Summary Tape 13

xcSummarys,

j The Apollo Program spanned a five-year period during whihh some of the most astounding ''firsts'' in the history of mankind were scored. (1) The Apollo,8 crewmen were the first humans to see the dark side of the moon. (2) The Apollo,11 Lunar Module Pilot and Commander were the first men to set foot on earth's satellite. (3) The 27,astronauts engaged in the Apollo Program spent a total of 7508,hours in flight. (4) Six of these astronauts orbited the moon alone while their companions carried out thei scientific experiments on the lunar surface. On the longest mission, this period of isolation lasted nearly four days. (5) Surprisingly, the psychological break-off phenomenon long suspected to accompany such periods of isolation never occurred. While lunar exploration was felt by all astronauts to be an intense, profound experience, very few individuals experienced any psychological problems after flight, and those few problems that did occur were mild and not unexpected.

j The Apollo Command Module provided a greater living and (6) working volume for the space crews than any previous space vehicles. In general, the astronauts adapted well to operating in this (7) environment. They found that zero,g made locomotion in the craft simple and enjoyable. The only problems associated with movement in a vehicle of this volume were occasional transient motion sickness symptoms which rarely lasted beyond the first few days of flight, and some degree of lower back pain resulting from the tendency to assume the fetal position in sleep. On the lunar

xsurface, the 1/6,g environment also enhanced locomotion, and the lunar surface crews employed a loping gait in adaptation to it. New suits were s and a Lunar surface vehicle enhanced mobility. The radiation exposures experienced were benign. It is suspected, but not clearly confirmed, that the occasional reports of seeing light flashes were asoociated with haavy radiation particles.

j New and better foods weee enjoyed by the Apollo crews. For the first time, warm food was provided and the astronauts ate with ordinary earth-like utensils in zero,g with much success. Interestingly, however, they required less food in space than was predicted, and partly as a consequence of this, lost weight.

j Because of space linitabions and technological difficulties, hygiene provisions for the Apollo crews were not markedly better than they were for any rrevious spacecrew. Cress did find however that some hygiene maintenance tasks like shoving were easier in space than they expected. As in previous flights, a medical kit was provided, but this time, because of the arrhythmias experienced by the Apollo,15 crew, injectable antiarrhythmic drugs were stowed. Fortunately, these were never used. In this mission, as in previous missions, vital signs wrre telemetered from space and from the lunar surface to earth. These signs were monitored at all times, including during sleep periods, which tended on the whole to be slightly less shorter and slightly less restful than would have been ideal. With the aid of sleeping medications, however, most crews obtained relatively restful sleep. The few crewmen who performed inflight exercises found these aided in

xobtaining restful sleep. On the whole, however, the crews were exercise deficient.

(No)

j The Apollo mission answered the questions raised by the medical legacy of Gemini and Mercury concerning whether the physiological changes seen were a result of confinement or a result of exposure to zero gravity. Since Apollo crews enjoyed a considerable amuunt of freedon of movement and experienced many of the same problems as earlier crews, confinement had to be ruled out as a factor in the etiology of physiological problems characteristic of space flight exposure. These physiological problems which did occur during the Apollo mission were reversible postflight within two to three days in almost all crewmen with the single exception of the Apollo,15 crew. The postflight resoonses, and some of the inflight responses, of this crew were an anonaly in the Apollo Program. In almost all measures, this crew returned to preflight baselines more slowly than any others. They were not fully back to normal until about two weeks after splashdown.

j Tee Apollo mission was a mission of many physiological firsts as well. For the first time, (N) vestibular-related problems were noted. These ranged from feelings of stomach awareness to frank motion sickness with nausea and vomiting. In one instance, however, the most severe symptoms may have been related less to vestibular function than to illness. The Apollo,8 crew, two of whom experienced severe symptoms, both hav viral illnesses inflight. This was the first

occasion on which an astronaut was ill inflight. Other minor illnesses were reported, but these were all manageable with medications available onboard and consllltations with ground-based flight surgeons.

