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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 abberant (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 basewide 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, particulary 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 colleages 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 $TCID^{50}$ 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 $TCID_{50}$'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 $TCID_{50}$ 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 $TCID_{50}$ and two 100 $TCID_{50}$. (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

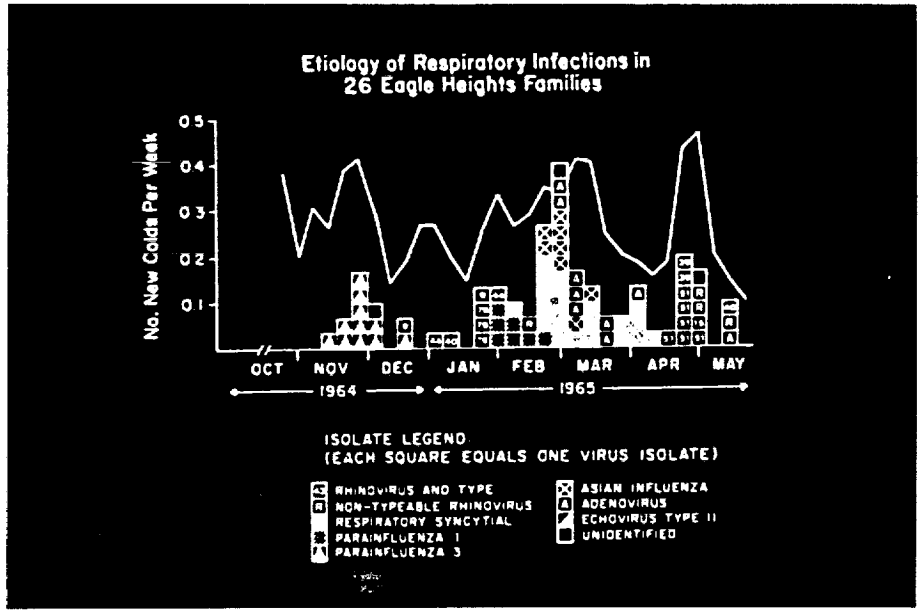
These many pages, figures and reprints have covered many years of research in open populations such as families and school rooms, in an isolated Antarctic station and, finally, in a series of human volunteer experiments based on the prior epidemiologic investigations. We have found that a variety of 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.

Slide 1 - The respiratory viruses.

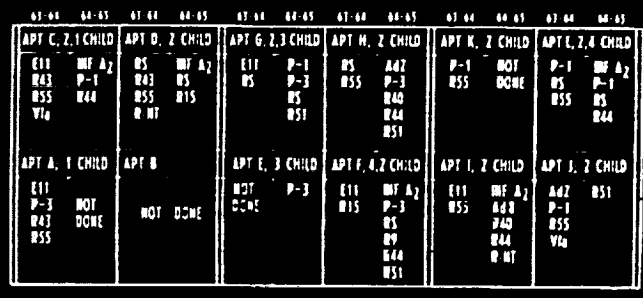
Viruses Causing Respiratory Disease in Man

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

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

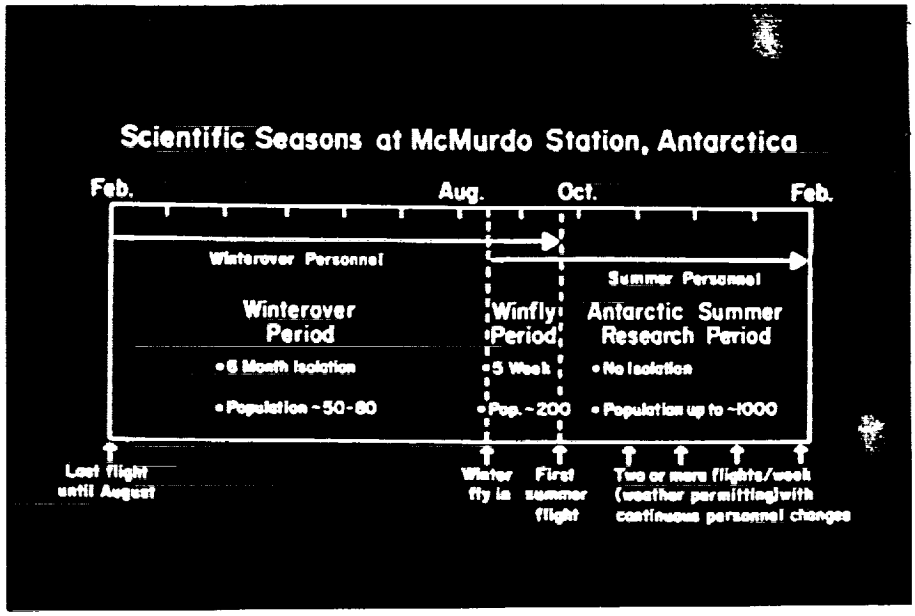


Slide 3 - Respiratory viruses in a single Eagle Heights building.

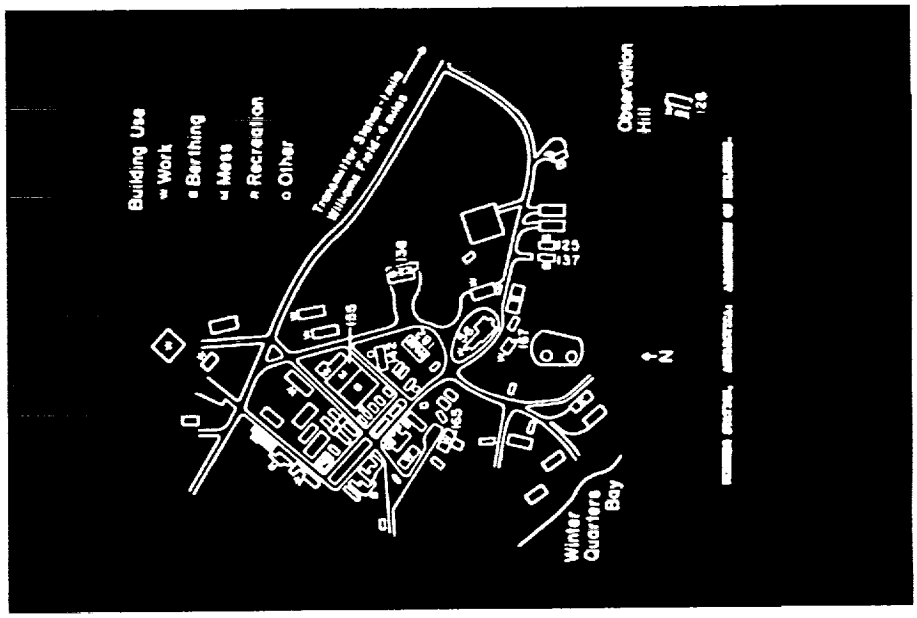


Viral infections in a single Eagle Heights apartment building, Madison, Wisconsin, 1963-1965. Ad, adenovirus; E, ECHO virus; INF A2, influenza A (H_2N_2); NT, nontypable; P, parainfluenza; R, rhinoviruses; RS, respiratory syncytial; V16, unidentified, virus-like agent. Numbers after letters refer to type: RS5, rhinovirus type 55. (From Dick, E. C., and Cheney, F. J.: Rhinoviruses. In Feigin, R. 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.

