The Beginnings of Space Medicine

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The beginnings of space medicine are those of aviation medicine and involved, among many pioneers, Dr. Harry G. Armstrong and the Aeromedical Laboratory. Space Medicine has advanced in a short 23 years from arguments about man being capable of survival in space through animal and manned flights to flight durations of 6 months. The public and private arguments about man's capability to survive and work in space and the early decisions about flight duration and safety are chronicled from a personal point of view.

I WANT TO THANK the organizers of this symposium, Gen. Doppelt, Col. Mohr, and especially, Dr. von Gierke for the honor of being invited to help celebrate the significant contributions of this laboratory to our beloved specialty—Aerospace Medicine. It is a privilege to return to my first family in aerospace medicine, the United States Air Force, and to see so many friends from those exciting times.

The beginnings of space medicine are really those of aviation medicine. The rich history of observations such as those of Copernicus, the French balloonists, Dr. John Jeffries (our own American balloonist), Acosta, Paul Bert, and hundreds of others who have contributed to the recognition of human problems associated with flying and the solving of those problems, laid a base for both aviation and space medicine.

Strughold in 1952 (8) and I again in 1962 (2) called attention to aviation medicine being the parent discipline of space medicine. (My paper was written while I was Chief of Aircrew Effectiveness in the Surgeon General's office, fighting daily for recognition of the fledgling specialty of Aviation Medicine with the well-entrenched clinicians.) The atmosphere of the Earth is the realm of aviation and the vacuum of space, that of spaceflight. The concept of space equivalent altitudes within the Earth's atmosphere was elucidated, linking the two environments even closer. Those practicing aviation or space medicine must not forget that the ground is also the domain for aircrews, and space crews spend much of their time there. Behavior patterns and stress responses are brought to the cockpit by crews in both areas. The single factor making space medicine different and new is the presence of weightlessness created by our ability to achieve the speed to place a spacecraft in Earth orbit or to have it leave Earth orbit and travel to the moon. Many of us had our first exposure to weightlessness at this very laboratory in the KC-135 aircraft parabolas.

Certainly the Air Force Aerospace Medical Research Laboratory, beginning on May 18, 1935 with Dr. Harry Armstrong, then a Captain in the Army Air Corps, was involved in the beginnings of space medicine. He was very active in identifying real physiological problems of flight and then developing protective measures to allow the flight crews to do their inflight jobs. It is interesting that one of the first problems noted by Dr. Armstrong was his difficulty in gaining acceptance by, or even

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the capability to discuss problems with, the engineers involved in making the vehicles fly. This certainly was a significant early problem in space medicine. The activities of this laboratory in the areas of acceleration and impact, hypoxia and explosive decompression, etc., and the development of partial pressure and full pressure suits for protection were key to the beginnings of space medicine (6).

In comparing aviation and space flight, we tend to forget their differing time scales. Aviation has spanned the time period from the Wright brothers first flight on December 17, 1903 to the present, a period greater than 80 years. Man first entered the space environment on April 12, 1961, with Yuri Gargarin's one orbit flight in Vostok I progressing to the U.S. Moon Landing on July 21, 1969 to the present long duration Salyut space station of the U.S.S.R., a span of only 23 years.

How many of us can remember the admonitions given us in the Air Force to not use the words space or spaceflight and how some titles were thus disguised? There were also those making strong statements that if any flights ever did get into space, they would be animal flights.

Payload: Machine, Animal or Man?

One of the first issues faced by the nation in developing a capability to launch any type of vehicle into space was: What shall the payload be? Looking back at some of the early rocket launches—all failures—one began to wonder if it would ever get there. Those in power in Congress and the scientific community seemed to doubt both the need to and our capability to get into space. There were those who were convinced that engineers and technicians could certainly build a vehicle capable of entering the space environment. They were much less convinced that man would ever be capable of surviving in this environment. This led to many arguments concerning the complexities of trying to build an intelligent machine able to acquire information about the space environment in a more advanced way than done in some of the early space probes. Strangely, even those who felt that man would be able to survive in the environment and, perhaps, be able to perform limited tasks there, remained unsure enough of that position to want animals flown first in each step before man could take the same step.

