<u>THEIR OTHER WORLD</u>

a series of thirteen documentary programs
for radio on bioastronautics.
as written and directed

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and narrated by

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It is the destiny of men to venture forth from planet Earth into outer space . . .
out . . . into an equation of the unknown. . . . What problems await them . . .
in this . . . Their Other World?

One — The Second Age of Discovery

An introductory program depicting the challenge of man's conquest of Space, the environmental problems he faces, and the importance of Space medicine.

Somewhere, a schoolboy fashions a dream out of the fabric of the past knowing that no danger deterred Columbus, or Diaz, or Vasco Da Gama; that no threat could throttle the urge to explore the outer reaches of human knowledge. Recently a noted scientist, Dr. Wernher Von Braun, spoke of this boy and of the Second Age of Discovery.

> We stand on the threshold of the Second Age of Discovery. When the craft is ready and the oceans of Space are calm, because we have learned the new medium and have prepared to sail on it, the new explorers will venture forth. The space-age Columbus or Magellan are presently unknown, but they are sitting somewhere today in a public schoolhouse, preparing for an adventure that exceeds their wildest daydreams . . . which distracts them from their books.

There! Look! Tomorrow stands tall and cylindrical amid its sandy, sea-shaped acres and from a distance this future looks to the layman lonely, and impossible. But close-up, optimism is the order of the day as the Cape makes final countdown preparations. And then . . . that moment of hope.

> May Godspeed John Glenn. Ten . . . nine . . . eight . . . seven . . . six . . . five . . . four . . . three . . . three . . . two . . . one . . . zero . . .

> GLENN: Roger: The clock is operating; we're underway! We're programing at roll. Okay! A little bumpy along about here.

> KENNEDY: We set sail on this new sea because there is new knowledge to be gained and new rights to be won and they must be won and used for the progress of all people.

The writ of challenge in the words of a president. Just one day before his death, President John F. Kennedy dedicated the Aerospace Medical Center in San Antonio, Texas, with this story; with this commitment.

> Frank O'Connor, the Irish writer, tells in one of his books how, as a boy, he and his friends would make their way across the countryside. When they came to an orchard wall that seemed too high, and too doubtful to try, and too difficult to permit their voyage to continue, they took off their hats and tossed them over the wall, and then they had no choice but to follow them. This nation has tossed its cap over the wall of Space and we have no choice but to follow it. Whatever the difficulties, they will be overcome; whatever the hazards, they must be guarded against.

So we enter this, The Second Age of Discovery, this unbelievable decade of infinite disclosure. But almost every school boy knows of the wonders of this fascinating, sometimes frightening other world from the imaginative voyages of early writers; Voltaire, Dumas, Jules Verne, Edgar Allen Poe, H. G. Wells, and one now recalled by a present day scientist and writer Dr. Willy Ley.

> There was a man who wrote a number of Space stories early in the century, you know, from about 1895 to 1905. His name was Garrett P. Serviss and he is, unfortunately, nearly forgotten. He did a good job, but he happened to be a professional astronomer part of his life. So it was not so much foresight, it was application of professional knowledge to the fiction on hand.

But space science is no longer fiction. Every school boy knows that. The Glenns and Grissoms of our time have made fantasy . . . real. Though it is but a beginning the planets are within reach and the future, somehow, seems a little less fantastic. Ask of one who has been there, What is Space really like?

> I think if you are speaking of the human experience you define Space as a condition of weightlessness.

You're listening to Scott Carpenter, explaining an astronaut's view of that void called Space.

> Well, it just looks farther away. The sky is black, this is different, and the clouds are all below you and very flat. You have this feeling you're very high, that the horizon is very definitely curved. The colors are spectacular particularly at sunrise and sunset.

Where does Space begin and the atmosphere end? You turn to the man who is called the father of space medicine. His name? Dr. Hubertus Strughold, the 67-year-old Chief Scientist at the School of Aviation Medicine, Brooks Air Force Base, Texas.

> We observe at an altitude of twenty kilometers, or about 12 miles, that the body fluids start to boil. That is the same as in a vacuum, or as in Space. So this means that from a medical point of view, with regard to this particular factor, Space begins already at 12 miles.

Dr. Strughold points out that at about 30 or 40 miles, one encounters ultraviolet and cosmic rays of an intensity experienced only in Space. At 60 miles up, there are the same light conditions observed in Space, the black sky, the brilliant Sun.

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> There is a gradual transition from the atmosphere in Space in steps with regard to various factors. The altitude of 100 kilometers, or 60 miles, has been determined as the border between atmosphere and Space in a decision by the Federation Aeronautique Internationale, in Geneva Switzerland, some three years ago. Anybody who has entered the area above 100 kilometers, or 60 miles, has had his nose into Space.

Against the black velvet of eternity, man eyes this other world. Seeing a Galaxy that lures him like the sirens of old. Human slide rules calculate a promise of increased thrust, heavier payload, and greater power to propel man through the endless reaches of outer space. But even as the rocket stands poised, there is cause for concern. For though silent and empty, as Space would seem, its peace is a paradox.

> There are certain regions in Space which are completely uninhabitable for man, notably the Van Allen radiation belt. Also, we know that after some solar events, so-called “solar flares,” the entire interplanetary space is infested with ionizing radiation, sometimes to such a level that within times of a few hours a deadly radiation exposure would take place.

That’s why men like Dr. Herman J. Schaeffer spend long hours in the laboratory learning the cause and effect of conditions in the outer reaches of our Universe. In the same building, at the Navy’s School of Aviation Medicine in Pensacola, Florida, the director of research, Captain Ashton Graybiel, concerns himself with yet another problem; the reaction of the inner ear to the suspended state of non-gravity.

> This is the kind of stimulus which the otolith organs respond to. In the real weightlessness there is no stimulus to these organs. If a person is truly in weightlessness and he has no other sensory inputs from his environment, he doesn’t know which way is up.

Weightlessness. That dream-like, true quality of Space, as described by Astronaut Alan Shepard:

> This sensation of weightlessness is, in fact, quite a pleasant one. The consensus of all six who have flown to date have substantiated this. A good analogy is that of floating in water where there seems to be quite a bit of freedom of movement. A very pleasant sensation.

It is a preternatural existence though, and like a ghost, it haunts the biomedical community.

> Much of our information about weightlessness has to be theorized on this sort of basis because we can’t recreate the weightless environment for any longer than a period of about a minute by flying parabolic flights in an aircraft. There is no way to recreate a weightless environment here on the Earth’s surface.

You’re listening to Dr. Charles A. Berry, Chief of Center Medical Programs, NASA Manned Spacecraft Center.

> Any information we get has to be hypothesized, or projected out, extended from the one-minute exposures we get in an aircraft, or looking at something which is similar like putting an individual at bed-rest or putting them in water.

Bed-rest and water emersion experiments have revealed what doctors have known, that long periods of immobility can cause a loss of calcium, a weakened bone structure. They suspect that a non-gravitational existence, weightlessness, may weaken the muscles as well. Some even predict that prolonged periods of weightlessness will have an effect on the heart and the blood circulation system.

Picture the prolonged flight. Our astronaut, having adapted to the light, effortless atmosphere of zero-G, now suddenly confronts the rigors of reentry! He plummets down through the fire of the Earth's atmosphere. The G-forces build and build! He feels crushed! His heart pounds!

Question: What if man cannot survive after long periods of zero gravity?

This discomfiting thought has prompted some scientists to think in terms of creating artificial gravity. In San Francisco at the Lockheed Missiles and Space Company, Dr. William Helvey, Manager of Bioastronautics, speaks of this problem:

> This is an area of great interest. A number of laboratories are experimenting with small centrifuges which could be placed on board a vehicle. Instead of rotating the whole vehicle, which is quite an engineering task, you have a small centrifuge, maybe the radius or diameter of this small wheel is only six feet, and you sit on it. You spin around at high rates to create a one-G, three-G, or five-G field due to the centrifugal force. Men have tolerated up to 30 and even 60 revolutions per minute on these small wheels. I might interject here that if you turn your head, you have a terrific case of dizziness and usually nausea and vomiting. So for every problem, we create a fix which has another problem and so life goes on. But these are the bases of speculation. You get five scientists together and you get at least three opinions. Only more Space experience will give us the answer to, "Can man tolerate weightlessness for long duration?"

To invade the vacuum of Space man must take along everything he needs to support life.

> This is where it sort of differs from the situation Columbus had, isn't it? In which he could more or less live off the land. The Arctic explorers, to a certain extent, could live off the land. But the man in Space is a long way from being able to live off the land.

Dr. Billy Welch is the Chief of the Environmental Branch of the Aerospace Medical Division at Brooks Air Force Base. You ask him, what are the essentials for man to live in Space?

> I think the essentials can be listed in the order that man has a requirement for them. First, would come oxygen because without oxygen we can't live for more than a matter of minutes. The second essential would be the removal of carbon dioxide, because in a small confined space of a spacecraft carbon dioxide would tend to build up quite rapidly and become intolerable to man. The next requirement would be for water, because without water man's life is limited in terms of his existence and usefulness. Lastly would come a requirement for food. One might also put in a requirement in a sealed cabin for removal of trace contaminants or micro-contaminants that would tend to be generated by either man himself or be generated by the materials that man has in the vehicle itself.

So the astronaut, capsule-bound to a certain beyond, turns to observe a vanishing globe called home. Outside his Plexiglas port there swirls emptiness that is death. Yet, he rides a profile of research and there is no fear.

Meet Don Keating, Project Engineer Respiratory Environment Branch, Wright-Patterson Air Force Base.

> One of our problems is thermo control. If we put the man outside of the spacecraft, he will immediately see the Sun or will be on the cold side of the vehicle. He might have a problem of being either too cold or too hot. So our problem here is to maintain him at a desirable temperature. We are presently working with a system that we don't have to actively cool or heat the man. We call this passive conditioning.

Meet Dr. Doris Calloway, Professor of Nutrition, University of California, Berkeley.

> The question of Space feeding is in two parts: One is, are there any special nutritional requirements? The second one is, are there any special food requirements? And these are not necessarily the same thing. In the case of foods and feeding systems, you have the problems that are imposed by a very constrained environment in terms of the space, or the volume, that's available to store food, the length of time it has to be stored, the weight of the food, and the weight of the packages, the question of the bacteriological factors that might be involved. And not only in the food, but the handling. What if you don't eat it all? What happens? Is this contaminated now? How do you handle this kind of problem? Then, how much of waste of another kind will the diet provide, so that you're increasing the problem, say, at both ends of the spectrum of the feeding question itself. Then, there are all the mechanical problems. Without the assistance of gravity, how do you pour things? How do you get things from hand to mouth? With the question of reduced pressures in the cabins, you can't get any high-level of heat. Things boil at a lower temperature. So, you have to provide cooked foods since you cannot cook them. Apart from these, which are purely food, now you have the nutritional considerations. Are the man's personal needs for nutrients any different in Space than they would be for that same man if he were right here?

Meet Dr. George Ruff, Associate Professor of Psychiatry, University of Pennsylvania School of Medicine.

> First of all, an astronaut in his work as an astronaut is going to face many of the same stresses that anybody else would face in any other job. You have problems of technical difficulties that arise and produce frustrations. You have difficulties with other people, where you may disagree with them about how something should be done, but you may have to accept a decision you don't like. You have two men competing for the same job. In a corporation, it might be for a new vice-presidency; in Project Mercury it was, "Who is going to have the next flight?"

> Then you begin to have the specific stresses for the orbital flight and the subsequent spaceflights. I guess the worst of these is the prolonged danger. Nobody can easily accept the idea that the chances of his death are fairly high. They weren't as high in this project as some people think, but even then they did have to be considered. This is something the man has to handle. Then you have a lot of others in larger-term spaceflights concerned with separation from Earth, isolation, confinement, and sensory deprivation.

Meet the many people, the many competent individuals of varied concerns who work for the conquest of Space. Meet and understand the human element. For man must understand man if tomorrow's mission is to include the Solar System. You must meet and know the multitudinous problems that plague the daily progress in finding the one sure way to enter into this other world. On landing fields and in laboratories, Space scientists and doctors labor long and hard to determine the limits of human tolerance to the rigors of Space. Rigors about which we know, or can only guess, as one might suspect. As Dr. Hubertus Strughold tells you now:

> This whole Space area is a logical extension of the air era, if I may say so.

A faint specter of the hope at Kitty Hawk; the same concern that followed the Spirit of Saint Louis; the same indomitable will that turned the pylons at Cleveland and conquered the skies over Dusseldorf, ride with the silver-suited astronauts of this Second Age of Discovery!

Much of what we know has been lifted from the pages of the past. Many of the biological stresses encountered in orbital flight were anticipated. For the techniques of aviation medicine developed for fighter pilots of World War II were applied successfully.

But now you're in Houston. You're standing with the director of the NASA Manned Spacecraft Center. From the panoramic view of his seventh-floor office you can see a vast complex of multistoried buildings and some 1,500 acres of future. Here is a place of purpose. Here optimism hangs like a haze in the hot Texas air.

The director, Dr. Robert R. Gilruth, observes:

> The largest problems in this area lie not with men and the people that will fly, but with the engines that it takes to drive the spacecraft. I don't think there's anything we need as much to explore the planets as a much better engine than we have with these chemical engines. I'm quite sure that, granted enough rocket power; we can devise ways of protecting the human occupants so they'll be happy and very alert on these journeys.

There is logic in Dr. Gilruth's concern. For one big task is to project into Space an environmental system capable of accommodating man. But so little, so very little is known about the perils of outer space, or for that matter, man's actual margin of safety. So greater attention is being focused on the human factors of Space exploration. This study, involving all aspects of Space medicine, is called bioastronautics.

This very day in NASA centers of research, in Air Force and Navy laboratories, in universities and colleges, in more than 80 industrial firms, including the giant aircraft industry; scientists, doctors, and engineers are working to unravel the biological mysteries of their other world. And to what end? Their discoveries will determine the booster and vehicle of tomorrow's mission. Their findings will formulate the plan, the extent, of our participation in Space exploration. But more importantly they are helping us to learn more about ourselves. Navy Captain Frank Voris, a medical doctor who once headed NASA's Human Research Division, put it this way

> We get a greater feel for what man requires for his betterment here on Earth. Previously we have felt that the man is in a perfect situation if he's sitting, say, in this room. This may not essentially be so. We may find out that we can give him a better environment. To date, this hasn't proven out, but it may. Space medicine has added another dimension, another tool whereby we can observe man and undoubtedly benefit him by this observation, and using Space as a tool and as an impetus, to study him further.

Each time a rocket reaches for that infinite other world, this planet called Earth comes into sharper focus. From a vantage point in Space, new horizons are seen in the field of medicine and human physiology. For this is, indeed, the Second Age of Discovery; a new era of challenge and change.

But then, you know that, whether you're an average schoolboy, or The President of the United States.

> PRESIDENT JOHNSON: Our foremost objective is not to send a man to the Moon, but to bring a greater measure of sunlight into the lives of man on Earth.

Two — The Vulnerable Man

The vulnerable, yet not-so-delicate, man has a history of daring precedents to point the way to his newest challenge — Space. And there are reasons why he must go.

Dr. Ursula T. Slager, a pathologist, is the author of a text titled, *Space Medicine*. You ask her, Should man go into Space?

> One of the reasons I'm kind of smiling is that you're almost raising a family joke because, when I first started writing this book, my husband, who is in the aerospace industry and is an engineer, was a fairly anti-man-in-Space man. For the obvious reasons, a machine is more expendable; you don't have to bring it back; you don't have to worry about reentry, it is more reliable in many ways; it doesn't have psychiatric problems to worry about.

At the Orange County Hospital in Los Angeles, Dr. Slager takes the stand of most scientists. She sees a man as the only means to explore the full secret of our vast Universe. For, as she puts it:

> A man can adjust to unanticipated situations and at least bring back something and maybe even make suggestions of what to do next time in order to get more information. On unanticipated situations in Space a man is much more adaptable at getting some information than a machine would be. But he is awfully vulnerable!

History has chronicled the courage of human determination and the conflict of human frailty. It even happened in Greek mythology. Despite his father's warning, Icarus flew high, exulting over his new and wonderful power! Nearer and nearer the Sun he soared until the wax melted, his wings came off and he dropped into the sea.

> My fuel, I hope, holds out. There is one G. Getting a few streamers of smoke out behind. There are some green flashes out there. Reentry is going pretty well. Aux-damp seems to be keeping. Oscillations, pretty good.

You're listening to Scott Carpenter; an astronaut who finds himself on the edge of reentry!

> We're at one-and-a-half Gs now. There was a flaming piece coming off. Almost looked like it came off the tower. Oh, I hope not. Okay, we're reading three Gs. Think we'll have to let the reentry damping check go this time. Reading now four Gs. The reentry seems to be going okay. We're getting some pretty good oscillations now, and we're out of fuel. Looks from the Sun like it might be about 45 degrees. Oh, it is coming. Like it is really going over. I think I'd better take a try at my drogue. Drogue out manually at twenty-five and holding. And it was just in time. Main deploy. Fuse switches on now. Twenty-five indicated. Snorkel override. Now, emergency flow rate on. Emergency main fuse switch at fifteen. Standing by for the main chute . . . at ten. Cabin pressure and cabin altimeter agree on altitude. Should be 13-thousand now. Mach ten. I see the main is out and reefed! And it looks good to me! The main chute is out!

From mythology to Project Mercury, into Gemini and beyond, the vulnerable man faces moments of uncertainty. But progress never comes the easy way and human resolve seems always set on the impossible. So it is, as man eyes this vast and mysterious Universe, this other world; Space.

As man goes forth to meet this challenge, to view the unexplored regions of this great void, you can be sure there have been thoughts: What if something should happen? In the beginning, they almost did, as Dr. Charles Berry, Chief of Medical Programs at the NASA Manned Spacecraft Center, reminds you:

> We've had our hazards. In Mercury, we had Gordon reenter on his own without any real problem. We had Scott down in the water when we weren't sure for a while. We had some loss of communication with him at the end of the mission there. We had John with his heat shield problem. All of these were overcome. Someday, I think the fellows face this problem too. They all realize that sooner or later we're probably going to have some sort of casualty, but it is not too different than what they've done in their normal aircraft environments in that any of us who have been associated with aerospace medicine have lost people in accidents and you know that this is a risk you take. I think, you always have that attitude that, "It is not going to be me!"