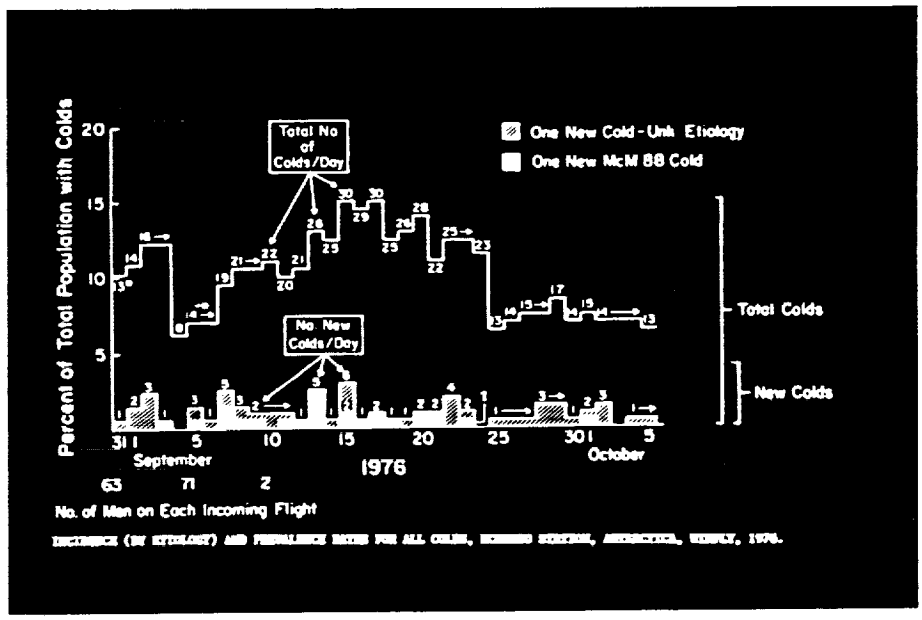


Slide 18 - The evening meal at the Building 155 mess hall.

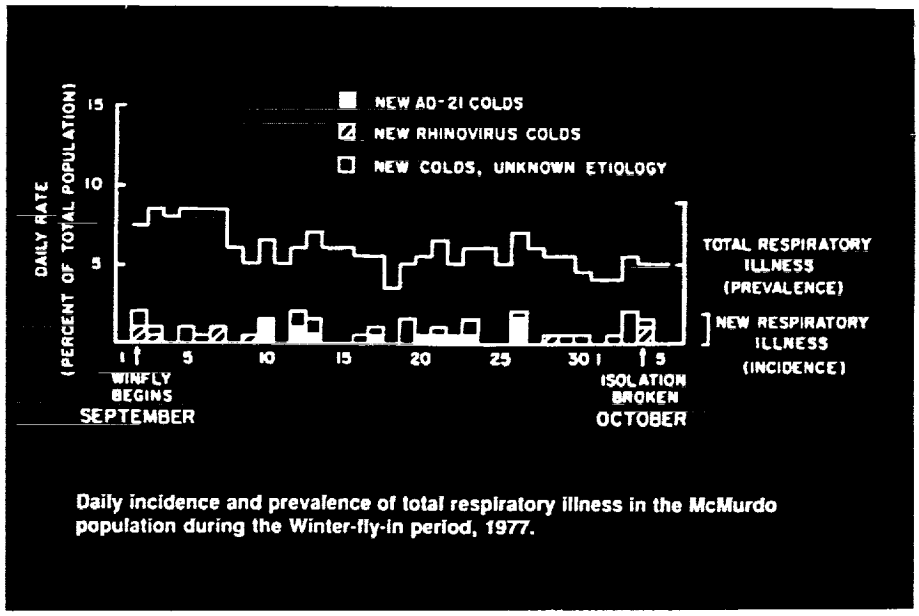
Slide 19 - The mess line at the Building 155 dining facility.

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.

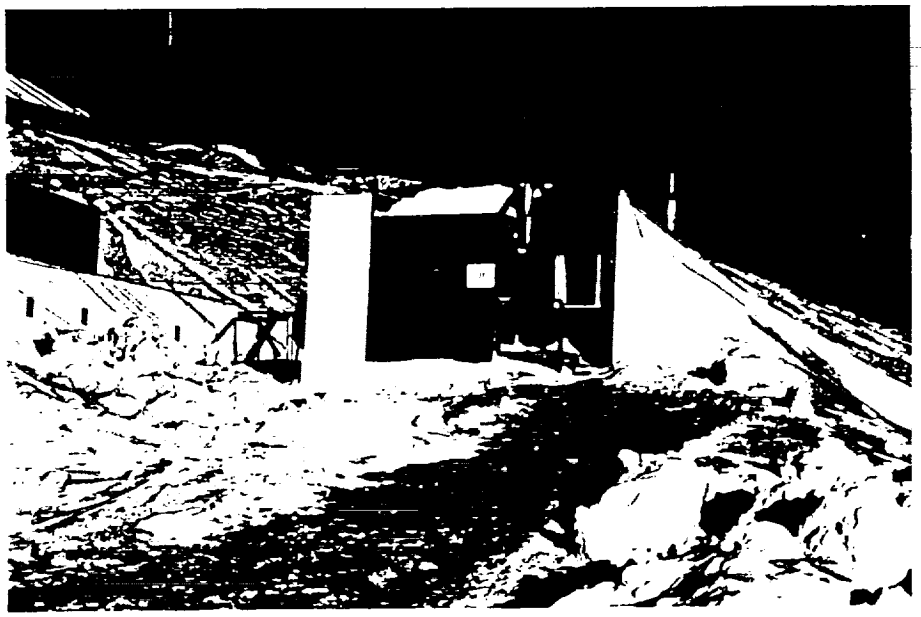


Slide 22 - Epidemic curve during Winfly, 1977.

