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MEDICAL LEGACY OF SKYLAB AS OF MAY 9, 1974

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The purpose of these summary remarks is to put into proper focus the magnificent achievement created by the Skylab Medical Team in concert with their engineering colleagues and most importantly, the astronauts who had to serve as both investigators and subjects. Indeed, by their ingenuity and capability of handling the numerous problems encountered due to engineering deficiencies, they have shown man to be indispensable in long duration space flight.

The most significant achievement which could be documented for the entire Skylab Program is remarkably a negative one. It is the existence of a large volume of negative data which leads one to direct understanding and belief that man is indeed capable of adapting himself to a 0g environment and further changing that adaptation, after a significant number of days, and readapting himself to his normal 1g environment. As scientists, we all know that negative data can sometimes prove more important than positive data and in the case of space flight this is certainly so.

In order to understand the significance of the achievement and the collection of data in the Skylab Program, it is necessary to review some pre-Skylab space medical history. Prior to the time that man was first launched on a 15-minute orbital mission in 1962, the engineers were going ahead rapidly to develop vehicles capable of lifting man from the earth's surface with the ultimate belief that they had every capability to make these vehicles function properly to do the job necessary. They did not, however, share the same degree of optimism concerning man and his capability to safely pilot such vehicles. Indeed, the original Mercury spacecraft was designed in such a way that man needed to do very little and could, in fact, only override a single axis of control at a time by pulling a special lever. Those of us charged with the responsibility for the medical well being of the astronauts who were to be launched into space had to rely upon our previous aviation medicine experience and a strong "gut" feeling that man really was capable of sustaining the rigors of the environment to which he would be subjected in space flight.

To say that little data existed is a gross understatement, for in fact, no space data existed and we were relying upon the best comparable data being that obtained from X-15 missions. Man was raised as the great question mark in the capability of our nation to really embark upon the sea of space. In fact, imminent clinicians, physiologists, bacteriologists, psychologists, virtually every type of scientist, developed some prediction of what would happen to man when he was subjected to the space environment, as the particular scientist felt he understood it to be based on the information available at that time, sparse though it was. These predictions reached some very high levels in government, including the National Academy of Sciences, the President's Scientific Advisory Board, and even the United States Congressional Committees. Many of the predictions centered about concerns of the heart's ability to withstand the stresses of launch, flight, and re-entry, though I can assure you that perusing the letters and notes at that time, there was virtually no system of the body left untouched by certain dire predictions.

It did seem prudent at the time to precede our manned launch, even though it was to be a 15-minute suborbital flight, with a launch of a monkey which would allow us to check out a live biological subject with telemetered data to our ground network. As is well known to those who have followed the history of the space flight program, this mission went well except for some premature ventricular contractions which were noted during the mission and subsequently found to be due to the positioning of the catheter touching the wall of the ventricle.

This flight was followed by the series of Mercury missions ending with a 34 hour, 20 minute mission, the longest to that point. The Mercury missions proved to us that man could indeed survive the space environment with the help of the small Mercury spacecraft, and we saw our first indication of physiological decrement. The first system in which this was noted was the cardiovascular system. We had seen some pooling of blood in the lower extremities on the next to the last mission and then the pilot following the 36-hour mission had a near faint on the carrier deck, and subsequent examination well demonstrated the orthostatic hypotension which was to become a hallmark of exposure to space flight.

As we were still cautious and concerns were still being expressed about man, the Gemini space flight exposures were set for what were considered long duration flights of 4, 8, and finally 14 days after initial exposure of a few orbits to test the system. These long duration flights were followed as you know by a series of docking missions and, thus, the entire Gemini experience was aimed at giving us the confidence necessary in techniques and in man's capability to perform a lunar mission. We were able to do some in-flight medical data gathering on the three longer duration missions, and these data left us with the conclusion that there were physiological changes occurring which all were short-lived after the return to 1g. The question we were left with was whether these changes, which basically involved the cardiovascular system, the musculo-skeletal system, and the red blood cell were to progress in their severity with additional flight exposure, whether they would cycle, or whether they would indeed stabalize at some given level. We gained the assurance that man could indeed safely conduct an Apollo mission from a physiological point of view based on flight duration and thus the Apollo series was launched.