How difficult, indeed, to dull the luster that lures mankind into the intriguing unknown of this other world. For the heavens hold a fascination that is man's constant challenge. Until now, only science fiction dared travel the dark regions beyond our sky-blue proscenium. But even as rockets reach for outer space, astronauts must acknowledge the pioneers who took the first steps to master the way of the air.

Even the atmosphere that enwraps our Earth is fraught with danger. Its hostility is legend. For instance, on a crisp October day in 1803, three men went aloft in a balloon, reaching an altitude at which all three suffered the effects of frozen hands and feet. Two of the men became nauseated and then, unconscious.

Balloonists began to take along bags of oxygen. They were then able to reach heights of more than 28-thousand feet. On April 15, 1875, Sival, Croce-Spinelli, and Gaston Tissandier, three experienced balloonists, ascended to an altitude of 28,820 feet. They intended to go higher and had carried along oxygen, but in the thin atmosphere they lost consciousness and dropped the bags. Tissandier survived. The other two died.

Yet, in spite of this hostile environment, man, vulnerable man, would not be denied entrance to the upper reaches of the stratosphere. In 1957, Colonel David Simons in a sealed gondola took his helium-filled balloon to an altitude of 102,500 feet. Four years later, Major Joseph Kittinger, dressed in a pressure suit and riding in an open gondola, reached a record altitude of 103,800 feet! Earlier experimental planes, needle-nosed and novel in design, cut impressive vapor trails in man's conquest of the sky. One such plane, the Bell X-1, exceeded the speed of sound for the first time in October of 1947. The pilot was Charles E. Yeager. Today, as an Air Force Colonel, Chuck Yeager is commandant of the Aerospace Research Pilot's School at Edwards Air Force

Base in California. At the time of his supersonic flight, he was a test pilot. His job then: to fly his plane to its fullest capability. As for himself, Colonel Yeager recalls:

> As far as the physiological strains on me as a pilot, there were none whatsoever. I wore a pressure suit, because I was operating at high altitude. I wasn't pulling any Gs. Here, again, I was familiar with my equipment, know the emergency procedures. As far as the mental attitude that I had? Sure, you have a feeling of anxiety when you're involved with something you don't know exactly what the outcome is, but, here again, you can't be too concerned or you wouldn't do it!

But there were those who did do it. The Yeagers, the Simons, the Tissandiers, the many who braved the wildest of blue yonders to bring back vital facts about man as well as machine. These were great moments in the history of flight. Equally important, they added new chapters in a growing volume of physiological data of human endurance to stress. With each new dimension of flight, the NASA-Air Force X-15 rocket plans for instance, vulnerable man moved ever closer to the great void beyond.

It is 5:30 am the morning of America's great vigil. See it now as you saw it then. For it is the morning of May 5, 1961. The white van has moved into an arena of eerie light and shadow. In the background, the Redstone rocket, round as a silo and reeking with vapors, waits on pad number five. The hero of the hour, Commander Alan B. Shepard, Jr. steps out of the van and walks with great stride toward the gantry elevator. A few minutes later, some 65 feet up, technicians help him squeeze through a hatch into his squat, black capsule. At 6:10, the hatch is closed and sealed. He will have three hours to wait. Nearby, two nurses stand, talking nervously. A fire-proofed Army personnel carrier stands by. Helicopters idle, waiting. The Sun has risen. There's hardly a cloud in the sky. The warning horn sounds.

The countdown resumes. The millions who have watched the long hours pass on their television sets, now breathlessly see the umbilical cord fall away. Alan Shepard is in his last moments before launch . . . Ten . . . nine . . . eight . . . seven . . . six . . . five . . . four . . . three . . . two . . . one . . . zero. Lift-off!

> Aye. Roger! Lift off and the clock has started! Yes, sir! Reading you loud and clear! This is Freedom 7. The fuel is Go! One-point-two G. Cabin at 14 P. S. I. Oxygen is Go! Cabin pressure is holding at five-point-five. Cabin holding at five-point-five. Okay, it is a lot smoother now, a lot smoother. Seven view: Fuel is "Go," four G. Five-point-five cabin. Oxygen "Go!" All systems are "GO!"

> Many people have the conception that although this was the first flight, in consideration of the fact that this was the first flight, that there were a great many unknowns.

Commander Shepard considered his epic trip the object of intense preparation, training, and experimentation.

> I would like to indicate here that there were, in fact, many areas of consideration that were not proven by actual flight. But I would point out that, prior to my flight; approximately three years of testing had been done in many areas. Testing, not only of the equipment, the materials that we intended to use, but also of the crew that were going to make the flights. The crews had been subjected to areas of stress, to areas of strange environments such as, reduced pressures; additional heat loads; weightlessness, admittedly for short periods of time; accelerations of fairly high order on the centrifuge; vibrations had been studied; noise environments had been investigated. So a great deal of data had been collected from these tests prior to the actual flight.

So an astronaut's faith rode the Freedom 7 on its arc of triumph. Even today, as Chief of the Astronaut Office, Alan Shepard makes a special point of this preparedness.

> I make this point because this is the only way that our team, or any team for that matter, that is going into an area that is unknown, can get the confidence that they need to actually agree to launch the individual on these flights.

The realization of manned space travel has not come by courage alone, but has evolved out of the long diligent search for a better understanding of man and the world in which he lives. A path to the planets will be measured by the moments of human achievement. It will materialize out of the laws of Newton and Galileo, out of lessons of Pasteur and Curie and Claude Bernard. More recently, out of the specifics of space research that this very day is locating the dimensions of man's tolerance to strange and unusual stresses. But courage, too, has played a part.

As on that day a decade ago when an Air Force flight surgeon volunteered to test the impact tolerance of the human body by riding a rocket-propelled sled six-hundred-and-ninety feet and braking from 632 miles an hour to a sudden stop, in one-point-four seconds!

Riding face-forward, Colonel John Paul Stapp felt the full impact of 40-Gs, forty times the weight of gravity. It contorted his features and ruptured the blood vessels of his eyes.

> There was no loss of consciousness, only a "red out." I mean everything was salmon-colored for about eight minutes, and my vision didn't return until I was laid on my back on a litter. It came back slowly as the congestion receded. I had difficulty in moving my eyeballs; I was moving them practically one at a time for a while there. My muscles were congested and I had diplopia. I didn't have single vision. They tried to give me oxygen, because I had turned pretty gray after that exposure. I pushed it away and said, "Take it away and get me to the hospital!" To one friend of mine who was standing by, I said, "The chimpanzees could take it; I wonder why this happened to me?"

Why did Colonel Stapp do it? He did it to measure the limits of the vulnerable man. And his conclusions?

> Even our flight surgeons had the medical concept of man as a fragile being, frequently ill, and certainly very vulnerable. This tendency of treating a man delicately and overprotecting him from hazards, if that attitude was still present today, there would be a frantic vetoing of spaceflight.

At the NASA Manned Spacecraft Center, the chief physician of the astronauts, Dr. Charles Barry, admits to being a confirmed optimist. He says:

> I personally feel that man will be able to conquer the Space environment. I think he's going to go to other planets. I think he'll even go to far greater missions even within our own planetary system.

But optimism cannot erase the obvious. Space is a hostile environment and its effects are not fully known to man.

Yet even now plans are being mapped out for Mars and maybe beyond. It is acknowledged that the way will not be easy. Already ill omens have been extrapolated into problems, not easily solved and posing a possible threat to the human who dares to venture deep into this unpredictable void.

> Of course, in spaceflight, there are some big unknowns, the primary one being the effect of weightlessness. There are certain regions in Space which are completely uninhabitable for man, notably the Van Allen radiation belt. It is entirely conceivable that if we were tomorrow to send someone up for 30 days, that we couldn't get him back! Whenever there is human life at stake, one must consider the extremes at all times; one must take a safety factor into consideration well beyond and above what you think is necessary.

Prudent voices pondering the odds that they hope may be altered to favor the vulnerable man. Science and technology work late hours seeking a safe and reasonable way to the ultimate conquest of outer space.

> Since we do not know what parameters man can tolerate for extended periods of time, our department of life sciences has the charter to establish, as far as possible, what the advanced requirements for humans will be. Of course the hardware groups will design equipment to meet those advanced needs for advanced missions.

Dr. James Waggoner of the Garrett AiResearch Corporation, explaining a part industry plays in the assembly of vital information concerning the tolerance of man. Though Space has inspired this research, a better understanding of man's normal strengths and weaknesses has emerged to broaden the future concept of human physiology. For as Mr. George Chatham, at NASA, points out: Space is complete in its demands on the human being.

> So that in the activity of exploring Space, every single facet of man's life is involved and being pressed very hard. That is, the spaceship is, in a way, a small Earth. Ultimately it will be a complete ecological unit. So our particular emphasis, the safety and the performance of this individual, the instrumentation, the equipment, the basic exploration

> into physiology, all of these things are being pressed in terms of research and new developments.

There seems little doubt today that technology will offset the vulnerability of mankind. That, with some assistance, Human adaptability will bridge the gap between an Earth-bound existence and the unknowns of outer space. But there is always risk. One wonders, is there not another way?

Colonel John Paul Stapp, who risked his life to save lives, applies his scientific imagination in the conception of a plan.

> We might successfully employ a robot in the place of the man's body, and have this robot linked to the operator on the ground through sense organs in the robot. In this way you would have an operator, who we might call the Earthonaut, in a plastic suit that has electro-pick-ups for any and every motion of the Earthonaut so that they are transmitted on a one-on-one ratio to the robot, seated in an identical cabin with the same instruments and controls. Every motion made by the operator will be duplicated, absolutely replicated, by the robot.

An idea. A dream. Not at all unlikely in the reckoning of man's ingenuity. And . . . yet . . .

> There is, for better or worse, this inherent quality of aggressive inquisitiveness that characterizes all primates from the marmoset to man.

The director of the Institute for Brain research at UCLA, Dr. Ross Adey:

> We can't get away from it. I don't think that we want to overestimate its usefulness in the development of society, in the development of man's intellectual achievements. However, I think that viewed from the very pragmatic point of view of what man can do in Space, as opposed to having machines that will tell us indirectly the things that man might see, man is very efficient. He, for his weight and size, viewed purely from that point of view alone, is probably the most efficient computer that we could ever put into Space.

So man, the not-so-delicate but vulnerable man, who climbs mountains because they are there, who explores the bottomless depths of the sea, or spins a skein of conquest in a yarn that is history; this same man eyes the invincibility of Space with eager anticipation. Are there not reasons for him to go?

> Oh my, yes. I think there are. I think there are at least three fundamental reasons why man should go into Space.

Dr. Julian Christenson is Chief of the Human Engineering Division at Wright-Patterson Air Force Base. He maintains that man offers the most effective Space capability, and that once there will provide more successful scientific observations. But Dr. Christenson also feels that there is much to be learned in meeting the challenges of this other world.

I think that even a superficial review of history of mankind will disclose that whenever man is confronted with a new frontier, a new challenge and when he makes effort to overcome this and finally does over-come it, he not only learns more about the thing that challenged him, but he learns more about himself. Once man has met and at least partially overcome this challenge of Space, not only will he have learned more about Space but, in the process, he will have learned more about himself. And quite frankly, to me, this is the most intriguing aspect of the whole thing.

Because the most intriguing problem of all lies right here . . . in man himself.

Three — An Astronaut's Atmosphere

To invade the vacuum of Space, man must take his own atmosphere and he must be protected against the perils of meteorites and the extremes of heat and cold.

The ascending astronaut leaves behind his Earth-bound atmosphere and enters the great vacuum of Space. What if he should confront this new environment without protection? Navy Captain Roland Bosee comments on the astronaut's fate.

> You can easily appreciate that by the time we get a hundred miles or so away from the Earth's surface that we are practically working in a vacuum. So, a man would die if he were to leave the capsule without a suit while in orbit or while en route to another planet.

This Earth, this oval suspended in the blue-black beyond of infinite Space is an exceptional and wondrous place. For by its nature, it nourishes life. Its cocoon of atmosphere protects and provides for the living beings beneath its sky. And yet, bewitched by the challenge of another world, man will depart in search of some distant star; a way that will take him without and into an airless Universe . . . a void . . . a vacuum.

> A space vehicle actually is surrounded by complete vacuum. There is no air in Space. You can say it is completely absent. So you have to take the air you need with you. Of course, this air is exhausted, as oxygen is considered, because man consumes oxygen and generates carbon dioxide. In other words, you have to take all the oxygen you need with you and you have to develop methods or techniques to absorb the carbon dioxide, to take it away so the air stays clean.

In the words of Dr. Hans Clamann, Chief of the Bioastronautics Laboratory at the U. S. Air Force School of Aviation Medicine: the man in Space must take his environment with him. Not only the air he breathes, but the essential pressure to sustain life in the emptiness of Space. You learn, too, that there is a relationship between the amount of pressure maintained – sometimes referred to as atmospheric pressure, or simply "atmosphere," and the amount of oxygen available. In other words, the lower the pressure, or to put it another way, the higher the altitude, the more oxygen required for the physiological welfare of any human being. At the time of Project Mercury, Dr. Charles Berry of the NASA Manned Spacecraft Center reported that:

> We're on 100 percent oxygen atmosphere. Five pounds per square inch. One hundred percent oxygen and we have no effects in respiration during flight at all.

All right. So Project Mercury succeeded. One hundred percent oxygen, at a pressure of five pounds per square inch. No ill effects at all. Would this not indicate what the American astronaut should breathe? The manager of bioastronautics at the Lockheed Missiles and Space Company, Dr. William Helvey, explains a point of indecision in the scientific community.

> I think that there is a general feeling in our area that a two-gas system would be very desirable. However, it is not without its own shortcomings and let me cite one of the most apparent. If you're breathing a mixed gas, nitrogen and oxygen mixture, and you're in, say, a capsule of a half atmosphere, or even one atmosphere, if it suddenly has a hole in it and it decompresses, and you must go outside of the Space vehicle to repair it, and go in your spacesuit, and the pressure is reduced to a half or a fourth of what it initially was, you're subject to the "bends," "caissons disease," or "decompression sickness," just as a diver is underwater. If you're breathing pure oxygen, you don't have that problem.

But Dr. Helvey will tell you that even though oxygen is the one essential for life, it can pose a problem. Too little and you die. Too much, at atmospheric pressure, and it becomes toxic. But at a reduced pressure, say, one third of normal atmospheric pressure, man can breathe pure oxygen for several days, even several weeks with no ill effects.

But what of the astronauts who venture deep into Space, will total oxygen be as efficient? At Moffett Field in California, NASA's Ames Research Center is concerned with the long-term effects of a given atmosphere. Dr. Jorge Huertas was in the tenth day of a three-month experiment.

> For this effect we have chosen the monkey as a subject, because it has one similarity with a human being, it can sit.

So the monkey, called Lizzie, sits in a sealed container, day after day being fed a diet of banana pellets and pure oxygen. A constant check keeps tab of blood pressure, heart rate, and brain-wave pattern. Aerospace medical authorities know that lengthy exposure to one hundred percent oxygen at atmospheric pressure will inflict pulmonary disorders, lung damage, and circulatory problems. Dr. Karl Schmidt, Chief Scientist at the Naval Development Center at Johnsville, is more specific:

> This pure oxygen in the lungs will also aggravate the lung collapse that takes place on reentry acceleration. The arterial oxygen unsaturation will be more intense under those circumstances than it would have been if there had been some nitrogen in the air breathed and the other is that the higher the oxygen tension in the alveoli, the greater the susceptibility to radiation damage. The people on pure oxygen at five pounds per square inch are going to be more susceptible to injury by the toxic radiation in Space than they would have been if they had been breathing ordinary air or a lower pressure of oxygen.

The constant threat of catastrophe. Fire hazard made imminent through the use of pure oxygen preys upon the minds of those who must decide the most efficient atmosphere for the astronaut. What is a fire like in an atmosphere of pure oxygen? Let Captain Roland Bosee tell you. He was the medical officer in charge of a flight simulator experiment in Johnsville, Pennsylvania. It almost turned into tragedy. To test a one hundred percent oxygen environment Navy personnel were living in a pressure chamber. A reading lamp went out and one of the men tried to change the bulb. An electrical fire started. He attempted to smother the small flame with a towel.

> The towel immediately caught fire. The man attempted to beat out the towel flames with his hands; his skin, of course, had been saturated with oxygen. His pajamas were saturated with oxygen. He then sounded the alarm and the other occupants of the chamber attempted to beat the flames out on the one subject and in a matter of seconds, all clothing and all combustible materials inside the simulator were on fire.

The men were hospitalized. A tragedy was averted. But, what if this incident had happened en route to the Moon? Or to Mars? All right, but we have to have oxygen.

> We've got to have oxygen. So that from there on out the controversy will pick up a little bit and you can get debate going as to whether inert gases, per se, are essential.

According to Dr. B. E. Welch, who is the Chief of the Environmental Systems Branch at Brooks Air Force Base, there is much to be learned about the effects of different mixtures at varying altitudes.

> There's also the prospect and possibility that one atmosphere will not turn out to be the universal atmosphere. That is the one you would select for a one-day mission, a one-month mission, or a one-year mission, etc. We might see that we would have different types of atmospheres, depending on what the overall mission requirements were.

So the search goes on. Many experiments have attempted to use helium as a second gas.

> One of the points in question regarding the use of helium instead of nitrogen in the spacecraft is that of communication.

The Director of Life Sciences at the Garrett AiResearch Corporation, Dr. James Waggoner:

> When an individual breathes helium at sea level, he gets very obvious changes in the sound of his voice. This has been done as a television trick and a gag for quite a few years inasmuch as a few breaths of helium at sea level pressure does make one sound a little bit like Donald Duck. During the course of a recent experiment, the test subject, in this case myself, was exposed to several levels of helium-oxygen concentrations at several total pressures.
>
> We are now at six-ninety total pressure, approaching seven hundred. The PO2 is remaining at a little over 180, about 185. This is the tone of your voice; I'm trying to speak normally. The total pressure is now slightly over seven-ten, the PO2 remains just a bit above 180. And there are apples, elephants, Indians, uncles, olives, and onions!