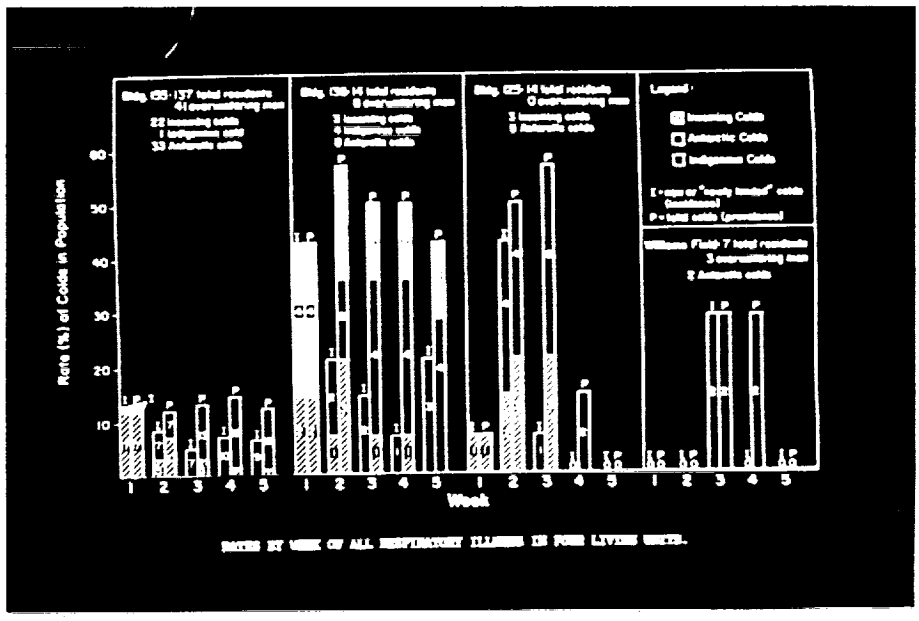


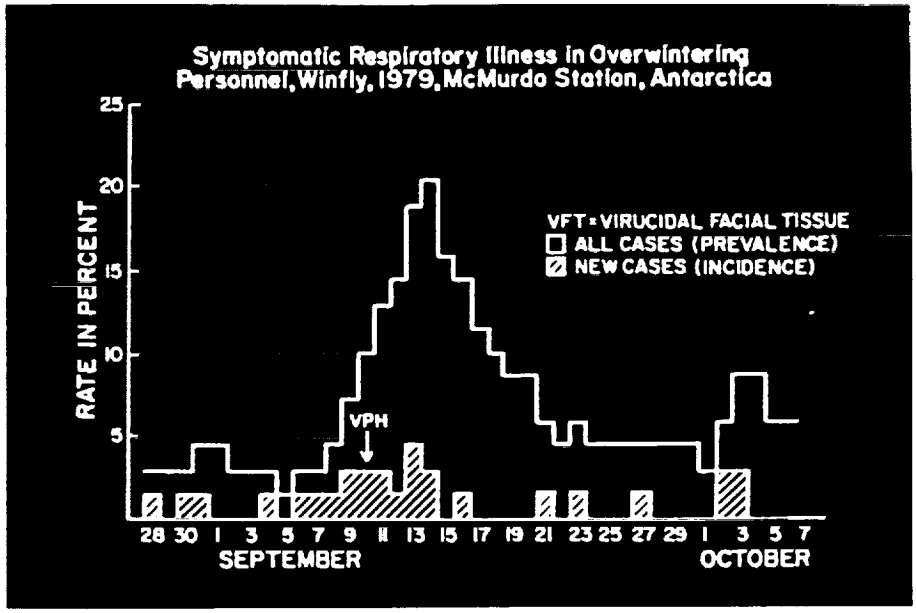
Daily incidence and prevalence of total respiratory illness in the McMurdo population during the Winter-fly-in period, 1977.

Slide 23 - Building 137, a small dormitory.

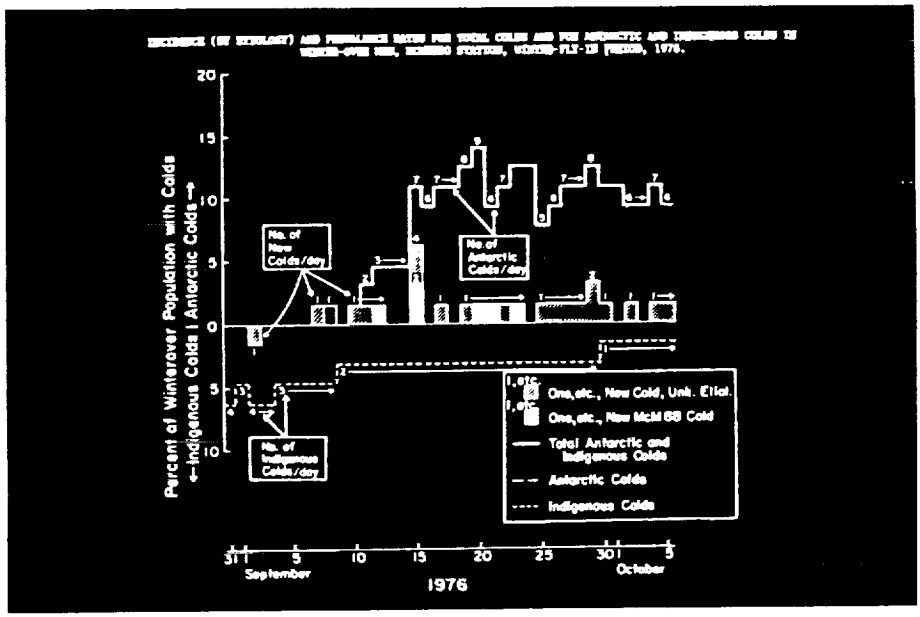


Slide 24 - Rate of colds and of McMurdo 88 colds in four McMurdo Station buildings.

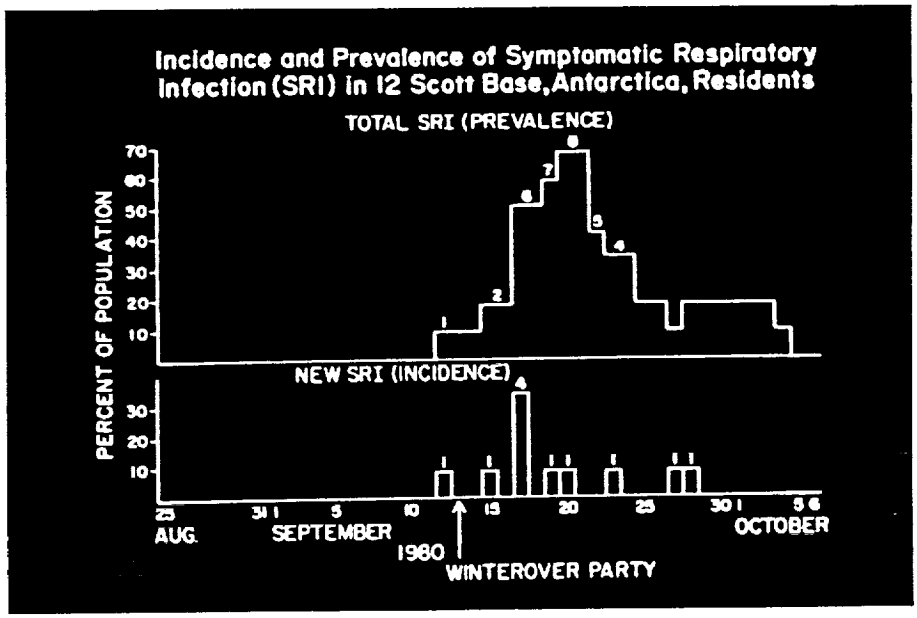




Slide 28 - Incidence and prevalence of respiratory disease in 69 WO 1979 personnel.



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.