Aside from the new findings involving our first experiences with in-flight illness and with motion sickness in space, we had no particular difficulties with these results until the Apollo 15 (July 26, 1971) exposure where again we had an anomaly occur. The results of this mission were in our entire flight program to that date. The most important was characterized by a short-lived cardiac arrhythmia in two crewmen which in retrospect we felt to be due in major part to a potassium deficiency coupled with the other operational effects of the mission. Still, it was a unique mission in our experience for it took the crew some 21 days to recover to the preflight baselines in regard to response to exercise and lower body negative pressure. This was a particular concern not only to us but to those who wondered about man's capability in this environment for the findings were reminiscent of the 18-day Soyuz 9 USSR mission of June 1, 1970. We had been greatly surprised that these crewmen were unable to get out of their spacecraft unaided and that they took some 20 to 25 days to recover to their preflight baselines. We could not believe that the four days additional flight exposure over our longest Gemini mission really could be responsible for such effects. The concerns of the more cautious, and thus of the Congress and various consultative scientific committees was raised further by two other significant events. One occurred at nearly the same time frame, the biosatellite flight of the monkey "Bonnie" in June 1969. This was indeed an unfortunate occurrence for it created a very confusing image in the minds of those who were honestly trying to evaluate man's capability. This monkey, while programmed to fly for 30 days, flew only for 8, was deteriorating during the mission and died some 10 hours after recovery. The details of all the above missions have been reported and I would only say here that it is my personal belief on looking at the data that this animal was very completely instrumented in order to try and acquire the maximum amount of data and thus had many factors introduced in both the preflight and flight situations which could have led to the results obtained. It was unfortunate that the results were blamed by some of the experimenter entirely on the effects of weightlessness in spite of our own manned flight experience and this led to difficult debate before Congressional Committees. Shortly after this experience the Soyuz 11-Salyut mission was flown (June 6-30, 1971) and three Cosmonauts spent 24 days in space only to die on reentry as their reentry module suffered a rapid decompression resulting in severe dysbarism, hypoxia and virtually immediate death. Here even some of our areospace medicine colleagues began to desert us and blame weightlessness for these deaths prior to obtaining the scientific data which have well shown these deaths to be the result of the rapid decompression.

The above facts are important in the present context in that they set the environment in which the decision to launch Skylab was made. There was deep concern expressed by many that man was indeed the weak link in the system while those of us who are immersed in the Manned Space Flight Program were convinced that only the procurement of carefully planned in-flight data would really answer this question. We also felt that the ability to run the various medical evaluations in flight gave us a large safety edge in such determinations. Thus, the significance of the negative data obtained in the longest duration flights of man to this date, 28, 59, and 84 days. Another most significant factor in the conduct of these missions was the use of these data to make operational decisions during the mission. Daily data analyses were done along with weekly evaluations of man's status and a conscious decision was made with NASA management as to whether we would continue the mission for another week. Consultant groups in the areas of the cardiovascular and vestibular systems were also formed and utilized to great advantage during these important decision sessions. It has indeed been one difficult year, one of great accomplishment, great stress and one which I would not like to live through again.