The search goes on. Some advocate ordinary air, the normal 21% oxygen-79% nitrogen mixture of our Earth's atmosphere. But remember, the less oxygen available, the higher the pressure. With an increase in pressure, the vehicle would have to be stronger. Strength means extra weight. Yet, the Russians provided an Earth's atmosphere for their early flights into Space. Do they feel this is a final answer? Eavesdrop, if you will, on the comments of Dr. O. G. Gazenko:

> But this does not mean that in future flights we will always be using the kind of atmosphere that we find here on Earth. It can further be stated that undoubtedly for future flights a new type of gas environment will have to be developed.

So, there must be a meeting of the minds: the engineer and the biomedical scientist. But in these considerations, is it just a matter of payload alone?

> If we had the payload so that we could lob the kitchen and the kitchen sink up there, then we could maintain him in his spacecraft at an Earth's atmosphere. We could maintain him the same as the Soviets.

Again, Dr. James Waggoner of the Garrett Corporation:

> However, this doesn't necessarily apply to his walk on a lunar surface. Because then, no matter how big the living room was you shipped up there, he's going to leave the living room. And then we must know about how he's going to react within the closed confines of a spacesuit. That type of thing requires knowledge, rather than simple payload. We have to be able to provide him with the equipment he needs; but, nevertheless, if he's to be an individual walking around on a lunar surface, we've got to know exactly how much heat he's going to generate, and how we're going to take care of that heat, well in advance of the time we open the door and kick him out on the lunar surface.

When that time arrives, and the hatch is opened and our astronauts step forth into the strange environs of their other world, they must be clothed against the vacuum of Space. And whether tethered in a weightless void, or treading the unknown terrain of some distant planet, these men of tomorrow must be pressurized and protected by an artificial atmosphere. A puncture by a meteorite is an ever-present danger.

Dr. Fred Whipple is Director of the Smithsonian Astrophysical Laboratory and a member of the Harvard University faculty. Since 1946 he has been investigating the hazards of meteorites in Space. Though highly remote, the danger does exist, he says:

> The chance for short periods of time on the Moon are more or less like the chance, somewhat greater than lightning on the Earth, but not a very high probability of serious damage in short periods of time. It would be advisable, however, to have some method for detecting the fact that a ship or a suit had been punctured, so that the hole could be sealed up quickly before very much air had been lost.

As the astronaut probes deeper into Space, he encounters more meteorite material. The Earth's orbit, Dr. Whipple explains, acts as a gravitational broom.

> Mars is so much smaller in mass that it is a very poor broom compared to the Earth. So as one goes beyond the Earth's orbit out towards Mars, he should expect to encounter very many more of these larger bodies. But even so, the numbers are so small; the chance of encounter is so small with any sizable one that that problem isn't serious for the Space traveler.

Although Dr. Whipple is encouraging, although the astronaut faces fair odds in outer space, one wonders what might happen to the human body if, by some tragic circumstance, it should be exposed without protection. You put the question to Captain Roland Bosee of the U. S. Navy Medical Service Corps in Washington.

> Those areas that did not have a gas entrapped would not necessarily disintegrate, but they would become almost immediately dehydrated. All the fluids would evaporate and there would be nothing left but skin and bones, and dehydrated tissue.

Would death come instantly? Dr. Hans Clamann, aerospace scientist at Brooks Air Force Base, reveals a recent and exciting discovery.

> What will happen if an astronaut outside of his spaceship will have a hole in his spacesuit? For instance, he may rip it on a sharp corner, or a meteorite may penetrate it. According to all that we have known, that man seems to be lost, because he's exposed to the full vacuum of Space in the shortest of time. We did some experiments with animals and we have found that, fortunately, this seems not to be so. It looks now that a man exposed to such a condition, if he is rescued within one minute, which seems feasible, can be saved. And not only saved, but he will possibly be back to good heath again.

> The method by which we protect the human body from lack of pressure is pretty rustic. .

The words of Astronaut Scott Carpenter. He was speaking before the Third International Symposium on Bioastronautics and Space Exploration.

> I'm sure that there is another way to protect the human from the Space environment than pressure suits. If this turns out to be not so, then I'm sure there is a better way to make a pressure suit. This is the greatest single handicap we have to operations in Space, or extravehicular, or on the lunar surface.

At Wright-Patterson Air Force Base, Major William Coffman expresses the hope of the Space community.

> One of the major problems in Space arises from the fact that still today Space crews wear spacesuits, even in the vehicle. It is the announced goal of I think everybody who works with Space problems that we hope to have a "shirt sleeve" environment eventually. That is, a man will be safe and comfortable inside his Space capsule without wearing a spacesuit.

Because man must leave his vehicle, a spacesuit becomes an important item of consideration. The very element that makes pressure suits essential also makes them a nuisance. Once pressurized, they become stiff; an astronaut's mobility is severely limited. In both design and profile of pressurization, they are trying to alleviate this problem, to bestow the best elements of body comfort.

> In Space, unlike an aircraft situation, the spacecraft is without a surrounding atmosphere.

You're standing in an environmental control laboratory at Wright-Patterson Air Force Base. You're listening to Bill Uhl.

> Therefore, we cannot depend on the normal conduction of heat away from our vehicle. The problem of providing a proper temperature for a man or for an item of electronic gear is one of being able to get rid of the heat that men and equipment produce.

This is no easy task, Mr. Uhl will tell you. For the equalization of temperature becomes a problem without convection currents and the normal mode of heat transfer experienced here on Earth. In Space, violent extremes occur between the Sun side and the dark side, and a man's comfort, indeed, his survival, depends on a judicious balance of heat.

> This is like saying a man with one foot on a stove and the other one in a deep freeze is, on the average, comfortable.

Heat, not cold, is the cardinal concern. Heat-generated by generators of countless complex systems. Heat, the metabolic action of the human body. Heat, the heartless onslaught of an unshielded Sun. Heat, the violent friction of the reentry phase!

How can it be dissipated?

Short flights have used expendable material, such as water. Extended trips will have to utilize the transfer of heat by radiation. As yet, the lights still burn late in the laboratory, as the search goes on to find new ways to conquer old obstacles that stand between our astronauts and their other world.

> The fuel is Go! One-point-two G. Cabin at 14 P. S. I. Oxygen is Go. Cabin pressure is holding at five-point-five. Cabin holding . . .

The check is routine. Oxygen mixture holding, temperature set, pressure is go. The astronaut prescribes his navigational arc through the endless, unknown regions of outer space. Everything is going according to plan, everything routine. Until, suddenly, he feels weak, strangely tired, and nauseous.

He has been poisoned in mid-flight!

> We're running into some considerations now for the more extended missions that we previously haven't had to consider to any great extent. For example, if you're going to cage a man, if you will, and allow him no sixteen hours out of 24 hours off, so to speak, to be home away from the hazards of his job, if it does have hazards, and to have no weekends off, then we must start to consider at that point in time, his ability to tolerate things that are in the air from which he cannot escape. In other words, he doesn't have a certain number of hours a day to re-metabolize if he has been insulted by certain toxins or

> poisons that may be in the air. In a closed system where the astronaut must live for 24 hours a day for two weeks straight, we don't know the maximum allowable concentrations of the various toxins in the air simply, for the fact that all of our previous data has been based on an eight-hour-day, five-day-a-week schedule.

As Dr. James Waggoner of the Garrett AiResearch Corporation is saying, much of what we know about contamination has been based on industrial limits, a work-day week. Perhaps the most useful contribution to the astronaut's situation has been the submarine studies conducted by the Navy. But research continues, for as the group supervisor of atmosphere control at Wright-Patterson Air Force Base, Fred W. Thompson, explains:

> As systems become longer in duration, we find that we have a host of materials which are sometimes called "toxic contaminants," sometimes called "trace contaminants." Certain medical people have put these into lists numbering up to three to four hundred compounds that might be present.

The outgassing of many materials, including metal, wood, paint and plastics, produces a gaseous chemical which Space authorities call a trace contaminant. It becomes toxic when the human body absorbs enough to cause injurious effects. The astronaut, himself, can poison his own atmosphere. He breathes out carbon-dioxide. His own body wastes produce volatile and harmful compounds. What must be guarded against? And what are human tolerances? The answers to these questions are being sought by scientists from coast to coast wherever Space is considered a challenge. Soon, they say, they'll have a method for detecting trace contaminants even eliminating them automatically. Recycling seems to be a thought for the extended spaceflight of the future. Perhaps with plants like algae which can live on the astronaut's expired breath and renew his oxygen supply.

So as the planets orbit within eyesight of an astronaut's dream, the intricacies of Space science are at work to enclose the human frailties of man in the ecology and comfort of an existence close to that of home. New chapters are being written in physiology about the breath of life, about the poisoned air that sometimes surround us, and about the tolerance of man to the temperature extremes of outer space.

It will be the success of this continuing search that will soon make the astronaut's dream, a reality.

Four — The G-Force Giant

To explore the reaches of Space, man must first escape the Earth's gravity pit — an achievement that comes not without the penalty of stress.

> Of course, the first thing is lift-off, when the rocket actually lights off, you hear the noise, you feel the thrust, and the thing starts to move.

This is the beginning. The genesis of a great giant that confronts man's will to conquer Space, as remembered by Captain Virgil I. Grissom, astronaut. On that day that Gus Grissom began his first odyssey into the unknowns of Space, this great giant of gravity began to grow in size.

> The Gs gradually build up and the first thing that occurred that I think would be of interest to all of you is the vibration that occurs just about 36,000 feet as we start going through Mach One. This is the vibration that caused Al Shepard a little bit of problem on his flight.

But then, on another day, Astronaut Grissom rode again the column of thrust up into the vast ocean of Space. But this time he came back to tell a different story.

> The powered flight was very smooth, smoother than we had any reason to expect and smoother than anything we had seen in our training and in our simulations. The booster runs smooth; you hear very little first stage noise and there isn't a jiggle or a bump in the whole first stage flight.

Can it be that our modern Jack whose planted seed is sending more than a beanstalk toward the stars has actually outwitted the G-force giant?

The thousand tick-tocks are but ten. For the time has drawn near and now, lying, molded to the contour couch, you stare at the instrument panel before you. During this lifetime in between minor moments become meaningful. But there is no fear, just . . . anticipation. A nation watches hopefully as the umbilical cord falls away. Now, ten has become one. The time is near. The great rocket blossoms at its base, and there is a moment of thunder.

You feel the giant's weight. And yet, it is no surprise, says Astronaut Scott Carpenter:

> Feels like you're being pressed into the couch. This is no surprise though. By that time you've ridden the centrifuge so much it is an old, familiar sensation.

Called the giant G, for short, which stands for, "gravity." His force, then, is not only familiar, but essential to our normal, everyday, Earth-bound existence. We live in a one-G environment. But it is when we multiply gravity, such as the resistance encountered with any accelerative force, that the strength resembles the brute dimensions of a mythical giant. As power took to flight, medical science began to wonder how much the human body could take when driven against the great resisting wall of gravity.

More than a decade ago, an Air Force officer dared to test human tolerance to the impact of high G. Colonel John Paul Stapp rode a rocket sled and remembers his tangle with the G-force giant.

> We got up to about 40 Gs, which is what we were after. In that duration seated facing forward, there was an immense congestion of head and face, which caused a rupture of blood vessels all around the eyes. Fortunately, none of the retinal vessels were involved.

Forty times the force of normal gravity. Colonel Stapp proved that man could survive high G, if certain essential precautions were taken, especially the position of the man when meeting this tremendous force.

> When you get above ten-G it starts to get rather rough and when you get above 20-G, it is very serious indeed.

An observation by Dr. James P. Henry, an Air Force officer on research leave at the University of Southern California. Dr. Henry holds a medical degree from Cambridge University and a PhD from McGill. He is a pioneer in Space research. He describes the first hurdle in man's pursuit of the Space-age challenge:

> Most of the effort has been concerned with getting in and out of the Earth's gravity pit and very little time has been spent sailing on this relatively force-free, interplanetary plain. We've been concerned with getting in and out of the harbor, getting over the breakers of the Earth's gravity pit. That's dominated our thinking. So we think of it as a rather horrendous thing. And it is horrendous. Just the same way as the inhabitants of a little atoll would feel that getting out of that surf is a terrific undertaking. And that is the time they're going to get killed; and that is the time when the stress is put on the whole situation, getting through these huge breakers. And getting back in, timing it just right. But actually, once they're out there on the ocean, the canoe is pretty safe.

There was early doubt as man stood on the beach of his Earth environment and locked out at that sea of Space. For it was, indeed, a fabulous feat to propel man beyond the crust of the Earth's atmosphere and bring him back unscathed through the scaldingly hot friction of reentry. Always, in between, the towering test of that mythical giant. So no man entered Space without first finding his capability to withstand unusually high levels of G-force.

According to Dr. Karl Schmidt:

> The Mercury astronauts had no serious problems over acceleration and, I believe, that the type of acceleration that is contemplated for the flights that are now going to come off is not going to be much greater than it was for the Mercury astronauts.

Dr. Earl F. Schmidt is the research director at the Navy's Aviation Medical Acceleration Laboratory in Johnsville, Pennsylvania. Though acceleration thus far has posed no problem in the conquest of Space, Dr. Schmidt underlines the limiting factor of human physiology.

> However, there are always the possibilities of emergencies, an abort on the pad, or an escape from the capsule shortly after take-off, which might expose them to high G forces. But it is worth stating that this is where one comes up against the limitation of human physiology in a very striking degree. In the position in which the astronauts will take G is the chest-to-back, or transverse position. The limiting factor is in the chest. What happens is, when the acceleration force gets to about five G or more, the astronaut begins to experience difficulty in breathing, pain in the chest, coughing and, if the G lasts for quite a while, his arterial oxygen saturation will begin to go down. The higher the G and the longer the exposure lasts, the greater will this anoxemia become.

At the NASA Manned Spacecraft Center in Houston, Dr. Rufus Hessberg speaks of man's measure of endurance:

> They'll come up and say, "How many Gs can a man take?" Well, a man can take in some directions three and four times the number of Gs he can take in another direction. So we deal with a problem of not only the magnitude of the G, but the direction in which man feels the G, or to which they are applied to man, the time for which they are applied, and then how fast you apply them.

These, then, are the criteria to be considered in preparing man for the onslaught of the G-force giant.

So far the fight man has waged against the colossus of gravity has been successfully won. Through technology and techniques, man has been able to cope successfully with the expected amounts of gravitational resistance. But as with any stress factor, the book is never complete. Research goes on. One scene for much investigation, and a great deal of training, particularly of the early astronauts, is the huge centrifuge in Johnsville, Pennsylvania. It is located in the Navy Air Development Center. You are there now, standing in the large, circular room.

> As you are aware, perhaps the most unique facility of this laboratory is the human centrifuge.

This is Don Morway, a research psychologist concerned with dynamic flight simulation. He is explaining the centrifuge.

> It is this centrifuge that gives us the capability of producing the G-forces which we can expect to find in the areas of spaceflight and planetary travel. The centrifuge is a large arm which is driven by a rather large motor. It weighs a hundred-and-eighty tons. At the end of the arm there is a cab in which we can install a mock-up of the various space capsules, such as Mercury, Gemini, Apollo, and any future space vehicles. The centrifuge has the capability now of swinging this cockpit, or the small cab at the end of the arm at tremendous speeds. It can accelerate from zero-stop to a hundred-and-eighty miles an hour in a little less than seven seconds. This is the equivalent of producing something like 40 G.

Each astronaut must log many hours of centrifuge experience. They must know what the G-force giant is like. So it is no wonder Scott Carpenter said of lift-off:

> This is no surprise though. By that time, you've ridden the centrifuge so much, it is an old, familiar sensation.

What is it like to ride the centrifuge? An Air Force jet pilot, Captain Edward J. Dwight, Jr., who has been through astronaut training, describes a centrifuge ride like this:

> It gets to the point where the weight, just mashing on your chest cavity, is so great that you can't even raise your chest cavity up to breathe. Your tear ducts clog up as a result of the forces involved and when your eyes start tearing, they don't have any drainage. The water pools and forms into droplets. By the time it gets over here, it'll hit back here, and it'll hit you on the ear. It feels like little BBs are beating on your ears!

> The centrifuge is not a product of the space age.

You're listening to Dr. William J. White of the Douglas Aircraft Corporation in Los Angeles, who has written a fascinating book about the history of the centrifuge.

> The centrifuge was first proposed by Erasmus Darwin about 1795 and it was proposed as a therapeutic device for treating certain disorders of the circulatory system, certain types of fevers, and so on. He had a theory that went with this and for many years it was thought of as a therapeutic device. It was used in many of the European countries to treat mental disorders at the time when people thought they had a pretty good grip on what was causing insanity. The theory and the medicine behind it was being developed at a fairly rapid rate. So it was found in many, many hospitals in Europe in the early part of the 1800s and all the way up until about 1860. During World War I, the centrifuge was used for the first time in aerospace medicine in a rather interesting way. The French and British introduced to the fighting fronts in Europe new types of aircraft that imposed airily high acceleration loads on the men. The Minister of Aviation noticed that the wings were cracking. The fabric was being torn off during pull-outs from dives. The question came up as to whether man should be allowed to expose himself to these stresses. So the first aeromedical experiment was done by Garcelle and his colleagues, in which they took a centrifugal dryer, used in the manufacture of gun powder, and used dogs as their subjects. They spun them around to determine at what level these animals suffered injury. They ran two experiments and the dogs made such a loud noise barking that they had to discontinue the experiments because the women who were working close by objected to this.

Today, animal experiments on this centrifuge form an important element of space research. Chimpanzees and chickens have been whirled at unprecedented G-loads in centrifuge tests, under many varying conditions, to discover new characteristics of the G-force giant. Even the young of animals and birds have been born aboard the centrifuge to test new generations that know no other existence than that of increased gravity. Still, the most impressive experiments are those in which humans participate. For the prime objective of all centrifuge experimentation is human tolerance. And not only to extremely high G-loads, but also to prolonged periods of slight increases as well. For, as Dr. Lloyd Hitchcock of the United States Navy Aviation Medical Acceleration Laboratory suggests, this may be the way to reach distant targets in less time.