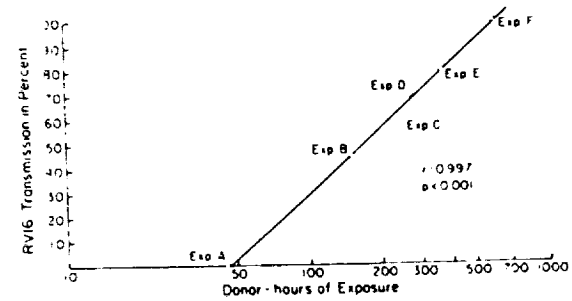
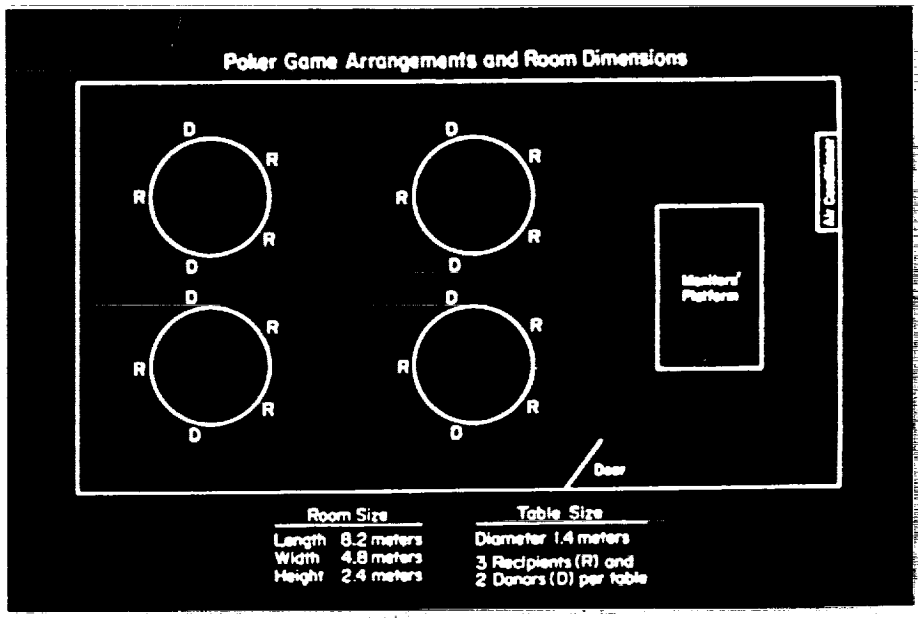


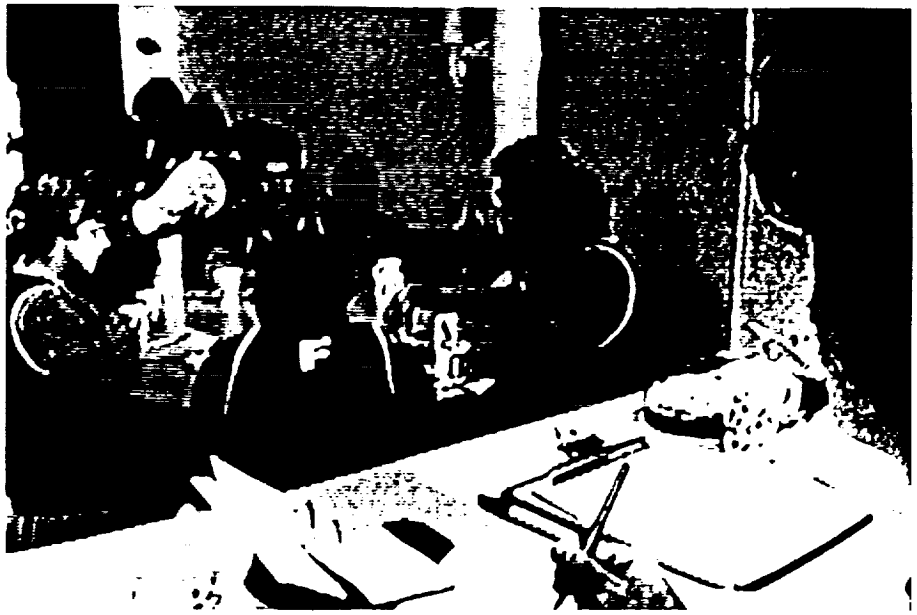
Figure 3. Semilogarithmic plot of donor hours of exposure vs. transmission of RV16 between artificially infected donors and susceptible recipients.

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 (R16) Transmission Using Virucidal Facial Tissues (Experimental Model: 8 Donors and 12 Antibody-Free Recipients Played Poker for 12 Hours)

	Cotton Hand'chiefs Exp. A	Virucidal Tissues Exp. B	Virucidal Tissues Exp. C	Cotton Hand'chiefs Exp. D
Number Recipients Who "Caught" R16 Colds (%)	**5/12 (42)**	**0/12**	**0/12**	**9/12 (75)**
Donors' Characteristics				
Mean Virus Shed ($TCID_{50}$)	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	16.9

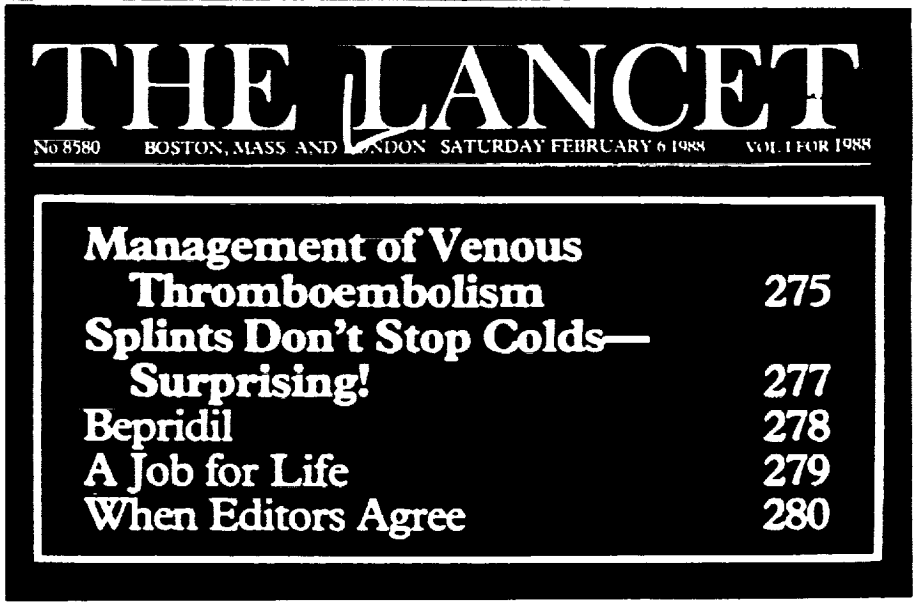
Slide 36 - Four experiments to determine how RV16 is transmitted.

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

	Aerosol Transmission Experiments*			Fomite Transmission Experiment*	
	A (Collars)	B	C (Arm Braces)	D	TOTALS
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/or aerosol transmission.

Slide 37 - LANCET editorial on our Antarctic Hut research.