The results obtained from this historic series of long duration flights has led us to several general conclusions and then to specific conclusions concerning the systems where most change has been observed. We have been impressed, in following the results obtained on the nine individuals flown, by the amount of individual variation shown. Fortunately, each individual has been followed according to his personal baseline. This has allowed a very careful evaluation of these individual differences, but certainly, they are evident as one views the data involving these nine people exposed to virtually the same environment. Any medical evaluation program utilizing human volunteers or subjects will find the same problems involving individual variation. It is very important to review our results as they apply to the total crewman involved and not as individual pieces of collected data. In short, a single biochemical determination or test result involving some particular organ system can only be best understood and interpreted for predictions as to the future if it is put in the proper perspective as to the total response of the individual in the space flight environment provided by the Skylab vehicle. Overall, the results on these nine individuals would indicate that all have adapted or at least acclimatized themselves to 0g over the flight period. Certainly this adaptation or acclimatization has been in stages with marked changes occurring in the first 24 hours and the bulk of the large changes occurring within the first week. It appears, however, that some of these changes still occur throughout the first 28 days. Therefore, we need to look even more carefully at the periods of adaptation or acclimatization. A most important point, is the remarkable ability demonstrated in all of these indivduals to readapt themselves to the 1g environment of Earth within a reasonable period postflight. As a matter of fact, this period has steadily reduced with increasing flight time. The 28-day flight crew took virtually the same period of time postflight to recover their preflight baselines (21 to 24 days). The 59-day crew took less time (5-7 days) and the 84-day crew still the least time of all (4-5 days).

All of these crewmen on recovery had a mixture of signs and symptoms relating principally to the cardiovascular, the central nervous, and in particular, the vestibular system and they showed a remarkable ability to overcome any of these signs and symptoms in responding to normal activity within the lg environment. This was amply demonstrated by the ability of all nine crewmen to assume the upright position, in some cases with the help of the lower body positive pressure garments, but nonetheless, all were able to egress the spacecraft under their own power and enter the medical examination facilities. This is indeed a remarkable accomplishment when it is viewed in the light of the findings of our Russian colleagues.

I would now like to review the individual body system findings of particular note.

Cardiovascular System: As is well known this was the first body system in which we demonstrated physiologic change as a result of exposure to the space flight environment. Even early in the Mercury flight program we postulated blood flow changes or shifts due to the weightless environment and certainly these have been documented by the crewmen in the Skylab flight series. They all expressed the feeling of fullness in the head, some fullness of the face, some filling of veins in the neck and face, and even redness of the eyes and flushing of the face, head, and neck. They were also acutely aware, both with and without lower body negative pressure, that there was a movement of fluid from the legs to the upper torso and that lower body negative pressure certainly increased the amount of blood flow returned to the legs. We demonstrated by means of the measurements of calf circumference. Therefore, there is a profound alteration in blood distribution which probably has some effect on blood flow to various organs which may have some effect on the other physiologic system changes noted. The change in muscle tension may also help to explain some of the effects seen in pooling during lower body negative pressure both in flight and in the lg environment back on Earth. Certainly, the effects of volume and pressure sensors within the body, the tissue pressure changes with the flow of tissue fluid into the central circulation and thus redistribtuion of volume and central nervous system effects causing changes in the autonomic regulation of heart muscle and rate and rhythm are all involved. Very significantly, we were able to show that the changes in the cardiovascular system noted postflight as orthostatic hypotension, confirmed by the lower body negative pressure results, were not due to degenerative changes in the heart muscle itself. Russian suggestions concerning this possibility were carefully checked by means of echocardiography used in conjunction with lower body negative pressure. The x-ray evidence of decreased cardiac size, while confirmed in the Skylab experience, was shown, through the use of echocardiography studies, to be due mainly to volume change and not due to loss in thickness of the cardiac muscle. We also were able to construct ventricular function curves with the use of echocardiography and lower body negative pressure that there was no change in the capability of the cardiac muscle to function. We do believe that some of the minimal electrocardiographic changes are the results of altered autonomic control of cardiac function. While the cardiovascular responses return to normal at a faster rate with increasing durations of flight probably was altered also by the amount of exercise done inflight, we still must consider the possible need for a countermeasure involving the cardiovascular system as we look at long duration space flight. The logical true countermeasure in this area is lower body negative pressure applied to the level of presyncope for a number of days pre-reentry. This has been tried in a number of ground based experiments and further work needs to be done to elucidate the proper time period for the use of such a countermeasure if deemed necessary.

The use of positive pressure garments, as done by ourselves and by our Russian colleagues on their missions, is the use of a crutch and not a true countermeasure. LBNP inflight offers the possibility of a true countermeasure.