> In essence, the individual would be accelerating at anywhere from one to three Gs, sustained, halfway to the goal, at which time deceleration would begin at the same level and continue until the surface of the target planet was reached. The effects of such a program on the time required for a planetary mission are fantastic.

But could a man endure the abnormal twice-gravity existence for weeks on end? Questions like these form the basis of continued research in the field of acceleration.

The future will focus on other areas of concern, as well.

> As you use larger and larger booster systems, you necessarily set up greater vibrations and, presumably, sustained for a longer period of time.

Dr. Bernard Wagner, chairman of pathology at New York Medical College.

> It would appear that vibrational forces have a greater deleterious effect on biological materials than acceleration; if you can separate these two.

As Project Mercury probed the initial acres of outer space, the tremors were felt as if the invisible giant had grabbed the rising rocket and angrily shook the invader of Space. But engineers found an answer and Gemini appeased the giant. The ride into orbit was smoother than ever. Tomorrow, undoubtedly, will yield a greater concept of power and perhaps some accompanying vibrational response. No matter how small the tremor, the element of time will measure man’s endurance.

One of the leading authorities in the study of noise and vibration is Dr. Henning Von Gierke. He is Chief of the Biodynamics and Bionics Division at Wright-Patterson Air Force Base. In designing the Mercury capsule, for instance, the National Aeronautics and Space Administration consulted Dr. Von Gierke to find out the effects vibration might have on human welfare and performance.

> We studied, for example, visual acuity under vibration. How large figures on a dial must be to still be readable under certain vibration conditions. We studied how much speech would be distorted under vibration.

A problem akin to vibration is noise. For in his spacecraft the astronaut is never without sound, even in the silence of Space. John Glenn described it quite well.

> Noise level of the capsule in orbit was very similar to what it is on the pad out here. You have the whine of the inverters, the gyros, the valves, and the hiss of the oxygen in the helmet hose. It is not a loud intensity.

Some sound is desirable, of course. Man would go mad if enveloped in absolute silence over a long period of time. But what would be the effect of sustained sound for weeks on end? What are the effects of infrasonic sound; sound so low you feel it, but you can't hear it? There are many unanswered questions; there is still much work to be done. Dr. Von Gierke explains the two rooms where research of this type is accomplished.

> Anechoic room is a room where all sound is absorbed at the walls of the room so that you have no reflections from the walls; you have no echo. That's why it is called "anechoic." The "reverberant room" is the opposite. All sound is reflected from the walls and the sound bounces back and forth between the walls like a Ping-Pong ball. You use these rooms to simulate different environmental conditions for your experiments.

The astronaut must meet again the great giant of gravitational force as the spacecraft returning earthward begins a fiery descent through a wall of atmosphere. The astronomical speed of the vehicle is absorbed in a phalanx of crushing moments and the friction creates an inferno that threatens both man and machine! Now, at this moment, the astronaut is expected to undergo the ultimate in extremes of human stress.

Gus Grissom returning from his first flight into Space.

> Okay, Gs are starting to build.
>
> MERCURY CONTROL: Roger. Reading you loud and clear.
>
> Roger. Gs are building. We're up to six. . . . there's nine . . . there's . . . about . . . ten.

> So he has many disabilities. One of these is just trying to get any air into his lungs at all. He feels as if he's being knelt upon by an elephant. It hurts. He struggles to breathe; it feels as if he's down underwater, struggling to get a breath and he can't quite get it.

Dr. Frederic Hoppin at the U. S. Navy Aviation Medical Acceleration Laboratory describes the ordeal of reentry. It is, indeed, a critical time.

> His spacecraft has to come in a fairly narrow envelope. That is, it has to come into the atmosphere at a very specific angle. Otherwise, it will either dig in or skip out. So the engineering requirements for how long he has to undergo what kind of a G are fairly restricted.

You're conscious of a cooperative tug-of-war that exists between engineering demands and human requirements. Each is dependent on the other. Out of a close alliance has come the knowledge and ability to conquer Space. It began at the beginning when concern for man and machine conceived the initial design for the Mercury capsule. At the University of Southern California Dr. James P. Henry recalls the development of the heat-shield as a remarkable event.

> This very clever design, this blunt design. It was an illogical approach. The logical approach was a pointed, streamlined design. They went completely the opposite direction, which is often a smart thing to do. They just went backwards. They put in a blunt object and burned it away, which was a stroke of genius. That solved spaceflight. This and the power of the rocket which was a fairly straight-forward problem. I mean, in principle. I don't want to underestimate the genius behind the development of rocketry, but I think that was a real stroke, that reentry body, which I believe was attributed to some engineers at Ames.

The NASA Ames Research Center. Out of this and other NASA installations, out of the research accomplished in the services, in industry, in education the way to infinite regions has been breached. Even the giant of friction and force, who looms between the launching pad and the relative peace of outer space, no longer seems the Colossus of earlier days. But he's there, always. As ambitious men of tomorrow plan today to reach some distant goal in the not-so-distant future, know this: He stands as an obstacle that cannot be ignored. But know this, too: They're constantly improving the way. Almost daily science adds new techniques and technical advancements that will assist the astronauts in bridging the great divide that separates home from the hope of the future. A case in point: Gemini 3. Shortly after Gus Grissom and John Young returned the director of the NASA Manned Spacecraft Center, Dr. Robert R. Gilruth, appeared before the press and reported:

> The one technical point that I thought was particularly interesting to me, and will be to many of you, I think we can report, without analyzing all the data, and that is, as you know, in the ballistic-type reentry you get about 8-G at peak drag during the reentry. With this controlled reentry in the Gemini, Gus reported to us this afternoon that they got about 4-G peak during the reentry. This is a very significant thing and gives some of the old-timers like myself, maybe, a chance that they'll be able to stand the rigors of Space travel as we get some of these things in the future.

Put yourself in the shoes of tomorrow's explorer of Space. You hear the thousand tick-tocks narrow into one and you are prepared to face the conflict of acceleration versus gravity. For men of medicine, and science, and engineering skill have made confidence possible in the face of this conflict.

In so doing, have increased our understanding of ourselves and of the world we leave behind at, Lift-off!

Five — Zero Gravity: The Great Unknown

Astronauts say it is pleasant, but Space experts fear the disturbing unknowns of weightlessness. Will zero gravity be the real barrier to Space exploration?

Not since Isaac Newton has science been so concerned with gravity. For the space age has uncovered a world of non-gravity and more than a few questions to perplex the guardians of tomorrow's challenge. A cardiologist, Captain Thomas Piemme, stationed at Wright-Patterson Air Force Base, puts the problem in these terms:

> It has been formally stated many times that all we need to do in going to outer space is to take a piece of our own atmosphere with us and live in our own atmosphere in a small container that we've scientifically managed to harness. Now, one can do this with oxygen; we can take our oxygen supply with us. One can do this with food; we can take food supply with us. One can do this with atmospheric pressure; we can take our generated atmospheric pressure with us. One can do this with temperature; one can generate temperature in outer space. The one thing we cannot take with us is gravity.

The long, slender rocket rises and the country below becomes a map of relief. Soon, its thrust carries the spacecraft through the Earth's atmosphere, and suddenly the astronaut is enveloped in a strange and wondrous feeling of freedom.

> I am very happy to report that there was just no ill effect at all that I got from zero-G. It was very pleasant, as a matter of fact. We had no tendency to particularly over-reach switches or have any trouble with the controls, as a result of zero-G. It was, indeed, a very, very pleasant experience. Some of the things that happened under zero-G sort of demonstrate how fast a human being adapts to this situation. I recalled last night, when we were discussing some of these things, the fact that I had this little hand camera once. I had taken a picture and I wanted to do something with a switch immediately. It just seemed natural at that time, after I had been weightless for, I guess it was about a half hour or 45 minutes, I had acclimated to this rapidly enough that it seemed perfectly natural that, rather than put the camera away, I just put it out in mid-air, and let go of it, and went ahead with the switch position here and reached back for the camera and went on with my work!

John Glenn. Remember? He voiced the optimism of astronauts before and since who have entered into this other world and found it pleasant. But wherever Space is the challenge, biomedical reservations still cloud the issue of weightlessness with doubt and suspense.

> When you talk the problems of weightlessness you're in an area, to many people, to many scientists, an area of the abstract or the unreal, or the unknown.

The area of the unknown as described by Dr. Bernard Wagner, pathology professor and Chairman at New York Medical College. The concern has been divided, he feels.

> You have in the United States a group of scientists who will dismiss weightlessness as a problem They will say that as far as they are concerned, there is no evidence, as yet, that it will be a problem for man to function in the weightless state, and that a lot of the so-called problems are manufactured and remain to be evaluated. The other extreme are those scientists who say that there will be tremendous problems with prolonged weightlessness because most of our physiological functioning has evolved in a gravitational state.

As always, the gaps of human knowledge are often filled with speculation, and if later proven true, such theories seem, in retrospect, clairvoyant conceptions. As early as 1638, for instance, Francis Godwin wrote a novel in which the hero noticed his weight was disappearing as he left the Earth on a raft drawn by swans. Once upon the Moon, the man even observed a pull weaker than that of the Earth, which enabled him to jump at great heights!

Now, you wonder when weightlessness became a subject of serious concern. Many competent scientists felt that man would die if exposed to weightlessness. The first significant experiment to find out was conducted at Wright Field in Dayton, Ohio. Of the two men involved, one is today a colonel in the United States Air Force, Dr. James P. Henry. The other is Chairman of the Department of Physiology at the Free University of Berlin, Dr. Otto H. Gauer. As Colonel Henry remembers it, they were really involved in a problem of acceleration.

> In about 1948 this question came up. They it was suggested to us would we put an animal in to see whether this nose cone, which was going to be put on a V-2 rocket, whether the accelerations would be unduly high. Since we were in the acceleration laboratory, it was suggested that we do this. So we slid into weightlessness the back way.

Telemetry told the investigators that the mice in the nose cone of their V-2 had encountered zero-gravity. This led to a series of experiments that delved deeper into the mystery of weightlessness.

> I suppose the first people to talk in a serious vein about weightlessness, which essentially is the chief physiological event occurring during spaceflight that is new and different, were Haber and Gauer.

Later, when you meet Dr. Gauer, you ask him about his early interest in weightlessness.

> I was one of the many authors writing in the monograph on aviation medicine in World War II in Germany. I don't know the exact title. I wrote the chapter on acceleration. In this chapter I made a little addendum some meditations on the possible effects of weightlessness. This was written in 1947 and printed in 1951. Dr. Strughold, who was the main editor said, "You should not just make a little appendage. You should write a small extra chapter. Get together with Hans Heber and write a chapter on the possible effects of weightlessness." I had the satisfaction that someone called it a classic in this field quite recently, I have forgotten the name; one of those monographs. Our predictions have not yet been disproved.

What is there to be proved or disproved? Make no mistake; Space is a curious domain of endless, yet exacting, dimensions. Its limits try the minds and courage of men who seek to enter this other world. Will the real barrier be weightlessness?

Colonel White of the USAF School of Aviation Medicine:

> When you have an unknown you can allow your imagination to go. You take facts on physiology, facts on illness, facts on man as we understand him and try to extrapolate this as you see the interplay of the removal of gravity. Immediately, you have a tremendous amount of proposed difficulties anticipated.

What difficulties? And how serious? These questions have generated more than speculation; they have inspired new activity in centers of research. For fears, grounded in basic physiology, predict a general deconditioning of the human body when exposed to prolonged periods of weightlessness. The heart, for instance, accustomed as it is to pumping against gravity and propelling blood over the circulatory system, now, in Space, suddenly finds itself freed of this obstacle and soon adapts to the ease of gravity-free state.

> So that it is conceivable that in prolonged weightlessness, once the cardiovascular system and then the nervous system, and the endocrine system, all adapt to zero-gravity that it may produce a decreased amount of heart tissue.

This is Dr. Wagner, the Chairman of Pathology at New York Medical College.

> In other words, you don't need as much heart muscle because you don't meet as much pressure. You require a smaller pump to have just as efficient a system. Your heart may get smaller; secondly, the kinds of signals that the sensors may pick up may be entirely of a different magnitude. Your brain has reset itself as a computer in determining what it will interpret and what it will not interpret. If such a man, after being up in Space for 30 days, or 60 days, or 90 days, reenters quickly and steps out of his vehicle, what happens? Theoretically, these three major systems will not adapt, and will need time, if they adapt at all.

The day Gordon Cooper completed his triumphant 22-orbit flight and emerged on the deck of the carrier Kearsarge, he experienced a spell of dizziness. They call it by a big term; "orthostatic hypotension."

> You may have noticed this if you've been hospitalized or been in bed for a long period of time and then get up suddenly. You may feel pretty weak and you have to hang onto something for a few moments. That's the sort of thing that we're talking about.

Dr. Charles Berry, Chief of Center Medical Programs, NASA Manned Spacecraft Center.

> It has been hypothesized for a long time that this was due to occur, due to weightlessness alone. This was theorized on the basis of bed-rest studies where, if you put an individual at bed rest for prolonged periods of time, even for a week, you'll find that they have indeed developed orthostatic hypotension.

Dr. Otto Gauer described the condition as a collapse of the circulatory system. He contends it will be a problem which all astronauts must face.

> This cannot be avoided. Everybody who will be up there for a reasonable period of time will have orthostatic hypotension.

But how much can be blamed on weightlessness? Dr. Hubertus Strughold, Chief Scientist at the Air Force School of Aviation Medicine, is undecided.

> At the present time we do not know exactly what is the cause. Is it zero gravity, that means weightlessness, or is it the general inactivity? Probably it is, in the first place, the inactivity.

Zero gravity the unknown, invisible, uneasy specter of outer space which, by its mystery, spurns the most learned views of its vacuous state. But medical authorities agree, the human heart and the blood vascular system will likely encounter some difficulty in that strange and wanton sea of weightlessness.

Make no mistake; Space is a different world with mysterious and hostile influences. Weightlessness seems to be the big question mark. At the Brain Research Institute at U.C.L.A., Dr. Ross Adey expressed this concern:

> What is going to be vastly altered is the input from the muscles, the joints, the inner ear mechanism, our balance mechanism, in the weightless condition. Normally, the brain is constantly bombarded by a vast volley of impulses. It is a tremendous influx of sensations which come to us from our joints, and our muscles, and from the inner ear. In the weightless condition, this is very drastically altered; in most areas, it will be substantially reduced.

Almost from the very beginning space authorities suspected that signals from the inner ear would cause confusion in the suspended state of zero gravity. For in this critical area of the human body there exists the delicate organ of balance and orientation. Dr. Wagner mentions the research being done in this field.

> We have a variety of programs here on Earth to try and determine what might be the effects on the inner ear. When I say the vestibular apparatus I mean the very sensitive organs that not only determine your balance, but connect with the hearing pathways, the optical pathways, and the higher areas of the brain.

At the Naval Aviation Medical Center in Pensacola, Florida, Captain Ashton Graybiel directs an extensive study of problems pertaining to the inner ear. The otoliths, for instance, which are no bigger than grains of sand, normally move in the semicircular canal with each turn of the head, establishing contacts for orientation. But in weightlessness, the otoliths will not respond.

You ask Captain Graybiel, exactly what would be the effects?

> It simply means that if a person is truly in weightlessness and has no other sensory inputs from his environment, by virtue of contact with his environment, or with eyes open, that he doesn't know which way is up.

It could be more serious than just a matter of orientation. The fluid-filled semicircular canals of the human ear might induce motion sickness if subjected to any accelerative force, even the turn of a head, in weightlessness. Yet, on this point, Astronaut Scott Carpenter is optimistic.

> To my knowledge, the only person who has who has demonstrated any nausea was Titov and, as he suggested, it may be only due to his peculiar organism.

Dr. Otto Gauer is not so optimistic.

> People say motion sickness will not occur and everybody feels wonderful in the weightless state. I'm not convinced whether this will really be all the way through. I'm sure there are people who will stand it and enjoy it, but others who won't.

Everyone agrees the human body will adapt to this other world of non-gravity. So well, in fact, that within weeks of prolonged flight in Space human muscles may lose tone. A research physiologist, Captain Robert Kellogg at Wright-Patterson Air Force Base, explains.

> If the muscles are taken away from their normal one-G field and there is not the necessity to use them as an antigravity device then, over a prolonged period of time, the muscles may atrophy, may lose their normal function and this may cause some very severe difficulties when it comes back to reentry.

The bones of the skeleton may be affected, too, by a loss of calcium which physicians feel may incur in the weightless state. According to Dr. Bernard Wagner this could mean problems in two ways:

> This excess calcium that's being lost gets into the circulation and, being excreted by the kidney, may block the kidney in the form of renal stones, an extremely painful experience, as well as producing severe damage to the kidney. But another possibility is that the bones may become so decalcified that they are unable to maintain weight with reentry so that there may be dangerous fractures.

Like a tightly woven fabric the functions of the human body are interwoven and though the effects of zero gravity may strain only one thread. The fabric is weakened and the astronaut is rendered vulnerable upon his return to a one-G environment. So there is no wonder that men of bioastronautics fear the perplexing unknowns of weightlessness.

Aside from fears of physiological change, who knows what might happen to a man's mental attitude after weeks of exposure to this other world?

> There are, of course, many other problems involved in weightlessness; man's performance, his general ability to carry out motor tasks, to use a wrench, to keep himself tethered correctly at a worksite, for example, so he can effectively do a job.

Yes, the frustrations of performance in zero gravity. As Captain Kellogg at Wright-Patterson has brought up the subject, Dr. Hans Clamann of the Air Force School of Aviation Medicine elaborates.

> If you do not have proper means to hold yourself against a banister or a rope, magnetic shoes or something, you're not able to do anything. Because that moment you touch something, you are pushed back according to Newton's Law. This is one thing. Second, is eating. Any fluid will not have a shape like here on the ground; if you drink coffee, your coffee stays in your cup until you drink it. This is not so in Space. Your coffee will drift away.

Weightlessness. The phenomenon of true Space that today looms large in the minds of those who must plumb the depths of a fathomless Universe. For zero gravity defies simulation here on Earth and scientists are haunted with the need to test their theories. One method is bed rest. Dr. James P. Meehan of the University of Southern California speaks of an experiment.