It's clear that the Russians had adopted this view very early in their program and had launched a number of "animals" in small rockets for brief "space" exposures, as we had done with mice. The first real public notice occurred when they flew the dog, Laika, in Sputnik 2 (November 3, 1957) for 1 week with no monitored ill effects. She was "put to sleep" in space, as there had been no plan to attempt reentry and recovery. In August of 1960 they flew two dogs, Belka and Strelka, along with rats, mice, drosophila and plant life, and recovered them after 24 hours of flight. Again in 1967 they flew two dogs for 21 days and recovered them successfully, as a prelude to longer manned flights (1).

The United States first ventures in sending biological payloads to space were sponsored by the Aero Medical Laboratory at Wright-Patterson AFB. Dr. James P. Henry was head of the Acceleration Unit of the Biophysics Branch, and he and his team used captured German V-2 rockets at White Sands, NM. They developed a capsule for a monkey, and a Rhesus named Albert was launched on June 18, 1948, but there were a number of operational failures including the parachute. A total of five flights ended with parachute failures. The first Aerobee rocket with a Capuchin monkey (April 18, 1951) also had a chute failure. The second one, on September 21, 1951, successfully carried a monkey and 11 mice. The monkey died of desert heat at the recovery site. Erich Gienapp made all the instrumentation for heart rate and blood pressure measurements on the monkey and the camera for the mice observation in-house at the Aero Medical Laboratory.

There were those who felt many more animal flights were in order. In late 1960, President Eisenhower's Scientific Advisory Committee (PSAC) cautioned as follows on Project Mercury: "A difficult decision will soon be necessary as to when or whether a manned flight should be launched in light of a high probability of unsuccessful flight" (7). As a new president took office in 1961, a chimpanzee, Enos, was launched into orbit in November 1961 completing only two (181 minutes) of the scheduled three orbits as the spacecraft began to tumble. Nonetheless, he did well and opened the door to manned orbital spaceflight.

I can well remember dancing with glee around the strip chart recorder at the Bermuda station as I observed my first real electrocaridogram from orbital space flight on Enos. This was short-lived glee because we very soon began to see premature ventricular contractions (PVC's) appearing with increasing frequency, leading us to deep concern about the cardiovascular system's response to space flight. This concern was relieved post-flight when we found that one of the catheters, many of which had been inserted in Enos prior to flight, was actually in too far and had been striking the ventricular wall and producing the PVC's which we had recorded.

Arguments persisted about needing more animal data to get a larger statistical "N." The proponents of incremental exposures of man prevailed, without having to project animal data to him. While temporarily dormant, the argument didn't die.

In 1958, I was involved with developing crew selection criteria at the School of Aerospace Medicine and had selected some Air Force volunteers for a Man in Space Soonest Program for Gen. Flickinger. Shortly, I received TDY orders to this laboratory where I found I was to participate in the selection activity for the first astronauts with Stan White's group.

Today, we enjoy some fair amount of data on the human response to the space environment and large crews are entering the environment at an increasing frequency. A brief summary of these responses should suffice, for the difficulty in obtaining them is the subject more than the findings themselves.

Cardiovascular changes were the first noted and are characterized by fluid shifts headward, plasma volume adjustments inflight, and the development of orthostatic intolerance postflight.

The vestibular system effects have been characterized by several days of space motion sickness inflight in 40–50% of astronauts or cosmonauts and some disorientation on head movement postflight.

The blood has shown a decrease in red cell mass inflight until about the 40th day when it begins to return to normal.

The musculoskeletal system changes were a decrease in both muscle mass and skeletal calcium.

The space motion sickness effects are of more concern on the shorter duration flights such as those of the present Shuttle missions, whereas the long-duration missions have the loss of skeletal calcium as the major concern.

We could then summarize the current status of man's responses to space flight in the following brief statement: While there has been some individual variability, man has always been able to perform his inflight tasks for short or long durations up to 7 months inflight. He has suffered no permanent physiological change postflight, but only time-limited readaptational changes when he is supported with adequate atmosphere, food, and hygenic facilities, exercise and workload planning, rest, time to acclimatize or adapt, and countermeasures where warranted (3).

We did not reach this current status without a great deal of blood, sweat, and tears, and in fact, the space effort has perhaps suffered because it was made to look too easy to the general public. The blood, sweat, and tears expended in support of man reaching the current status of space flight are what should be remembered as we advance on the frontier, so the same battles won't be refought (4).