THE LANCET

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

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 Arhthritis		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 operatory
Misc -	2 person hyperbaric chamber

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

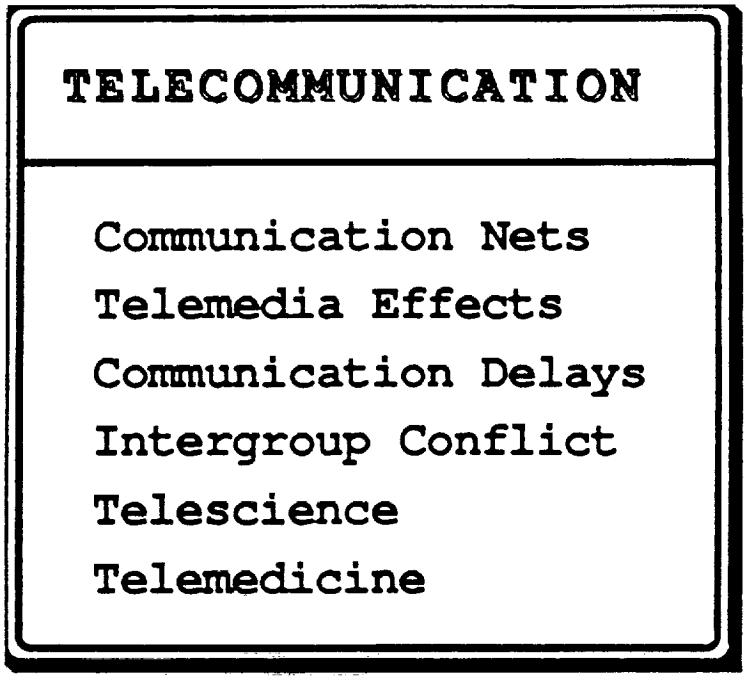
Historical Determinants (LSQ)
Chronic Environmental Factors - Isolation, Confinement
Acute Situational Factors - Weather, Workload, Events
Personality Moderators and the Experience of Stress
Objective Stress Control Mechanisms ("Threat Control")
Subjective Stress Control Mechansisms ("Fear Control")
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

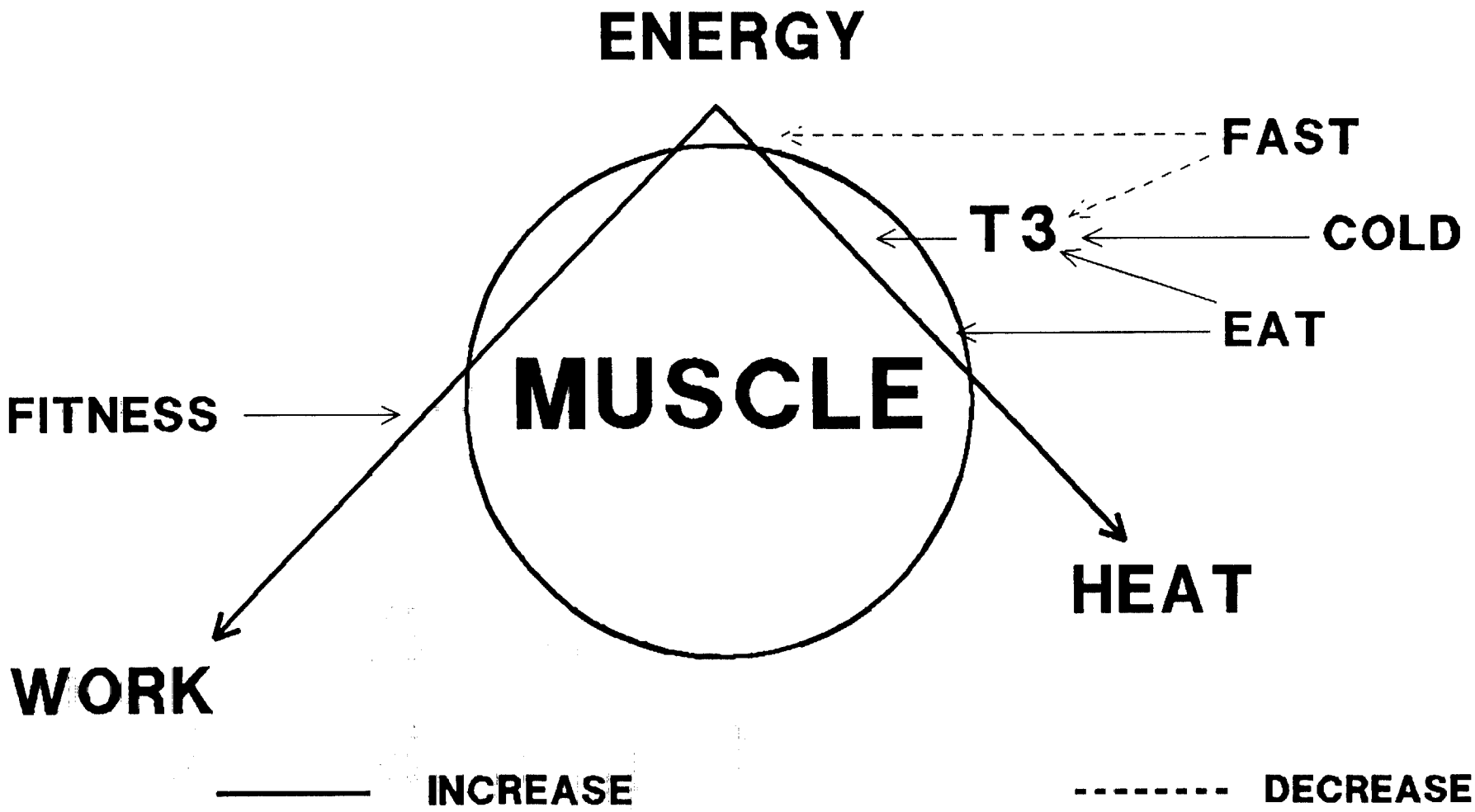
Exude Competence
Join the Team
Avoid Penalizing Participants
Attend to Ethics
Promote Information Dissemination and Utilization
Cultivate Newcomers