> We've just finished a rather extensive program this summer in which we had fourteen healthy young men in bed for a month. This experiment was designed to simulate the effects of weightlessness. We were interested in seeing if we could protect the subjects from some of these effects by having them exercise or pressure breathe while they were lying in bed.

But even bed rest is far from being weightless. Contact cues still exist and a second method, that of water immersion is equally inefficient, as Captain Graybiel explains:

> Underwater, or immersion, relieves the person of the contact cues from his environment, but it doesn't abolish the action-at-a-distance force of gravity. So the otolith organs are stimulated just the same if you're underwater or in air.

Free-fall, such as that experienced from a parachute drop-tower, or a leap on a trampoline produces brief but impractical moments of weightlessness. Similarly, an airplane flying a Keplerian trajectory can yield up to forty seconds of zero gravity. It is this method that is used to test equipment, to run brief experiments, and to introduce the astronauts to that feeling of non-gravity. Each day, weather permitting, two planes, a DC3 and a Boeing 707, take off at Wright-Patterson Air Force Base in Dayton for what is known as the parabolic flight.

You're aboard the DC3. You're riding with our reporter, Art Freeman, and through his words you'll feel the sensation of weightlessness. The interior is padded and Air Force personnel in orange-colored flight suits stand ready to assist the persons who float and tumble in the fleeting seconds of weightlessness. You're told that the plane at 10,000 feet will dive to 8,000 feet, then climb to 12,000. As it goes over the peak, you'll feel the effects of zero-G. The plane will then dive to 8,000 feet, returning to 10,000 to repeat the maneuver.

The maneuver is about to begin.

> We are now experiencing two-Gs. I feel like about ten people are sitting on me. My hand is shaking. I don't know if my voice sounds funny or not. We're now weightless!!! We're now weightless. Good lord! What an interesting feeling this is!

So as tomorrow's long, slender rocket rises and the country below becomes a map of relief, its astronauts will face the effects of prolonged weightlessness. What if it proves a problem? Perhaps exercises will strengthen muscle tone. Perhaps pressure cuffs will aid the circulation of blood through the body. Perhaps it may be necessary to simulate the pull of gravity by a built-in centrifuge or, even by the engineering achievement of spinning the vehicle. But as Dr. Alvin Hyde, medical research official at Wright-Patterson Air Force Base cautions, perhaps we may not need such bizarre methods at all.

> The man could have extra vitamin D and extra calcium. This may be adequate replacement therapy for the loss of calcium induced by the lack of gravity. Until we know whether the cheapest and most effective countermeasures are not as good as vehicle rotation, we have good reasons to believe that this is true, that in one or two areas that vehicle rotation may be an advantage. In many other areas, which may be the serious decrements of zero-G, the simple, cheap counter-measures, a pill or a simple, anti-G suit-like device, a pressure device, a pneumatic device a little air under pressure applied to bladders appropriately placed, can do more in terms of protecting the man, perhaps, then spinning the vehicle.

Again, from the Naval Aviation Medical Center, Captain Ashton Graybiel:

> I think that the disturbing thing about weightlessness is that we know so little about it in advance of actual experience. It is something that we just simply can't simulate on Earth, except for those few seconds we spoke of earlier. So it represents the greatest unknown. We probably are much more frightened of, radiation hazard aloft, but we know in advance precisely what the radiation hazard will amount to, where to go or not to go in Space, how much shielding and so on. In other words, we can, there's a problem, the parameters of which we will know. Weightlessness is something we don't know.
>
> So this is why it is our greatest unknown problem at this time.

Six — Occupation: Out of this World

The astronaut occupation demands the daring of reasonable risk and is confined to the caliber of select men who must undergo firm procedures of selection and training.

> We are still holding at T-minus-35 minutes but we expect to pick up the count momentarily. The erector has been lowered and we expect that within a minute or two to resume the count. A final status check is being taken at this time in the blockhouse preparatory to picking up the count. Meanwhile, during this hold, which began an hour and ten minutes ago, the crew has passed at least a part of the time taking catnaps.

Perhaps you heard the report that June day as Gemini 4 poised on pad number 16 preparatory to launch. No doubt you wondered; what manner of men must it take to conjure up sleep on the eve of great adventure and uncertainty? And yet McDivitt and White were but two in a growing occupation of modern-day explorers, who by their courage and their conviction seem to most to be rather extraordinary people.

Even as you watch your hands grow clammy and your heart beats many times faster than the slow-marked eternities of countdown. You breathe deeply, hopefully, as the rocket rises and your prayer follows the flame of its thrust. You think about the men who, pinioned against their contour couches, must now face the ever-widening challenge of Space. What sort of men must meet this challenge?

> I don't know the specific criteria but, in general, you have to have an all-around American blue-ribbon boy as it were.

So aptly put by Navy Captain Frank Voris, a physician who once headed NASA's Human Factors Division. But you're curious to know the specifics. How does one choose an astronaut?

In Philadelphia, you talk to Dr. George E. Ruff. He's an associate professor and psychiatrist at the University of Pennsylvania School of Medicine. Dr. Ruff figured prominently in the selection of the original seven astronauts. He tells you:

> The picking of astronauts is no different than picking anyone else in that you have certain principles that you are guided by. The first thing whenever you're picking somebody to do a job; you have to know what the job is. The description of the tasks the man is going to do is always crucial. Then, when you know what the job is, you have to define the characteristics that you want to have in a man to do that job. When you know the characteristics, these are now your criteria, you have to have a system of testing to find out which of the various candidates meets those criteria. So here's where you're going to be using interviews, psychological tests, and other devices to see whether he really does meet the criteria that you've set up. Finally, when you've made your choice you have to follow it up later on and see whether or not the people you chose were the right people. In an astronaut selection program, you can't do a good follow-up study.

What, precisely, are the characteristics of a good astronaut? You wonder; what do they look for? Dr. Ruff, who had little to go on at the time, and who helped name the first seven, explains that standards were set pretty high.

> First of all, all the candidates had to have a high level of general intelligence, because not only were they going to have to make quick decisions based on getting information at a rapid rate in the future, but they were going to go through a tough training program. They were going to have to learn a lot in a short time and you needed a man who was pretty bright. Another thing was we wanted a man with a good bit of drive and, hopefully, some creativity, so that he could make a contribution from the pilot's standpoint to the project as a whole. We were interested in freedom from emotional conflict. It is important that an astronaut be a stable individual and not be a person who gets easily rattled from trivial stimuli. Then, we didn't want people who were too dependent upon other people, people that wouldn't be able to get along on their own in a mission; but on the other hand, we didn't want people who would not be able to accept dependency. Because some people are able to be independent, but if they are in a position where they have to be helped, which the astronaut often does; I mean, he can hardly move in that vehicle once he's inside of it, then things wouldn't go too well. So we had to have a man who could be as dependent or as independent as the project required. As far as the relationships with others are concerned, we also had to have a man who could get along with other people because this is a vast team project. If you have a man who can only work by himself this would be a problem. We wanted a man who could respond predictably in the situations that we could foresee but who could respond flexibly to the ones that you couldn't foresee. Because if you know what's going to happen, you can decide ahead of time what's the best way to do it. You don't want somebody who's such an individualist that he can't do the thing he's required to do, but then, if you get a man who's so rigid that when something new happens he can't change, that's not so good either. Then, motivation was an interesting thing. We wanted a man who was strongly motivated, but the amount of motivation wasn't the whole story; it depended on what kind of motivation he had. You wouldn't want a man to go up in Space just because he liked danger and thought that he would go up in order to test his own feeling about being able to avoid danger. What you want is a man who is primarily interested in the objectives of the project, of carrying out the goals of a project like Project Mercury, but who was willing to take whatever risks are necessary to accomplish that in the course of doing his work.

Dr. George Ruff, who helped select the first seven astronauts enumerating the qualities that were found in men such as Shepard, and Glenn, and Grissom; in Slayton, in Cooper, and Carpenter and Schirra. How did it all start?

> Nobody said, "Who would like to volunteer?" If you do that you're inclined to get a lot of flagpole sitters. So what the group did was to decide what experience they wanted. They decided that they wanted a test pilot with a degree in engineering or the equivalent, who had 1,500 hours of flying time, including high performance jet experience, because this kind of experience would be the closest thing to the job of the astronaut.

Dr. Ruff, recalling the beginnings of Project Mercury.

> They went over the records of the Army, Navy, and Marines and selected 110 men who met these criteria, plus certain others as far as their height, their physical health, and things of this kind. Most of these 110 men were then invited to Washington, where they were told about the project. Nobody had heard about it then; it was a classified project. The men were able to find out what was going to be done in Project Mercury, and then were given some time to think over whether or not they'd volunteer. Those who did volunteer, and that was most of them, were interviewed by Project Mercury officials, by psychologists, by a psychiatrist, by an Air Force and Navy flight surgeon. Then, those who looked like the best bets were put through the other two weeks of the selection program.

The first week was an intensive physical and laboratory examination at the Lovelace Clinic in Albuquerque, New Mexico. The second week was spent at Wright-Patterson Air Force Base, where the candidates underwent many stresses in a continuous series of tests. Dr. Ruff was Chief of the stress and fatigue section of Wright-Patterson's Aerospace Medical Laboratory at the time. Also present was Dr. Mildred B. Mitchell, a research psychologist. She remembers:

> We gave them many psychological tests, but we were also interested in observing their behavior under stress. For instance, I gave them a battery of six tests before they went into the heat chamber where we kept them at 130 degrees for two hours. Then I reexamined them when they came out. I also examined them with a battery of six tests before they went into the high altitude chamber. In that, we took them up to the equivalent of 65,000 feet and kept them there for an hour. Then we raised them to the equivalent of 100,000 feet, if they didn't pass out first.

It was an arduous week. The astronauts-to-be were subjected to grueling tests of acceleration, were whirled on a tilt table, were plunged into ice water, and were forced to endure high limits of noise and vibration. On top of it all, there was the frustration of coping with something called the, "complex behavior simulator."

> This was a gadget which had been developed by the School of Aerospace Medicine down in San Antonio where a man had a job he couldn't possibly do. The objective was to find what would happen when a man had been told to do something, but then found that he was falling hopelessly behind. What kind of frustration would develop? It was an engineer's nightmare. The responses didn't make sense. If a light flashed and you turned it off by pushing a button down, or throwing a switch to the left, why, if another light flashed, you'd have to throw a switch to the right. If the light that flashed in the upper left hand corner had to be turned off by a switch in the lower left hand corner, while another light on the opposite side might have to be turned off by a switch you couldn't even see while you looked at the light. This kind of thing to make it tough. Just in case people didn't have trouble right away, after twenty minutes the speed that he was required to show was doubled. Finally, to make it completely impossible, after twenty minutes, the speed was doubled again!

> One of the first men of the astronaut group who to go through this was Alan Shepard. We still remember how he went along and the first time he kept up with the machine. So, we sort of chuckled because when he got up to the double speed he'd never be able to do it. When we got to the double speed, he still did it! We couldn't imagine! We were recording some of his physical responses that show how relaxed a man is. Finally, we put it on the top speed and he began to fall behind a little bit, but he was sort of whistling to himself. As we looked at his physiological recordings, he was showing more and more relaxation all the time! This is the only time up until then that we had ever seen a response like that. After he was finished we asked him what he thought about it. He said it was great! That he would like a little more chance to practice it and then we could get up to a higher speed. Well, of course, we didn't even have a higher speed!

And thus it was. Out of thirty-one final candidates America's first seven astronauts were selected. These men, dedicated and determined, entered a strange program of training for an equally strange profession, that of being an astronaut. Well you know the story. How that on the morning of May 5th, 1961, Commander Alan Shepard made our first suborbital flight.

> Many people have the conception that although this was the first flight, in consideration of the fact that this was the first flight that there were a great many unknowns. I would like to indicate here that there were, in fact, many areas of consideration that were not proven by actual flight. But I would point out that prior to my flight approximately three years of testing had been done in many areas, testing not only of the equipment, the materials we intended to use, but also of the crew that were going to make the flights.

Naturally, as more and more experiences were logged in outer space, astronaut training became more and more refined and specific. In the beginning, as indeed today, astronaut preparation was long and hard and all-inclusive. Their training sites were all over the country, at the McDonnell plant in St. Louis for capsule consultations, at the Morehead Planetarium in Chapel Hill for celestial navigation studies, at Wright-Patterson in Dayton for parabolic flights and zero-G experience, at the Navy's Acceleration Laboratory in Johnsville for centrifuge training, at the Cape, at San Antonio, at sea, wherever they might learn of the slightest possibility of what could occur in Space. And always simulation runs training routines to test endurance, to establish human tolerance to stress.

To this day, the centrifuge looms as the most distasteful phase of astronaut training. Mr. Don Morway, a research psychologist at the U. S. Navy Air Development Center, remembers the original seven astronauts and their encounter with the laboratory's huge centrifuge, which they called, "The Beast."

> The dynamic flight simulations that we do on the centrifuge can be very real at times. We have gotten the astronauts up at two o'clock in the morning and have them take their shower. Have a low-residue diet. Brought them here to the medical lab. Gave them their psychological tests. They've had their physicals they were suited in their pressure suits and we brought them up in the centrifuge and they climbed on board the mock-up of the Mercury capsule and got situated inside. We closed the hatch and we even went to the extent of simulating equipment malfunctions on the pad. Telling the pilot that we had

> problems. We would have something like a two-hour hold period. During this time, we just sat around and monitored the pilot to see if he could endure this type of stress.

With the Gemini program the second group of astronauts reached maturity, and a third group entered training phases that would fit them for missions of the future. Scientists, too, were added to compliment the pilot-astronauts. Selection was still rigid, the right of only a few: The dedicated. The strong of mind and heart. Young, intelligent men are needed to undergo the arduous training, which Dr. Frank Voris points out:

> They are given a rather thorough training in the physiology of the body. They are psychologically introduced to the problems of spaceflight. They are, of course, given a tremendous amount of training in navigation and in the engineering of the space vehicle itself. They go through hours and hours of procedural training, in which they get into capsules that are identical to the one they are going to fly in.

Physical fitness is left to the individual, you find. Some play tennis, water ski, play handball or swim. But there is no set program of calisthenics. You wonder about this. You ask the Chief of medical programs at the NASA Manned Spacecraft Center, Dr. Charles Berry, isn't a program of physical training necessary?

> This is always a difficult question because there's a lot of argument. It is the same old thing we see in pilots who say, "I'm going to fly the airplane; I'm not going to carry it on my back! So why do I have to go out and become a great big physical education enthusiast of some sort?" We felt all along that a reasonable state of physical fitness is certainly necessary, because this prepares the body to face stress. There's no doubt about it; there are a number of stresses in the spaceflight environment.

Commander Alan Shepard is Chief of the astronaut office. His job is principally one of coordinating astronaut activities, which involve two fundamental tasks.

> Our two basic jobs are, training for the flights themselves and, secondly, providing a pilot input, or a pilot opinion, in the testing phase of the actual hardware. All of the astronauts are assigned specific duties in a technical area such as; responsible for the pressure suits, or electrical systems, or the guidance systems. Each has a collateral duty of this nature, in addition to being assigned the prime responsibility of preparing himself for a flight.

This involves practice, practice, practice. At the NASA Manned Spacecraft Center, you walk through the second floor simulation area of Mission Control. Here, the mission is run over and over again until everyone, from the control group to the astronaut himself, is familiar with every possible phase. Your guide is Mr. Richard Holt, Chief of the Network Operations Branch.

> So the way we play the game is we run the mission from either here on the second floor or the third floor, whichever control room is committed to that mission. We tie it in through computers to the simulation facility. We have one computer that's actually simulating all the data that would normally be coming in from the remote sites.

Adjoining rooms represent the worldwide tracking stations, Australia, Hawaii, the Canary Islands, and others. Communications crackle, static flares, malfunctions are faked. The masquerade seems real!

> We also know that the results of a serious error would be perhaps less forgiving and the consequences more severe in a space program. A number of studies which have been done on behalf of NASA have indicated that the real limitation of how much we can get done in a given vehicle in Space is a function of your crew.

At Lockheed Dr. William Helvey is explaining that microminiaturization has made it possible to put up more equipment; that more tasks have to be performed by the astronaut. The astronaut then must be especially acute, must be capable of thinking clearly, of acting quickly, of coping with sudden changes in routine. It is no wonder then that the astronaut must be a select individual; that he must be trained to perfection.

What will the astronaut of the future be like? Who will it be that receives the accolade of the Earth for exploring the distant planets? What manner of man will it take to prescribe the course of distant missions, to acknowledge the wonders of strange lands, to endure the prolonged periods of Space hostility? Dr. Helvey brings up a point.

> There's been a lot of thought to the role of women in Space. Certainly, I know some qualified women pilots who feel that women would make quite a contribution to the space crew. As a matter of fact, I guess I know some astronauts who would agree with them.

After the Russians put up Valentina Tereshkova there was considerable speculation as to the possibility of female astronauts. While attending the Third International Symposium on Bioastronautics and Space Exploration in San Antonio, Texas, Soviet physiologists, Dr. O. C. Gazenko and Dr. N. N. Kosenkov were asked if Russia had any further plans for women in Space.

> The question is, "Do you plan to use women in future spaceflight experiments, and why did you use a woman in Space?"
>
> God knows what has not already flown in spaceships! After all, there were individual microscopic cells, both human and others. There were flies. There were mice. Rats. Frogs. Dogs. Monkeys. . . . Men.
>
> Then, why not women?

As the requirements for future missions vary, it seems likely that women may be considered, and qualified, for the journey into Space.

> There are a lot of people thinking about what training is needed, what kind of people do we need to look at way down the line.

Dr. Charles Berry considers the future.

> There's a lot of thought when we start talking about Apollo follow-up programs and orbiting laboratories, and things of this sort. You get into some fantastic numbers of astronauts! Certainly nothing we've got on the books today. If you start this then you ought to be thinking about, what kind of people?

Scientists, for one thing. Heading NASA's Manned Science Program is Mr. Willis Foster. You ask him, what are the criteria for any scientist-astronaut?

