza	4	1957-1962	Croup, Pneumonia, Colds
Respiratory Syncytial	1	1956	Pneumonia, Common Colds
Enteroviruses	15	1950-7	Sore Throat, Common Colds
Adenoviruses	10	1954-7	Acute Resp. Disease, Common Colds
Coronaviruses	2	1965-7	Common Colds
Rhinoviruses	100 +	1956-7	Common Colds
<b>TOTAL</b>	<b>135 +</b>		

Slide 1 - The respiratory viruses.

### Etiology of Respiratory Infections in 26 Eagle Heights Families



ISOLATE LEGEND  
(EACH SQUARE EQUALS ONE VIRUS ISOLATE)

- |  |  |
|--|--|
| <ul style="list-style-type: none"> <li><span style="display: inline-block; width: 10px; height: 10px; border: 1px solid black; background-color: white; margin-right: 5px;"></span> RHINOVIRUS AND TYPE</li> <li><span style="display: inline-block; width: 10px; height: 10px; border: 1px solid black; background-color: white; margin-right: 5px;"></span> NON-TYPEABLE RHINOVIRUS</li> <li><span style="display: inline-block; width: 10px; height: 10px; border: 1px solid black; background-color: white; margin-right: 5px;"></span> RESPIRATORY SYNCYTIAL</li> <li><span style="display: inline-block; width: 10px; height: 10px; border: 1px solid black; background-color: white; margin-right: 5px;"></span> PARAINFLUENZA 1</li> <li><span style="display: inline-block; width: 10px; height: 10px; border: 1px solid black; background-color: white; margin-right: 5px;"></span> PARAINFLUENZA 3</li> </ul> | <ul style="list-style-type: none"> <li><span style="display: inline-block; width: 10px; height: 10px; border: 1px solid black; background-color: white; margin-right: 5px;"></span> ASIAN INFLUENZA</li> <li><span style="display: inline-block; width: 10px; height: 10px; border: 1px solid black; background-color: white; margin-right: 5px;"></span> ADENOVIRUS</li> <li><span style="display: inline-block; width: 10px; height: 10px; border: 1px solid black; background-color: white; margin-right: 5px;"></span> ECHOVIRUS TYPE 11</li> <li><span style="display: inline-block; width: 10px; height: 10px; border: 1px solid black; background-color: white; margin-right: 5px;"></span> UNIDENTIFIED</li> </ul> |
|--|--|

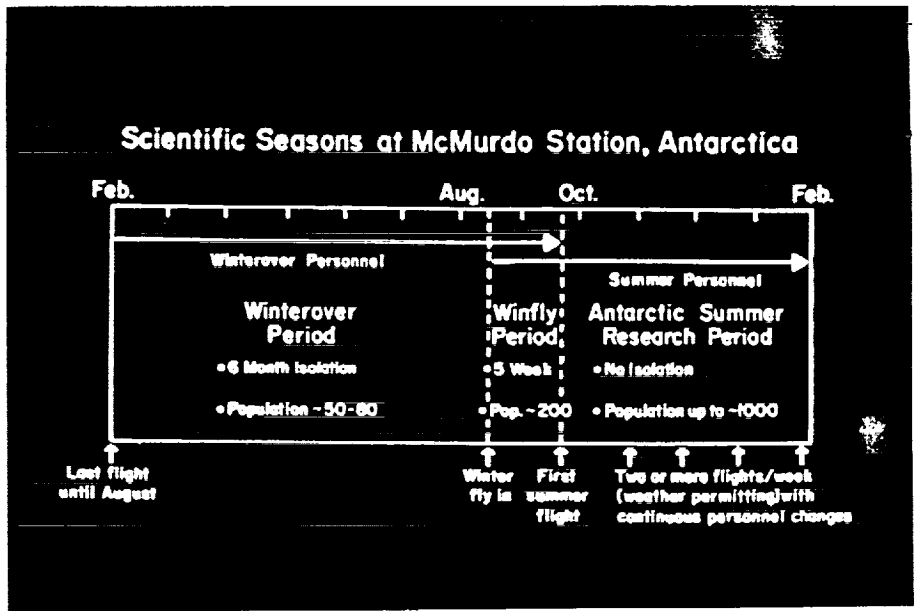
Slide 2 - Epidemic curve of viruses in a 25-family population.

Slide 3 - Respiratory viruses in a single Eagle Heights building.

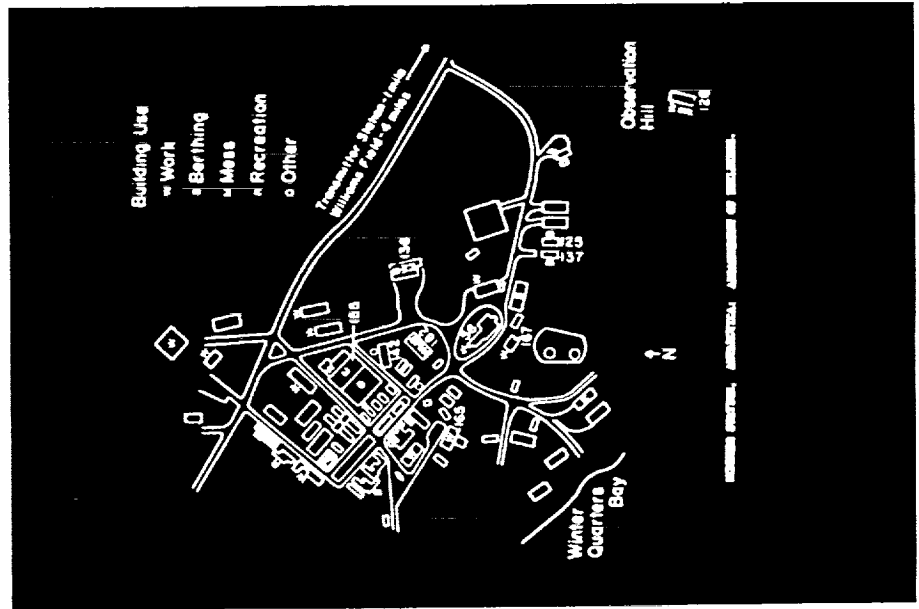
01-04	04-05	07-01	02-05	07-04	04-05	07-04	04-05	07-04	04-05		
APT C, 2, 1 CHILD E11 INF A2 R43 P-1 R55 R44 V1a	APT D, 2 CHILD RS INF A2 R43 RS R55 R15 R NT	APT G, 2, 3 CHILD E11 P-1 RS P-3 RS R51	APT H, 2 CHILD RS A42 R55 P-3 R40 R44 R51	APT I, 2 CHILD P-1 NOT R55 DONE	APT L, 2, 4 CHILD P-1 INF A2 RS P-1 R55 RS R44	APT A, 1 CHILD E11 P-3 R43 R55	APT B NOT DONE	APT E, 3 CHILD NOT COR!	APT F, 4, 2 CHILD E11 INF A2 R15 P-3 RS R9 R44 R51	APT J, 2 CHILD E11 INF A2 R55 A42 R40 R44 R NT	APT K, 2 CHILD A42 RS1 P-1 RS
APT A, 1 CHILD E11 P-3 R43 R55	APT B NOT DONE	APT E, 3 CHILD NOT COR!	APT F, 4, 2 CHILD E11 INF A2 R15 P-3 RS R9 R44 R51	APT J, 2 CHILD E11 INF A2 R55 A42 R40 R44 R NT	APT K, 2 CHILD A42 RS1 P-1 RS						

Viral infections in a single Eagle Heights apartment building, Madison, Wisconsin, 1963-1965. Ad, adenovirus; E, ECHO virus; INF A2, influenza A (H2N2); NT, nontypable; P, parainfluenza; R, rhinovirus; RS, respiratory syncytial; V1a, unidentified, virus-like agent. Numbers after letters refer to type: R55, rhinovirus type 55. (From Dick, E. C., and Chesney, P. J.: Rhinoviruses. In Feigin, M. D. and Cherry, J. D. (Eds.): Textbook of Pediatric Infectious Diseases. Philadelphia, W. B. Saunders Co., 1981, pp. 1167-1136.)

Slide 4 - Antarctic research seasons at McMurdo.



Slide 5 - Map of McMurdo Station.



Slide 18 - The evening meal at the Building 155 mess hall.



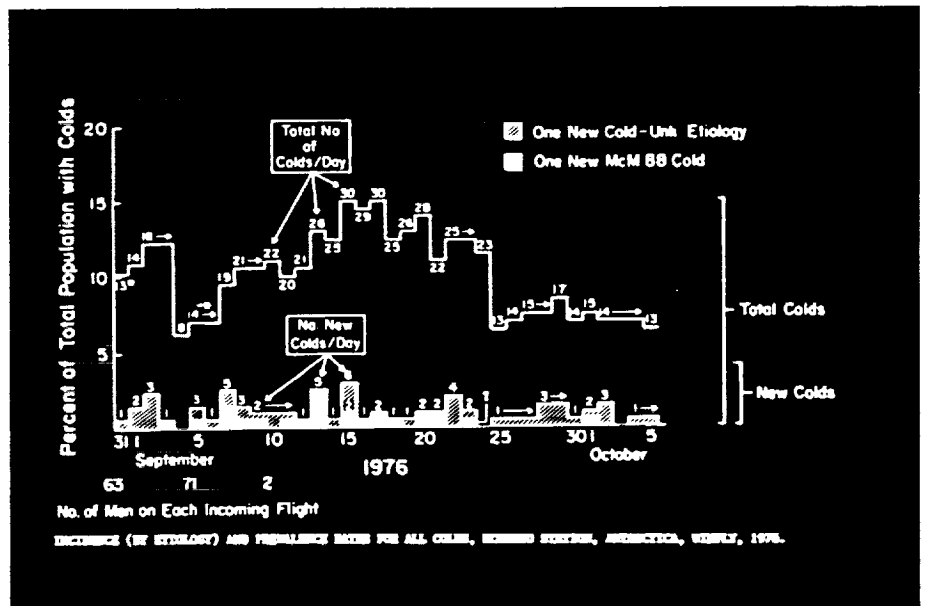
Slide 19 - The mess line at the Building 155 dining facility.



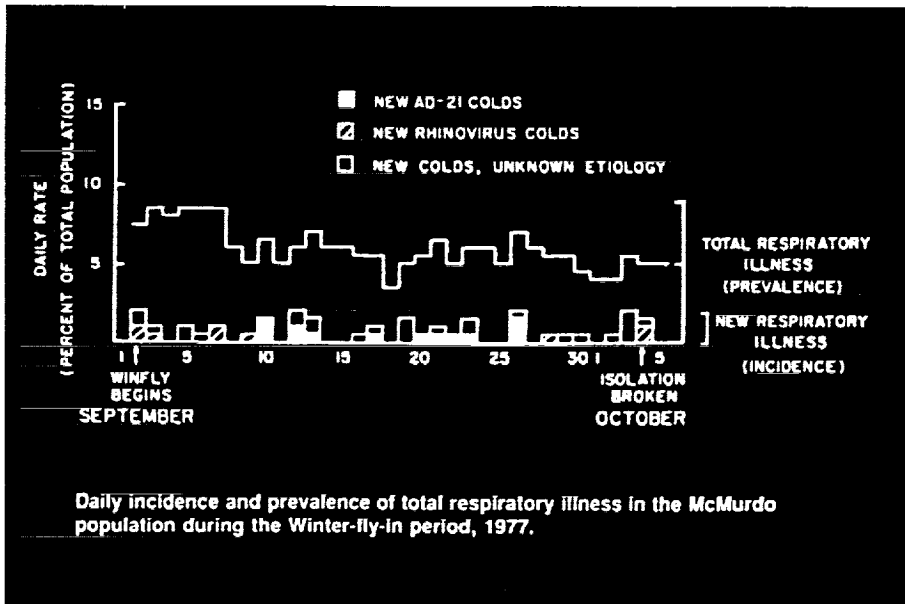
Slide 20 - Dr. Adrian Mandel interviewing a Navy man in the Building 155 mess line.



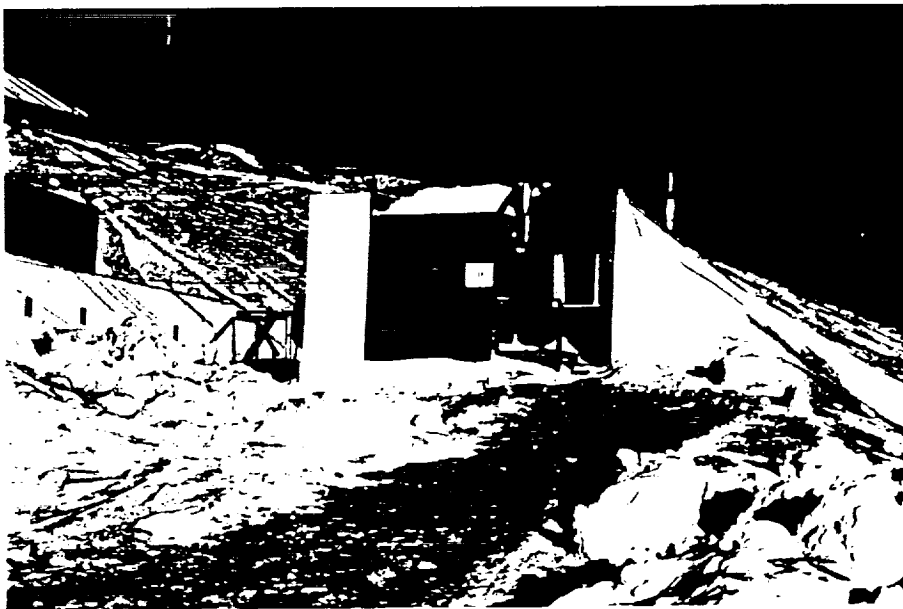
Slide 21 - The epidemic curve of respiratory virus disease at McMurdo Station, Winfly 1976.



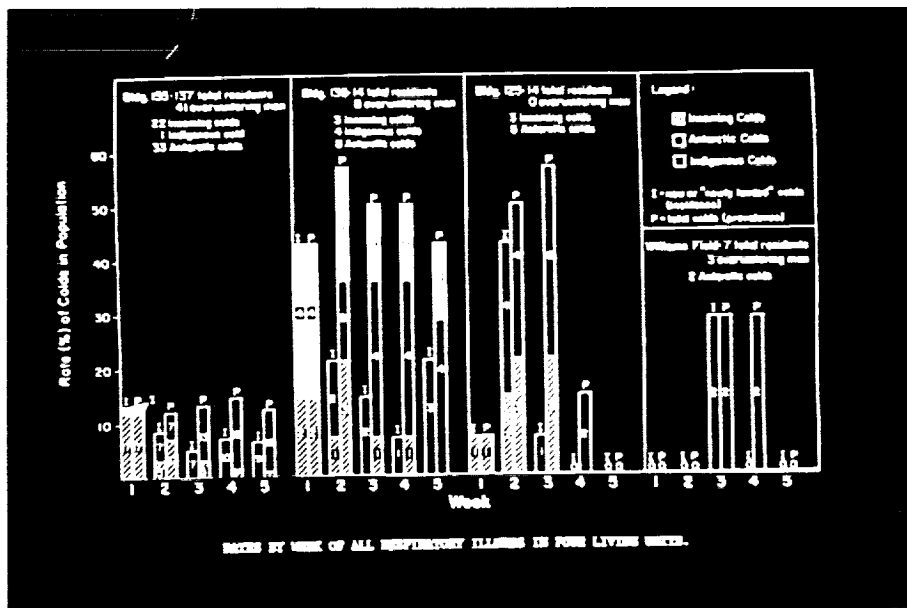
Slide 22 - Epidemic curve during Winfly, 1977.



Slide 23 - Building 137, a small dormitory.

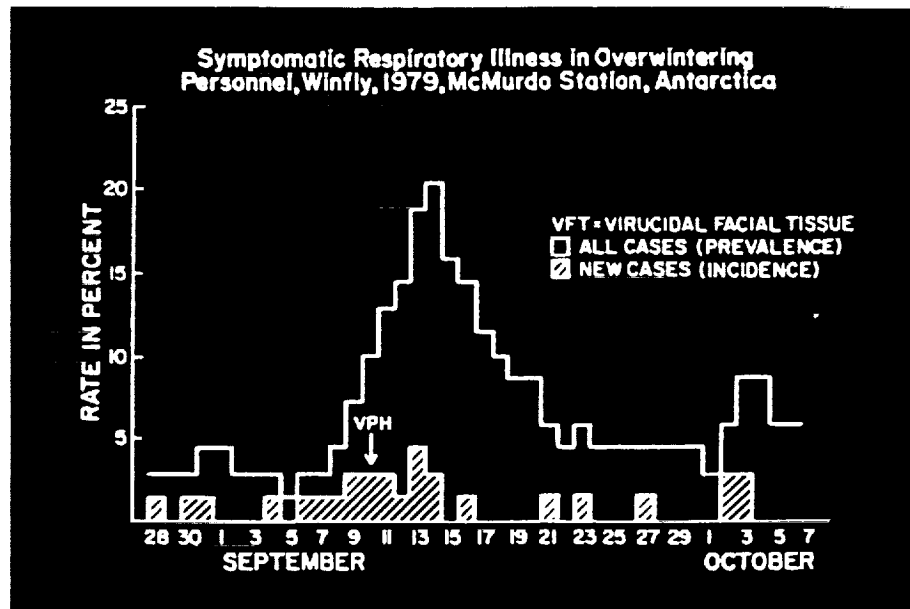


Slide 24 - Rate of colds and of McMurdo 88 colds in four McMurdo Station buildings.