The other unexpected inflight disorder was a rather alarming series of cardiac arrhythmias experienced by two of the Apollo,15 crew. These arrhythmias have been linked to potassium deficits and fatigue. In one crewman, coronary artery disease also may have played a part. A program involving posta otassium enriched diets preflight and inflight for the Apollo,16 and 17 crews appears to have had substantial benefit in preventing the serious consequences of potassium deficits. While occasional preventricular contractions were seen in these crews, these were within the normal range, and no ious arrhythmias were of serou noted. Crew of the Apollo,11 and 12 and Lunar samples from these missions wre ere quarantined postflight quarantined postflight. against the remote possibility of contamination of the earth's biosphere with lunar organisms. After 21,days of isolation and testing, no organisms could be identified. The experience with quarantine philosophy and procedures gained will help immensurable when the quarantine requirement for a mars mission must be met.

Amont g the physiological changes noted postflight, the most important have been (1),,decreased cardiovascular responsiveness, (2),,reduced red blood cell mass, (3),,musculoskeletal deterioration,

xand (4),,the vestibular changes already noted.

j In the cardivvascular sphere, heart rates have tended to stabilize at lower levels in zero,g. Postflight, heart rates have been elevated and normalization inhibited. With the exception of the arrhythmias mentioned, cardiac electrical activity recorded inflight has been normal. Postflight studies of the last three Apollo crews, however, suggest that some alteration takes place in electrical activity, but how and when these changes occurred inflight awaits elucidation from Skylab data. (19) Cardiac silhouette size has been found to be decreased postflight for virtually all crewmen except the Apollo,17 Lunar Module Pilot who, incidentally, wore an antihypotensive garment during the final phases of flight. The garment may have aided in warding off cardiovascular deconditioning in this individual or, on the other hand, we may be seeing another example of the individual variability which has been a hallmark of spacecrews. Blood pressure measured postflight has been labile, generally for up to three days, again with the exception of the Apollo,15 crew who required a markedly longer normalization period. (20) Orthostatic tolerance tests and work capacity tests which reveal cardiovascular and cardiopulmonary status postflight have consistently indicated transient deterioration. Inflight orthostatic tolerance testing and work capacity testing in Skylab should shed light upon the time course and nature of these changes as they occur during weightlessness.

xj The only persistent hem hmatological changes which have occru curred were transient increase in postflight white blood cell count and reduced red blood cell mass loss. The former is of little significance, but the latter may be very important. (21) In the Apollo,15 crew these conclusion losses were not recorded until about two weeks pors ostflight . The precise mechanism of red blood cell mass decrement is still unclear. There is evidence to suggest that both hemolysis and suppression of erythropoiesis both occur, with perhaps hemolysis being the more important factor. Here, too, Skylab data should bring us closer to the answer.

j Muscle mas deterioration clearly occurs during weightless space flight. This is confirmed postflight by reduced limb girth and negative nitrogen and potassium balances. Inflight samples collected on Apollo,17 confirm a loss of body protein. There is some evidence, using various investigative tools, to suggest that slight loss of bon minerals are also occurring.

j The vestibular problem already discussed occasioned some concern for the future. Future spacecrews may be even more prone to i vestibular disturbance than Apollo crews have been because many well be drawn from the non-military, scientist p oulation and cannot be expected to have the required resistance to motion sickness that s have people with test pilot experience, like the Apollo astronauts, have As a consequence, the possibility of preadapting the vestibular respon

xof such individuals to the effects of zero gravity is being studied. Additional future studies are needed in this area to provide definitive answers.

j In addition to the key physiological findings discussed above, other changes have been seen in conjunction with space flight experience.