> In the first place we insist that he have a bachelor's degree from a recognized college or university and that he have a doctor of philosophy degree in a natural science, or in engineering, or have the equivalent in experience. These are the minimum scientific qualifications expected of the scientist-astronauts. Then, of course, in terms of special qualifications beyond his education or experience, we wanted him to have this special quality, this ability to observe.

In short, the ability to be keenly aware and the capability of making subtle though meaningful discoveries in strange environments.

The astronaut profession is no longer new; no longer the unusual occupation of our modern age. Though it still demands the daring of reasonable risk, though it is yet confined to the caliber of select men, its job characteristics envision an exciting future that may soon involve people of many professions, but with only one paramount interest:

To explore, for the good of all mankind, the ultimate dimensions of: Their Other World!

Seven — The Bill of Fare Beyond

The fate of many conquests has been told in the fortunes of food. The conquest of Space is no exception. Important research reveals some vital facts concerning space nutrition.

> But as soon as man goes into Space, then does he need a minimum of nutrition? Can you, in a seven-day run, give him a candy bar or let him eat anything he wants? It is possible; it wouldn't hurt him much, seven days. But we are expecting these people to perform better than anyone has ever performed before. They have to be alert, they have to be ready to go in case of an emergency and they have so little time in case of a real serious emergency out in Space. So, we feel that man has to be fed in the very best manner that we can within the weight and volume requirements of the aerospace systems we are thinking and talking about.

Dr. Alton Prince, of the Bio-specialties Branch at Wright-Patterson Air Force Base, defining a problem that is history. For the fate of too many conquests has been told in the fortunes of food. Astronauts, like armies, do indeed travel on their stomachs. As man moves deeper into Space, a vital consideration is food.

> Do we need the total calorie intake per day that we do here, that we've set up for the lite worker, the heavy worker, the medium worker, the male, the female? The nice little charts that we have; do they hold?

A question is asked. The concern of Lieutenant-Colonel Stanley White of the United States Air Force School of Aviation Medicine echoes the complexity of man's goal to conquer Space. For in this strange and unique environment of outer space, one might well wonder about eating habits, about the nutritional demands on the human body. Please understand these are concerns that cannot wait until tomorrow's mission. At the University of California in Berkeley, Dr. Doris Calloway, a professor of nutrition, is very much involved in basic research that will one day lead to some vital answers. You talk to her about the problem of space feeding.

> The question of space feeding is in two parts. One is, are there any special nutritional requirements, and the second one is, are there and special food requirements; and these are not necessarily the same thing.

Dr. Calloway admits there is much to be known.

> The major question that we need to resolve in nutrition is what the man's level of energy expenditure will be. This would be important even if we didn't send any food at all because he will go right on metabolizing his stored energy to support his body functions and, in the course of this, he uses oxygen and he produces carbon dioxide. So that this now becomes a problem in control of environmental factors of oxygen supply and carbon dioxide removal.

All right, now. Something you hadn't thought about. As you talk to Dr. Calloway and to others, the parts of this vast mosaic of human physiology in Space begin to fit into place. You see a relationship, an overlapping of individual problems. Food in Space, then, is more than a matter of sustenance. Its considerations may influence other factors that will, in the final analysis, spell success or failure of a given mission.

The nutritionist, too, must face the phenomenon that still remains the concern of all who prepare the way to another planet. Weightlessness is still that open sea of unanswered questions.

> We can't predict with any accuracy what the effects of weightlessness may turn out to be. For example, you could say that it may take less energy to raise your foot, but it may take more energy to maintain your posture without gravitational assistance.

Undeniably, Space is a strange world into which man has entered cautiously. Despite reports that weightlessness is pleasant, doctors suspect the human body will not endure prolonged periods of non-gravity without some detrimental effects. One effect, possibly, will be the loss of calcium. For you see, the human body will adapt to the floating ease of weightlessness and like the bed-rest patient after weeks of confinement, may experience decalcification of bone structure. Such losses, in time, may be serious. Many have wondered if by adding to the diet this problem might be solved. Dr. Calloway considers this.

> Whether or not the diet could in any way prevent these losses is a separate consideration. If the loss is a metabolic one, it may not be at all susceptible to treatment by just adding more of these things in the diet. If the man isn't in a condition to retain them, all that we will do is send more through the system without necessarily bettering matters at all. In fact, in the case of calcium, if there is mobilization from his skeleton, then his blood levels of calcium may be quite high. If, at the same time, he has a problem with water there is some risk that he might retain his calcium for longer periods of time at higher concentration in the bladder and run some risk of kidney stone formation.

Prolonged weightlessness may not be pleasant at all. The chairman of the pathology department at New York Medical College, Dr. Bernard Wagner, suggests yet another problem.

> Normally, on Earth in the erect position we have a gas bubble that floats up to the top of the stomach and this is fine. If this gas bubble ever gets too big, we get uncomfortable. But in the weightless state, this gas bubble doesn't have to float to the top. It can sit almost any place. If it gets into the wrong place, it may seriously impede the flow of food.

Weightlessness, then, as a way of life, takes on a serious note.

> This immediately forces you to deviate quite a bit from your normal habits; you cannot have a fork, you cannot have a spoon, you can't use it, because your food would go away from your dish the moment you put it on it.

To facilitate eating in the weightless condition, freeze-dry foods are provided in special plastic containers. The astronaut reconstitutes each tube with water, kneads it with his fingers and squeezes the contents into his mouth. The Mercury astronauts found out the hard way about some important little things that have since led to vital improvements. When he spoke before the Third International Symposium on Bioastronautics and Space Exploration, Astronaut Scott Carpenter revealed some of these problems, not just as a matter of nuisance, but as a real menace:

> We have all had difficulty with improperly packaged food; it crumbles. The spacecraft environment, pre-launch, and launch, and during flight is not good for packaged food and quite often it crumbles. When you have a lot of crumbs in a space capsule it is very hard to contain them. Gordon Cooper had the same problem that I had. His cookies crumbled in the bag and you're afraid to open the plastic bag because in the weightless state, the crumbs will just fly out like bees! You can ingest them very easily and I think this is a hazard. Plus another thing that happened to Gordo which caused all the trouble on his last orbit, his drinking water was not well contained. It broke up into small droplets that were attracted to the relays and shorted them out, and this is what gave him his problem.

Astronaut Scott Carpenter. Later, at the same meeting in San Antonio, Texas, the Chief of Medical Programs at the NASA Manned Spacecraft Center, Dr. Charles Berry, made reference to this same incident in describing the problem of dehydration among astronauts.

> As far as the hydration is concerned this was not solved in Gordon's flight either. You know that he had problems. He only ate about a third of a package of roast beef and gravy because that's all he could get hydrated. There was a leak in the adapter, so that he every time he tried to hydrate the food, the adapter leaked and that got water out. Then as he pulled the adapter out, the water chased it out, too, and came right back out with the adapter. So he had a lot of loose water in the cockpit, which he was chasing around with a handkerchief trying to mop up.

But these problems are within the scope of man's ingenuity.

> So, this water gun. I don't know if you saw this. What I was just talking about a moment ago, but there is a water gun that's been developed. The packaging has been changed, so that there is a separate opening that goes in for the insertion of the water gun and it goes to the base of the container and you insert the water then at the base of the container and you're sure that you're going to get all the water in it, and will hydrate the food.

Even on Earth water is vital to the health and welfare of the human being.

> If man doesn't have enough water, if his losses are much greater than the supply, he cannot function more than a few hours. He can go without food for a very long time. Obesity studies, where people have been in total fasting, do indicate that man can withstand the absence of food for a long period of time. But water; not so.

Does space environment, weightlessness, influence dehydration, or an acute loss of water? Gordon Cooper lost seven pounds in his less-than-forty-hour exposure to Space, a loss due almost entirely to the passage of water. No doubt a temperature control problem accounted for an abnormal loss by perspiration. But no human can risk becoming dehydrated and water balance is a critical consideration in the planning of future missions.

Water. This precious commodity becomes the concern of those who plan and construct the craft, who chart the course for far and future destinations. For water is required for the machine as well as man. Yet only a limited supply can be taken aloft. What then, when missions lengthen into weeks, even into months?

Science is busy perfecting a method of recycling water; of utilizing a set supply, of reconverting even waste water into a reusable product. But the astronaut might need some encouragement, Dr. Calloway feels.

> We also try to put in enough beverages, dry beverages, so that the man will be encouraged to take water. Did you ever drink distilled water? Do you know how flat this is without any dissolved air in it? If you're taking either water off a fuel source or your own more or less reconditioned waste water, there's a certain aesthetic problem.

Water supply becomes a problem because of its weight. Water is heavy. For this reason and for storage facility, dehydrated foods are used.

> If we could just send the canned goods off the shelf there would be no problem. But if you would add up what you eat at home in a week, we might have a hard time getting it off the ground in the foreseeable future. So we have been looking at things that would serve and the best we've got now is precooked, freeze-dehydrated foods that are highly selected. These are about a pound-and-a-tenth per man per day. This is really pretty good in terms of weight and for volume.

An observation by Dr. Alton Prince, a civilian scientist at Wright-Patterson Air Force Base. The problem is echoed by Dr. Doris Calloway.

> Do you know how bad these weight limitations are, by the way?

Dr. Calloway will tell you that for the Apollo mission, a mission that involves three men for fourteen days, the total weight allotment for food is 75 pounds.

> This was also to fit into a volume of about four thousand cubic inches. Four thousand cubic inches would be 20 inches by 20 inches by 10. The average woman couldn't go on a weekend trip with a suitcase that size! Let alone send three men with this as their total. . . . This is a very small picnic basket.

In Space, the problem of space is to be taken literally.

> I hope planning is somewhat better in future crafts than is proposed at the moment because, not only is the volume for food storage quite limited, but it is not symmetrical storage space. It isn't in one neat little cabin where all the food is stored; it is kind of in cracks and crevices left over from everything else. So there have been some problems just in the physical engineering of the food supply.

Restricted by weight, by volume, by the demands of any given mission, a nutritionist's work in the area of space feeding becomes a fine and meticulous art. At the Aero-Research Medical Laboratories at Wright-Patterson Air Force Base, Lieutenant Elwood W. Speckmann speaks of the individuality of astronaut needs.

> The problem that we are working at is the nutrition of the individual, the tremendous variation that one individual has for various nutrients as regard to another. For instance, my wife could probably get by on almost nothing, whereas I require a lot more food. We don't want to send, say, my wife out into Space with a whole lot of food because she'd waste it. Then you wouldn't want to send me out with just a little bit of lettuce or something because I would require more. So, we have to look at the specific individuals and what they require.

To meet the needs of the individual in Space the natural tendency is to predict high, says Dr. Calloway.

> Because if we are wrong, it wouldn't matter very much if the man was slightly thinner or slightly fatter when he came back from Space, as far as that's concerned. But if we are wrong, then the oxygen supply that was predicated on our assumptions may be inadequate. On the other hand, we may send more along than is needed and we have occupied some space and some weight in the craft that could have been used for another instrument or something like this. So it is very important and I think it is a major area for research in this field.

Even the little things must be considered in the complexities of planning meals for the astronaut. How he sleeps in Space. How he thinks. How he works in Space. How he reacts to given moments of stress.

As the rocket stands ready on the pad, its nose of human occupants pointed to distant planetary horizons souls of solicitude stand beneath the gentry tower, waiting, watching, mindful of their respective concerns. For even as the engineer is interested in the operation of the booster motor, the nutritionist is similarly anxious about the metabolic action of the human being who now reclines up there in a position preparatory to launch.

> It is kind of how fast your engine is running.

Metabolism is very much like the operation of an engine according to Dr. James Waggoner, the director of life sciences at the Garrett AiResearch Corporation in Los Angeles.

> A basal metabolism test in a doctor's office is taken when the individual has had a night's sleep and you try to get him there as sleepy as possible. He's had nothing to eat or drink so as to cause any increased motor running because of a digestive phenomenon. Then, he sleeps in the doctor's office for a half an hour. Then you measure his oxygen consumption. This is what we call, "basal." In other words, there should be nothing going on in that individual, barring any nervousness he might get from a little claustrophobic reaction when the doctor comes in and puts that funny-looking mask over his face. He should be running his motor at the lowest possible level.

Metabolism is important because its rate of performance must be appropriate to the circumstances encountered. But frankly, the true circumstances of deep, outer space are not yet known. So what will be the bill of fare beyond? Ed Michaels of the NASA Manned Spacecraft Center speaks of the astronaut's diet.

> We've run some long-term studies with subjects during our chamber tests and it is a very well accepted diet. We have a soups, and meat items, and salads, and vegetables, deserts such as pudding and fruits. Then we have bite size pieces. We have such things as bacon or compressed bacon bars and chicken bites, and beef bites, and all types of dessert items; brownies and cereal-type cubes.

Through hardly dinner by candlelight, it is filling, appetizing and practical. As Gemini has proven, giant steps have been taken in rectifying the wrongs of earlier spaceflights. Now, bite size food enclosed in special icing prevents crumbling. Advances in packaging and the conditioning of food for the space environment pose a promising future, indeed. Still elements of doubt wrinkle the scientific brows of those who must work and live in suspect of the future. Questions like this one, for instance, by Dr. Karl Schmidt, Chief Scientist at the Naval Air Development Center.

> What is going to happen to the bacteria of the gastrointestinal tract under these circumstances, when a man is on a highly purified, concentrated, artificial diet for a period of four weeks or more on end?

Yes the extended mission. Will the diet selected be suitable?

> Just as the muscle of a heart can be reduced in its size during prolonged weightlessness, so the muscle of the gastrointestinal tract, the stomach and intestines, can also be reduced in its size and effectiveness if it doesn't have some work to do.

Dr. Bernard Wagner at the New York Medical Hospital, suggesting a possible need for bulk in the diet. Suggesting that possibly tube-fed, semi-soft diets may not in themselves be the answer. Yet, a low-residue diet is recommended for the problem of waste, too, becomes more perplexing as the trips into Space are extended.

> We plan, should there be any waste food left in any of the containers, that the astronaut would drop a disinfectant tablet into this and knead it into the waste food prior to storing.

Because of the volatile gases that might occur, explains Ed Michaels of the NASA Manned Spacecraft Center. For you see, all waste must be stored aboard and will not be jettisoned in Space. Waste management, therefore, becomes a difficult and important task confronting space experts. As Dr. Wagner so aptly puts it.

> Not only is it a problem in Space, it is a problem here on Earth as well.

So as a course is plotted to far-away planets, ingenuous plans envision what is known as, "a closed ecological system." It would be a regenerative cycle, into which would go waste products that, in turn, would produce useable products. In its simplest form, such plans involve microorganisms such as algae, or a plant called duckweed. These plants would absorb carbon-dioxide and give off oxygen. Body wastes could be utilized to grow the plants and as the plants flourish, they would serve as a source of food for the astronaut. At first glance, according to Dr. Doris Calloway, this looks good. But it has its drawbacks. For one thing, there are dietary deficiencies in algae. For another, it produces considerable quantities of indigestible material. Of course, there is the fact that it just doesn't taste good. Like grass or raw pumpkin someone said.

> Why don't you feed it to something else? A lot of things have been suggested by serious people, not lightly at all. The Russians suggested a chicken as one thing you might take along. I have heard lots of people recommend things like rabbits. But preferentially smaller things like water fleas or fish. The water fleas eat the algae, the fish eat the water fleas, and you eat the fish, or something like this. It is getting pretty elaborate already. If you want to take a chicken or a rabbit or perhaps even a goat, because they would love all this, you're taking a whole zoo with you, like, "Noah's Ark is Off in Space!"

Each day we witness great wonders of man unfold in this age of discovery inspired by Space. For as men go forth to plumb the depths of our Universe, human risks must be minimized. Food technology is meeting the challenge of this other world. But no matter the changes induced by the demands of Space, it will be the man himself who must be satisfied. It will be the man himself who passes judgment.

> In the end, it isn't going to matter what we say. Food is one area where the man feels he can take some latitude. Even though we've planned it all out very nicely with three meals and a bedtime snack, if he got hungry in between and it didn't interfere with anything, who's to restrain him from reaching over and taking out that freeze-dried peach and eating it?

On a more serious note, Dr. Calloway remarks:

> But the more fundamental question is whether his appetite will be better or poorer in a space environment and how he would react to tension?

Food to man is many things. For those who must plan the bill of fare beyond, there are more than calories to be considered. Even in its concentrated form, space food must have color and variety. For food is morale and often an outlet for frustrations.

> You always expect everyone's going to complain about the food anyway. It is standard in the military or a hospital, for example. If a private is very unhappy about his military experience and he can't go out and punch the sergeant in the nose, so he'll say, "Oh, these rations are awful!" In this sense, it is maybe a good thing to have an outlet that somebody can vent his spleen against, and the whole world says, "We sympathize because we know that's bad. Food is always bad."

The fortunes of history sometimes fall heir to the simple considerations of food, for food is indeed more than sustenance. It is the basis of human function. It is the tie with home. It is the will to conquer.

It will be fundamental in reaching the ultimate goal of space exploration.

Eight — Ill Blows the Solar Wind

Occasional waves of ionizing radiation emanate from the Sun, sometimes in the fury of solar flares, to infect areas of outer space with deadly particles.

At the U. S. Navy School of Aviation Medicine at Pensacola, Florida, Dr. Hermann J. Schaeffer, head of the Biophysics Department, speaks of the radiation hazard in Space:

> Before the satellite era we thought that the ionizing radiation is somewhat higher than at sea level on the Earth, but by far not of any level which would cause concern for acute radiation hazards. We know that this is not so. There are certain regions in Space which are completely uninhabitable for man, notably the Van Allen radiation belt. Also, we know that after some solar events, so-called, "Solar flares," the entire interplanetary space is infested with ionizing radiation, sometimes to such a level that within times of a few hours a deadly radiation exposure would take place.

It was early morning, March 1958. Washington, the city of monuments, was sleeping. Only an occasional cab and the distant hum of nocturnal activity stirred in the nation's capital. High above the boulevard, a lighted window gave little evidence of important events. Yet, in a hotel room, a college professor from Iowa was deeply engrossed in charting an amazing discovery!

> That was the first real flash of light as I was plotting these in my hotel room in Washington. I was up about three o'clock that morning, I had to catch an early morning flight, working there plotting these on a pad of graph paper that I had bought from the drug store down the street.