The pronoun word "I" is used in this personal account, though I was really an instrument—in the right place at the right time—and privileged to develop a team to represent aerospace medicine through use of the rich heritage from previous pioneers to further man's advance on this new frontier.

Is Man Capable? . . . How Long?

The same PSAC group, questioning whether a manned flight was indicated, said, "Man in space cannot be justified on purely scientific grounds" (7).

The next major issue was "Can man do it?" Can he not only survive, but perform work in this space environment? This question dogged every single step that was made from the first manned flight with Alan Shepard through the long duration flights of Skylab. With each increment, a new group of scientists from the National Academy, some particular experimenter, a Congressional committee or the President's Scientific Advisers would raise the issue about whether man really was capable of performing that particular mission.

Even if it was deemed that man could at least do the mission, the question always remained—for how long? We're still involved in answering that question today.

The first major task was to do a 15-minute suborbital flight with Alan Shepard. Obviously, there was no space flight data on man. A very prestigious group of medical and physical scientists on the President's Scientific Advisory Committee argued that Al would go into cardiac failure as his heart rate would exceed 180 beats per minute during the launch and 15-minute suborbital flight. They were particularly critical that while an electrocardiogram was available, there was no method for obtaining blood pressure. This was a position which recurred many times. Scientists, who were used to dealing with patients, tried to apply patient data to healthy human beings in a challenging environment and did it erroneously. President Kennedy overruled his scientific advisors and the first 15-minute flight was successfully flown with no heart rates of 180 and no cardiac failure (peak heart rate was 136 beats per minute). It seems strange to say that today, but it was a very real problem at the time.

The initial Gemini flight on the books had a stated duration of 7 days. As I reviewed the Mercury data, in particular that from the Schirra and Cooper flights, I was concerned that we had seen the first evidence of physiological change postflight. It involved pooling of blood in the legs and feet in the case of Wally and a near faint on the carrier deck in the case of Gordo. I began to review that list of potential space problems. I was personally scornful of the list, but still did not want to be caught by some problem we had failed to recognize or anticipate. Hardware was available for another Mercury mission and Al Shepard was more than ready to fly an orbital mission. We did some quick planning and developed a potential additional Mercury flight which would extend our stay in space past the 2-day mark and perhaps even to 3. Admittedly, this was in a very tight spacecraft but it would have given us a data point between our 36 hours and the projected 7 days for the first Gemini flight. We visited Mr. Webb, NASA administrator in Washington, and tried to convince him of the value of such a mission. He carefully considered it, but stated that he felt it was vital that we devote our experience and expertise toward getting the Gemini program underway, and he felt that flying the extra Mercury mission would further delay that and an early attempt at a lunar landing. A wise decision!

I began to develop a duration position which I could hopefully sell to the Gemini program manager, Chuck Matthews, and then to Bob Gilruth, Chris Kraft, and Jim Webb. I felt we needed some interim duration between the 36 hours accomplished and the 7 days planned, and decided that if we could increase our flight increments by a cautious doubling of the duration, it would make some biological sense. We would get to look at information from a flight of a given duration and then double the duration the next time and so on to a total of 14 days. The 14 days was selected for two reasons: first, it seemed the maximum reasonable time you could ask a crewman to stay in the confines of a Gemini spacecraft; and secondly, there would be no projected lunar mission which would be longer than that time period. Therefore, if we carefully evaluated two crewmen's responses to 4 days, 8 days, and finally 14 days, we should have at least minimal information which would allow us to go ahead with lunar missions without undue physiological or psychological concerns about the crew of such missions. Finally, in August of 1964, these durations were accepted by management in Houston and in Washington and I breathed a little easier. This decision was aided by the fact that the fuel cells which were to be our source of power in Gemini were not ready and had to be replaced on the 4-day flight by batteries. This gave management a hardware excuse also for the 4-day limit, since there was a reluctance to admit to concern about man's ability to perform for increased periods in space.

An additional problem, which made this decision even better from my point, was the fact that a few months prior to the June 1965 launch of Gemini 4, we had developed a plan to try extravehicular activity on that mission. Chris Kraft and I had rooms in the new Mission Control Center (MCC) where we lived during the mission and prior to this mission both had received phone calls from well-meaning physicians and physiologists warning that we were sending men to their deaths with 4 days in space, and that surely they would be unconscious on recovery and probably drown getting out of the spacecraft. Even some of my own staff had subscribed to these feelings.