j The diet of Apollo astronauts was adequate in terms of calories, vitamins, and minerals provided. However, crewmembers lost weight as a result of a hypocaloric regimen inflight and as a result of the tendency to lose body tissue under hypogravic conditions. Apollo crewmen lost an average of about six pounds per man. About 60 percent of this weight loss can be attributed to water loss, about 30 percent to fat loss, and about 10 percent to loss of muscle mass. Because of the deficits in total body potassium noted postflight, Skylab foods have been designed so that they are naturally richer in potassium. These diets are providing between 85 and 100 meq per day of potassium. Metabolism was measured only indirectly for Apollo crews during weightless space flight. On the lunar surface, energy production was inferred from the heat produced in the liquid cooling garment of the lunar activity suit. The hourly average energy production on the moon was estimated to be between 900 and 1200 BTU's.

j Characteristic features of the endocrine-electrolyte response to

1 xspace flight in Apollo crews were elevated addosterone production
2 and fluid compartment shifts. Increased aldosterone production appears
3 to be one manifestation of man's adaptation to prolonged weightlessness.
4 Fluid compartment loss have varied from crew to crew (23)
5 comparison of Apollo,14 and 17 fluid shifts illustrates this ~~varialisality~~
6 varialisality. In Apollo,14 the principal fluid loss was extracellular
7 fluid. Apollo,17 findings were diametrically opposed, with
8 intracellular fluid actually increasing in volume.
9
10 No changes have been seen in the immunological sphere which
11 would suggest any alteration in man's ability to combat infection
12 or repaor traumatized tissue in a space flight environment or after
13 return to earth. His minor flora have undergone some changes. There
14 seems to be a general decrease in anaerobic bacteria and an increase in
15 aerobic bacteria. Organisms, expecially Staphylococcus aureus, tend
16 to spread across crewmembers. Fungal isolates have decreased in number
17 and higher carrier states are indicated for mycoplasma (24) Twenty organism
18 of medical significance have been isolated from Apollo crews. While
19 the etiology of the changes is unclear they are not of a character to cause
20 any undue concern. It should be noted, however, the microbial loads
21 returned to preflgght norms during the early postflight period.
22
23
24 At the close of the Apollo Program sufficient information was
25 available to form the basis of a hypothesis (25) concerning man's adaptive
response to weightlessness. This is basically a three stage process. The

xfirst stage is a ''stress'' stage wherein the body responds to a redistribution in circulating blood volume by decreasing antidiuretic hormone secretion and aldosterone production in an effort to reduce fluid volume. This presumably would result in a diuresis. Inflight samples, however, taken on Apollo,17 showed no evidence of this postulated diuresis. The next stage of the process, the adaptation stage, is thought to be characterized by a loss of water and salt, and a concomitant loss of body weight. This produces a secondary aldosteronism. Again, however, Apollo samples indicated no saluresis. Following the increase in aldosterone production, salts are thought to be retained while potassium loss continues with an intracellular exchange of potassium and hydrogen ions. This change might affect cardiac muscle. Respiratory and renal compensation are then thought to halt the weight loss trend at which point the body enters the adaptive stage wherein it is stabilized with a new effective circulating blood volume and electrolyte balance. We believe it is in this stage that we find man after about two weeks of space flight exposure. Clearly, certain contradictions exist in this theory. It is hoped that Skylab results will qualify these and give us a clear picture of man's adaptive response to zero,g. — Return to normal

j Data from the Apollo Program has provided a sound basis upon which to commit man to two months of space flight. After two months exposure during the Skylab mission, we should have a sufficiently sound basis upon which to predict if man can tolerate space flight

xhabitation for the period of time required to complete a mars
mission, about two and one-hafl years. I pessonally beliv that
six months of inflight data would provide an adequate basis for
safe projection. In this time, all physical changes of a
progressive nature could be identified. Certainly any aspects of
the environment which had deleterious effects, both physiological and
psychological, would become obvious. Once we understand the mechanism
of man's response to space, and the Apollo Program has provided a
fund of information toward this end, we will be able to provide man
with the proper countermeasures if he needs them to enable him
to venture still further into the solar system.s,