Attachment 6

attachment 6

ALTERATIONS IN THYROID HORMONE METABOLISM WITH PROLONGED ANTARCTIC RESIDENCE

ENERGY DISPOSITION



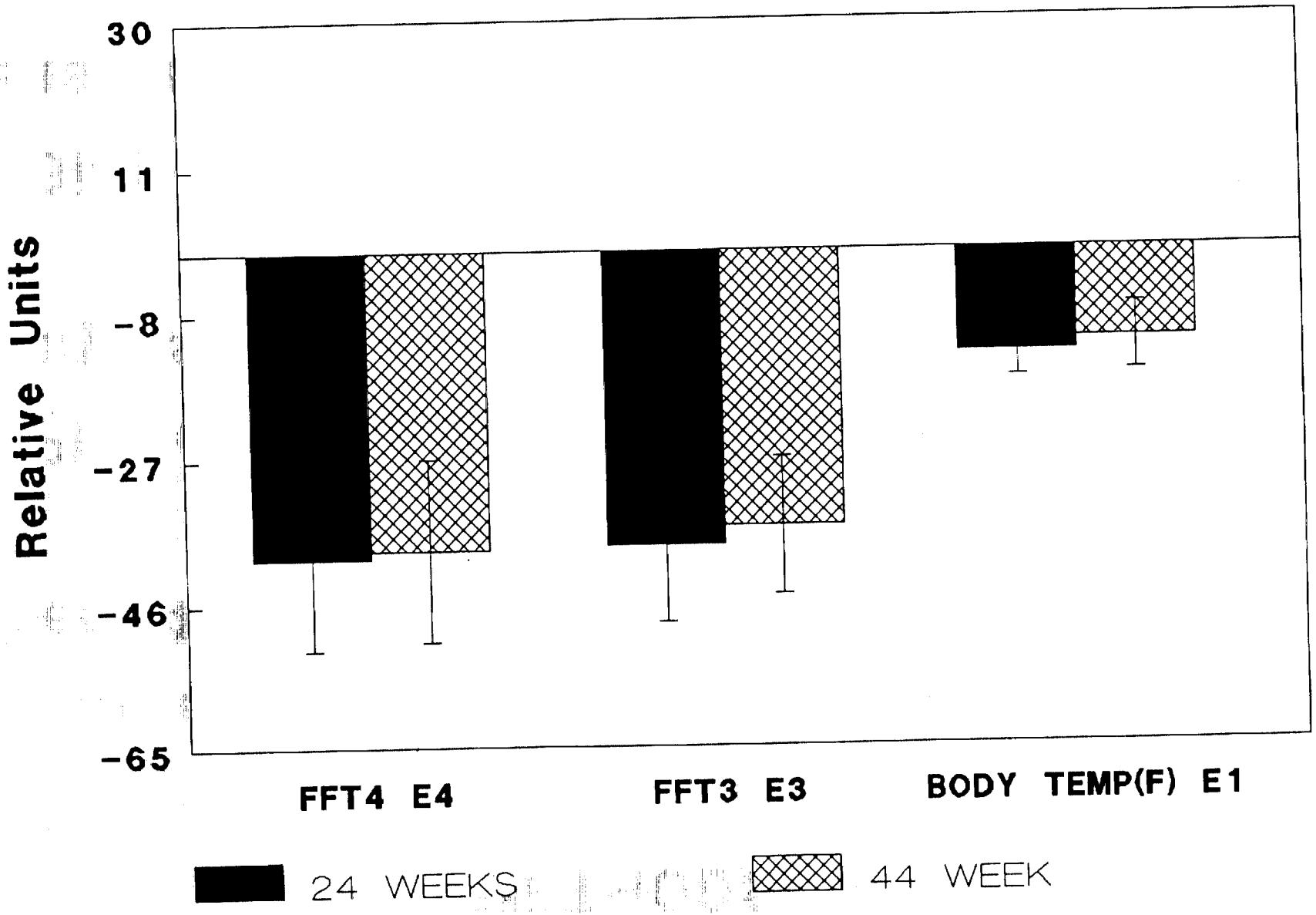
METHODS

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

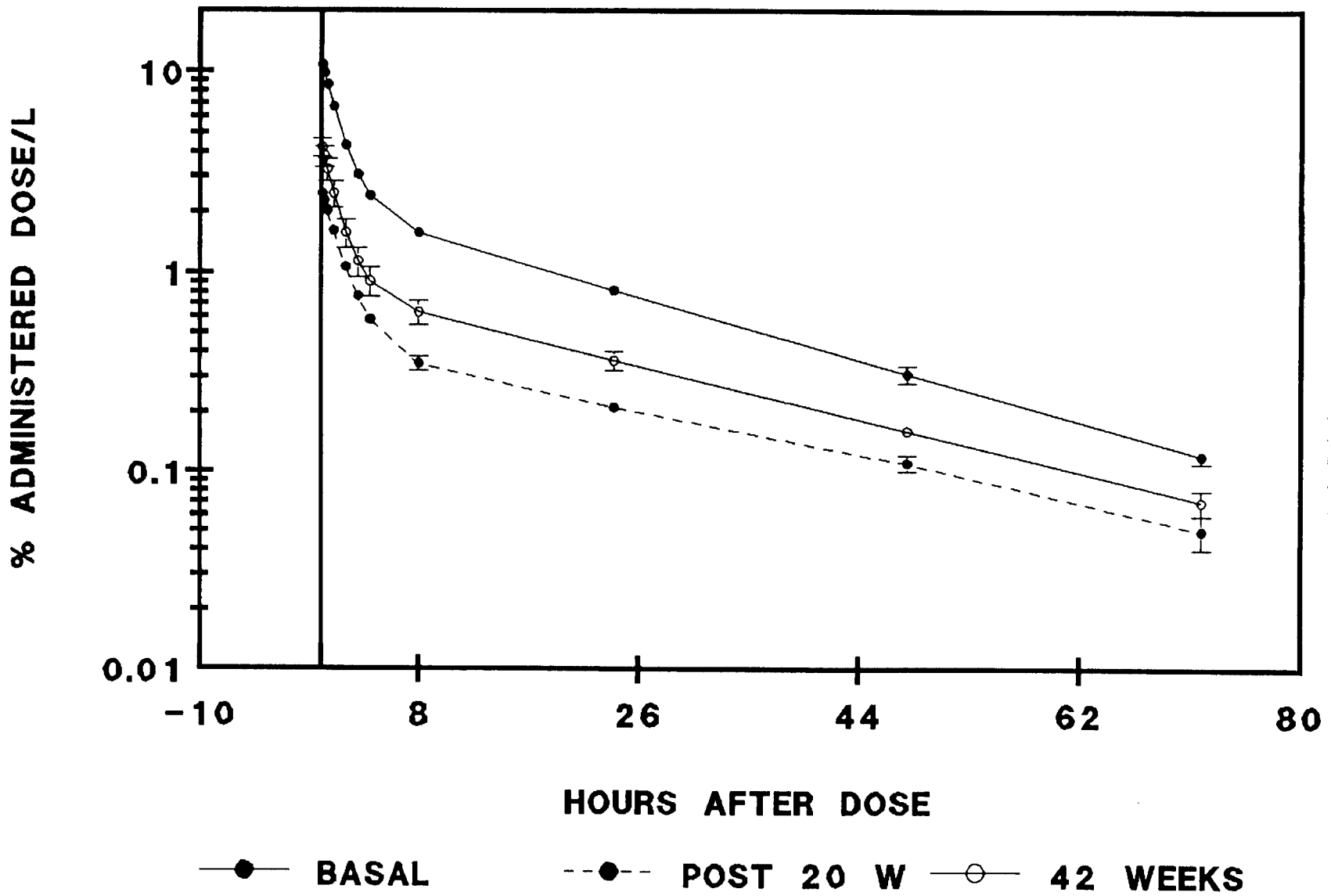
- Photoperiod Control and Paired Analysis