The crew was recovered in good shape and they were able to walk across the carrier deck without support. The crew and I were rather ecstatic for this represented a day that many of the "straw men" were knocked down, as Ed and Jim wrote on their photo. Space medicine came of age.

The next big milestone occurred only 2 months later in August of 1965, when Gordon Cooper and Pete Conrad completed an 8-day flight, and again our medical data was most heartening. Following this mission, Gordo, Pete, and myself had the opportunity to talk at the Academy of Sciences about our feelings on man's capability to perform for these durations in space. Certainly, Pete and Gordo were living proof that we could do it for 8 days, and I strongly felt that we could do it for 14.

Only 4 months after the successful 8-day flight, we launched Gemini 7 with Frank Borman and Jim Lovell to spend 14 days in the space environment. This they did superbly well, collecting a large amount of medical data under very difficult circumstances operationally and even added our first space rendezvous by flying close formation with the Gemini 6 spacecraft launched near the end of their mission. To say the least, I was overjoyed at the completion of the data review from the 14-day flight. Their cardiovascular responses and even calcium loss appeared to be not only no worse, but in some instances better than the crew of the 8-day flight. In view of these findings, I felt we were well prepared, from the duration point of view at least, to look ahead to our Apollo missions.

Special Tasks—EVA

We still had one problem to solve with the remaining Gemini flights, however, and that was the question of further exploring man's capability outside the spacecraft. Could he do a specific work task and get to a specific spot? That would be necessary if we had to transfer between the two vehicles that would be used in the Apollo program. If this transfer could not be done in such a manner, then we might find ourselves in a situation with astronauts left in lunar orbit. The EVA planned for Gemini 4 was a large step and was planned very secretly. Our Russian colleagues had completed such activity with Leonov outside the spacecraft 3 months previously, in March of 1965. Jim McDivitt, Ed White, and I watched films which had been obtained of that EVA activity many, many times, trying to see how the movement outside the spacecraft was occurring and how Leonov seemed to be orienting himself. We still had a high level of concern at that time about the possibility of motion sickness in space. The 4-day flight including the EVA with Ed was accomplished and, while he had some high heart rates during the EVA, there were no postflight effects. He had not had a specific task to do outside which required him to reach or stay at a particular location.

EVA was conducted in Gemini 9, 10, and 11, from June through September 1965 by three astronauts, Cernan, Collins, and Gordon, and in each case some problem was encountered with the activity. We had observed increased pulse rates and respiratory rates and development of heat load indicating excessive work loads to accomplish the task. Even preparation by underwater simulations did not allow the crewmen to do these tasks without what seemed to be undue physiological response. It was, therefore, extremely important to get the data from the last Gemini flight in November of 1966 when, after careful preparation, Buz Aldrin was able to complete two standup EVA's and one umbilical EVA utilizing handholds, foot restraints, and waist restraints very effectively with little increase in work load. In fact, the largest increase in heart rate noted was during a time when he was outside the spacecraft and really without motion, giving a speech recorded on the television and being seen live by the President and thousands on the surface of Spaceship Earth. (In retrospect, this was a hint of things to come after the Apollo 11 flight.) This gave us the peace of mind that we needed as we went ahead to the Apollo program.

Apollo, Skylab, and Beyond

As we prepared for the Skylab missions to be flown in 1973, many of the doomsayers among scientists and politicians again reared their heads. I had continually felt this undercurrent of concern, for at every postflight press conference and even the press briefings during the mission, I felt much like the physician ready to examine a patient with stethescope in hand, facing a battery of television cameras, multiple microphones, and reporters with pencils raised, and as soon as the stethescope was placed on the chest they all ask in unison, "Now doctor, what did you hear and what does it mean to the future of the space program?" Indeed, the press has shown a proclivity for touting any medical or crew responses noted as being limiting factors for man's continued exploration of space.