Muscular System: We have evidence from two sources that there has been actual muscle loss in spite of the large amount of exercise done. We have evidence of negative nitrogen balance and at the same time we have seen decrease in muscle circumference and certain muscle power. Certainly, the magnitude of these changes has been decreased by what is probably a countermeasure, the use of exercise inflight. The exercise levels were increased on each of the succeeding Skylab missions and may in part by responsible for the more salutatory results of each longer duration mission. Our Russian colleagues have also examined the possibility of electrical stimulation of muscle groups inflight as a means of maintaining muscle mass. This certainly needs to be studied further in bed rest studies on the ground. It would appear that a large amount of time must be devoted to exercise and if more simple means could be found they would be welcome as a countermeasure.

Vestibular System: No motion sickness or vestibular effects were observed on the first Skylab mission as has been reported while all three crewmen on the second mission exhibited symptoms of motion sickness and one crewman on the third mission exhibited motion sickness. In addition, there is a possibility that one of the crewmen of the first mission on sober reflection feels he may have had some vestibular-related symptoms during the first day or so. We also observed by means of the testing by head movements and the rotating chair that the vestibular system, once it became adapted after several days (no more than 7 in the 0g envirnoment) became totally refractory to stimuli such as those produced by head movements in the rotating chair. This insensitivity to such stimuli persisted for 7 to 10 days postflight in spite of the fact that there was evidence of vestibular difficulty as the system tried to readapt itself to the 1g envirnoment which was evidenced by discomfort on head motion and by the use of a wide gait in the immediate postlfight recovery period. Skylab offered us the opportunity to physiologically dissect the vestibular system. This was in contrast to the only opportunity afforded on the ground which would be anatomical dissection and severing of various nervous pathways. This is an important area of research and certainly the incidence of motion sickness inflight during the adaptational period is a problem which must be addressed. The countermeasure for this area are unknown at the moment. Current selection procedures have been notoriously poor. In fact, the individual we woud have selected as being least susceptible to inflight motion sickness turned out to be the individual who developed such sickness on the last mission. We have utilized medication as the crutch in the treatment of this condition. But it is just that, a crutch, and selection and training in this area offers the only true countermeasure and must be researched in detail. Exchange with our Russian colleagues in this area is of grave import as we evaluate future flight programs.

Red Blood Cell Loss: One of the really remarkable findings following the first 28-day Skylab missions was the 15% loss in red blood cell mass that was noted. We had not seen this in our ground based study in the same atmosphere and certainly did not expect it as we were convinced from our Gemini and Apollo experience that this was the result of a 100% oxygen environment and that a small amount of nitrogen in the gaseous environment would protect against such an occurrence. We were, therefore, quite surprised to see the 15% decrease in red cell mass following 28 days of space flight and further to note the very delayed reticulocyte response postflight. This led to concern as to whether this would be doubled if we doubled the space flight duration, and inflight hemoglobin determinations by the crew were arranged as a means of trying to follow this situation during the actual space flight. Fluid shifts which occur make it difficult to interpret the inflight hemoglobin data but did leave us with the feeling that we were not getting into serious difficulty. We were delighted to see the results at the end of 59 and 84 days where we indeed saw no increase in the amount of red blood cell mass loss with increasing flight durations. Therefore, there appears to be some sort of "governor" that does not allow the red blood cell mass to go below a certain level. In fact we feel as the investigators have explained in their detailed papers that there probably is a replacement of these red blood cells even during the longer flight phase and that thus you catch the individual at different replacement phases the longer the flight. This mechanism is of importance because it has not been previously known and should be researched in detail for it may have great benefit to medicine on the ground. The need for a countermeasure here does not appear to be significant because it is a self limited process not endangering the individual during or after space flight. We should, however, understand the mechanism of this response as it may apply to other disease situations on the ground.