Dr. James A. Van Allen recalling a moment in a momentous discovery. It had all begun with an interest in measuring cosmic ray intensity in outer space. Dr. Van Allen and several associates at the State University of Iowa had placed sensitive apparatus aboard the American satellites, Explorer I, II, and III. Later, as they analyzed the taped results, it became apparent that a great body of radiation existed just beyond the Earth's atmosphere. Dr. Van Allen concluded that an assembly of radiation particles had been entrapped by the attraction of the Earth, and thus posed a threat to any man who dared to venture beyond into this other world of Space. Dr. James A. Van Allen, remembering a moment, but as he will tell you, there can be no one special moment.

> It wasn't exactly a sharp, clean-cut moment in time, but the most important moment was something like the following: We'd been getting the measurements in from Explorer I, but you must recall this was the first satellite America had ever put into orbit and the situation both as to where the satellite was at any one moment, the quality of reception, was very uncertain and poor in many cases. The data was fragmentary, we had a rather poor idea of where in Space the satellite was at any one moment, and so we had a very confusing picture. Furthermore, it turned out that our apparatus had much too small a dynamic range to cope with this new radiation belt; it had been built to measure cosmic rays which are very low intensity.

The existence of a radiation belt had been suspected on theoretical grounds by a number of scientists. In fact, almost a year before the first Explorer satellite penetrated Space, Dr. Fred Singer suggested the possibility in a paper. But it was Dr. Van Allen's work that confirmed the discovery; that told the men of space that a band of intense radiation actually barred the way just beyond the atmosphere.

The so-called Van Allen Belt of radiation is an assembly of electrons trapped in the magnetic field of the Earth. It encircles the globe in the classical shape of a donut diminishing at the polar caps and becoming heavily concentrated above the equatorial regions. This is deadly ionizing radiation. At the Pensacola Naval Base, you ask Dr. Herman Schaeffer, What is ionizing radiation?

> Ionizing radiation is distinguished from all other types by its ability of direct destruction of molecular bonds. It is a radiation in which the quantum energy is so high that if it penetrates living matter it immediately destroys, by the primary action of absorption, molecular bonds. If these molecular bonds are now the bonds in a biological molecule which is essential for cellular function, this is a disastrous event.

Radiation, you discover, comes in many forms and runs the gamut from the powerful beta, gamma, X-ray and of the spectrum down through the dividing line of ultra-violet rays, to the nonionizing variety exemplified in visible light, infrared or heat, or even the means of extending my voice across fields and along highways into your home, radio waves. Ionizing radiation usually results in an unstable situation that occurs when certain atomic action takes place due to the fact that the radiated energy is sufficiently intense or powerful. Nonionizing radiation, usually of low energy, can affect sensitive molecules also, but never at a level to induce atomic interaction. Therefore, it becomes a matter of degree. Sufficient exposure to ionizing radiation can be deadly or it can create changes that we sometimes refer to as mutations which can affect the physical and genetic welfare of an individual. Yet, sometimes, ionizing radiation can be helpful, as in the usage of X-ray, but its exposure has critical limits. Nonionizing radiation can be harmful too, like heat, for instance, if the energy is sufficiently intense. But normally, we look upon non-ionizing radiation as beneficial, as in the case of visible light.

> The process of vision is where nonionizing radiation interacts with a chemical substance in the eye to produce the stimulus, which produces the nerve excitation which is involved in the process of vision.

No doubt you've witnessed the rising mushroom cloud, or the delicate handling of an isotope, so the consequences of time and exposure to ionizing radiation has been impressed upon your mind. In the past, man-made radiation from high altitude atomic explosions has been cast among the heavens to collect in assemblies such as the Van Allen Belts. But these particles, in time, dissipate. Other high energy particles are added, however, by a constant bombardment from the suns of our Universe. Clouds of these sweep through Space and are sometimes referred to as the solar wind. It would seem, therefore, an unpredictable and precarious existence for the astronaut traveling in Space. Dr. Schaeffer refers to the findings of a Mariner space probe to Venus.

> The entire space, except for brief periods of solar activity, was remarkably clean with regard to radiation intensities. In fact, one could almost say once you are a larger distance from the Earth away from the Van Allen Belt and the other trapping phenomena which occur in the Earth's magnetic field, the radiation climate is better than in closer vicinity of the Earth.

Close to home, then, the astronaut might expect his severest radiation hazard. For apparently, as Dr. Schaeffer indicates, the Earth's magnetic field grabs a lot of ionizing debris from the solar winds and holds it trapped in orbiting belts. But away from Earth, the deep space between the planets is clean. Mariner 4, en route to Mars, revealed that a penetration of the Van Allen Belt could be accomplished within the limits of human safety. In Houston, at the NASA Manned Spacecraft Center, they're optimistic, though prudently cautious. Dr. Charles Berry, director of medical programs, feels that the Apollo Mission to the Moon will be well within a profile of radiation safety, barring any unusual solar activity. As for the future . . .

> If we're going to have missions where you're going to keep throwing people through the Van Allen Belts, where you're going to try missions where you're going to go out to other planets or things of this sort, looking way into the future, then, certainly, radiation is going to be something we always have to consider and we do look at it.

But suppose something goes wrong? A supposition now advanced by the director of bioastronautics at the Air Force School of Aviation Medicine, Lieutenant-Colonel Stanley White.

> Supposing all of our best plans have gone awry. The man has gotten more dosage than we ever thought we would get. It is a matter of whether he will be damaged enough that he could not bring the ship back.

In Pensacola, Dr. Schaeffer offers these observations:

> Unless extremely high doses are involved, the radiation injury from ionizing radiation develops on a rather slow scale. It is entirely conceivable that if a person receives a very serious radiation exposure, even an exposure which might eventually lead to the death of that person, that person would still be capable of near normal performance for a number of days after exposure.

Not only dosage but exposure time, too must be considered in determining a point of incapacity. The senior scientist at the NASA Ames Research Center, Dr. Webb Haymaker, maintains that there is a big difference between a radiation exposure administered in one fell swoop and a similar exposure stretched over several days.

> It is very curious that in the body within seconds after radiation, the body's defenses come into play so that the longer a certain dose is given the more defensive mechanisms are brought into play in the body. So that this is an important factor.

What are the effects of radiation exposure? Dr. Herman Schaeffer classifies the effects in two categories; genetic effects and somatic effects. As for genetic effects:

> Genetic effects occur in all cells, but actually they are of interest only if they occur in germ cells which are later on used for fertilization. They change the hereditary constitution of a cell and we call this a mutation. A mutation is the change of a hereditary quality. Most mutations are considered harmful.

But Dr. Schaeffer feels this possibility will be no more serious than the actual contacts with radiation already experienced on Earth; medical X-rays, atomic plants, nuclear powered devices, and that because so few people will be exposed to the radiation of Space, the hereditary factors are not of immediate concern.

> We are, for space travel, mainly concerned with somatic effects, that means, with real damage to the individual engaged in space travel.

The effects of radiation have been studied in test animals and in accident cases. Dr. Schaeffer explains the prodromal phase.

> For the astronaut in particular we are especially worried about what is called the "prodromal phase." If a human being receives an objectionably high radiation exposure, above all, a total body exposure, then this person will go, the first 24 or 36 hours, through a symptom complex which is called the prodromal phase. That person would develop unusually high fatigue, would feel nausea up to vomiting. But these symptoms would disappear after a day or two and there would be an, apparently, symptomless period of about five to eight days, where everything would seem to be alright. But then the actual acute radiation syndrome would develop. This would depend now on the dose received.
>
> Man represents a genetic jungle. He is not a pure-bred line by any stretch of the imagination and consequently has highly individual susceptibilities to radiation.

Chairman of the Pathology Department at the New York Medical Hospital, Dr. Bernard Wagner.

> You take a hundred people and irradiate their kidneys, for example, at a given dose. You will find that about three to six of them will come down with severe radiation damage to the kidney. The other 94 will walk away and are fine: There is no way to predict or identify who will be damaged and who will not be damaged. So it might be that we will come up with some answers here on Earth, but be unlucky enough to send up that astronaut who falls into the susceptible range. Then have him come back and make the assumption that this will happen to everybody.

Soon astronauts will break from their idle orbit to enter where no man has dared to go. As the blue-black void of Space swallows their craft and the Universe becomes their other world, the hopes of the many who made it possible ride with them on this odyssey into the unknown. For science this very day is forging a way to link the planets in man's greatest adventure. But danger lurks on every side.

Ask Major John Pickering, Brooks Air Force Base. He'll tell you. It is all around you.

> Radiation comes from what is referred to as, "four pie geometry." That is to say it comes from all directions; sides, bottom, top, up, down; whatever direction is in Space.

So science seeks a way to shield the astronaut from harm. This is not always easy, as explained by the Chief Scientist at the Navy Air Development Center, Dr. Karl Schmidt.

> We have to be prepared to protect our astronauts against miscalculations. It would be possible to put such heavy shielding in the cabin that they would be safe against any type of radiation. But to do this would involve heavy metal, such as lead, and this would make the capsule so heavy that, in the present state of the art, we couldn't get it up.

Science then is looking for a lighter, more effective way to shield human occupants from any deadly onslaught of radiation. Like, for instance, a magnetic field. Reputable scientists like Dr. Terquate Gualtieratti at the NASA Ames Research Center, and Dr. Dr. Dietrich Beischer of the U. S. Navy School of Aviation Medicine, have devoted such attention to this subject. While it is known that a magnetic field would be an effective radiation repellant, effects of such fields must be studied, they may have an influence on the working of the human body. Another possibility for radiation protection may evolve from the field of pharmacology.

> Whatever might be said about the probable value of drugs for other purposes, I think there's hardly any doubt that what the use of drugs to improve man's resistance against toxic radiation is one of the greatest opportunities and challenges for the application of pharmacology to spaceflight.

Dr. Karl Schmidt, Chief Scientist at the Naval Air Development Center, was formerly a professor of pharmacology for many years at the University of Pennsylvania. He tells you that radiation protection by drugs is possible but only experimentally, and not without accompanying problems.

> According to existing experimental evidence it is possible to protect an animal against as much as twice the otherwise lethal dose of toxic radiation by means of certain combinations of certain chemicals, more specifically, sulphur derivatives, taken by mouth and injected intravenously. In higher animals, such as monkeys, these things have to be taken by mouth, another one injected intravenously, and along with it a dose of a barbiturate sufficient to throw the animal into profound coma. Under these circumstances, monkeys will survive as much as twice the lethal dose of X-radiation.

Dr. Schmidt points out that the amount of drugs necessary to provide protection are, within themselves, toxic and would make one decidedly sick. Moreover, to gain the protective benefits of such drugs, an astronaut would have to administer them just before entering a field of radiation. They cannot be taken continuously or they lose their protective quality. And they are ineffective if taken after an encounter with radiation.

How blows the solar wind? Let it be known we are now in the year of the quiet Sun. But soon, the solar maximum will be upon us. And one day soon the Sun will erupt!

Explosions will rip the molten surface! Gaseous flames will leap out and Space will be suddenly filled with the volcanic violence of a solar flare! Here on Earth, scientists will eye this eruption of their Sun with studied reserve and scholarly concern. There will be no spaceflights planned for that day. Hopefully, no astronaut will be beyond the atmosphere of his Earth. At the United States Navy School of Aviation Medicine at Pensacola, Florida, you ask Dr. Schaeffer to explain a solar flare.

> We interpret a flare as an electro-dynamic process in the solar gas which manages to move up from the interior of the Sun very hot gas masses to the surface and ejects them into Space and beyond the solar gas mass. These flares are known to be powerful emitters of proton radiation.

Powerful emitters of proton radiation. For two days after a large solar flare, the great vastness of Space is filled with deadly radiation. Only until it dissipates, will it be safe for the astronauts to venture forth again into this their other world. What is known about solar flares?

> We have since 1750, the last nineteen solar cycles, very accurate recordings of the sunspot number. Since flares are closely correlated in their frequency of occurrence to sunspots, we have a good record on objectionable solar particle events and flare events since 1750.

And what do the records reveal?

> The Sun goes through a cycle of eleven years. Every eleven years we have a maximum of activity which lasts for about one or two years and then, after about five or six years this drops to a minimum where only occasional, very small spots are observed and practically no flares which amount to anything. Then the next maximum develops. The next maximum is expected around 1969 or 1970. This eleven-year cycle is not a strict and regular rhythm; it is a statistical rhythm. It is a mean of eleven years.

This day we are in the year of the quiet Sun. But in 1969 or 1970 we shall enter the solar maximum, a year the Sun will unleash eleven years of pent-up fury in heat and holocaust and a shower of deadly radiation.

This is also the year man hopes to make it to the Moon.

> At the present time flare events can be predicted for about two days ahead at the most. For the Lunar Mission, which will last eight days this is not enough. However, astrophysicists are hopeful that these prediction capabilities will improve and at the end of our present decade, when we will be ready for the Lunar Mission, we might be able to predict for the entire duration of the mission.

On that day the Sun erupts they say there will be about fifteen minutes between the visible flash and the full impact of high energy protons. But any astronaut underway is committed to ride through the storm. He may maneuver his spacecraft to provide more shielding between him and the impending onslaught. He may be able to take a pill or he may be able to employ some other measure of safety.

The means to protect men who dare to venture deep into Space have not yet been perfected. But ask anyone, the astronauts, the engineers, the scientists, the men of space medicine; they'll tell you: The means are not beyond reach. Even now, with plans well underway for a mission to the Moon and eyes toward more distant targets for the future, they're optimistic that the radiation problem will be solved in time.

Lest you doubt this optimism, please remember these are the men who made tomorrow's dream a reality today!

Nine — A Microscopic View of Space

Exciting things are being accomplished in the realm of space biology, for our vast Universe is being measured in terms of life, life here and the possibility of life on other planets.

The key to the Universe may come in the curiosity of the space biologist, whose microscope scans various possibilities; the effects of Space on the body cells, the chance of disease in a new environment, the speculation of life on other planets, and indeed the origin of life. For you must be told: The evidence of the early beginning of life here on Earth has been erased.

> The microorganisms tend to eat up rapidly any organic material in their environment. So that on the Earth it is not possible to do anything about this; we can't find out what the early organic constituency was like because we can rightfully assume that the present organic material is all mostly the product of living organisms on the Earth.

Dr. Orr Reynolds, director of the Biosciences Program for the National Aeronautics and Space Administration.

> However, in some other places like the Moon, if it turns out to not have any living organisms present; or Mars, if it turns out not to have any living organisms present, now we may find evidence of this existing complex of organic, that is carbon, molecules.

Space is a puzzle, a vast jig-saw of many parts which science is slowly, tediously putting together. When it is completed, who knows? It may reveal the image of life itself!

You may wonder, what is the view of space as seen in the magnification of a microscope? Look deep. For there, in the great chasm of our Universe, biological mysteries give promise of new knowledge. Even at the cellular level, man may uncover valuable secrets that will aid his entry into Space. The possibilities of life on other planets stir the imaginations and the resolve of dedicated men.

When it became evident that man would someday soar beyond the atmosphere of this Earth, scientists began to send up tentative feelers to find out what Space was really like. In the nose cones of earlier rockets, mice, then monkeys, and an occasional specimen on a slide were exposed to this new environment. But the beginnings of man's pursuit of Space were primarily devoted to finding the power to push heavier payloads into an Earth-orbit and eventually to propel a human dream of conquering the planets into the realm of reality. Technology would triumph, of course, and soon man had spanned the dividing line between the Earth's atmosphere and outer space. There was a need to know more about the effects of this hostile environment; there was a need to know more about the tolerance of man. Because the problems of Space were difficult to simulate, vital information was brought to Earth by biological satellites. At NASA headquarters, Dr. Orr Reynolds will tell you what a job there is to be done.

> There has been very little research on living organisms in Space. Although the Russians launched several satellites with biological experiments aboard, the experiments they were doing were more or less range-finding experiments. They weren't, at that time, able to perform experiments in which you had formed a specific hypothesis to try to test it in spaceflight. In other words, they weren't able to apply the experimental method to the conditions as these were early. The U. S. has also had a number of these range-finding biological experiments. In general, both the Russian and the U. S. work have tended to produce questions rather than answer any.

But only until the proper question was asked could the proper answer be found. Space biology, therefore, has been effectively employed in studying the many problems man must encounter in outer space.

> One would expect, as is common in most of terrestrial biology, that the things we learn about fundamental relationships between the space environment and lower organisms will have application to the behavior of man in the space environment.

So the countdown is completed. A special spacecraft designed to be exposed to an extremely low accelerative force rises above the Florida peninsula. Its only passengers: sea urchin eggs and perhaps a pig-tailed monkey. Its promise: to test the interaction between weightlessness and radiation.

Such missions mark significant data-gathering steps taken by NASA through the formation of its bio-satellite program. Each experiment undergoes many months of planning and is quite an achievement in scientific development itself. Yet, while these probes bring back vital firsthand data, the space biologist spends most of his time in the laboratory. To understand Space effects on a complex, biological organism such as man, it becomes necessary to examine the effects upon the individual components of the organism; in other words, the cells. At Brooks Air Force Base, for instance, Dr. John E. Prince will tell you that cells are important, that without cells and their organization into tissue, we are nothing.

> We just simply don't exist. The cell is a unit of protoplasm. It is a unit of organization as well. There are other super units like the tissue systems; liver, spleen, heart, lung, and so on. But we keep coming back to the cellular level, and it is our thought, as cellular biologists, that we are going to find a lot of explanations for what is going on with the whole animal at the cellular level.

Studies at the cellular level will contribute understanding of the physical well-being of man, especially in the face of certain stresses to be encountered in outer space. As Dr. Prince puts it:

> We are interested in elucidating and describing what is happening to man at the cellular level when and after he is exposed to these stresses, or "modifiers," I prefer to call them, from the aerospace environment. This is a very difficult thing. We depend a lot on laboratory art for this. Each year cellular biology becomes increasingly more capable because the state of the art is improving, so that we can take and look at the cellular level of man without destroying him.

So, men of bioastronautics and biology hope to unravel many mysteries pertaining to the problems of Space; nutrition, radiation, weightlessness. For example, the effects of radiation can be created right in the laboratory and the cellular structure studied in detail.