This attitude had been strangely aided in June of 1969 when a monkey named Bonny was launched by experimenters in the NASA biosatellite program. This was 1 month after Apollo 10 and a month prior to our lunar landing. Obviously, we had flown multiple crewmen for durations of 12 to 14 days. This monkey was to have flown 30 days, but showed signs of deterioration during the entire mission. The flight was stopped after 8 days, and the monkey died some 10 hours after recovery. The cause of Bonny's death was stated by the experimenters to be "the effects of weightlessness." The monkey had deep brain probes, multiple catheters, and had been subjected to a number of invasive procedures. Other animals in the ground based controls had died of complication, including infection. Still, Congressman Karth called special hearings of the House Space Committee at which I spent a whole day testifying trying to convince him that space might be bad for monkeys like Bonny, but we had not found it so for man. (3)

Our Russian colleagues had added fuel to the doubters concern by the flight of Soyuz 9 in June of 1970 when Nikolayev and Sevastyanov had flown nearly 18 days. This was only 4 days longer than our 14 day Gemini flight, but this crew had evidence of marked cardiovascular response on trying to get out of the spacecraft. They had to be carried out and they had marked increases in heart rate when they sat up and could not assume the standing position without starting to faint. It took them 21 days to totally recover from the flight and achieve their preflight test values, and again the specter of man's physiological demise was raised.

In June 1971, just before Apollo 15, the Russians had a disaster when Dobrovolskiy, Patsayev, and Volkov returned in their Soyuz 11 spacecraft all dead after they had spent nearly 24 days in a Salyut 1 space station. The hue and cry of the doubters even gained the voice of some of my close colleagues in aerospace medicine. Our difficulties in explaining this were added to by the secrecy of the Soviet program and only years later were we able to actually confirm the thing I felt to be true from the outset, that this had to be the results of decompression. I was finally allowed to see all of the data confirming this in Moscow in 1973 after repeated requests to do so. Then, it was done under very controlled circumstances, and I was allowed to take no one along.

For whatever reasons, I was bombarded by conversations from our Russian colleagues at meetings and by the doubters saying that we must be out of our minds to be considering 28-day and 56-day flights in the Skylab program. The Skylab missions were absolutely vital from a medical point of view for this was the first time that we would be able to get detailed inflight data from some excellent inflight tests. Repeated meetings with congressional committees, individual members of House and Senate space committees, closed door discussions and meetings with the Academy of Sciences led up to our launch of the 28-day Skylab mission in May of 1973. This flight represented a number of milestones, not the least of which was the repairs accomplished by this crew including the first physician we had flown, Joe Kerwin. They were able to free the large solar panel which was necessary for power and were able to put a parasol heat shield up to replace the micrometeorite shield which had been torn off on launch, taking with it one of the solar panel wings and pinning down the other in a useless position. I viewed a picture of the one-winged Skylab proudly orbiting the Earth as a great illustration of man's capability, in which I have believed so long. Contrary to many of the early doubters, man proved himself better than the work of the engineers. I can't help but smile as I think of the many hours we spent in meetings and discussions with engineers prior to the Apollo missions. They had been able to develop 0.999 reliability figures for all of the parts of the spacecraft and launch vehicles. They wanted me to do the same for man. They had an elaborate quality assurance program which allowed them traceability from base metal through the development of single parts, subsystems and systems, all of which could be tested to destruction. Thus, they had mean times to a failure, allowing them to come up with 0.999 reliability figures. In the astronauts' case, I had repeatedly said that, while I could not do that, for I had no opportunity to select the vendors nor to have the quality assurance development of parts or subsystems or systems and certainly not to test any of them to destruction, I felt man would indeed prove himself equal to any of the engineers' hardware.

Following the 28-day Skylab mission, we had a big job to do in rapidly turning around the medical data from that mission before launching another, and we found two things which were disturbing. One, there was obvious evidence of cardiovascular deconditioning during the flight and postflight, with the crew taking almost as long postflight to return to their normals as the duration of time they had been in orbit. This indeed began to look like the Soviet 18-day mission. And two, we were disturbed to see a loss in red cell mass of up to 20% and no evidence of red cell production in the immediate postflight period. Following the 28-day mission, I gathered a number of cardiovascular authorities from around the nation and asked them to meet me at the airport in Chicago. We went over the data from the 28-day flight, and made some plans then to continually review this during the next 56-day mission. I cannot say enough about the help and support I received from this group of individuals, for we had to repeatedly reassure our own NASA administration and the congressional committees to say nothing of the scientific community represented by the Academy.