Perhaps the geratest legacy of all from Skylab will not be to the future of long duration space flight, although it is hard to imagine how this could not be so, but will be the fallout to ground medicine. We have had an unusual opportunity to observe adaptation or acclimatization of the human with a very particular stressor, that of weightlessness, which cannot be duplicated here on the surface of the Earth, though we have tried in several ways. This study in adaptational physiology and biochemistry has great import to many fields of medicine on the ground. The ability to physiologically dissect the vestibular system in the unique way provided by weightlessness is leading us to examine our thoughts concerning this particular organ, its function and diseases thereof. The cardiovascular system with its response to weightlessness involving pressure and volume changes offers us the unique model to study for possible relationship and help to problems involving hypertension and other cardiac disease. The use of lower body negative pressure and echocardiography combined offer an unusual method but a simple one for obtaining good ventricular function curves. The calcium loss observed will continue to be studied and may indeed lead us toward solutions of the osteoporosis problem here on Earth. Bed rest, as we all know, has been utilized since the dawn of man as a form of therapy whether done voluntarily by the patient or prescribed by the physician.It has become apparent from our studies that we must understand as much about the effects of bed rest as we would of any drug as we used on our patients. There are indeed profound physiological readjustments, some of value and some not, depending upon the particular patient. These should be understood and corrective measures developed.

Finally, I would like to leave a personal note for I have been asked by so many at this meeting why I have decided to involve myself in the development of a Health Science Center rather than continue to tackle the challenges of Space Medicine. My life has been deeply enriched by the people with whom

I have worked for the last 15 years solving one of man's greatest challenges. I have learned much and I feel that ~~health~~ the health of the people of our nation and the world and how we can best assure it is a key challenge of the next decade. I feel I have been well prepared by my space medical experience to accept this challenge and therefore I hope to bring to bear many of the things learned over the last several years as we look at man ~~and~~ his diseases, and try and maintain his health in a ground environment. Let me assure you that I will always remain in aerospace medicine, that that is my primary field of interest and training and that I will continue to develop it both academically and through my official ties in a continuing consultant role to the space agency. In summary, the Skylab program has produced a very rich legacy to the future of man both in space and on the Earth. Those who have been so deeply involved and some not yet exposed I'm sure will continue to evaluate these data and put them to use for the benefit of all mankind.

The End.

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SLEEP: EEG recordings have been made and analyzed on one crewman from each mission giving us data on three individuals, one for each mission duration. There are individual variations but the significant finding is the presence of adequate amounts of each level of sleep including REM. Adequate restful, sleep can be obtained in the zero g environment though there were times due to mission problems when rest was adversely altered and then the deficit was later recouped. No predicted pathology of sleep was noted.

CELLULAR FUNCTION:

The detailed growth curve study of fibroblasts of the WISTAR strain revealed no abnormalities of cellular functions observed and the data were of good quality.

Lymphocytes stimulated by an antigen (PHA) showed a reduction in RNA and DNA synthesis to zero on recovery day. These studies should be repeated with specific antigens such as staph, mumps or Candida and the relation to post flight immunity evaluated. It is an isolated unexplained finding at present and only that.

There are many who state in the present economic environment that aerospace medicine is a dead specialty, that all the problems of flight are solved and no more work need be done. They even cite oxygen, acceleration and man-machine relationships as examples of solved problems. Still, while we have accumulated much knowledge in these areas vigilant practitioners of aerospace medicine must point to these other problems involved in design and operation of air and space craft and prevent repetition of preventable incidents and accidents. The knowledge gained must be constantly used and people and aircraft are still lost due to hypoxia, faulty man-machine designs etc. Aerospace medicine is far from dead, it has just come into it's era. We have only scratched the surface of spaceflight and you must remember that man can perform in space if he has adequate rest, if he has adequate food, if he has adequate exercise, if his work load is carefully planned, if he is given time to acclimatize or adapt and if he is helped with countermeasures or have invented. You and the profession are needed to see the "ifs" are considered and covered. The problems aren't all solved. Sky Lab has led us toward many

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beckoning answers and also raised many unsolved problems as has been the case in medical research always. The future is yours. Don't be fooled by apparent solutions and easy answers.