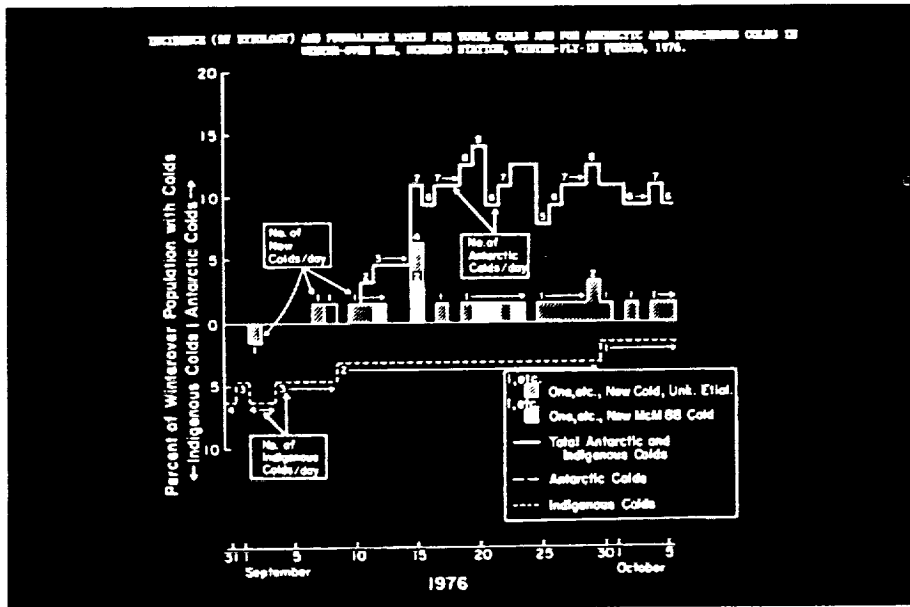




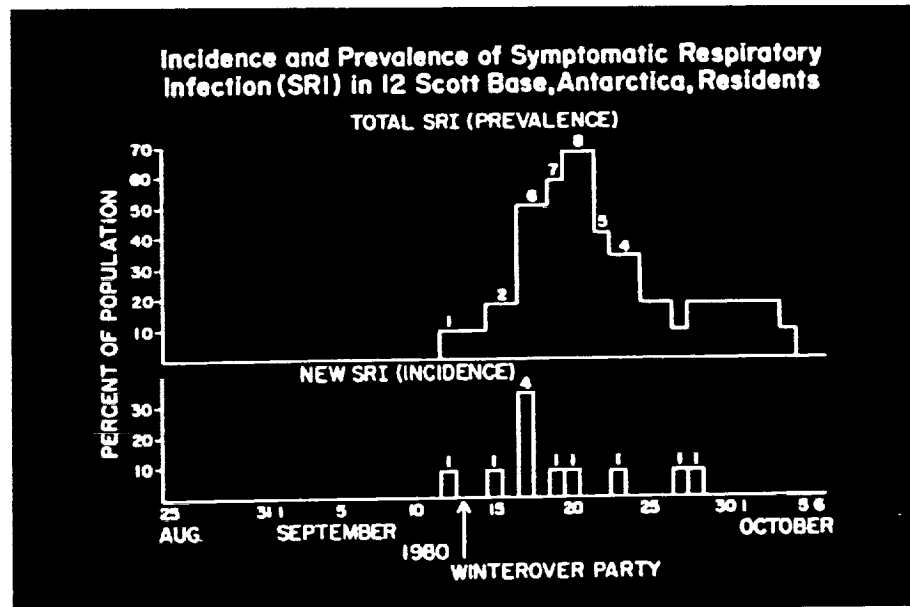
Slide 28 - Incidence and prevalence of respiratory disease in 69 WO 1979 personnel.



Slide 29 - Normal WO epidemic curve (Winfly 1976).



Slide 30 - A sharp outbreak of cold-like illnesses at Scott Base during mid-Winfly.



Slide 31 - Relationship between number of hours... probability of becoming infected.

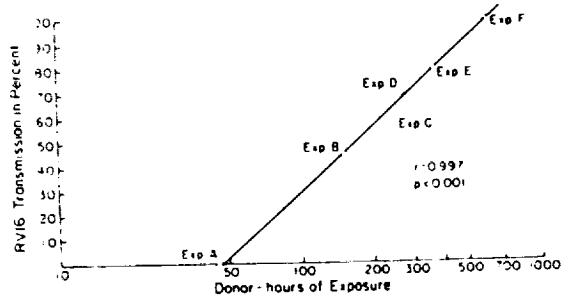
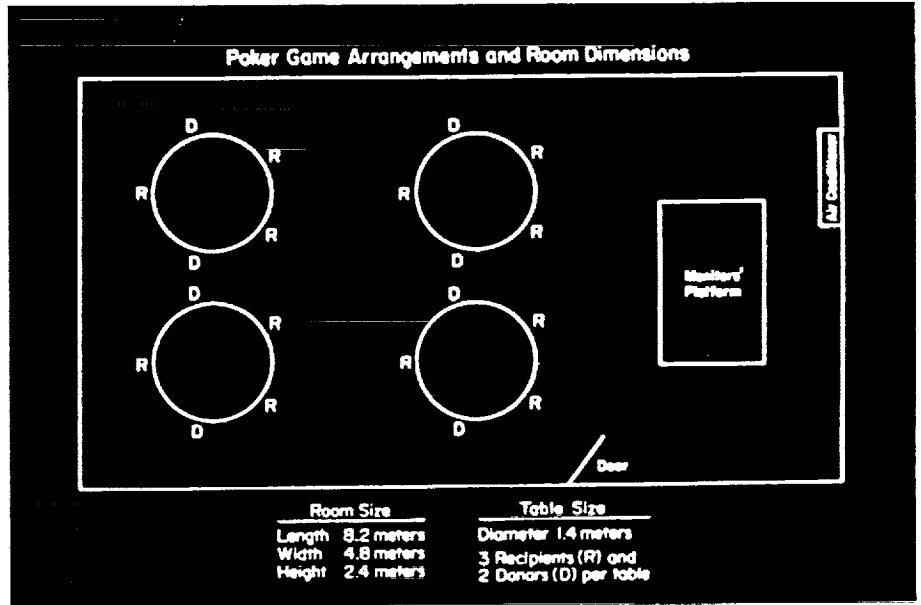


Figure 3. Semi-logarithmic plot of donor hours of exposure vs. transmission of RV16 between artificially infected donors and susceptible recipients.

Slide 32 - The 12-hour poker game (Antarctic Hut) transmission model.

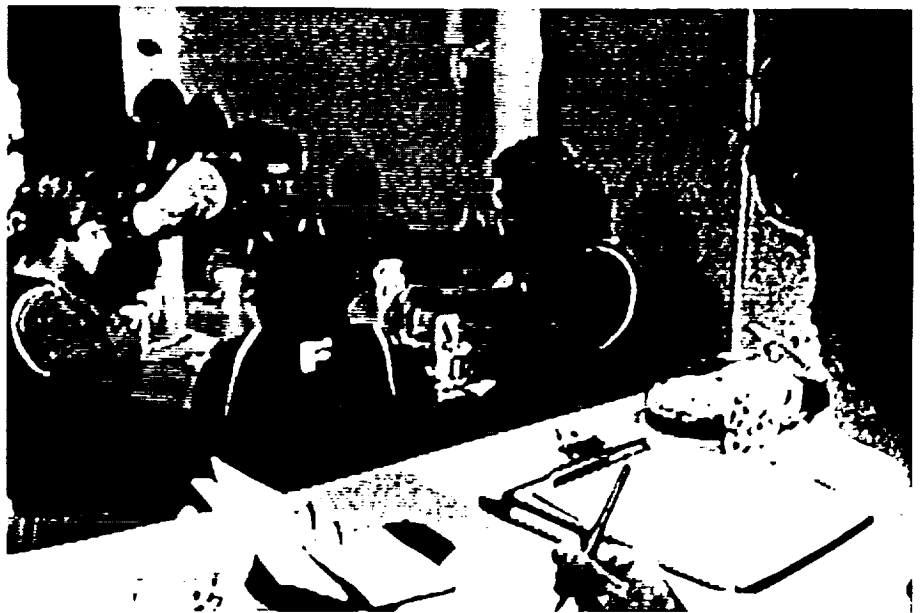


Slides 33 & 34 -

View of the interaction room through the lens of a video camera.



Slide 34 - same as #33



Slide 35 - Complete interruption of RV16 transmissions by a virucidal tissue.

**Interruption of Rhinovirus 16 (RV16) Transmission  
Using Virucidal Facial Tissues (Experimental Model:  
8 Donors and 12 Antibody-Free Recipients Played Poker for 12 Hours)**

	Cotton Handchiefs Exp. A	Virucidal Tissues Exp. B	Exp. C	Cotton Handchiefs Exp. D
Number Recipients Who "Caught" RV16 Colds (%)	5/12 (42)	0/12	0/12	9/12 (75)
<b>Donors' Characteristics</b>				
Mean Virus Shed (TCID <sub>50</sub> )	11,300	8,900	25,500	42,500
Highest Titer Virus Shed	1,000,000	320,000	>3,200,000	1,000,000
Total Coughs	611	679	192	652
Total "Nose Blows"	273	182	278	313
Mean Symptom Score	11.2	10.1	11.0	12.2
Mean Highest Symptom Score	15.2	13.7	13.8	18.9

Slide 36 - Four experiments to determine how RV16 is transmitted.

**Aerosol Transmission of Rhinovirus type 16 Infections Among Poker-playing Male Volunteers**

	Aerosol Transmission Experiments*			Fomite Transmission Experiment*	TOTALS
	A (Collars)	B (Arm Braces)	C	D	
Rate of Transmission Among Control Recipients (%)†					12/18 (67)
Rate of Aerosol Transmission Among Restrained Recipients (%)					10/18 (56)
Rate of Fomite Transmission Among Recipients (%)					0/12 (0)

\*Experiments A-C, donors and recipients in same room. Experiment D, donors and recipients in separate rooms. †Experiments C and D used the same pool of donors. ‡Includes person-to-person, fomite and aerosol transmission.

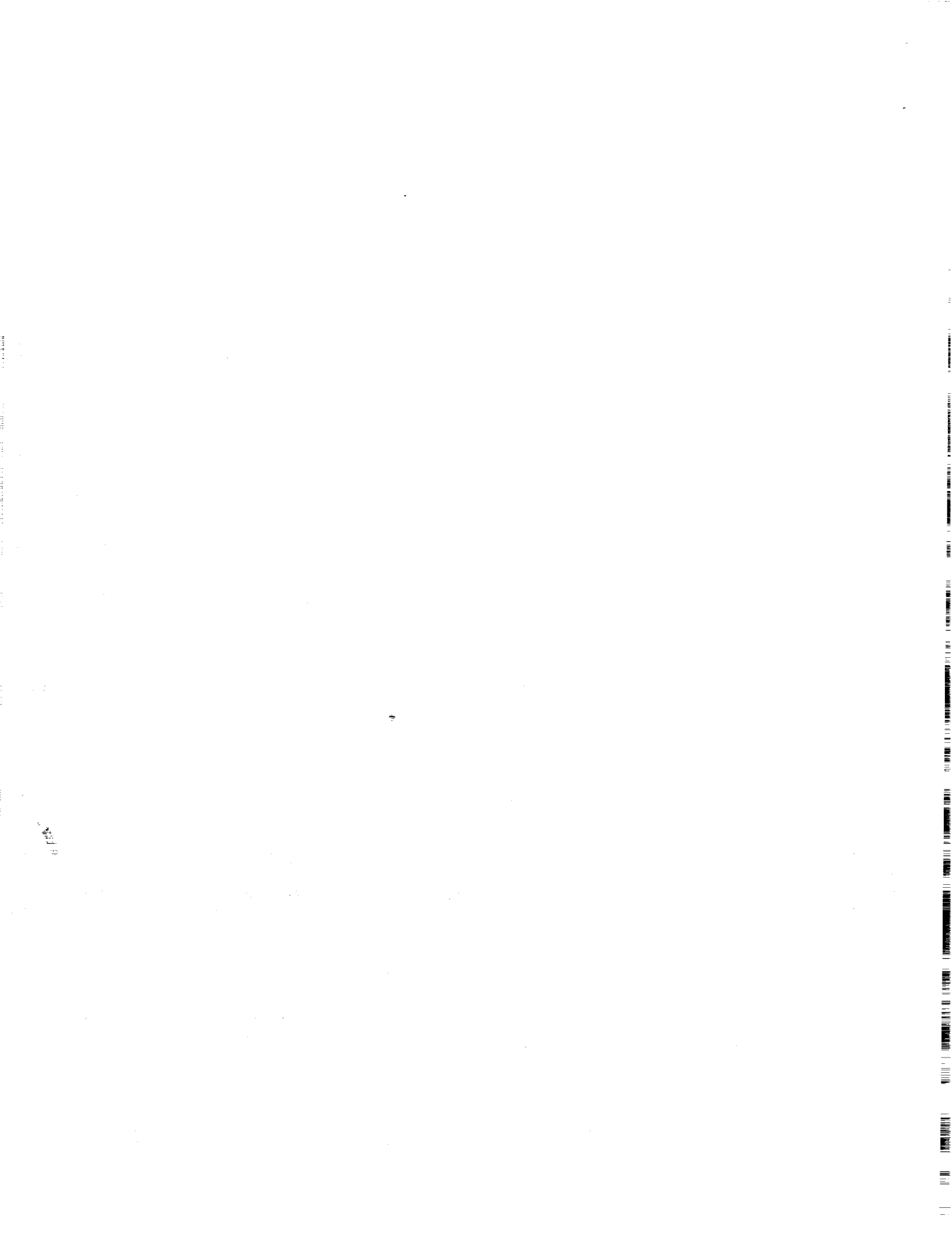
Slide 37 - LANCET editorial  
on our Antarctic  
Hut research.

# THE LANCET

No 8580 BOSTON, MASS AND LONDON SATURDAY FEBRUARY 6 1988 VOL 1 FOR 1988

<b>Management of Venous Thromboembolism</b>	<b>275</b>
<b>Splints Don't Stop Colds— Surprising!</b>	<b>277</b>
<b>Bepridil</b>	<b>278</b>
<b>A Job for Life</b>	<b>279</b>
<b>When Editors Agree</b>	<b>280</b>

**Attachment 4**



## NAVAL MEDICAL TREATMENT FACILITY - MCMURDO

## AUSTRAL SUMMER

Category	82-3	83-4	84-5	85-6	86-7	87-8	88-9	89-90
Patient Visits	2795	2321	2040	2431	2582	2821	2498	2997
Lab Procedures	1553	949	1621	1254	921	2895	627	763
Radiographs	666	645	535	632	551	925	539	613
Prescriptions	2655	1171	1303	1538	2520	1766	2509	2213
Minor Surgery	-	29	22	28	0	58	36	26
Accident/Injury	261	246	-	241	360	261	299	237
Ethanol Related	21	16	-	19	18	15	19	15
Cold Injury	-	10	6	7	9	4	2	2
MVA Related	-	-	-	2	5	16	2	1
Ward Admissions	66	11	13	20	17	18	18	35
Sick Days	-	-	-	186	234	473	258	213
Medevacs	16	18	20	14	16	6	12	12
Consultations	-	-	-	22	23	17	7	29
Fatalities	1	0	0	1	2	3	1	0
Dental Visits	733	558	449	638	-	444	500	618
Dental Procedure	2747	3586	3555	4568	-	2974	2868	3621
WINFLY Start	8/23	8/26	8/22	8/22	8/20	8/26	8/22	8/22
Mainbody								
Opening	10/5	10/3	10/3	10/4	10/1	10/4	10/4	10/3
Closeout	2/23	2/19	2/20	2/28	2/25	2/27	2/25	2/26
Mainbody Season								
Length	141	139	140	147	147	146	144	146

MCMURDO - EIGHT YEAR SUMMER EXPERIENCE (1982-90)

ACCIDENT RELATED MEDEVACS/CONSULTATIONS	98
NON-ACCIDENT RELATED MEDEVACS/CONSULTATIONS	115



MCMURDO - EIGHT YEAR SUMMER EXPERIENCE (1982-90)

ACCIDENT RELATED MEDEVACS/CONSULTATIONS

Fractures/Dislocations	30
Knee Ligament Sprains/Meniscal Injuries	13
Low Back Pain/HNP	11
Hand Trauma (non-fracture)	11
Other Sprains/Strains/Arthralgias	9
Burns	5
Multiple Trauma	4
Ocular Trauma	4
Dental Trauma	4
Frostbite	3
Perforated TM	2
Head Injury	1
Soft Tissue Trauma	1
Total Accident Related	98

MCMURDO - EIGHT YEAR SUMMER EXPERIENCE (1982-90)

NON-ACCIDENT RELATED MEDEVACS/CONSULTATIONS

Abdominal	20
Pregnancy	20
Genitourinary/Gynecologic	18
Cardiologic	12
Hernia	10
Neurologic	9
ENT	5
Psychiatric	5
Dermatology	3
Dental (non-trauma)	2
Miscellaneous	11
Total	115

Abdominal	20	
Acute Abdomen/Abdominal Pain		11
Gallstones		2
Small Bowel Obstruction		2
GI Bleeding		2
Hepatitis		1
Hemorrhoids		1
GE Reflux		1
Hernia	10	

Pregnancy	20	
Uncomplicated		18
Complicated		2
Genitourinary/Gynecologic	18	
GU misc		8
Nephrolithiasis		6
GYN misc		4

Cardiologic	12	
Chest Pain/AMI		9
Arrhythmias		3
Neurologic	9	
Neuropathy/Radiculopathy		3
TIA		2
Migraine/Cluster		2
Vertigo		1
Seizures		1
Psychiatric	5	
Depression		3
Suicidal Ideation/Gestures		2

ENT		5	
	r/o Oral CA		1
	Laryngitis		1
	Peritonsillar Abscess		1
	Sinus Mass		1
	Nasal Polyposis		1
Dermatology		3	
Dental (non-trauma)		2	

Miscellaneous

11

Hypertension	2
Pulmonary	2
Rheumatoid Arthritis	1
Chalazion	1
Weight Loss	1
Digitalis Toxicity	1
Claudication	1
Leukocytosis	1
New Onset Diabetes Mellitus	1

## Physical Screening Process for Summer Participants

- (1) Complete History and Physical
- (2) Dental Exam with Bite Wings
- (3) CBC, UA, RPR
- (4) Blood Type and Rh Factor
- (5) CXR PA & Lateral (every 5 years)
- (6) ECG 12-lead (baseline, annually after age 40)
- (7) Lipid Panel (annually over age 35)
- (8) Intraocular Pressure (annually over age 40)
- (9) PAP Smear (annually for women)
- (10) Chemistry Panel (if on diuretics)



Physical Screening Process for Winter Participants

- (1) All the above
- (2) Psychiatric evaluation
- (3) HIV Screen

MCMURDO MEDICAL CAPABILITIES - LABORATORY

- Hematology - CBC, Reticulocyte Count
  - Sed Rate
  - Type & Cross
  - Direct Coomb's
  - PT, PTT
- Chemistry - Electrolytes, BUN, Creatinine
  - Ca, Mg, P
  - AST, ALT, CK, LDH, Alk Phos, TBR
  - Amylase, Uric Acid
  - Theophylline
- Urine - UA with microscopic
  - Acetones
  - HCG
- Serology - RPR
  - Rheumatoid Factor
  - Monospot
  - Rapid HIV
- Micro - Aerobic & Anaerobic bacterial C&S
  - Gram Stain, KOH

MCMURDO MEDICAL CAPABILITIES

- Radiology - All routine radiographs  
IVP
- Surgery - OR with standard major/minor  
instrument trays
- Monitors - ECG 12-lead  
ECG Monitors/Defibrillators  
Pulse Oximeter
- Dental - Fully equipped operator
- Misc - 2 person hyperbaric chamber

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# **Attachment 5**



**ANTARCTICA AND SPACE**

Albert A. Harrison

Department of Psychology

University of California - Davis

Davis, California 95616

## **THE HUMAN EXPERIENCE IN ANTARCTICA**

**Involve Operational Personnel and Researchers**

**Apply Contemporary Theories and Methods**

**Build Support for "ICE" Research**



## **CONFERENCE COVERAGE**

**Settings**

**Orientations and Perspectives**

**Isolation and Confinement Effects**

**Interventions and Outcomes**

**Conference Reports**

## SOURCES OF VARIABILITY

$$B = f(p, e)$$

Personality Moderators

Dimensions of Complex Environments

Station Culture

Environmental Variability Over Time

Factor Analytic Studies

## STATES OF CONSCIOUSNESS

Sleep

Hypnotic Susceptibility

Absorption: Imperviousness to Distraction

Imaginative Involvement: Creativity and Fantasy

Task Moderators

Automaticity or Mindlessness: Mental Cruise Control

## STRESS

Historical Determinants (LSQ)

Chronic Environmental Factors - Isolation, Confinement

Acute Situational Factors - Weather, Workload, Events

Personality Moderators and the Experience of Stress

Objective Stress Control Mechanisms ("Threat Control")

Subjective Stress Control Mechanisms ("Fear Control")

Training Programs

## **AUTOMATION**

Perceived Control: Who (What's) In Charge Here?