- Diet, Activity, Exposure And Weight Measured

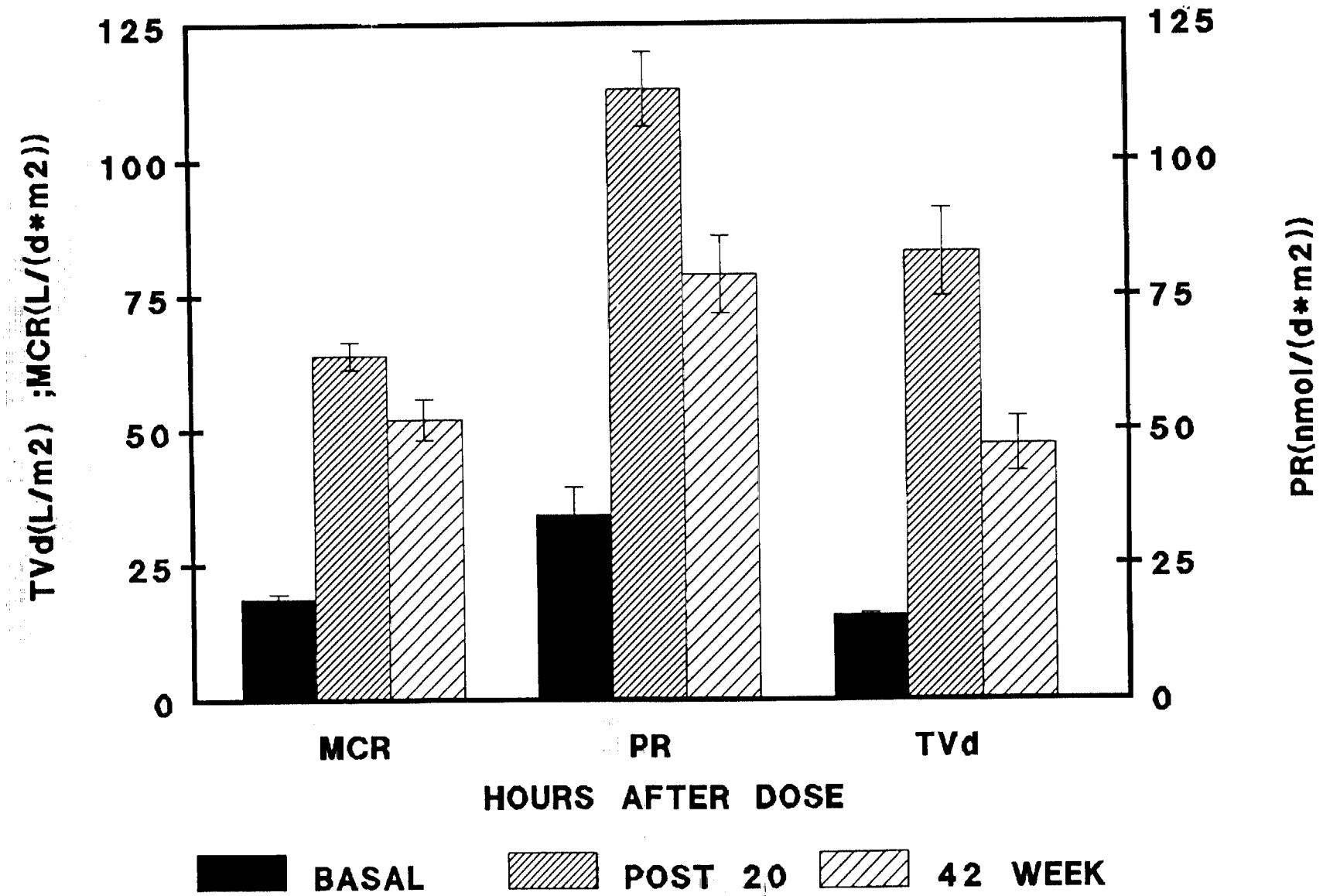
CHANGES IN THE FREE FRACTION OF THYROID HORMONES AND BODY TEMPERATURE



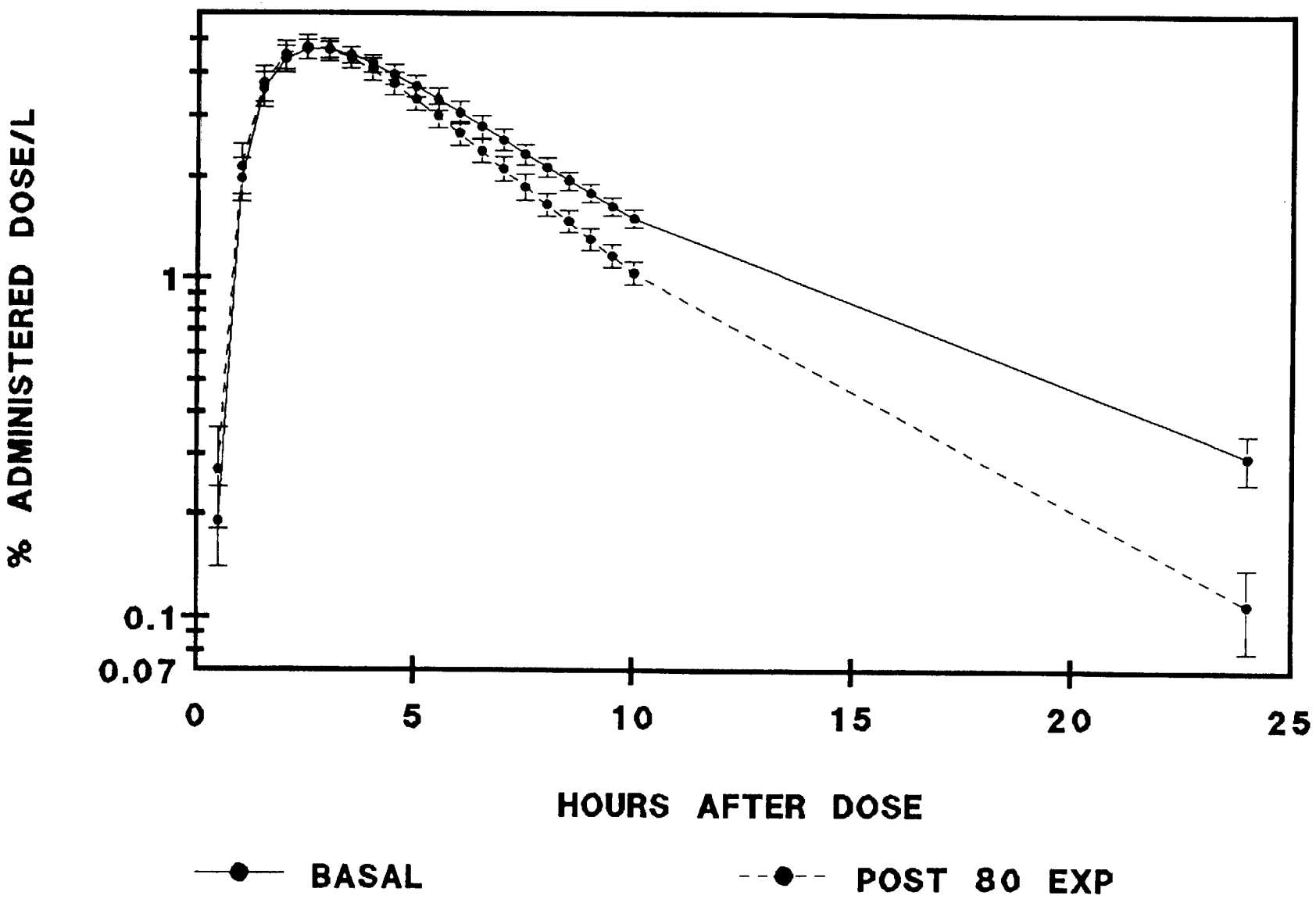
T3 CLEARANCE
WITH ANTARCTIC RESIDENCE



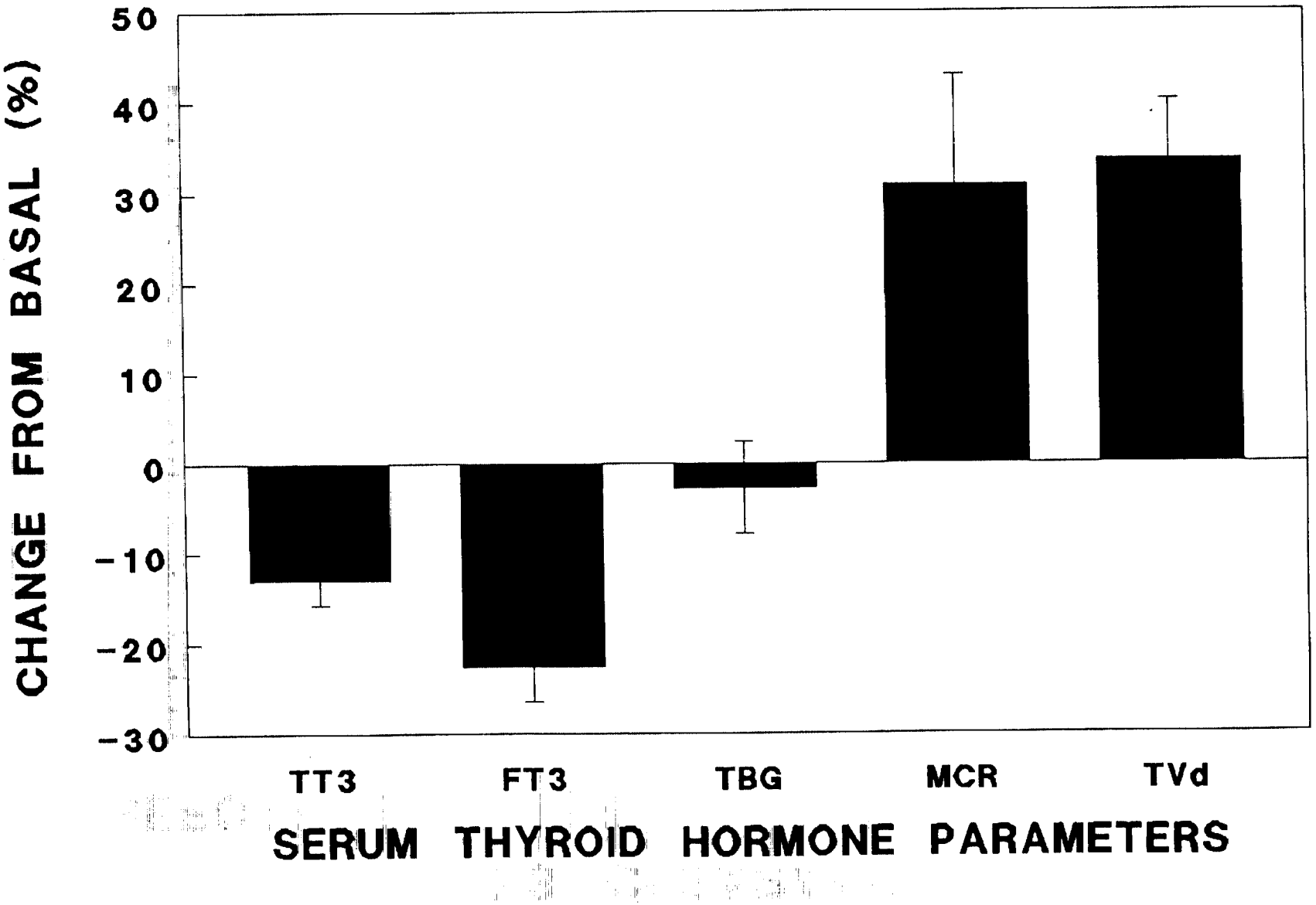