Calcium: The detailed mineral balance study which was performed on this ~~mission~~ series of missions has demonstrated that the calcium loss as measured in increased urinary ~~sec~~ ex cretion, and indeed in a negative calcium balance, has progressed a~~s~~t a small but rather constant rate with duration of flight. These data tend to be confirmed by the bone mineral evaluations which were done. ~~and~~ All the results show that the losses observed, while having individual variation as expected, do follow remarkably closely the results obtained from bed rest study. It is clear from the early ~~looks at~~ study of the data that there does not appear to be a plateauing of the loss of this mineral, but instead there is ~~indeed~~ a constant small loss additive with duration in flight. It appears from Dr. Vogel's data concerning bone ~~marrow~~ mineral measurement that the prediction formula which he has utilized in bed rest patients is applicable to this situation inflight and one can ~~indeed~~ predict with a fair amount of certainty the amount of mineral loss expected of a given individual. This was an extensive and difficult experiment and of course data are still being compiled. A countermeasure in this area certainly appears to be indicated if we are to consider very long duration flights. The losses thus far observed have not been of a magnitude to cause concern as to fracture ~~of~~ or production of renal stone, but we ~~certainly~~ must look again at the various methods tried, and in particular look at the combination of oral calcium and phosphorus as a potiental countermeasure by trying it ~~at~~ on long term bed rest studies. In planning for any countermeasures, we are and must be especially careful about interfering with the bodies natural acclimitazation or adaptation schedule mechanisms.

Renal: While we have no evidence of interference with renal function, certainly blood flow to these organs could be altered and they are involved in the fluid balance and adjustment activity. We have seen weight loss on all of our missions but have managed ~~to~~ on the last mission to have one individual actually regain his weight in flight. We are sure from the post flight pattern observed that a large amount of this loss is fliud and therefore have carefully studied the body fluid compartments. We have not been successful on these missions in getting excellent urine collection data in the first few hours and ~~certainly~~ the first 24 hours appears to be a very rapidly changing and unstable period as far as the body's acclimitazation is concerned. We have no good evidence that diuresis actually occurrs, though we have postulated this from a theoretical point of view, and this still remains puzzling. Chamber flight data and data from XXXXXXXXXXXXXXXXXXX our Russian colleagues would confirm that there is some increase in insensible water loss in the space craft atmosphere. This may help to account for some of the fluid loss at any rate.

Biochemistry: Biochemistry was intensively studied on both blood and urine in the pre, during and post flight periods. The experimenter has reported these data in a preceeding paper and it is quite obvious there has been a tremendous amount of information obtained relating to the body's total biochemistry including the important horomones and electrolytes which will help us to make a much clearer picture of the sequence of events occurring in this adaptation and readaptation sequence. I will not belabor the details of these results here, but point ~~to~~ with pride to the magnitude of the data in the light of the difficult envirnoment in which it was obtained.

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What are the effects of these findings on future programs? Certainly, one of the effects on future programs is that we must be sure to provide for the things mentioned above no matter what the programs or the flight duration. We should be prepared to support man properly in conducting this task and we should be able to match the individual to the task wherever this is possible. ~~As we consider the shuttle vehicle,~~ The findings of motion sickness in a significant percentage of the Skylab crews makes this a high priority item for solution as to a countermeasure as we consider Shuttle flights of 7 days duration with scientists as passengers. Secondly, the findings involving the various body systems should be defined XXXXX in a way that they may be made applicable in the selection process of individuals to fly. Our objective is to keep people flying and we should be aware of details of the responses in several areas which might relate to or predict their response to the space flight environment. The vestibular area, the amount of bone mineral, the state of blood cells and their response to various stresses, the stability of the cardiovascular system and renal response all may play a role as we consider the selection of future passengers and crews.