Allocation of Tasks to Persons and Machines

Transparency

Trust and "Reality Checks"

Manual Override

Skill Degredation

## **SOCIAL DYNAMICS**

Cultural Variability

Crew Coordination - Cockpit Resource Management

Group Decisions: "Groupthink" and Extremity Shifts

Intergroup Conflict and "Microaggressions"

Informal Conflict Resolution Mechanisms

Justice Systems

Intergroup Relations

## **TELECOMMUNICATION**

Communication Nets

Telemedia Effects

Communication Delays

Intergroup Conflict

Telescience

Telemedicine

## **RESEARCH STRATEGIES**

**Focus on Moderating Variables**

**Longitudinal Research**

**Long Term Follow-Up**

**Multivariate/Cross-Lagged Analysis**

**Neurometric Measures**

**Use of PCs for Data Collection**

**Telemetry**



## **ANTARCTIC/SPACE ANALOGUES**

Surface Ships ("ENDEAVOR 1,000")

Nuclear Submarines

The NOAA Habitat "Aquarius"

Biosphere II

Balloon Circumnavigations

Remote National Parks

## **RECOMMENDATIONS FOR AGENCIES**

**Clear Research Priorities**  
**Regular, Sustained Funding**  
**Realistic Time Lines**  
**Continuing Dialogs**  
**Interagency Cooperation**