The NASA administrator at this time, Jim Fletcher, asked that I provide him with a weekly briefing at which time we would make a decision as to whether we would continue to fly another week. Bill Schneider, the Skylab Program Director, and myself, each ended up signing a slip saying that we felt it was safe to fly another week and this information was then passed to the President. Detailed review of the Skylab data left me with a very satisfied feeling that we had shown that man could perform through 84 days very successfully. While we had encountered some problem areas, they were really evidence of the human body adapting or accommodating itself to the space environment, and we had identified some potential countermeasures to help man readapt himself to the 1-G of Earth after prolonged stays in space.

All who are involved in aerospace medicine can certainly understand the position in which I found myself early in the manned flight program. This position never really changed and I'm not sure it totally has today. On the one side, the doubters, including those responsible for appropriating adequate funding in Congress and our national science organizations, were saying man was not really capable of performing in the space flight environment. They demanded that we collect large amounts of data to try and prove he was, and in the interim certainly we should go into the environment with extreme caution. On the other side, the astronauts were equally convinced that they certainly could perform, since space flight was no more difficult than flying the very fast, high altitude aircraft that they had done in the past. How could anyone question this? Thus, they could see no basis at all for trying to collect medical data to prove that man was capable. In the middle, between the antagonists, I felt strongly that man was capable of doing this, and that if we progressed sensibly, collecting data enroute, we would be able to prove it. Thus, while I needed data, the very people I was trying to support and protect were saying there was no need and were, thus, not cooperative in its collection, believing it would interfere with their capability to operationally do their job, which was test piloting, not being a research subject. An interseting attitude about this can best be described in the words of one of the astronauts, Mike Collins, as he wrote in his book *Carrying the Fire*: (5)

> Our own medics were not particularly helpful either as a number of them had been prophets of doom and gloom from the very beginning. It had been like pulling teeth to get them to admit that man had escaped unscathed from each successive foray into weightlessness. When Al Shepard seemed to be his normal, healthy, obnoxious self after 15 minutes of weightlessness aboard Freedom 7, the medics moved the decimal point over one place and said, "Well yes, man can endure for minutes and perhaps even for hours, but for days—Horrors!" At the very beginning they had said that even a few seconds of weightlessness would impair bodily functions. One would not, for example, be able to swallow properly, especially fluids, and those nutrients which did reach the stomach would not be properly assimulated. Even worse, the heart and lungs would become confused at best or incapicated at worst and the efficient human machine would quickly grind to a halt. How quickly, remained to be seen but as the data poured in, the medical threshold was not removed but simply pushed a little bit farther backstage to reappear in full force at each successive press conference. So little by little, as the Mercury and Vostok results proved them wrong again, the medics stubbornly retreated another yard or two, raising hell with the mission planners and the equipment designers. The truth of the matter is that the space program would be precisely where it is today had medical participation in it been zero or perhaps it would be even a little bit ahead because we could have gone without all the impedimenta and medical claptrap such as blood pressure cuffs, exercise ergometers and urine output measuring devices. All they did was add weight and complexity and rob time and energy from tasks of greater value. But if the medical problems existed mainly in the minds of the doctors, the engineering problems existed in everyone else's minds including the astronauts.

That is a revealing bit of prose from an astronaut who had flown in Gemini and then on the first Apollo mission to the Moon. He obviously never got the message of what was going on in the minds of the scientists and the Congress, nor did he even understand the battles being fought on his behalf by the group he condescendingly called "the medics."

Thank heaven for the support of such giants as George Low, Bob Gilruth, and Chris Kraft, who vocally and in writing said that Apollo would not have succeeded without the medical advice, decisions, and skill.

In 1951, Werhner Von Braun wrote, "I believe that the time has arrived for medical investigation of the problems of manned rocket flight, for it will not be the engineering problems but rather the limits of the human frame that will make the final decision as to whether manned spaceflight will eventually become a reality."

The limits have been tested and man found capable. In 1967 in the U.S.S.R., I first stated that if we could get data on man's performance for 6 months in space and it was satisfactory, I would be willing to commit to a planetary mission such as Mars. The U.S.S.R. now has such data. Let's get on with it!

Senator Jack Schmitt, scientist astronaut on Apollo 17, recently wrote, "One of the most exciting medical discoveries of the century has been the realization that man can survive extended exposures to the environment of space and that he can also prosper there. Contrary to many, if not most, expert opinions prior to the beginning of space flight, human beings have so far fully adapted to life in this new sphere of human endeavor. Additionally, human beings have fully adapted to their return to the environment of Earth. Realization of these facts means that civilization can indeed move into space and out to the planets."

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