There is a good deal of concern being expressed in many quarters at the lack of flying opportunities envisioned over the next several years. This relates also to the feelings that there is little to be done in the field of of Aerospace medicne. As a matter of fact, the flight programs for the comming years do leave us with a number of gaps. Some spaceflight gap in the immediate future can be put to execellent use however, in mining the Skylab data and developing the questions and thus the experiments that could be done advantageously on 7 and 30 day Shuttle missions. This gap should be used to great advantage.

We do have a flight program currently scheduled though, with some missions with life science interest. The first of these of course, is the Apollo-Soyuz test program (ASTP) which is the joint US-USSR docking mission to be flown in July of 1975. This mission, while having great international significance, also has some scientific experiments aboard including a few in the area of life sciences. The life sciences experiments currently undergoing development for this mission include those involving a study of microbial exchange; one on zone forming fungi; one studying the light flashes first noted in Apollo; a repeat of the biostack experiment successfully flown in Apollo; a study of human cellular immune response; and a study of polymorphonuclear leukocyte response. In addition to these designated experiments, there will be pre and postflight detailed physiological and biochemical evaluations of the crew.

An unmanned life science experiment of great importance will be launched in the summer of 1975 also. This is the Viking mission. The Viking spacecraft consists of an orbiter and a lander and careful decisions will be made concerning the landing site for the lander on the surface of Mars. It is planned to try and land the first of these vehicles on the Martian surface as close to July 4, 1976 as possible. This mission has several scientific objectives, but I feel that the biology portion of the mission is by far the most important, for it will ~~give us an answer~~ possibly give us an answer as to whether there is life in any form on the Martian planet. The three life detection experiments are rather simply described as follows: (1) A Pyrolytic Release Experiment - This is concerned with the photosynthetic and respiratory fixation of radioactive inorganic and carbon-14 gases into organic compounds determined by pyrolysis and chromatographic column separation of organic compounds from other volatiles. (2) Labeled Release Experiment - Concerns the release of volatile radioactive compounds from an aqueous solution containing labeled organic substrates during incubation with a Martian soil sample. (3) The Gas Exchange Experiment - It concerns changes in gas composition over a Martian soil sample incubated in contact with a liquid medium determined by chromatographic column separation and detection of the gases. A positive finding in these experiments indicating that there was organic material of life orgin on Mars would be a true scientific milestone and we will wait the results with great anticipation, particularly in view of the more recent descriptions of the Martian surface obtained by orbiting vehicles.

In the life sciences community we have been concerned for some time about the gap in obtaining further data of biomedical importance as we progress in the development of the Shuttle vehicle. We have therefore concurrently developed plans for a Biomedical Experiments Scientific Satellite (BESS). We had originally proposed that this be capable of a Scout launch in order to get some early experience with its use, but this has been delayed and it will more than likely be Shuttle deployed and Shuttle recovered. We would like to make this capable of carrying animals, animal subsystems, tissues and cells and also capable of being left in orbit for longer periods of time than the Shuttle would be capable of staying. This would provide us with further long duration infomation, all be it at a level lower than the human. It is hoped that future budgeting cycles will allow progress in the development of this module.

As the Shuttle becomes operational we will be far along in the development of the space lab which will provide us a laboratory which can be carried in the bay of the shuttle, giving us the capability to conduct experiments with cells, organ subsystems and man all at the same time in the space flight environment. This laboratory should offer us a tremendous opportunity to carry out the experiments to answer the many questions which have been raised as a result of the Skylab data and which remain one of the great legacies of this program. Individual scientists can develop experiments and can indeed fly as the scientists with their experiments to be conducted in the space lab as carried aboard the Shuttle.

We are currently in the phase of rapid development of the Shuttle prototype and find ourselves faced with some of the common problems always faced by those in aerospace medicine in trying to provide for crew comfort and improved capability for the crewmen and the scientitst to do their jobs. We are concerned about the crew quarters, conditions in the Shuttle, space and separation for adequate sleep and exercise, the capability to provide and measure adequate food intake and to measure urine intake and output. These are capabilities which will be needed aboard this vehicle and continue to be negotiated. The motion sickness concern has already been mentioned and is certainly one which must be addressed by the aerospace medical community.