## RECOMMENDATIONS FOR P.I.'S

Exude Competence

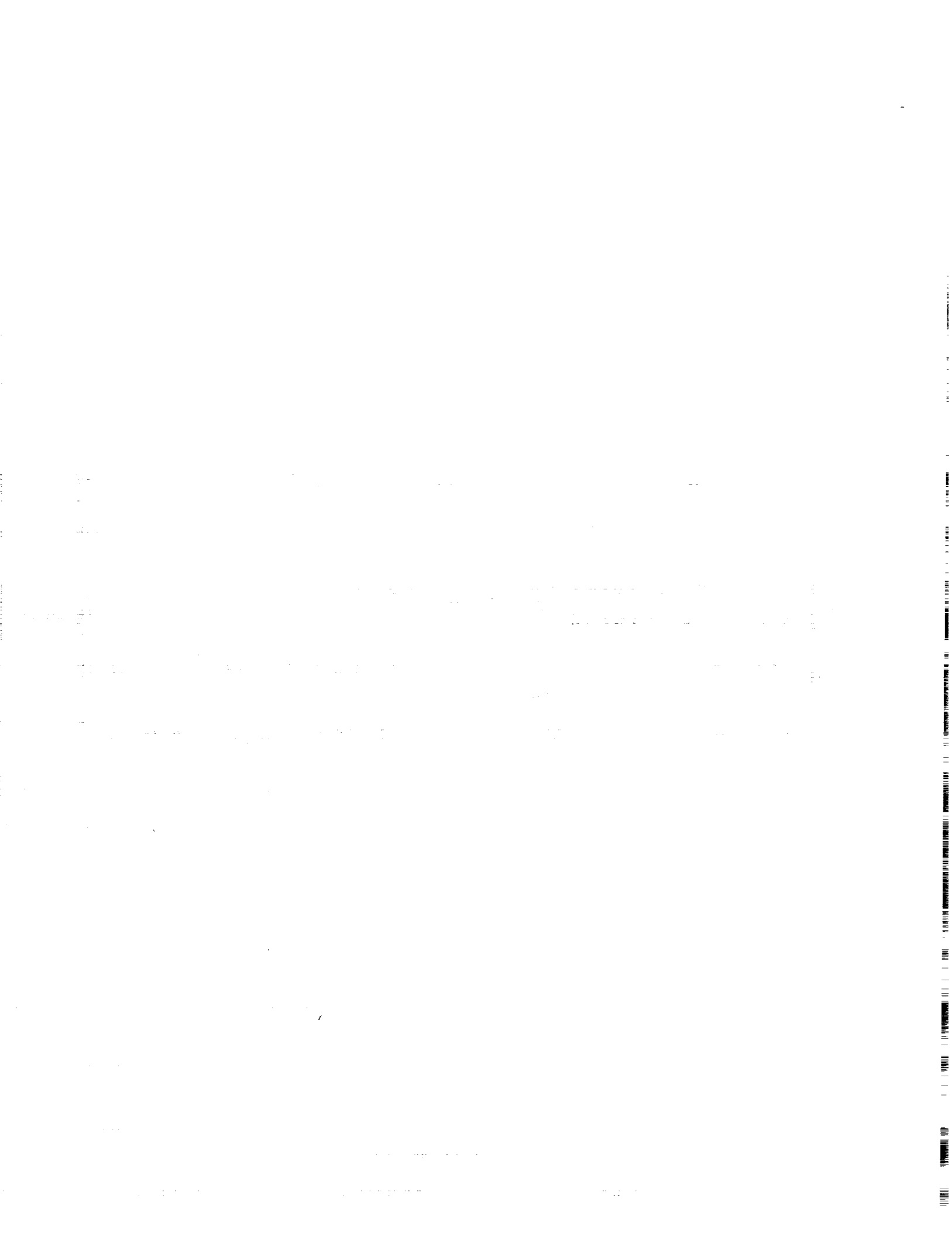
Join the Team

Avoid Penalizing Participants

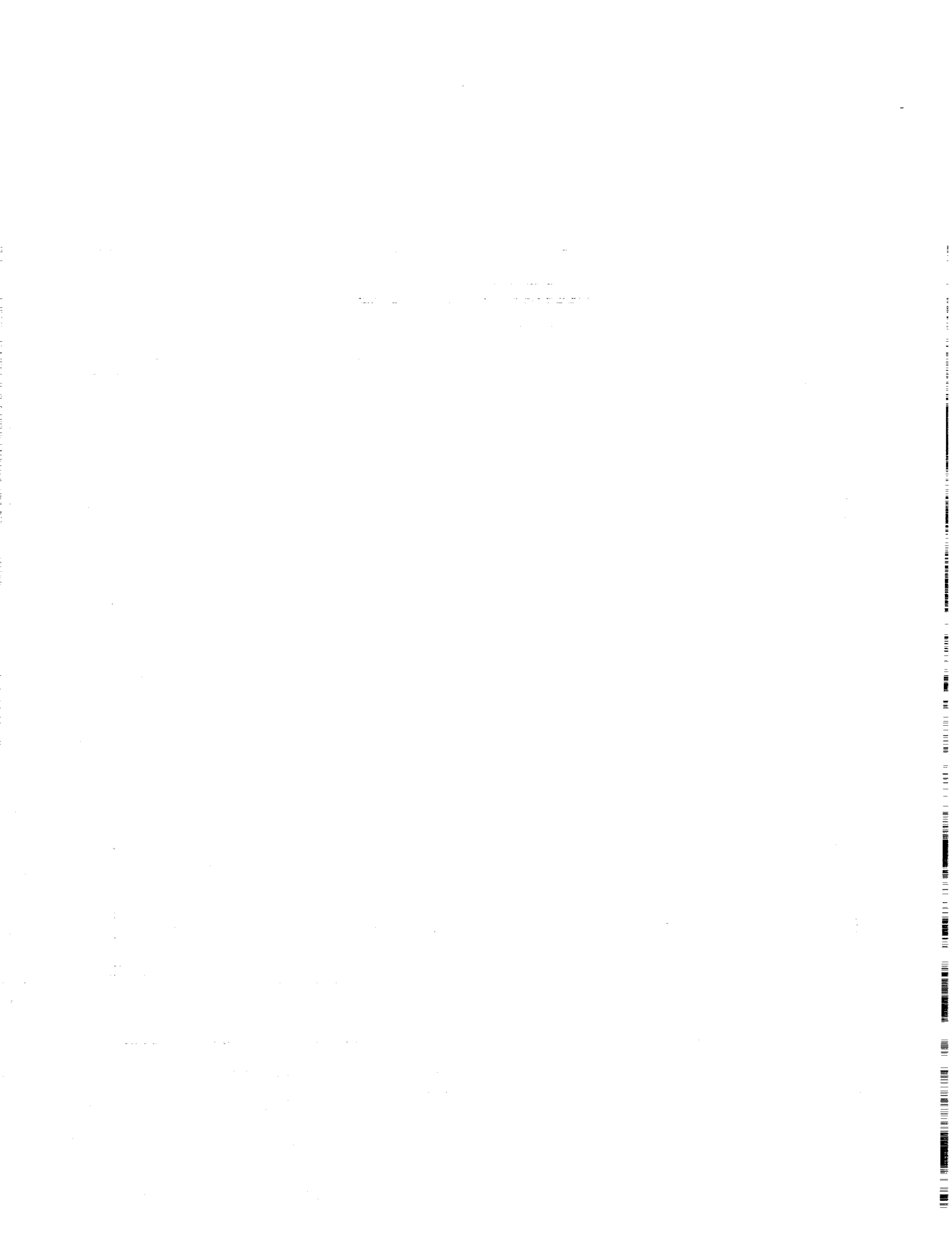
Attend to Ethics

Promote Information Dissemination and Utilization

Cultivate Newcomers

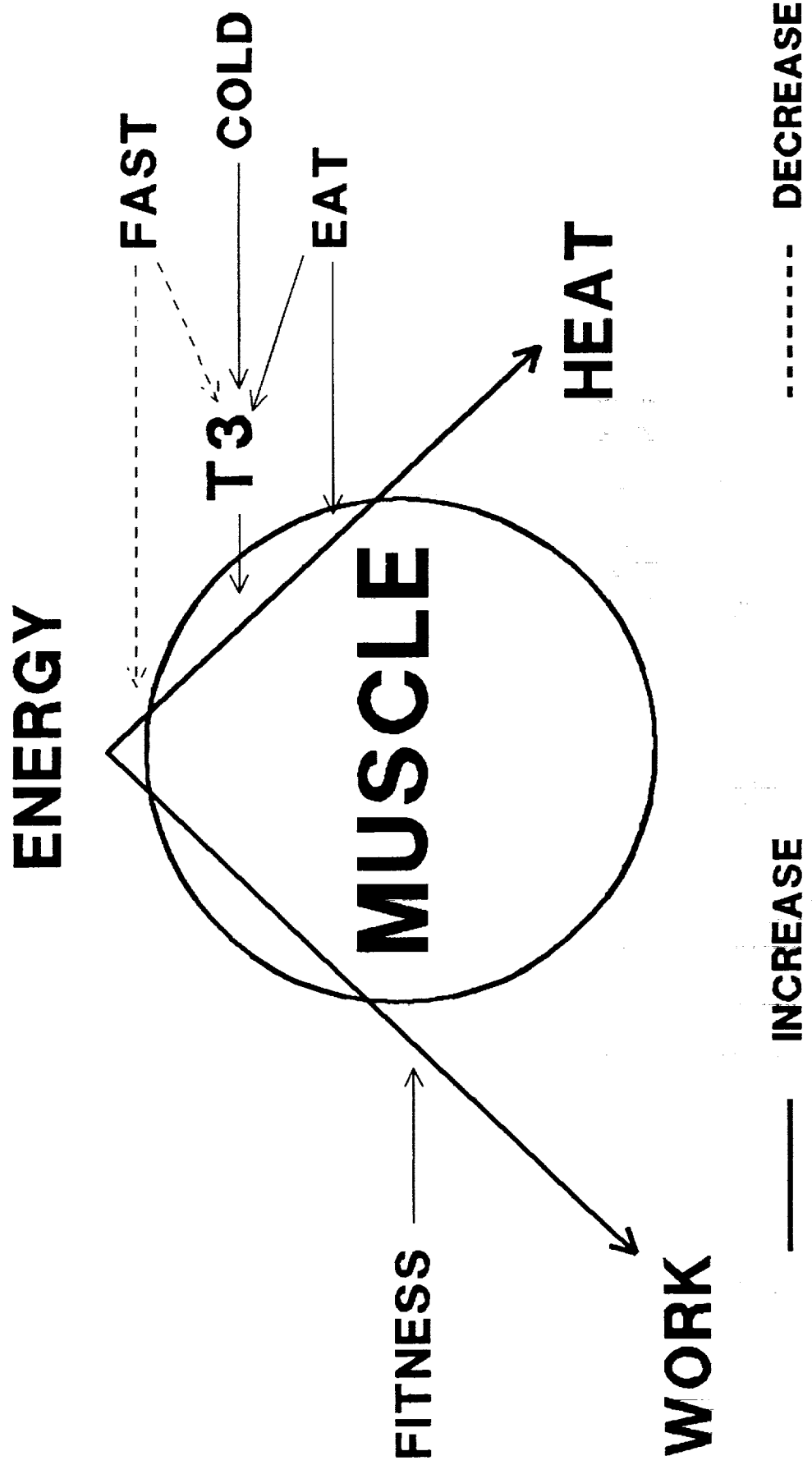


# **Attachment 6**



**ALTERATIONS IN THYROID  
HORMONE METABOLISM  
WITH  
PROLONGED ANTARCTIC  
RESIDENCE**

# ENERGY DISPOSITION





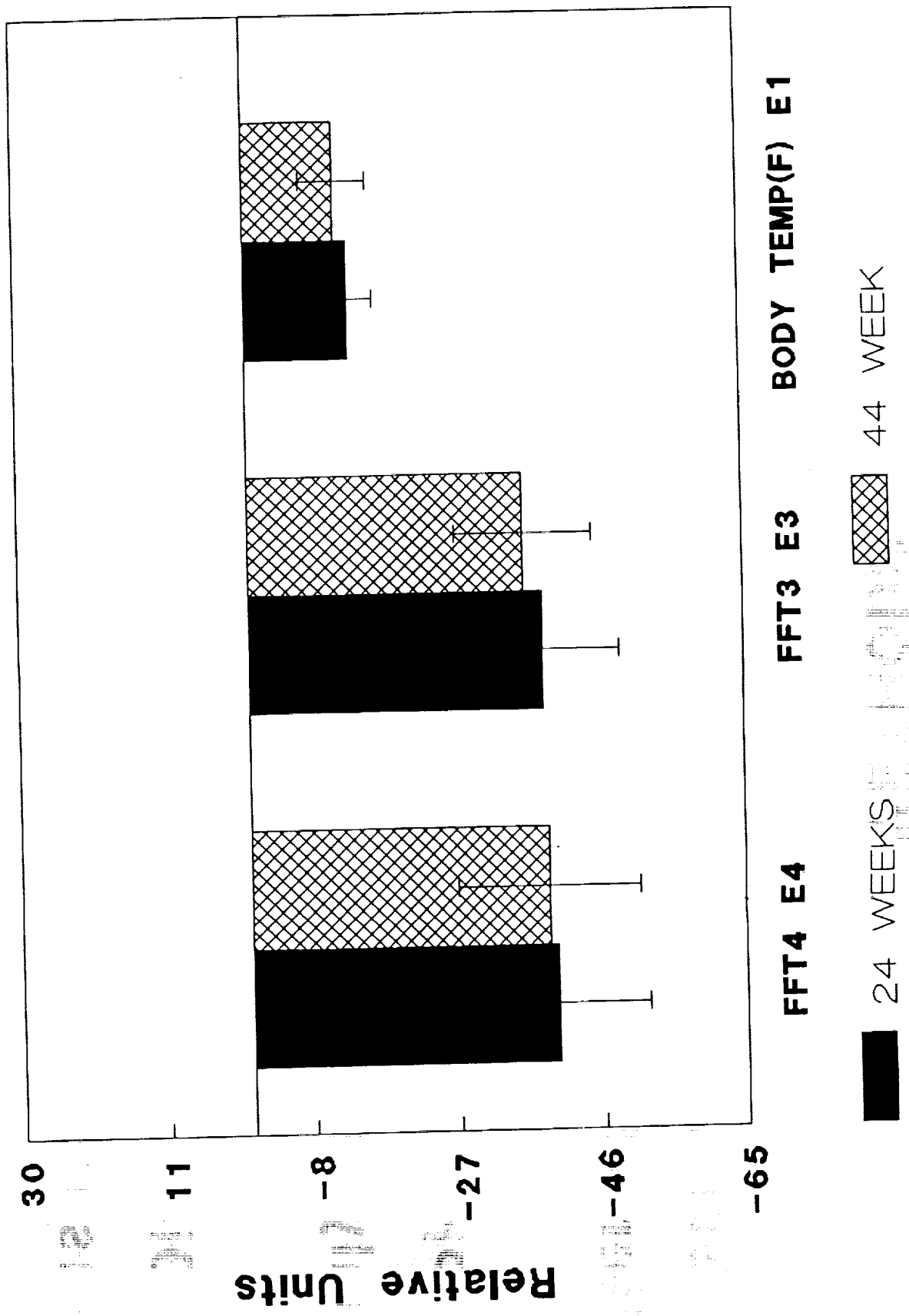
## **METHODS**

- **Subjects Studied Before And After 4(Jan) and 11(Aug) Months AR**

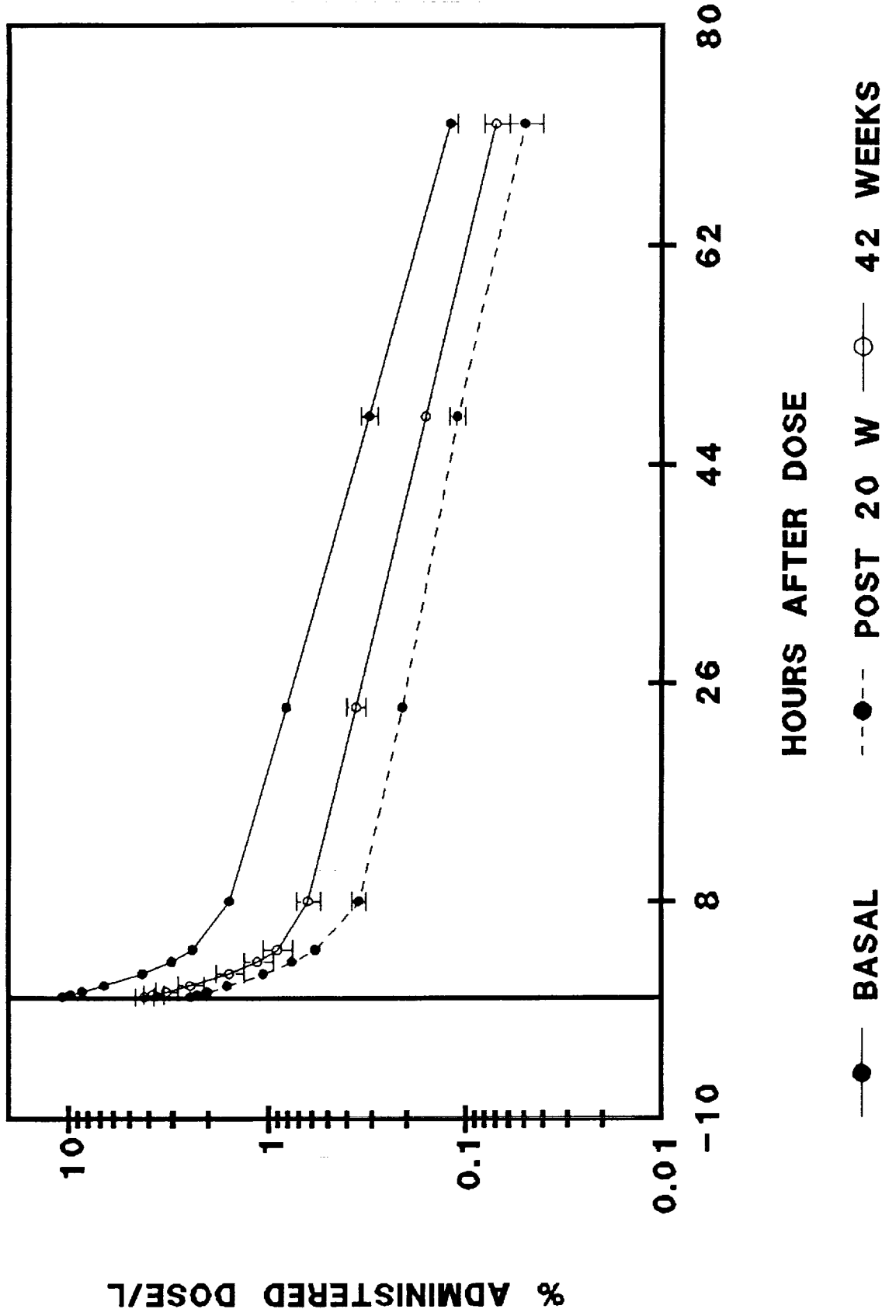
- **Photoperiod Control and Paired Analysis**

- **Diet, Activity, Exposure And Weight Measured**

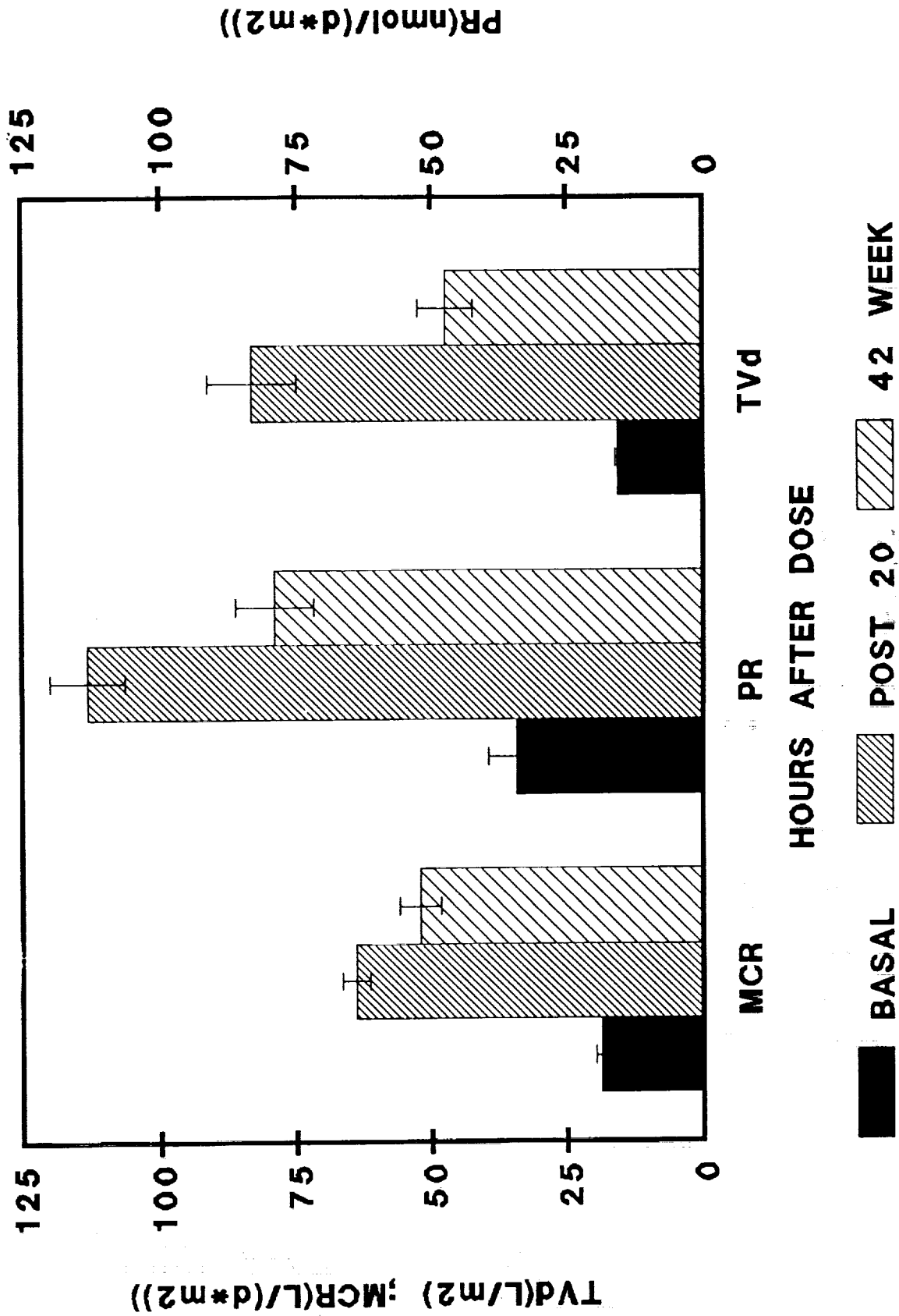
# CHANGES IN THE FREE FRACTION OF THYROID HORMONES AND BODY TEMPERATURE



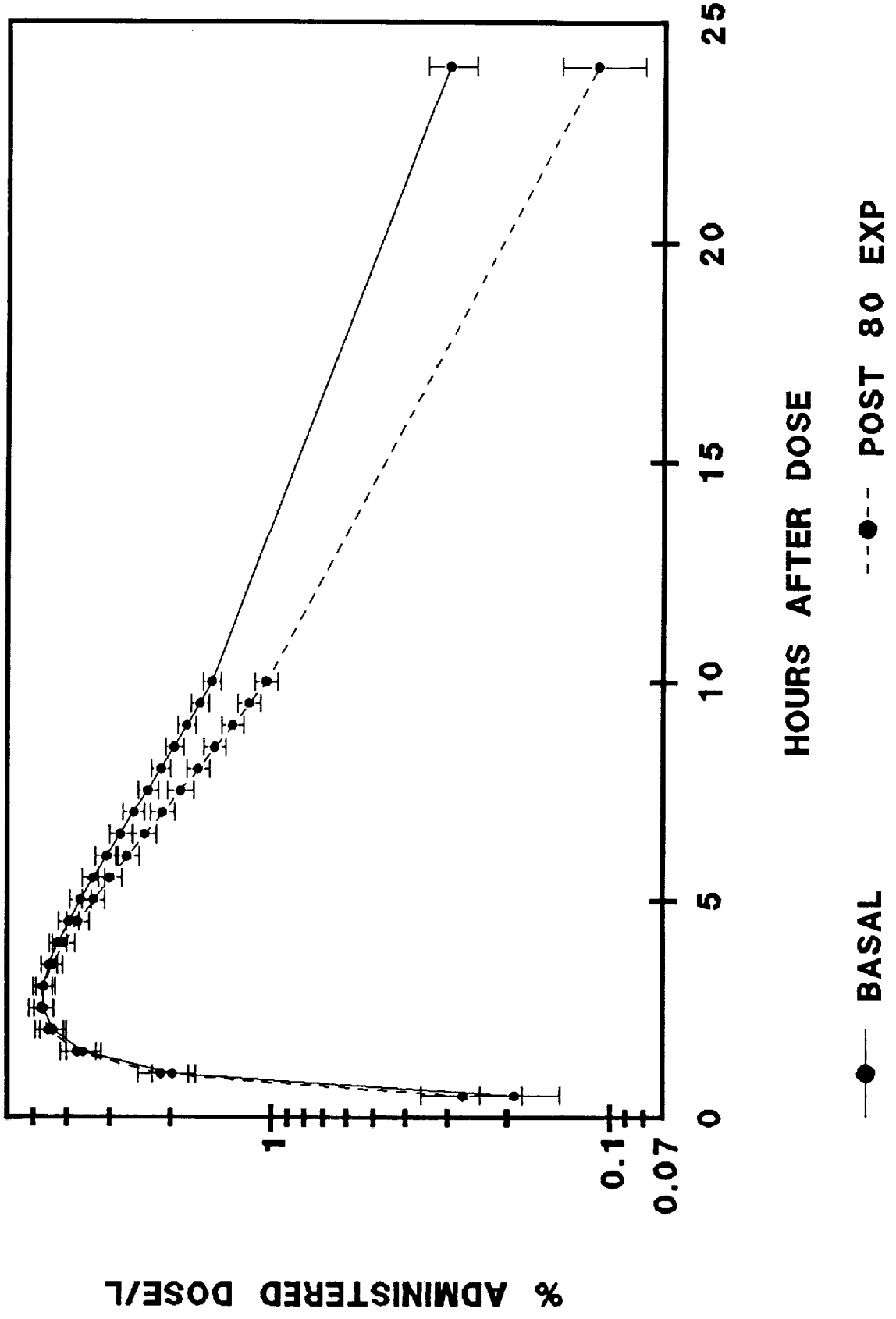
# T3 CLEARANCE WITH ANTARCTIC RESIDENCE



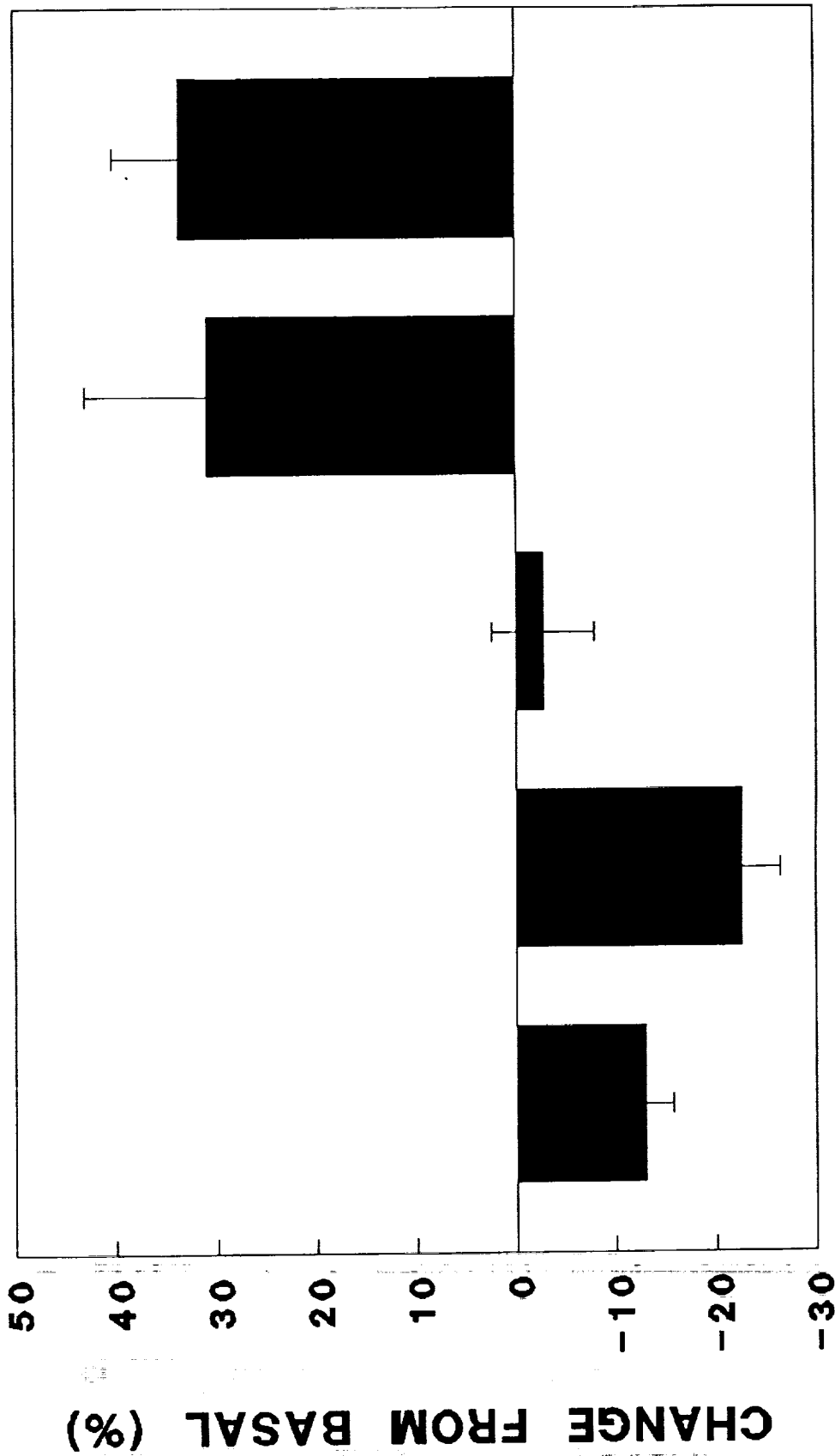
# T3 KINETIC PARAMETERS WITH ANTARCTIC RESIDENCE



# T3 CLEARANCE BEFORE & AFTER 80 COLD EXPOSURES

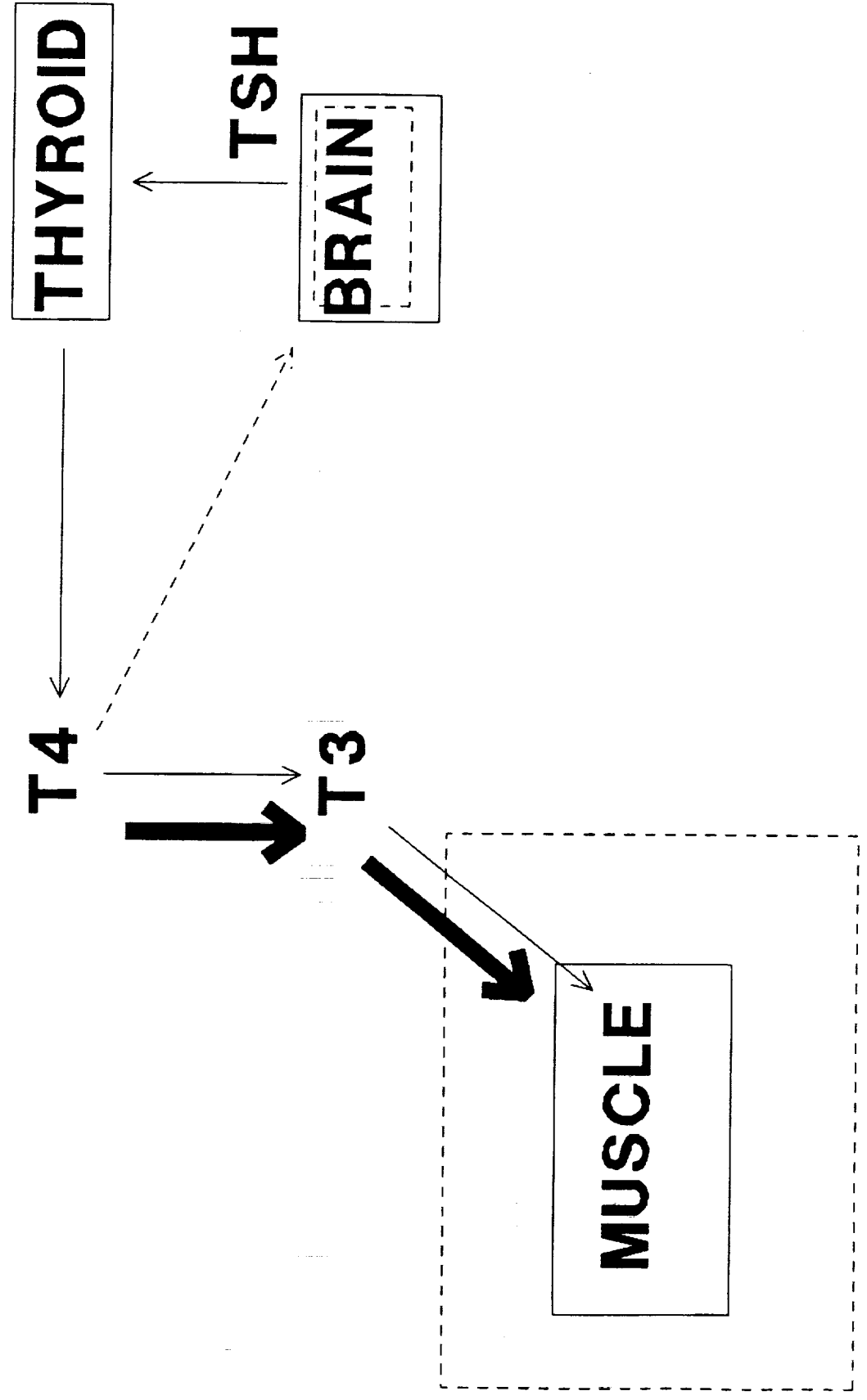


# CHANGES IN THYROID ECONOMY WITH ARCTIC CONDITIONS



TT3 FT3 TBG MCR TVd  
SERUM THYROID HORMONE PARAMETERS

# CHANGES IN T3 KINETICS WITH COLD



## **SUMMARY**

- **Polar Residence Doubles T3 Distribution and Production**
- **Brain Content of T4 and T3 May Be Decreased With Polar Residence**
- **T3 Kinetics Change With Season, Cold Chamber, and In Cold Exposed Swine**