T3 KINETIC PARAMETERS WITH ANTARCTIC RESIDENCE



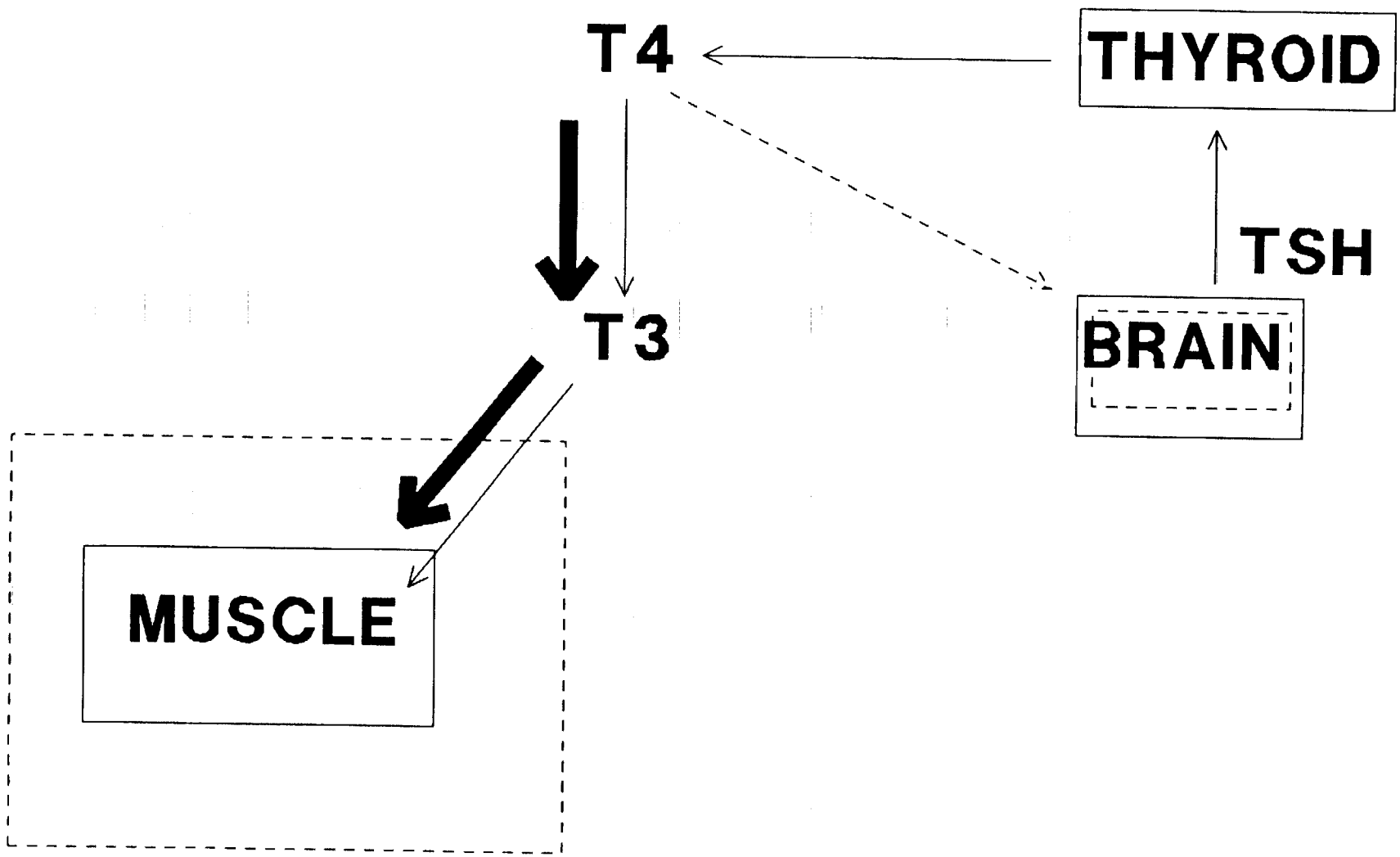
T3 CLEARANCE
BEFORE & AFTER 80 COLD EXPOSURES



CHANGES IN THYROID ECONOMY WITH ARCTIC CONDITIONS



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