# **Attachment 7**



N 9 3 - 1 6 8 0 1

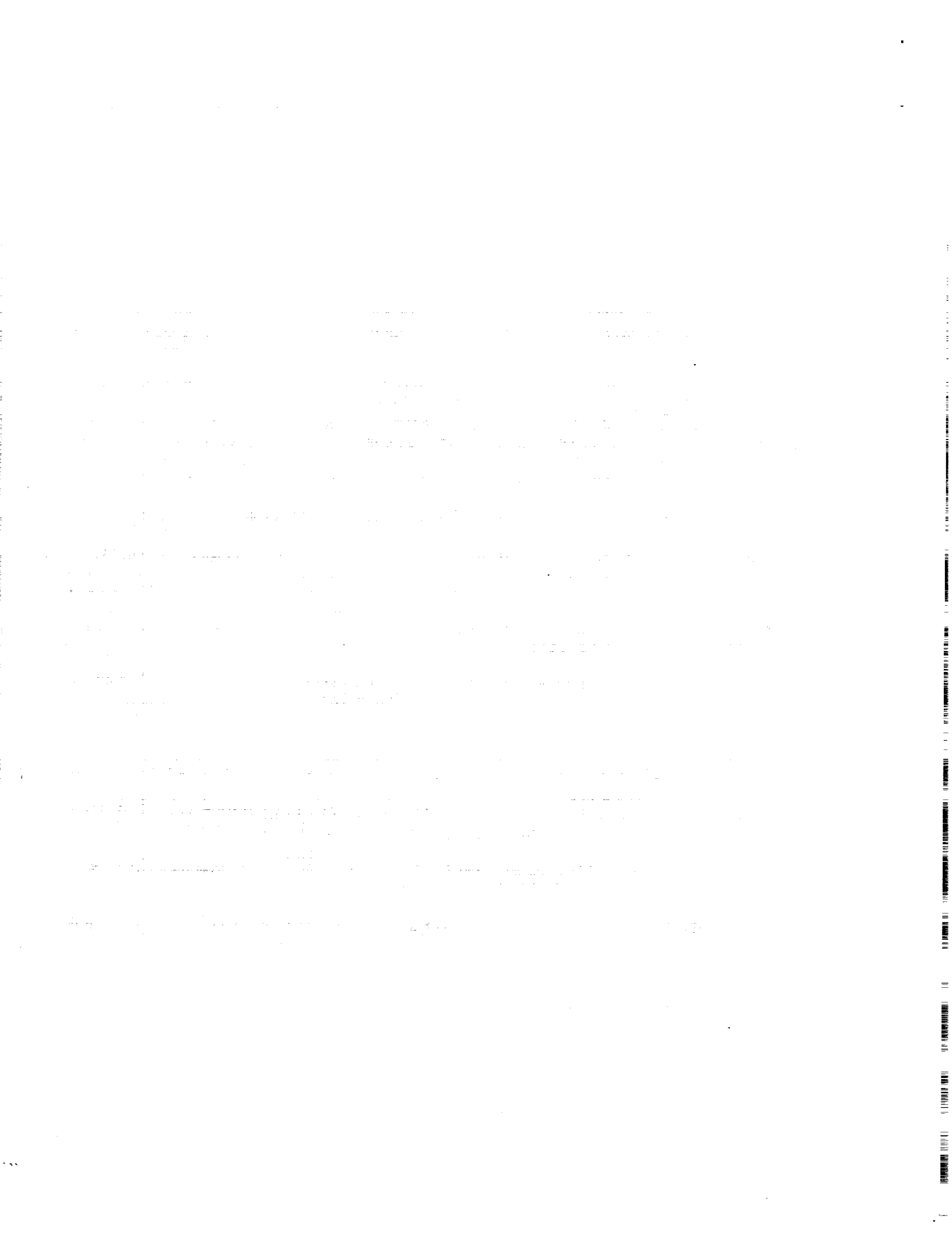
*Summary of Presentation for Research on  
Social Structure, Agreement, and Conflict in Groups in  
Extreme and Isolated Environments*

Despite a vast amount of research, little is known concerning the effect of group structure, and individuals' understanding of that structure, on conflict in Antarctic groups. The overall objective of the research discussed is to determine the interrelationships of group structure, social cognition, and group function and conflict in isolated and extreme environments.

In the two decades following WWII, a large body of research focused on the physiological, psychological, and social psychological factors affecting the functioning of individuals and groups in a variety of extreme and isolated environments in both the Arctic and Antarctic. There are two primary reasons for further research of this type. First, Antarctic polar stations are considered to be natural laboratories for the social and behavioral sciences and provide an opportunity to address certain theoretical and empirical questions concerned with agreement and conflict in social groups in general and group behavior in extreme, isolated environments in particular. Recent advances in the analysis of social networks and intracultural variation have improved the methods and have shifted the theoretical questions. The research is motivated by three classes of questions: 1) What are the characteristics of the social relations among individuals working and living together in extreme and isolated environments?, 2) What do individuals understand about their group, how does that understanding develop, and how is it socially distributed?, and 3) What is the relationship between that understanding and the functioning of the social group? Answers to these questions are important if we are to advance our knowledge of how individuals and groups adapt to extreme environments.

Second, although Antarctic winter-over candidates may be evaluated as qualified on the basis of individual characteristics, they may fail to adapt because of certain characteristics of the social group. Consequently, the ability of winter-over groups to adapt to these extreme conditions has varied dramatically from year to year. In the past, differences in personality, background, and social status have led to conflicts between individuals or cliques precipitating, in turn, an overall decline in morale, failure to accomplish work tasks, and increases in insomnia, depression, anxiety, and alcohol abuse. A better understanding of the role of group structure and social cognition in processes of group adaptation and conflict in Antarctica would contribute towards the revision of existing screening methods, potentially leading to a reduction of group conflict and improved performance of scientific research and support activities. An improved screening protocol for the Antarctic would also have applications for other isolated environments such as scientific outposts and the proposed NASA space station.

In sum, this research will (1) contribute significantly to our theoretical understanding of the role of social structure and cognition in the functioning of groups in isolation, (2) complement current work on health and adaptation in polar environments, and (3) provide for models of the formation of group structure that will aid in the development of improved procedures for assembling groups for the Antarctic and other isolated environments (e.g., space stations).



# **Attachment 8**



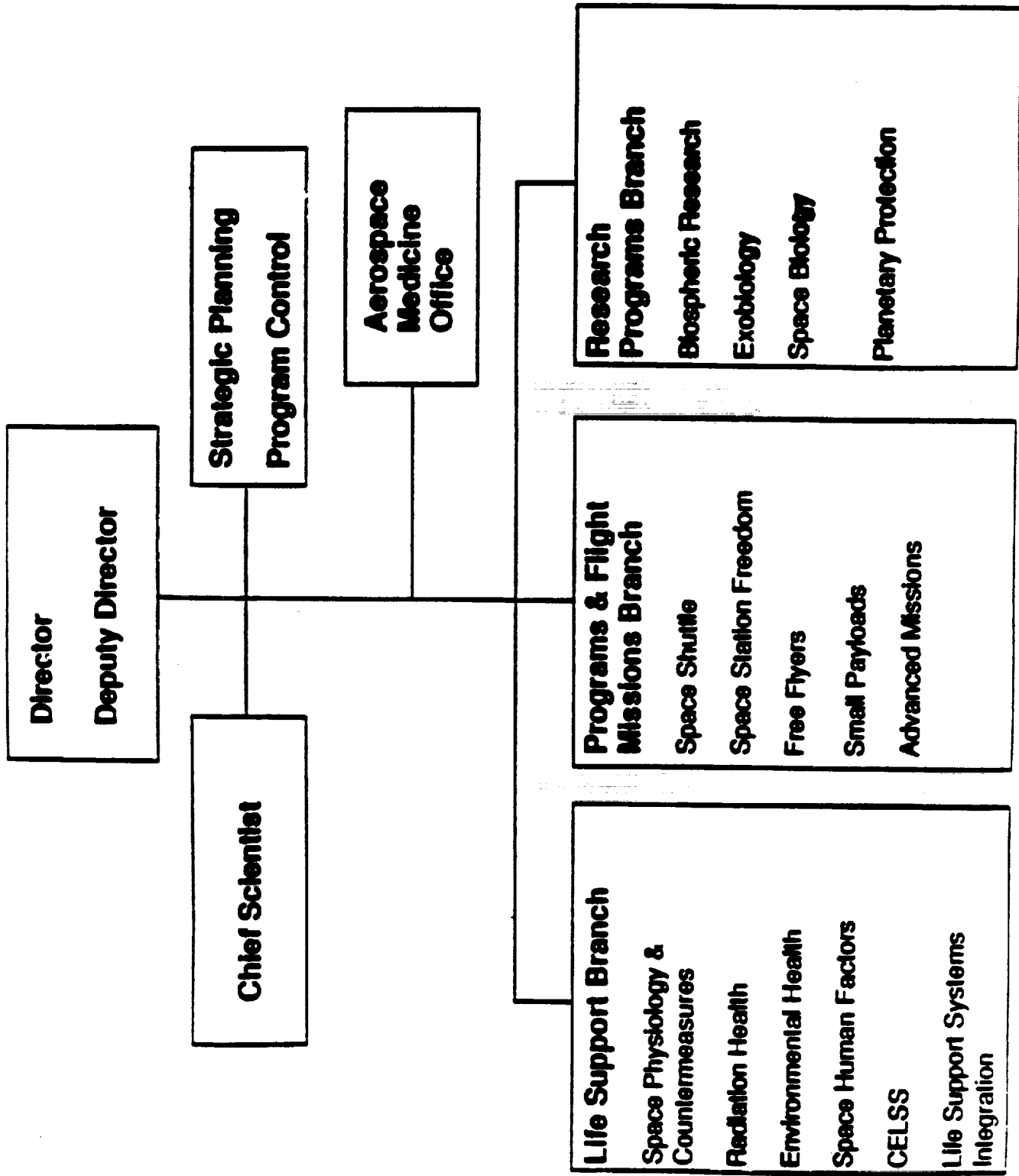
# NASA/NSF Antarctic Science Working Group

NSF - 16802

Dr. Janis H. Stoklosa  
Program Manager  
October 11-12, 1990  
Washington, D.C.



# Life Sciences Division Organization





## **Tentative Schedule for Space Exploration\***

---

<b>Space Station</b>	<b>1997-2003</b>
<b>Humans Return to the Moon</b>	<b>2004</b>
<b>Lunar Presence</b>	<b>2005</b>
<b>Lunar Habitat</b>	<b>2007-2009</b>
<b>Humans Land on Mars</b>	<b>2018</b>

\* Schedule currently under scrutiny by various outside Advisory Committees

## **Biomedical Programs**

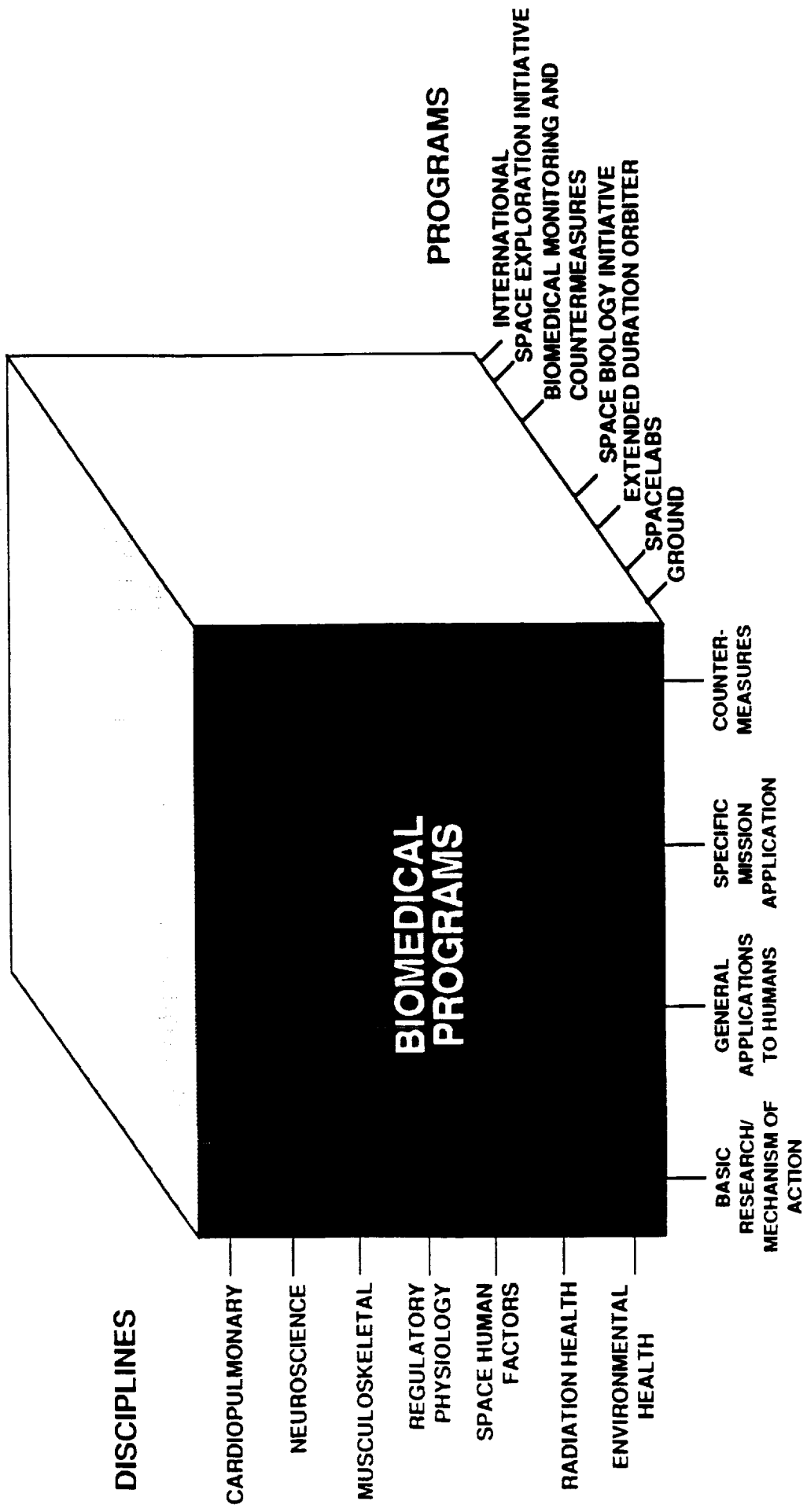
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### **Goals**

- **Develop an understanding of the physiological, psychological and behavioral adaptation to space**
- **Ensure the health, well-being, and performance of humans in space and on return to Earth's gravity**
- **Promote the application of biomedical research to improve the quality of life on Earth**

### **Objectives**

- **Determine the acute and long-term physiological and behavioral adaptation to space**
- **Determine the psychological and sociological implications of space flight**
- **Determine the crew performance and mission consequences of the physiological, psychological and behavioral adaptation to space**
- **Develop adequate monitoring techniques and countermeasures**
- **Verify adequate models and/or analogs for space**



**DISCIPLINES**

- CARDIOPULMONARY
- NEUROSCIENCE
- MUSCULOSKELETAL
- REGULATORY PHYSIOLOGY
- SPACE HUMAN FACTORS
- RADIATION HEALTH ENVIRONMENTAL HEALTH

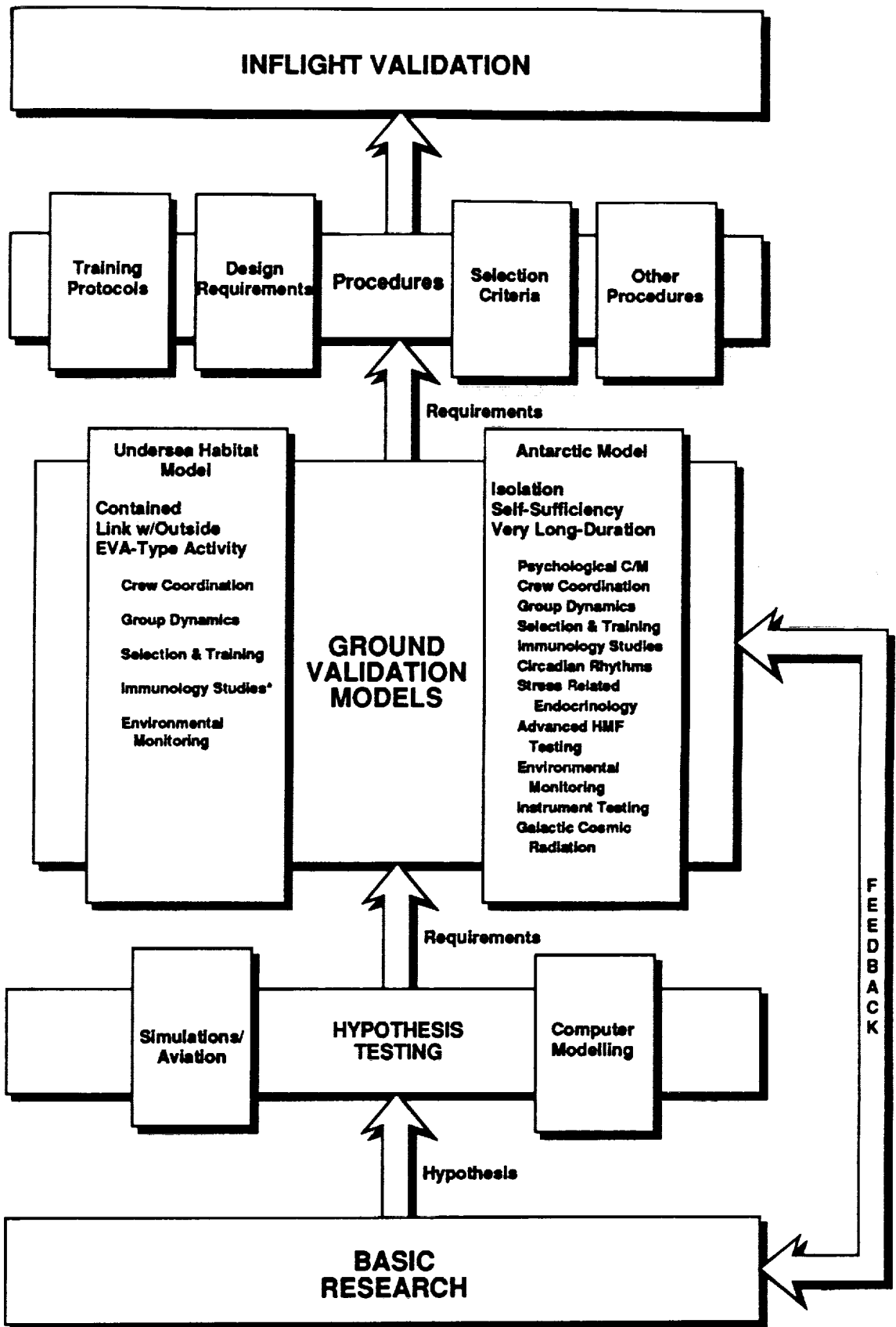
**BIOMEDICAL PROGRAMS**

- BASIC RESEARCH/ MECHANISM OF ACTION
- GENERAL APPLICATIONS TO HUMANS
- SPECIFIC MISSION APPLICATION
- COUNTER-MEASURES

**RESEARCH ELEMENTS**

**PROGRAMS**

- INTERNATIONAL SPACE EXPLORATION INITIATIVE
- BIOMEDICAL MONITORING AND COUNTERMEASURES
- SPACE BIOLOGY INITIATIVE
- EXTENDED DURATION ORBITER
- SPACECELABS GROUND



\* If longer than 2 weeks

# **Justification for Using the Antarctic as an Analog**

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## **• Similarities Between Extended Duration Space Missions and Antarctica Conditions**

- Long Duration**
- Extreme Environments**
- Isolated Location**
- Delayed Communications**
- Confinement**
- Small Group Dynamics**
- Diverse skill mix**
- Various Nationalities**

# NASA Proposed Biomedical Research in the Antarctic

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## Goal

- To use the Antarctic as an analog for space exploration to study human behavior and performance, physiology under stress, and environmental health.

## Areas of Research Interest

- Space Human Factors
- Human Physiology
- Environmental Health

## **NASA Proposed Biomedical Research in the Antarctic (Continued)**

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- **Space Human Factors**
  - **Crew Selection and Training**
  - **Isolation**
  - **Psychological Support/Countermeasures**
  - **Human-Machine Interactions**
  - **Work Station/Habitability Requirements**
  - **Workload**
  - **Small Group Dynamics**
  - **Command and Control Structure**
  - **Crew Composition: Gender, Nationality, Skill Mix**
  
- **Human Physiology**
  - **Stress-Related Endocrinology/Immunity issues**
  - **Circadian Rhythms and Sleep Disorders**
  - **Sedentary Issues Related to General Fitness/Motivational Aspects of Exercise**
  
- **Environmental Health**
  - **Microbiology and Toxicology Issues**
  - **Epidemiology of Infectious Diseases**

# Science Working Group Schedule of Events

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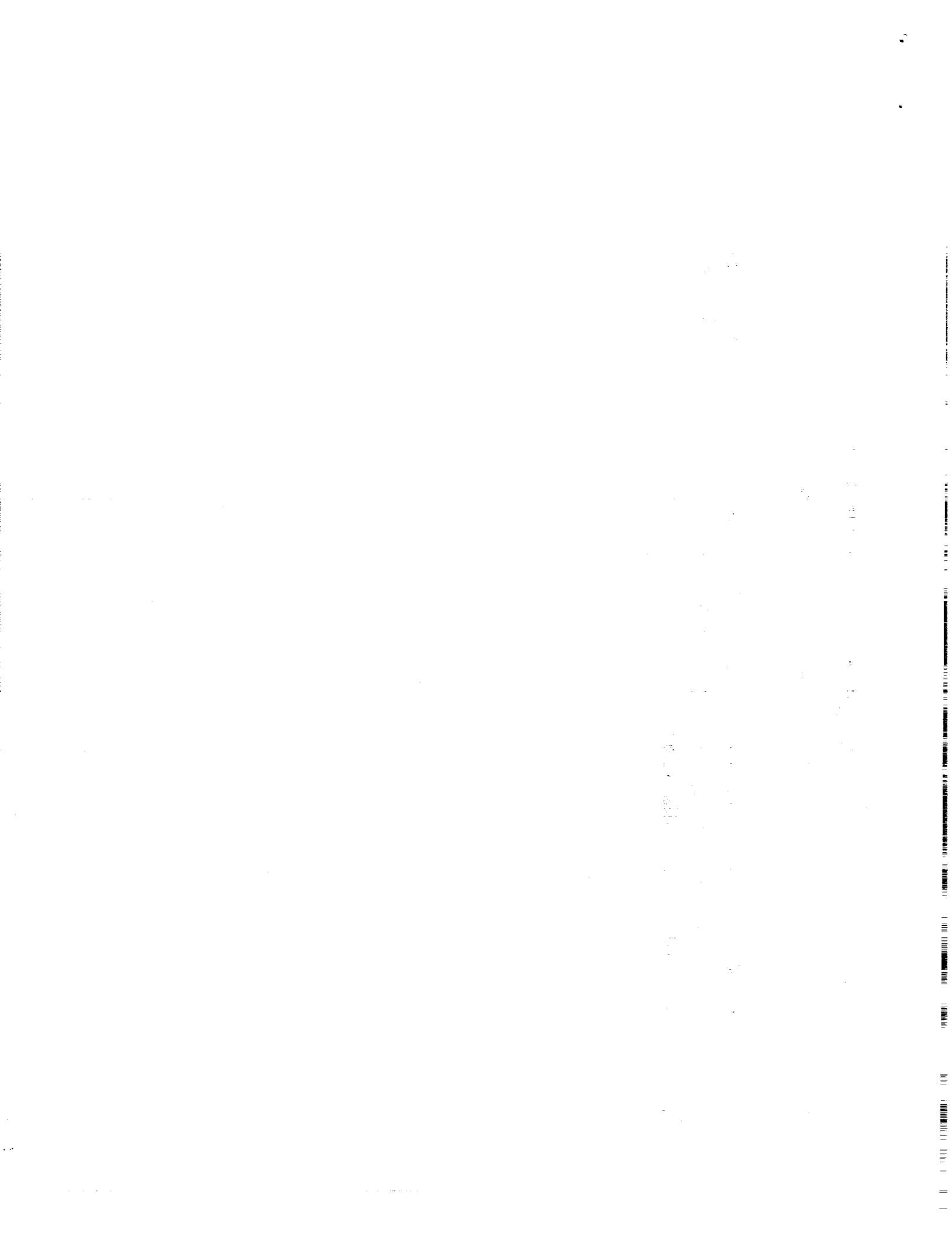
<b>Initial Meeting of the Science Working Group</b>	<b>October 11-12, 1990</b>
<b>First Draft of NASA/NSF Research Announcement</b>	<b>January 2, 1991</b>
<b>NASA/NSF Research Announcement Release</b>	<b>March 1, 1991</b>
<b>Proposal Submission Deadline</b>	<b>June 1, 1991</b>
<b>Investigation Selection</b>	<b>Summer 1991</b>
<b>Investigation Initiation</b>	<b>Fall 1991 (FY92)</b>



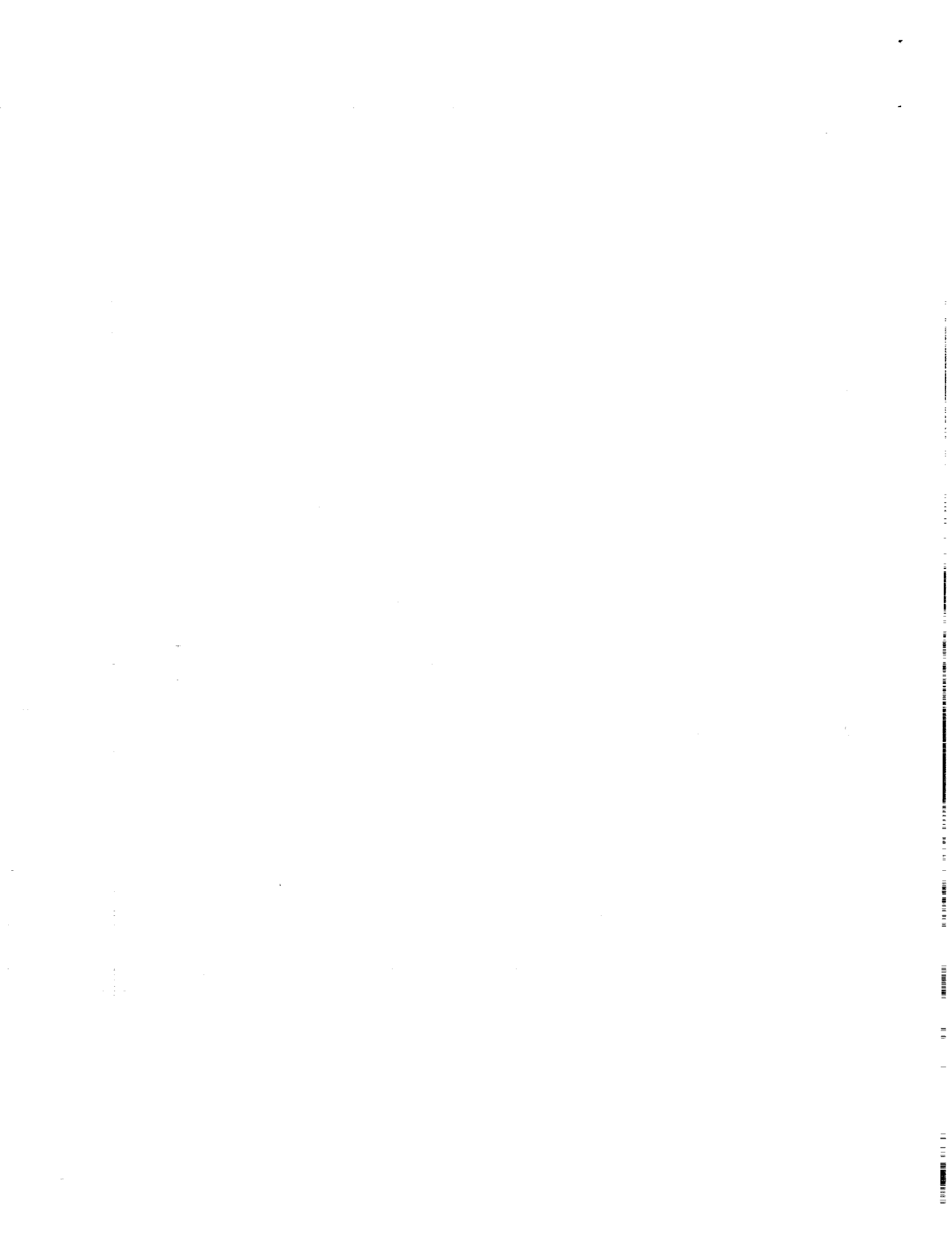
## **Charge to the Committee**

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**The NASA/NSF Science Working Group is charged with defining specific science requirements and priorities for biomedical research to be conducted using the Antarctic as an analog for space exploration.**



# **Attachment 9**



**NASA/NSF WORKSHOP ON ANTARCTIC RESEARCH**

**Mary M. Connors**

**NASA-Ames Research Center**

**Washington, D.C.**

**October 11-12, 1990**

**N 9 3 - 1 6 8 0 3**

**Currently Supported Life Sciences Activities:**

- \* **Crew Training Evaluation; Selection Strategies**
  - \* **Automation/Crew Performance Effects**
  - \* **Social/Organizational Influences on Team Performance**
  - \* **Leadership Influences on Team Performance**
  - \* **Workload Measurement Techniques (complex tasks)**
- 
- \* **Meta-Analysis of Behavioral Effects of Isolation and Confinement**

P. 20

**ANTARCTIC RESEARCH AREAS OF  
SPECIAL INTEREST**

---

- \* CREW FACTORS
- \* HUMAN/AUTOMATION/TELECOMMUNICATIONS
- \* STRATEGIC BEHAVIOR/WORKLOAD
- \* SLEEP/FATIGUE/CIRCADIAN RHYTHMS
- \* VIRTUAL REALITY/SPATIAL INSTRUMENTATION

## CREW FACTORS

### **NEED:**

To develop requirements and strategies for the selection and training of crews to work together on long-duration space missions.

### **EXAMPLE RESEARCH:**

Systematically investigation of effects of crew size, structure, and organization. Examples include:

**Crew Rotation - Learn to integrate new members**

**Crew Roles - How leadership, specialization, etc. change over time**

**Team Building - Evolution of relations over time**

**Multicultural/multinational crews**

**Meaning of "Performance" - Not just task mastery**

**Testing of Research Findings - "Select In" research suggests new approaches that much be confirmed.**



## HUMAN/AUTOMATION/TELECOMMUNICATIONS

### **NEED:**

To formulate requirements for combining Human, Automation, and Telecommunication Systems into an integrated, synergistic and fully functioning crew system capable of supporting long-duration and distant space missions.

### **BACKGROUND:**

Combining human and non-human intelligence has resulted in a significant number of serious errors. Methods for protecting against such failure and/or countermeasures for correcting them must be identified and incorporated.

### **EXAMPLE RESEARCH:**

- \* Determine nature and time-line of H/A errors (e.g. in monitoring behavior) in isolated and confined environments and identify design and procedural requirements.
- \* Determine effect of automated (e.g., decision) systems on interactions within the crew.
- \* Determine effect of telecommunications variable (e.g., choice of media, delays) on effectiveness of interactions with home or base camp support (ground).

## STRATEGIC BEHAVIOR/WORKLOAD

### **NEED:**

To understand the relationship between environmental stress (and its physical and mental correlates) and the ability to manage work requirements.

### **BACKGROUND:**

"Strategic Behavior" is currently being investigated as an alternate and supplementary approach, in an effort to explain variance in performance not accounted for by workload.

### **EXAMPLE RESEARCH:**

- Identify strategies (individual and group) successful in isolated settings for organizing information, making decisions, scheduling, pacing activities, etc. and determine how these strategies change over time.
- Determine methods for dealing with low workload conditions
- Develop training systems for potential use during low workload.

## SLEEP/FATIGUE/CIRCADIAN RHYTHMS

**NEED:** To identify strategies to manage sleep/wake activities in space-relevant environments.

### **EXAMPLE RESEARCH:**

- \* Determine quality and duration of sleep and objective/subjective measures of fatigue for varying conditions and durations of isolation and confinement.
- \* Determine course of changes in circadian rhythms for exploration-relevant cycles and relate circadian rhythm to phases of sleep.
- \* Identify countermeasures (e.g., light, exercise) and quantify effects on performance.
- \* Develop appropriate sleep/wake and work/rest schedules.

## VIRTUAL REALITY/SPATIAL INSTRUMENTATION

### **NEED:**

To Integrate interactive visual models and interactive telepresence interfaces and to investigate how these systems can be used in spaceflight, particularly planetary exploration.

### **BACKGROUND:**

Virtual reality and telepresence interfaces have developed separately and without focused attention on how humans, using these aids, are able to perform real work in a real environment.

### **EXAMPLE RESEARCH:**

Antarctica offers the opportunity to conduct real (geological) research, with humans utilizing virtual reality/telepresence systems. Through an applied research program, evaluation can be made in this space-relevant environment of:

- \* Adequacy of Virtual Reality System for human user
- \* Perceived quality and responsiveness of Telepresence System
- \* Acceptability of total system, and
- \* Quality of scientific product.

# **Attachment 10**

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**INFECTIOUS DISEASE**

**Duane L. Pierson, Ph.D.**  
**Biomedical Operations and Research Branch**  
**NASA Johnson Space Center**

**N 9 3 - 1 6 8 0 4**

# Long Duration Space Missions

## Major Concern:

- **Recurrent outbreaks of Infectious Diseases that jeopardize the health, safety and/or performance of crewmembers.**

## Preventative Measures

- **Preflight Microbiological Screening**
  - **Immune status (viral and bacterial)**
  - **Microbiological examination for bacteria/parasite pathogens**
- **Preflight Quarantine**
  - **Prevent contact with ill personnel**
  - **Covers most viral incubation periods**
- **Review of Payloads/Experiments**
  - **Limit risk of zoonotic diseases**
- **Environmental Surveillance**
  - **Air, water, food, and surfaces**



## **Antarctic Environment**

- **NASA Relevance**
- **May allow additional insight into the effect of stressors on the human immune system.**
- **Provide excellent model for more refined epidemiological studies.**
- **Provide additional information on persistent viral infections (viral reactivation)**

## Proposed Studies

- **Measure physical parameters of environment (eg., temperature, relative humidity, ventilation rate, make-up air, etc.)**
- **Measure Airborne Contaminants**
  - **Bacteria/Fungi**
  - **Volatile organic compounds**
  - **Gas composition (eg., CO, CO<sub>2</sub>, etc.)**
- **Measure Effects on Immune System**
  - **Humoral**
    - **immunoglobulin and antibody levels**
    - **antibody formation**
    - **immunoglobulin and antibody levels in external secretions**
  - **Cell Mediated**
    - **PMN number and function**
    - **macrophage function**
    - **lymphocyte proliferative response**
    - **lymphocyte phenotype numbers**
    - **delayed hypersensitivity**

- **HSV Shedding**
  - **Collect oral secretions before, during , and after isolation**
- **Refined Epidemiological Studies**
  - **Collect nose/throat swabs (weekly) before, during, and after isolation**
  - **Collect serum samples monthly**
  - **Utilize latest techniques for storage/handling of specimens**
  - **Utilize latest technology for viral/serology studies**
- **Institute a case control study for occurrence of all apparent infectious disease; collect appropriate specimens.**

## Questions

1. **What is the laboratory capability?**
2. **Are there good and complete medical data on symptoms and illnesses for repeated years at the pole? If so, does it reveal anything other than URI?**
3. **What has been done with monitoring of normal flora? Have there been no cases of staphylococcal or streptococcal disease?**
4. **How do they prepare their food?**
5. **How are gastro-intestinal upsets treated? Are causative agents identified?**
6. **What type of viral/microbiological studies are performed before they go to Antarctica?**

**NUTRITION**

**Helen W. Lane, Ph.D.**

**Biomedical Operations and Research Branch**

**NASA Johnson Space Center**

**N 9 3 - 1 6 8 0 5**

## **Nutrition**

### **Goals**

**Role of nutrition and foods in an isolated hostile environment accompanied by heavy work in low ambient temperatures.**

## **Background**

- Isolation in itself increases turnover of nutrients**
- Energy requirements increases with cold, and/or hostile environment**
- Monotonous food choices in hostile environment affects psychological responses to eating and dietary need to evaluate and counter**

## **Studies**

**Energy utilization - using noninvasive, non-time consuming technique-doubly labeled water**

**Protein/amino acid metabolism - using <sup>15</sup>N**

**Lipid/carbohydrate metabolism**

**Micronutrients, e.g. ascorbate**

**Fluid Balance**

**Psychological response to the limited diet**



# **Attachment 11**



N98-16806

IMMUNOLOGY PRESENTATION AT THE 1990 NASA/NSF  
ANTARCTICA BIOMEDICAL SCIENCE WORKING GROUPRichard T. Meehan, M.D.  
University of Colorado Health Sciences Center

October 11/12 1990

A review of prior space immunology studies and relevant stress immunology studies were presented. In order to determine the unique effects of the space flight environment, including microgravity and novel types of ionizing radiation on human immune function, it will be necessary to define those changes which can be accounted for exclusively by the stresses associated with landing. This is especially important, since only one inflight experiment with an appropriate 1-G centrifuge has been performed to date.

An overview of methodology used for determining human *in vitro* lymphocyte activation, proliferation and effector cell function was presented and results of previous manned space flight immunology studies from Apollo through Shuttle were reviewed (1,2). Until the Shuttle era, lymphocyte assays were not very sensitive and had such large variations among normal subjects that it was difficult to define a consistent effect of space flight. More sensitive assay, however, even with Shuttle missions as brief as 6 days indicate depressed T-cell proliferative responses are routinely observed following space flight. Using a slight modification of the Shuttle assay, five different human stress-immunology models have been studied over the last 6 years in our lab. These have included: academic examinations of medical students having blood drawn during major test periods on three separate groups of first year students and two hypoxia studies (at 25,000 feet in a 6 week chamber ascent to the equivalent of Mount Everest and twice on Pikes Peak at 14,000 feet). These studies are particularly pertinent to Antarctica, since the altitude equivalent of 11,000 feet at the South Pole may affect some of the variables that are being measured in immunology, physiology or cognitive studies. An extravehicular study was performed drawing blood from 35 individuals before and immediately following a chamber exposure study (3). Preliminary results from 30 Shuttle astronauts investigated immunophenotype analysis and the role of a novel monocyte population in modulating the previously observed suppressed *in vitro* immune function (4). The results of the Air Force Academy cadet stress study were also presented.

Summary of Operation Everest II

An approximately 30% reduction in mitogenic proliferative responses were noted at 72 hours as was previously observed from Shuttle crews and this defect could also be observed in the first 24 hours of culture by measuring protein synthesis (5). In contrast, interferon production in the supernatants was extremely variable and therefore large numbers of subjects would be required to detect a uniform change in cytokine assays. B-cell function was completely unimpaired as measured by *in vitro* immunoglobulin product and nasal wash IgA levels. Serum IgM and IgA levels were actually increased in the plasma after 4 weeks of altitude exposure. This may be the result of depressed T-cell function. NK activity despite cytokine augmentation at 3 different effector: target ratios was unaffected. No changes were observed among T-cell helper: suppressor ratios by immunophenotyping, or B-cells whereas an increase in the percentage of monocytes was

observed. These results are consistent with previous human altitude studies by the Soviets which also show impaired T-cell function whereas B-cell function was unimpaired.

#### Summary of Medical Student Academic Stress Studies

Subject selection was crucial since less stress was observed in subsequent years when the method of recruitment did not induce as many reluctant students to participate. There was a trend ( $P < .05$ ) of subjects with an increasing number of URIs to have lower in vitro T-cell proliferative responses. We also noted that females rated themselves as perceiving more stress during both control and test periods, emphasizing the importance of gender differences in these studies. The greatest change in stress-induced proliferative responses were observed when monocytes increased as they did during Operation Everest II, whereas cytokine production IL-2, and gamma interferon were variable and NK activity was unimpaired.

#### Shuttle Crew Study

A brief summary of some Shuttle studies indicated that a reduction in several T-cell subsets were observed when expanded immunophenotyping assays were performed. Decrease in NK-cells, T inducer and T cytotoxic subsets were seen whereas monocytes increased to a similar magnitude as was observed during OE II. Furthermore, characterizations of these monocytes by flow cytometry indicate a novel population that may be more immature since their expression of insulin and insulin-like growth factor receptors were distinctly different from normal monocytes (4).

#### U.S. Air Force Academy Cadets

To correlate associations between reduced in vitro T-cell responses and susceptibility to viral illness, during stress, a more homogeneous population was studied at the United States Air Force Academy. Advantages of this study include similar exposure to infectious agents, and the subjects are homogeneous regarding age, social/economic status, intellect, diet, lifestyles. Since all subjects are single and do not have children, they are at a more uniform risk for contracting infectious diseases. They also have excellent health care monitoring, at the cadet clinic and experience major stressors at the same time. Their personality profiles are very similar to astronauts. The negative aspects of this study however, are that it's difficult obtaining low stress control periods with this group of highly and continually stressed individuals, and the findings may not be applicable to the general population. Furthermore, they experience different stress depending on their own unique talents, as some individuals find the academic load most stressful, whereas others find physical or physiological hazing to be more traumatic. The 89 cadets did rate themselves as having significantly more perceived stress as well as a greater response to stress during basic cadet training and this was associated with significant reduction in PHA responsiveness of 20-30% similar to what was observed from Shuttle crews. This in vitro reduction could be prevented by co-culturing cells with IL-2. This reduced proliferative responsiveness did not discriminate between those 63 individuals who remained free of illness and those 27 who had one or more upper respiratory infections during the observation period. Therefore this study did allow us to investigate potential mechanisms of neuro-endocrine mediated stress-induced immune suppression in humans. A strong correlation between reduced immune responsiveness in vitro and susceptibility to viral illnesses was not demonstrated.

Specific areas of investigation to exploit the uniqueness of the Polar environment as a space station analogue should include infectious disease studies which investigate transmission of infectious agents, reactivation of latent viruses, and studies which identify mechanisms of host immunocompetence and susceptibility to viral diseases. Immunologic studies should be interdisciplinary and focus on mechanisms of the daily or seasonal variation in human immune responsiveness and the relation to circadian rhythm. Clinical trials could also be performed in this environment including active immunizations, antiviral chemotherapy, prophylactic regiments or biologic response modifiers. Also, testing potential markers for immunosuppression or cellular dysfunction could be conducted since immune effector cells are readily available from peripheral blood. Endocrine studies should also be done concomitantly to identify potential mechanisms of seasonal variation, differences between women and men in this environment and possibly studying bone mineralization in an environment where stress-induced endocrine responses might be invoked. Additional suggestions to improve the scientific yield from Polar/NASA studies would include more attention to subject selection; include both men and women and match personality and psychosocial features to astronauts likely to travel to the Space Station Freedom, Lunar Colony or Mars. Perhaps subjects could be selected in a nation-wide competition, similar to astronauts to insure a higher quality of subjects who would also agree to not abuse alcohol which could be a major confounding variable in interpreting results of any physiological or cognitive of studies in this isolated, controlled environment. The station physician or PhD investigator could learn the specific assays to be performed during the winter-over period at the PIs lab. The Polar science facilities may require expansion but this would be an ideal environment to verify the use of automated instruments and telecommunication capabilities in a remote laboratory similar to those planned for the Space Station Freedom. It is also recommended that an appropriate control group perhaps remaining at Christchurch, N.Z. be studied simultaneously.

Collaborators for the above studies have included: from NASA/Johnson Space Center; Gerald Taylor, Nitza Cintron, Clarence Sams, Laurie Neale, and Elizabeth Kraus. From the University of Colorado; Morey Smith and Chris Robinson. From the University of Texas Medical Branch at Galveston; Charlie Stuart, Eric Smith, David Lee, Ed Blalock and Russ Gardner. University of Oklahoma; Harold Munchmore and Nan Scott. U.S. Army Research Institute of Environmental Medicine in Natick Massachusetts; Paul Rock, Charlie Houston and Allen Simmermen. U.S. Air Force Academy; Gary Coulter, Paul Sherry, Tom Mabry, Ron Reed and Robert Ginnett.

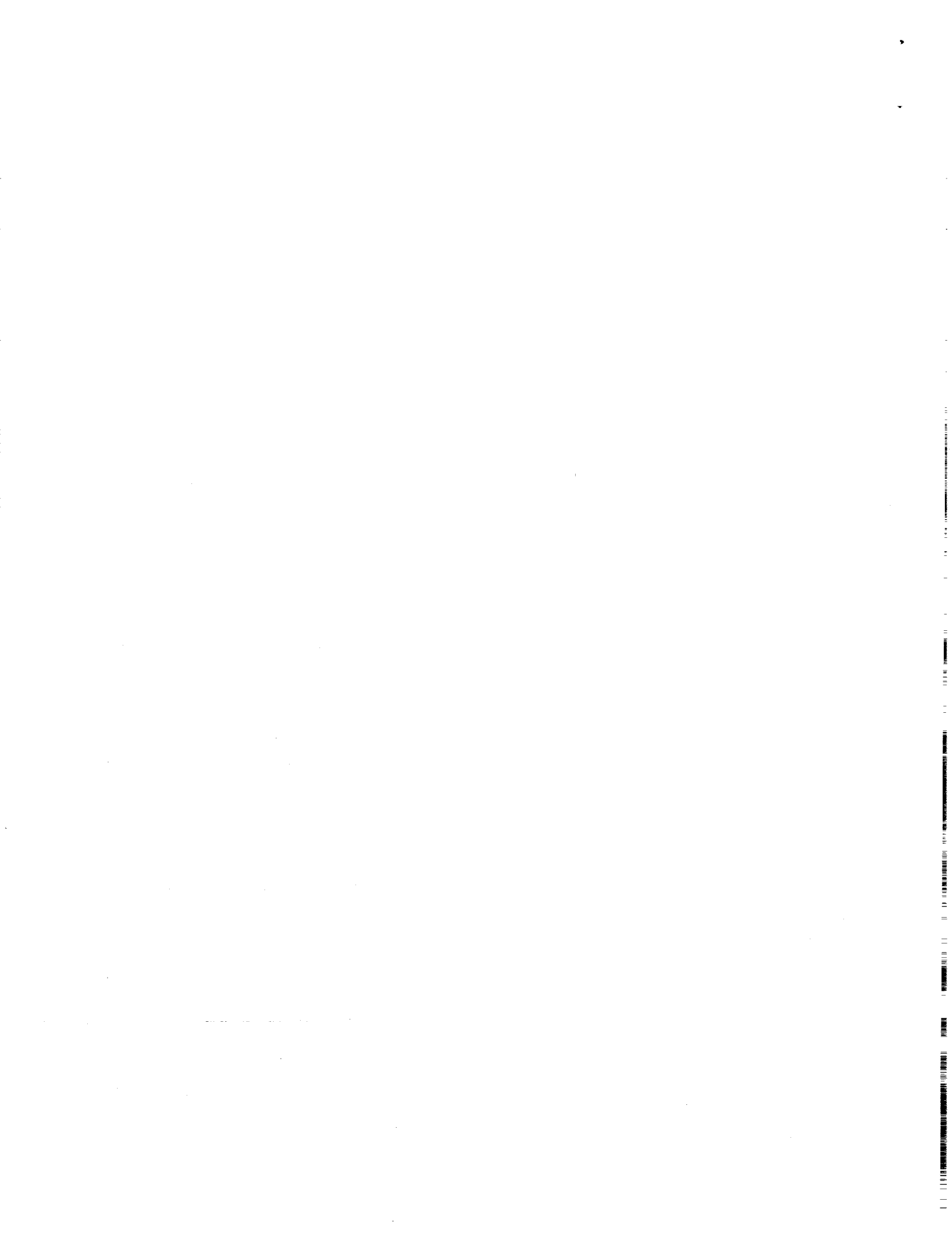
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5. Meehan RT, Duncan U, Neale L, Taylor G, Muchmore H, Scott N, Ramsey K, Smith E, Rock P, Goldblum R, Houston C. Operation Everest II: Alterations in the immune system at high altitudes. *J Clin Immunol.* 8:397-403, 1988.

# **Attachment 12**





N93-16807

**ANTARCTIC BIOMEDICAL SCIENCE WORKING GROUP: NASA - NSF****EXERCISE DURING LONG TERM EXPOSURE TO SPACE****Value of Exercise During Space Exploration****PHYSIOLOGICAL**

There appears to be two general physiological reasons why exercise will be beneficial to space travelers who will experience a weightless and isolated environment for many months or a few years; one, to alleviate or prevent tissue atrophy (principally bone and muscle), to maintain cardiovascular function, and to prevent deleterious changes in extracellular and cellular fluid volumes and plasma constituents, especially electrolytes; and two, to maintain whole organism functional physical and physiological status with special reference to neuromuscular coordination (physical skill) and physical fitness (muscle strength and power, flexibility, and aerobic endurance). The latter reason also relates well to the ability of the crew members to resist both general and local fatigue and thus ensure consistent physical performance.

**PSYCHOLOGICAL**

It seems important to utilize all available resources to provide distractions and diversions to isolated space crews who will not be continuously busy with pertinent tasks. Various forms of exercise, performed regularly, could help alleviate boredom and assist the travelers in coping

with stress, anxiety, and depression.

#### COMPLIANCE TO HABITUAL EXERCISE

There have been numerous exercise training studies conducted over several weeks or months and even under the most optimal conditions the subject attrition rate in these studies is very high. Even under conditions where the consequence of not exercising regularly is life-threatening it is difficult to maintain the interest and compliance of participants. However, the results are obvious if a highly motivated and highly specialized and homogeneous group (e.g., astronauts, elite athletes) engage in a regular program of physical exercise. The awareness of astronauts and athletes of the important intrinsic benefits and values of exercise provide them the necessary incentive to comply.

#### IMPORTANT EXERCISE TRAINING FACTORS

1. Type
2. Frequency
3. Duration
4. Intensity

1. **Type.** The type or types of exercise recommended for long-term space exposure should be both physically and psychologically appealing. That is, the exercises should meet the physical, physiological, and health goals of NASA and at the same time should be preferred by the participants. Exercise training should emphasize the development and maintenance of flexibility, muscular strength and power, and aerobic endurance. A training program with

this emphasis will help insure optimal and cardiovascular-respiratory function, muscle tone, and joint mobility. The type or types of exercise will, for the most part, be determined based on the limitations of the space habitat and 0g environment. If exercise has priority in long-term space exposure then the development of exercise equipment and apparatus especially designed to elicit specific training stimuli in a weightless environment must be carefully considered. The use of stationary exercise equipment designed to simulate walking-running (treadmills), stepping, cycling, rowing and cross country skiing should be carefully considered in order to elicit the optimal aerobic response whereas specially designed flexibility and strength training equipment should also be considered. Furthermore, opportunity for choices and diversity of exercises will help maintain interest and compliance among participants.

2. **Frequency.** The number of recommended exercise sessions per week will depend on individual fitness status and previous training habits although a minimum of three days/week is sufficient to cause a training effect while two days/week can maintain fitness gains. The usual recommendation for the recreational athlete is 3-5 days/week but if regular exercise participation is projected to also serve as a diversion to the boredom of isolation the frequency can be safely increased to 7-14 sessions per week (maximum of 2 exercise training sessions per day).

3. **Duration.** Similar to frequency, the duration of each exercise training session will depend on the fitness status of each crew member and will also be determined by the specific objectives of each exercise session. Participants

with low fitness status usually use a 10-20 min range; those with average fitness status, 15-45 min; while highly fit crew members can exercise for 30-60 min.

The length of the training session will therefore depend on the energy level of the participant and the intensity of exercise.

**4. Intensity.** The most critical of the four training factors is exercise intensity as only a small change in this stimulus can have dramatic effects on the training response. The intensity levels for flexibility, muscle development, and cardiovascular respiratory exercises can be determined in the following ways:

Flexibility -- easy to control as specific static stretching exercises are performed for only 10 sec followed by full recovery.

Muscle Strength-Endurance -- exercise intensity can be based on a variety of evaluations including isometric, isotonic, and isokinetic. For strength, a high resistance-low repetition evaluation regimen is recommended while muscle endurance is best evaluated by a low resistance-high repetition protocol.

Cardiovascular-Respiratory -- the determination of target heart rate seems to be the key to controlling intensity for cardiovascular-respiratory exercise training. Target heart rate is simply defined as the proportion (%) of maximal heart rate one intends to exercise. Maximal heart rate can be determined most accurately by exercise testing in the laboratory but can also be estimated by taking 220 and subtracting the age of the participant (low estimate) or taking 210 and subtracting age X 0.5 (high estimate). To determine the crew member's target heart rate simply multiply maximal heart rate by the desired exercise intensity. Based on individual fitness status

the usual recommendations are as follows:

fitness status	recommended % of maximal heart rate
low	60
fair	65
average	70
good	75
excellent	80-90

For example, if a participant's maximum heart rate is 180 beats per minute and if the desired exercise intensity is 70% the target heart rate would be  $180 \times 0.70$  or 126 beats/min. It is important to remember that target heart rate is not the rate to be achieved by the end of exercise but instead should be maintained for as near the whole duration of exercise as possible. Increasing exercise intensity to extremes can have deleterious physical and physiological effects culminating in general discomfort, muscle and joint pain, and possible injury.

There is no need to exercise at high intensities to realize gains in cardiovascular-respiratory fitness. Someone performing continuous exercise for as little as 10 min 3 days per week at "conversational pace" can see increases in fitness. "Conversational pace" means exercising at a pace or rate that would permit the participant to converse with someone.

#### PHYSICAL FITNESS EVALUATION

Before the exercise training factors can be used as a successful recipe for fitness, each participant must be evaluated. Fitness levels of crew members may differ significantly and thus it is important to individually

prescribe fitness programs based on the crew members' responses to tests of flexibility, muscle strength, power and endurance, and cardiovascular-respiratory function. Although periodic pre- and post-flight testing can be conducted in the laboratory, emphasis should be on simple, but effective, self-testing procedures designed to complement the laboratory tests. In this way both the immediate and long-term effects of exercise training can be measured.

#### EXERCISE AND ISOLATION

I am not aware of any studies that have reported data concerning the specific effects of isolation on physiological responses of exercise or vice-versa. In almost all cases where isolation was a factor the principal aspects of investigation were environmental, not isolation. In such cases, most data regarding the effects of isolation have been anecdotal. It is well known that training programs designed to improve and maintain physical fitness are, for the most part, very boring. This problem in concert with isolation could seriously jeopardize compliance.

Our earlier studies, which were designed to determine the effects of both acute and chronic altitude exposure on exercise, although involving isolation, did not specifically consider this factor. Over the last several years our laboratory has studied the effects of high intensity exercise training on the performances of elite athletes much of which was done in quite isolated conditions. The preparation for competition of these athletes has many similarities to potential problems to be encountered by crews on long space flights or isolated for long periods on station. Groups of 20 or more rowing athletes have consistently been cloistered and isolated for as long as 12

weeks for the purpose of team selection and training for international competitions including Olympic Games. These selection and training camps (as they are called) are characterized by a highly competitive atmosphere where athletes are competing for team positions, high intensity exercise training sessions, an extremely scheduled life style, and the monotony and boredom of twice-a-day training. In addition to the isolation, the athletes must often cope with environmental extremes, dehydration, hypoglycemia, negative nitrogen balance, decreased glycogen stores, rhabdomyolysis, and hematuria. Incidents of fatigue and overtraining are common. In addition, the athletes seem vulnerable to such communicable diseases as hepatitis, mononucleosis, upper respiratory infections, and viruses. Besides being chronically tired, the isolation of rowers during preparation for international regattas contributes to the rapid transmission of communicable diseases; the participants live close together and share sleeping, lounging, eating, and toilet facilities. Although the sport of rowing makes excessive physiological demands on the competitor where exaggerated stress is placed on muscles and joints, the most common medical problems relate to communicable diseases.

The physical and physiological problems related to extreme isolation may seem pale compared to the potential psychological stress imposed on the space travelers. Although our information is strictly anecdotal the following responses have been observed consistently over several years of my association with National and Olympic rowing camps; participants tire of: spartan living conditions, close living, each other, lack of privacy, and competitive tension (often a prolonged selection process where team candidates are constantly pitted against one another in order to earn a position on the team).

Our elite athlete model also represents many personality characteristics

that are comparable with those of astronauts. Successful elite rowers are:

1. A part of a highly selected homogeneous group possessing very high egos
2. Bright, intelligent, and usually well educated
3. Aggressive and highly competitive
4. Dedicated, highly motivated and have excellent work habits
5. Tenacious, push themselves to exhaustion and have increased pain tolerance
6. Quick learners, highly skilled, and have high energy levels
7. Narrowly and highly focused and cool under pressure
8. Constantly seeking evaluation
9. Loyal and take pride in their training and competitive efforts
10. Excellent leaders but can function equally well as cooperative team players

#### HELPING COMPLIANCE IN EXERCISE

There have been considerable data reported describing successful efforts to encourage people to maintain an exercise training program (see references) however most compliance studies have dealt with physical fitness exercise training for the recreational athlete and exercise rehabilitation following coronary infarction or bypass surgery; little or no data are available for special asymptomatic groups.

A variety of methodologies have been used to help compliance most of which were very straight forward and simply involve common sense. The trick is to keep people exercising. The development and nurturing of a positive attitude toward exercise is very important. This will probably not be a



difficult obstacle in the case of prospective space dwellers as they will most likely have a similar attitude toward exercise as our elite athlete model. Exercise must be a priority with emphasis on inherent physiological and psychological benefits. Exercise must be as normal and as regular as eating and sleeping. Successful exercise training programs, even for highly motivated groups, must be realistic, attractive, varied, and individually designed. It has been our experience that highly motivated groups such as astronauts and elite athletes seem to enjoy challenges thus exercise training should have an element of competition, e.g. racing against a computer competitor or time on a bicycle ergometer. However, at the same time keep training fun and include as many game situations as possible. Although there is controversy concerning whether a participant should associate or dissociate themselves during exercise training, it appears that dissociation or distraction from the boredom of exercise is a common ploy for the recreational athlete; witness the widespread use of television and audio tapes to keep the exerciser compliant. On the other hand I would strongly recommend that a highly motivated group such as the astronauts and elite athletes emphasize association so that they may keep "in tune" with their bodies. Association before, during, and following exercise training can be an important source of information for evaluation of the effects of training. This more subjective self-evaluation should be complemented periodically with more objective evaluation procedures that can measure specific effects of exercise training. Whether these objective tests are self-administered or conducted by an onboard specialist, portable and accurate technology is currently available to easily assess a host of physiological functions. These evaluations will probably prove valuable in maintaining compliance. An introduction of a simple awards

system often insures compliance as well as the use of partnership or group participation; mutual or reciprocating motivation is often an excellent compliance stratagem. I have found through my research with the isolated and highly trained elite athlete that the keys to maintaining compliance are leadership, communication, and education. Whether this leadership comes from an exercise specialist or a designated crew member, it must be a part of any successful exercise training program. Constant accurate and reliable information concerning the effects of exercise must be communicated to the crew at a level and language they understand and in this way education becomes a bonus of the program.

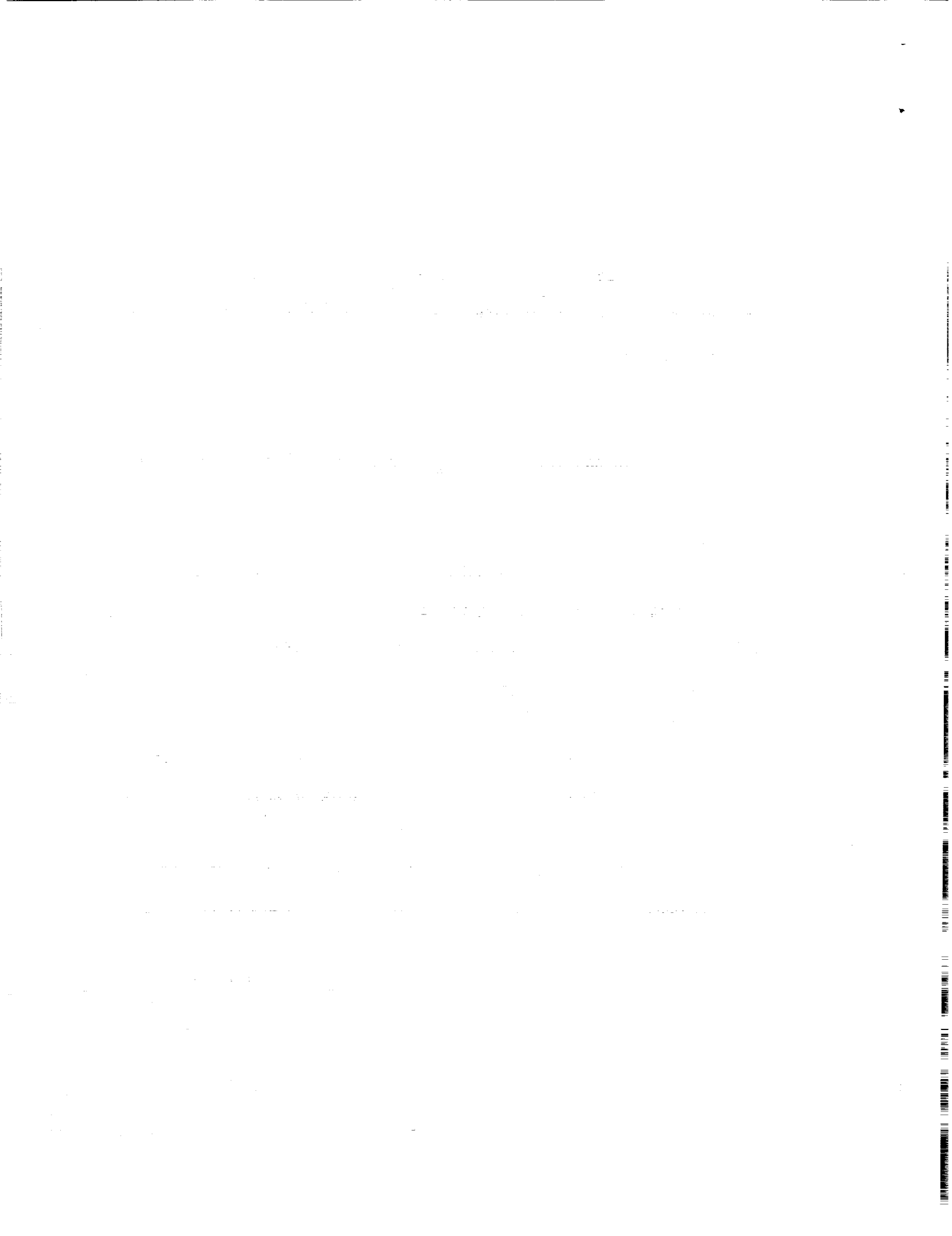
In summary, it seems that a regular and well-planned exercise training program in an isolated environment should be designed to blunt the boredom of isolation, prevent the expected anatomical and physiological deterioration of tissues associated with prolonged exposure to weightlessness, lessen the prospects of joint and muscle pain and injury, and alleviate fatigue. If exercise is a high priority for NASA in prolonged space exposure for the future, then it may be important to include a master motivator, communicator, and educator as an exercise training specialist as part of the crew. I also see exercise as being an integral part of possible interdisciplinary research with other pertinent NASA life science areas such as nutrition, immunology, biochemistry, circadian rhythms and sleep, endocrinology, and psychosocial sciences.

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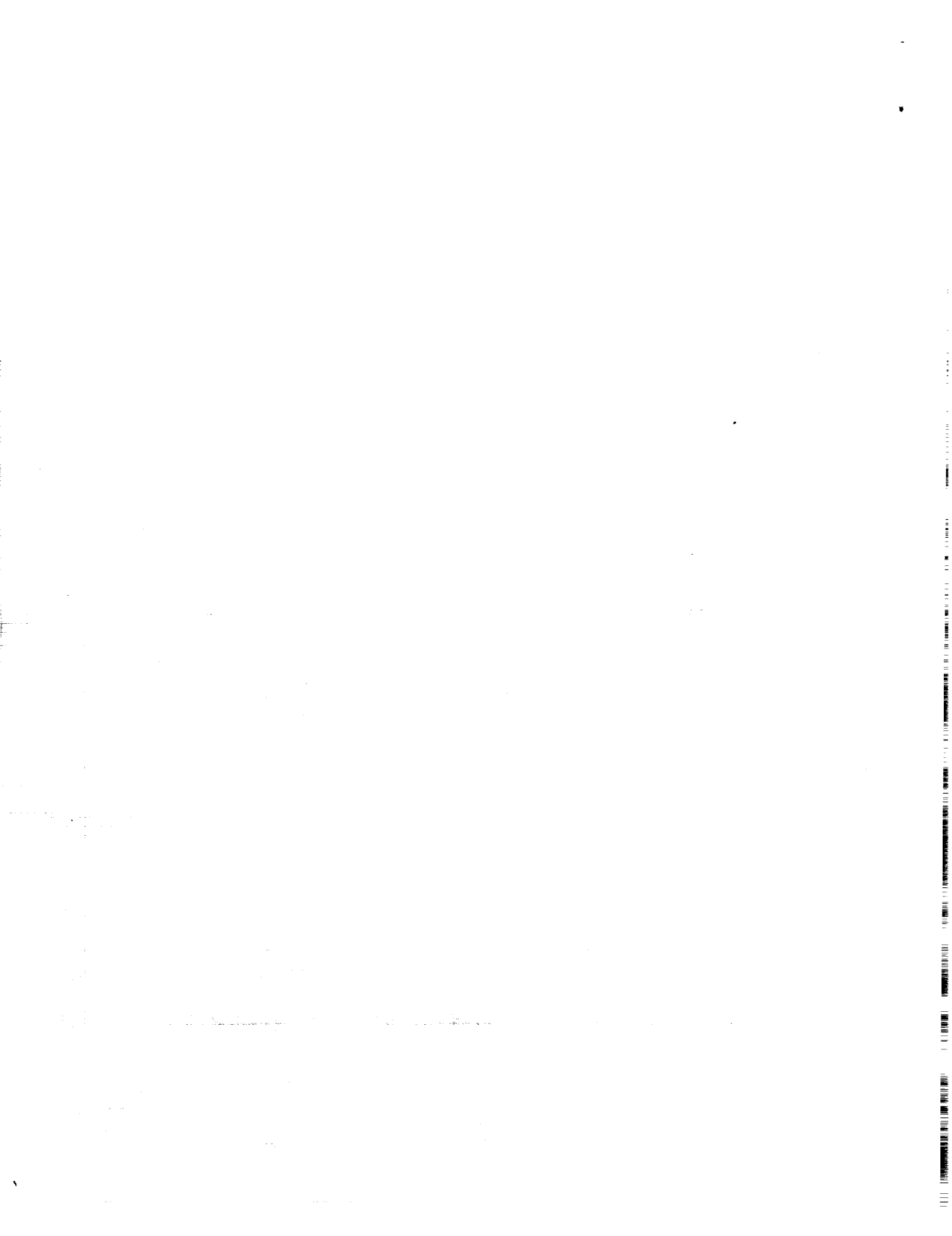
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# **Attachment 13**





**LONG-DURATION ISOLATION AND CONFINEMENT:  
HUMAN FACTORS ISSUES AND  
RESEARCH REQUIREMENTS**

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**ANACAPA SCIENCES, INC.  
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**NASA/NSF**

**ANTARCTIC BIOMEDICAL SCIENCE WORKING GROUP**

**Washington, D.C.  
11-12 October 1990**

**ANACAPA SCIENCES, INC.**

**93 - 16808**

<b>Rank</b>	<b>Analogue</b>	<b>Score</b>
1	Skylab 4	86.81
2	Sealab II	70.95
3	Tektite I	69.40
4	Tektite II	66.89
5	Submarines	63.46
6	South Pole Station	59.35
7	Saturation Divers	57.12
8	Long Distance Yacht Racing	56.66
9	Commercial Fishing Vessels	54.10
10	Coastal Research Vessels	53.45
11	Ra Expedition	52.99
12	Supertankers	49.21
13	Offshore Oil Platforms	41.52

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## **HABITABILITY ISSUES WITH DESIGN IMPLICATIONS**

**Sleep**

**Clothing**

**Exercise**

**Medical Support**

**Food Preparation**

**Habitat Aesthetics**

**Group Interaction**

**Outside Communications**

**Recreational Opportunities**

**Privacy and Personal Space**

**Scheduling and Workload Assessment**

**Onboard Training and Task Preparation**

**HABITAT PROJECTS THAT HAVE INCORPORATED  
DESIGN RECOMMENDATIONS  
BASED ON ANACAPA ANALOGUE STUDIES AND  
HUMAN FACTORS EVALUATIONS**

\*\*\*\*\*

**Space Station Freedom**

**Monobaric Underwater Habitats for North Sea Oil Production**

**Command and Control Centers for National Security Personnel**

**US Navy Long-Endurance Airships**

**US Air Force Rail Garrison Alert Trains**

**European Space Station**

**European Interplanetary Spacecraft**

**ANACAPA SCIENCES, INC.**

## **A FEW RESEARCH REQUIREMENTS THAT COULD BE SATISFIED BY BEHAVIORAL STUDIES CONDUCTED AT ANTARCTIC RESEARCH STATIONS**

*Research is required to...*

**Develop techniques for routinely (and unobtrusively) monitoring mental health, & providing psychological support.**

**Evaluate the applicability of the results of small group dynamics research to the crews of spacecraft.**

**Develop personnel selection procedures based on interpersonal skills, in addition to technical competence.**

**Define leadership responsibilities and identify required personal qualities and capabilities.**

**Define the most appropriate organizational structure.**

**Establish a cross-training plan to permit the effective use of personnel, and for contingency purposes.**

**Identify the appropriate equipment and motivational framework(s) to encourage regular physical exercise.**

**Develop procedures and equipment for handling critical incidents, like fatalities among crew personnel.**

**Establish policies regarding outside communications, including "negative personal news."**

**Identify appropriate recreation and relaxation equipment/materials/programs and policies.**

**Develop meaningful tasks to occupy crew during interplanetary transits.**

**Explore the advantages and disadvantages of various forms of meal preparation.**

**Support the development of training programs to sensitize crew personnel to problems of isolated & confined living.**