> When it comes to the radiation effects, we look at the parameters like cell division and survival. We can then destroy the cell and look at its internal anatomy with the electron microscope.

But naturally, the concern is with living cells. When radiation damage occurs, for instance, certain cells may be completely destroyed, and yet in time these cells may be duplicated and the person may recover.

> But what about the cells that aren't destroyed? What about the sub-lethal effects? What about the ones just injured a little bit? What's going to happen to that one? Supposing that one gets hit again and again, just enough to keep it agitated. This is the one I'm curious about. The one that's destroyed, that doesn't bother me because it's gone.

Dr. Prince also concerns himself, as do countless other scientists who seek the answers to the problems of Space, with the great unknown of weightlessness. This, too, can be studied at the cellular level. He tells you that this is accomplished by using a combination camera and microscope.

> What we will look at here primarily is the effect of weightlessness on dividing cells. The bone marrow, the skin, the lining of the intestines are sites of high proliferation. There is cell division going on here at a very great rate. If weightlessness is to have a profound effect at the cellular level, one of the first things we should look at is the division mechanism.

Almost everyone agrees that prolonged weightlessness may bring about physical deconditioning, a weakened bone structure, muscles, heart, and some feel it may seriously affect the routine countermeasures taken by the body in times of emergency. At the University of California in Berkeley, Dr. Cornelius Tobias, a biophysicist, explains a research project with which his laboratory is involved.

> We now know that after breaks have been produced in a chromosome sometimes they can heal by themselves, or you can provide a biochemical milieu which promotes healing. We do not know, however, what the role of gravity is in this healing process. So, some experiments were designed by this group and also by other groups to test radiation effects and weightlessness together.

Could it be that man in space may be more susceptible to body deterioration and perhaps disease? Yes, other kinds of cells may be affected by the space environment; for instance, bacteria. How vulnerable man is to disease becomes a concern of the man with the microscope. At NASA, Dr. Orr Reynolds draws an analogy with submarine experience.

> You bottle up 85 or 100 men in a submarine for an extended cruise. When they first start they'll have their run of little infectious diseases that everybody will go through the course of getting these things, flu and colds, one thing and another. Then it all subsides, and they're remarkably disease-free for the entire period of the cruise until they finish it and come back and join the normal society again. In the meantime, they have lost a lot of their resistance because apparently, this resistance to disease organisms has to be maintained by continual attempts at infection by the environment.

The space environment could bring about unexpected developments.

> Bugs change with environment, and here we are changing the environment.

The possibility of bacterial change is mentioned by Dr. Walton Jones, the Chief of the Human Factors Branch at NASA headquarters. He suggests that the very biological processes that protect man in an Earth-bound environment may turn against him in outer space.

> We are a bit concerned and this is on a long-term thing, days, months, years type of thing, that the bacterial flora may change to where some particular bacteria will become a pathogen and hurt man, where normally he lives in amiable symbiosis.

There will be confidence, though, as man embarks on his long journey into Space for he will know that science will have considered even things that may never happen. The way will be difficult, to be sure, but it will be possible and men will ever strive to explore the deeper regions of Space, their other world.

Yes look deep! For there could be more than a billion planetary systems analogous to our own within the range of our own Galaxy! According to Dr. Orr Reynolds:

> If that's true and there are all these planetary systems around the Universe, and if it is also true that in the formation of any planet you would have the formation or organic compounds as a natural development of the cooling of the planet. Then it seems quite likely that the circumstances required for the origin of life would have been present literally billions of times in the Universe. We don't know that the formation of life was not a unique phenomenon to the Earth. It may have been unique here. However the statistical probabilities would seem to be against it.

The astronomical distances to some planetary systems inevitably discount discovery, at least, in our lifetime. But man today looks with great interest to the celestial bodies of our solar system.

> In our own solar system, the planet that shows the greatest likelihood of having life forms on it, either now or at some previous period is Mars.

The Red Planet. Twice the size of the Moon, and anywhere from 150 to 300 times as far away from the Earth depending on its position of orbit. Mars: The mysterious planet which seems to offer some signs of seasonal change. The planet that has excited the imaginations of writers of fact and fiction. The planet that proffers strange curious theories especially as to whether or not life there exists.

Several decades ago in Paris, a prize was offered for the first successful communication between Earth and another planet. So certain were officials that life, even intelligent life, existed on the Red Planet, Mars was excluded from the contest as being too easy!

The known conditions of Mars make higher forms of life there most unlikely but scientists are eager to discover any existence of life anywhere in outer space.

> The possibilities of life existing on the Moon or one of the moons of Jupiter, for example, or on Venus, or even on Mercury are not zero but they are so much less likely than they are on Mars that we are concentrating our efforts on Mars.

Except at particular times, a blue haze seems to engulf the planet Mars. Astronomers have recorded certain color changes that some at first thought to be seasonal. Yet, scientists know that these changes cannot be explained in terms of Earth-familiar biologic systems. For while the dark areas appear to be vegetation, no plants like those here on Earth could prosper in the extremes of a Martian climate. Dr. Hubertus Strughold, Chief Scientist at the U. S. Air Force School of Aviation Medicine, suggests that there may be a frozen ocean on the planet Mars and that below its surface, there is a source of water.

> So we have a water layer below the frozen ocean layer. If this would be true, this would be of great interest for Mars expedition. The existence of such a frozen ocean layer, let's say some one hundred meters below the surface, would mean that the Mars visitors would have a source of water and also, they could, by some physical, chemical processing gain oxygen from this water. This would be of greatest interest from the standpoint of bioastronautics. It would be also of interest from the standpoint of astrobiology namely, the science concerned with the question of life on other planets.

If life which developed independently, is found on any other planet, it will be of great philosophical and perhaps even theological importance. Certainly, it will mean that life here on Earth is not unique. That it might have occurred many times in our Universe. If an astronaut discovers life anywhere in outer space, he will likely find that it has developed under physical conditions vastly different from those back home. According to Dr. Strughold:

> On the planets from Mars, on the Earth and Venus, he encounters oxidized atmospheres. They contain nitrogen; they contain carbon dioxide, or free oxygen as, for instance, the Earth. But beyond the belt of asteroids, the planets like Jupiter and Saturn, these planets contain hydrogen atmospheres.

In the spartan, hostile environment of most planets how can life be possible?

It was just over fifteen years ago, Dr. Stanley Miller, in company with Nobel Laureate Dr. Harold Urey, a leading physicist, conducted a classical experiment that today is a basis for continued study in a fascinating search for the origin of life. They subjected a mixture of reducing gases to an electric spark. The reaction resulted in the formation of amino acids, the constituent of protein molecules of our living forms. And that wasn't all! Practically all the simpler organic substances found in living organisms were formed. At the NASA Ames Research Center in California, and at several universities, investigation is underway in an extensive program of research.

> As the work proceeds, it becomes more and more apparent that these chemicals that we heretofore have associated entirely with life would be the natural product of an early planetary atmosphere.

Now, it begins to tie in. Dr. Orr Reynolds explains the application of these theories to a possible existence of planetary life:

> In other words, when planets were formed originally, their atmospheres consisted of these reducing gasses because they contained a lot of hydrogen. The natural thing that would have formed in such atmospheres in the presence of heat, electricity, ultraviolet light, ionizing radiation, almost any source of energy, would be organic compounds similar in nature and, in fact, many times identical to those we find on the Earth in living organisms.

You wonder, what exactly is a living organism? Dr. Reynolds answers your question like this:

> A complex chemical entity that is capable of reproduction and of controlled energy conversion. In other words, it would have to display two things: the ability to extract energy from its environment to utilize for its own purposes, its own purpose being primarily that of reproducing itself.

When that glad day of some recent future arrives and American scientists step forth on a strange and far-away world, what if there is no evidence of living organisms? The trip will still be well worth the effort. For in such virgin environment, the very secret of life itself may be better revealed. Dr. Reynolds will tell you that living matter is formed in the basic constituency of organic material. That only by looking at the original organic soup, as he calls it, can we determine the basis of life. For you see, whenever living organisms are introduced, such organic materials are soon absorbed. On Earth, therefore, it would be impossible to assess our early beginnings.

> However, in some other places, like the Moon, it turns out to not have any living organisms present; or Mars, if it turns out not to have any living organisms present, now we may find evidence of this existing complex of organic, carbon, molecules.

It is important, then, that every man and every machine sent into Space be hygienically clean.

> The international biological scientific community feels that because Mars is practically the only planet that offers us the opportunity of finding out this question of whether there is life outside the Earth, that we cannot take the risk of contaminating Mars with Earth

> organisms because then the question, from then on, would always be ambiguous as to whether life was there before we contaminated it, or not.

Dr. Orr Reynolds informs us that everything going to Mars will have less than one chance in ten thousand of containing a single living microbe.

Is there life on Mars?

Some scientists feel that life on Mars does exist. Although hardly the bug-eyed monster of the science fiction story. Instead, microorganisms that, according to Dr. Cornelius Tobias, will turn out to be quite different from those we know here on Earth. Dr. Tobias is a biophysicist and director of the Donner Laboratory at the University of California.

> I think that it is possible that there are some forms of life there that we are not familiar with. The possibility does exist that interaction between that and our usual forms of life might occur. I should mention that, according to our usual concept life, it is rather unlikely on Mars. Although we do see color changes and similar events that sometimes are interpreted as an indication of something changing and therefore, life. We also know that certain organisms can form spores, which could exist in the dire atmosphere of Mars. Spores of this kind, particularly when buried underground, might live for a very long time and still be viable. At this point I am afraid we are entering the realm of science fantasy rather than knowledge. That's precisely why we have to go there and look.

And go, man shall!

Until that day when fantasy becomes either false or the foundation of truth, mankind will continue to imagine what it is like out there, in that other world.

Ten — Mind and the Mission

Long, extended missions into Space may bring increased emotional stress on the astronauts. What will be the effects of long confinement and the strange environment on the human mind?

> This is Texas CAPCOM Friendship Seven. We are recommending that you leave the retro-package on through the entire reentry. This means that you will have to over-ride the O-five-G switch, which is expected to occur at 0-4-4-3. This also means you will have to manually retract the scope. Do you read?
>
> JOHN GLENN: This is Friendship 7. What is the reason for this? Do you have any reason? Over.
>
> CAPCOM: Not at this time. This is the judgment of Cape Flight.
>
> JOHN GLENN: Roger. Say again your instructions, please. Over.
>
> CAPCOM: We are recommending that the retro-package not, I say again, *not* be jettisoned. This means that you will have to . . .

Acknowledge the feelings of an astronaut as he is projected through the unknowns of Space.

Acknowledge those moments of doubt and uncertainty and afterwards, tell about them as did Astronaut John Glenn.

> You could see the fire and the glow from them as they would come back up past the window. This obviously was the retro-package tearing up and breaking off, as we knew it would, if it had been retained. I thought at that time, however, that the retro-package had already been jettisoned. So, there were some moments of doubt there as to whether the heat shield had been damaged and whether it might be tearing up itself. This this could have been a bad day all the way around, if that if that had been the case.

Try to place yourself in the shoes of an astronaut. As you walk toward the tower that marks the beginning of the great adventure, think the thoughts of an astronaut. As you feel the full thrust of power, the final release and the freedom of zero-G, think the thoughts of an astronaut. Now as the calendar records the days of unending space, the agonizing moments of uncertainty, the interminable period of close confinement, the torture of uneasy expectancy and the ever-present realization that you are going where no man has gone: Think the thoughts of an astronaut.

Even as your course cuts infinity, know that no man escapes the prejudices and problems of an Earth-bound existence.

In the Human Factors Division of NASA Headquarters in Washington, Mr. George Chatham puts it this way:

> One of the things that is apparently often overlooked is that the psychological environments that man will encounter in spaceflight are not new. It is spaceflight that is new. These same conditions have been explored for many years. One of the things that makes man unique is that each time he tries something new, he is able to put his whole past history into the new adventure.

Man's behavior in Space, then, might be traced in the social patterns of his past. But spaceflight, especially extended missions, will be no picnic and normal stress may be magnified into monumental problems. An astronaut, therefore, must be capable of withstanding rigors that soon become extreme in this hostile environment. Frustrations are quickly generated in this ceaseless, silent void, where men, cramped in isolation, must endure many days of strange and unusual sensations. Even the suspended, relaxed feeling born of weightlessness may in time induce a dangerous state of lethargy. At the Brain Research Institute at U.C.L.A., Dr. Ross Adey speaks of important study that correlates brain function and man's behavior in Space:

> In this case, we are speaking of judgment and discriminative functions. We wonder very much whether some of the apparent relaxed mood that has been reported in both the United States astronauts and the Soviet cosmonauts may not relate to a drastic alteration in the way the brain is functioning in respect of this judgment capability. For example, we know of one of our own astronauts that was persuaded with difficulty to stop taking photographs at the time that he was supposed to prepare for reentry, and, being a normally well-disciplined individual, had no real explanation for this sudden aberration of behavior. There are a number of accounts of an elevation of mood, an elation, a feeling of freedom that is difficult for them to explain precisely when they return to Earth. These things may all be transient they may be merely individual reactions to this very unusual environment.

And yet, it is important to know the effects of this unusual environment on the minds of men who go forth into Space. For this reason, as Dr. Adey tells you, dream sleep becomes a vital source of information.

> In this way, one comes to learn a great deal more about how the brain is organized in making judgments, how it is organized as one goes to sleep. One can tell in great detail, and very importantly, how much time is spent in dream sleep, for example. Why stress the dream phase? It turns out that this is a very vital aspect of our sleep and if, for any reason, it is upset or abnormal, then neurotic behavior will occur in the waking state. So this leads us to the question of, if we impose a 24-hour day cycle on the astronaut in Space how much time does he need to spend asleep, and how much time can he work and what is the optimum time he should actually be engaged in critical work?

Here on Earth, the coming and going of the Sun is cosmic business we daily acknowledge as routine. Everyone, from the milkman to the night patrolman, will pattern his life accordingly. But the patterns of light and darkness in space will change. So the astronaut, encircling the Earth at incredible speed moves in and out of night and day with breathtaking frequency!

> First off, it was quite a day. I don't know what you can say about a day in which you can see four beautiful sunsets in one day, but it is pretty interesting.

John Glenn acknowledging the novelty of an initial conquest of Space. But now with eyes toward the Moon and beyond, many factors become important considerations. One of these is, how will a man fare in an abnormal cycle of existence?

> You will admit that this is not the normal day-night cycle. Those people who put so much emphasis on this always try to make it clear that modern man has long since left the cave. He does not live any more in a diurnal cycle. You see, in a building like this, you are surrounded by artificial light, artificial air conditioning. We do not feel summer and winter-time. It is the same temperature, the same light. We carry on sometimes to midnight. So modern man very often turns night to daytime.

But even as Dr. Hans Clamann of the Air Force School of Aviation Medicine makes this observation, research is being accumulated. Dr. W. Dean Chiles, a psychologist at Wright-Patterson Air Force Base refers to this.

> There have been over the past years a lot of research done during the arctic night. Research has been done in caves, where there is no natural light. Generally, the man has a clock built into him and this is reflected in his the variations in his temperature and his heart rate, things of this sort. So that, in a sense, his body knows what time it is even though the dark and light cycles caused by going around the Earth may not bear any constant relationship to that.

At the Max Planck Institute near Munich, West Germany, Dr. Jurgen Aschoff, its director, concerns himself with circadian rhythms, or, if you like, biological rhythms of animals and man as affected by the cycles of night and day.

> When we could find in animals these rhythms were self-sustained, going on like an oscillator we were curious whether it was in man, too like this and we, therefore, started these experiments with isolated subjects. We enclosed them in an underground bunker, and we had to take care that no sound came in this bunker because so long as a subject lives alone, he is very much interested to know whether outside it is day or night. So they had no watch, no time cues at all. Then we studied their behavior; when they went to bed, when they stood out of bed. It came out that even these conditions, without any time cue, these people went on to have a rhythm of being awake and going to sleep and having a rhythm in body temperature, and in urine excretion and so on. So even human has an indigenous, innate, self-sustained oscillation with a period of about 24 hours.

Although man is sensitive to diurnal rhythms, space authorities feel that it will be necessary to institute established routines for work, for rest and for sleep. So what is the most effective routine for an astronaut? At Wright-Patterson, Dr. Chiles was involved in research that might well determine an astronaut's working day.

> We assume the man will work at least 12 hours a day. One of the major goals of this research that we have done in this area has been to determine, first of all, can the man carry on his job efficiently working 12 hours a day and what is the best way of scheduling his work?

So, naturally, since the human system is so involved in a 24-hour cycle, it would be assumed that a routine derived of multiples equaling this division of time would serve his purposes best, possibly four hours on, four hours off.

> If you have a four-to-four work-rest cycle, you have three work times in twenty-four hours on such a cycle, but only one of these you will be really perfect in your performance.

If the voyage goes for weeks, it might even be necessary to . . . well, let Dr., Aschoff tell you.

> If it goes on for weeks, it may be most important not just to have a work-rest cycle, but perhaps to introduce in the spacecraft a light-dark cycle, or something like this; to have a better entraining agent, as we call it, a better synchronizer, so that the system keeps on going with a 24-hour rhythm.

Space is an area of endless time, empty and invincible for so many ages, but which now stands vulnerable to the ingenuity of man. Space is a promise. It is desolate and hostile. Space is a lonely place. You try to think the thoughts of an astronaut.

> There are only certain phases of the flight that require this extreme concentration. Of course, launch is a very critical phase, and the first few seconds following it. Actually, once you're in orbit, the main thing is just monitoring your instruments, and this is, rather than an extreme concentration, has a tendency to fall into the category of boredom.

Dr. Rufus Hessberg of the NASA Manned Spacecraft Center. He is suggesting that long, extended trips may eat into a man's mental endurance. To quicken the deterioration of mind and nerves, there is always confinement. Dr. Bryce Hartman, a psychologist at the Air Force School of Aviation Medicine:

> Confinement by itself poses two kinds of problems upon men. One set of problems is related to psychological changes which take place when a man is deprived of his normal level of sensory stimulation. In the absence of normal sensory stimulation he can experience illusions, almost hallucinatory in character, which seem to serve some sort of replacement function for the sensory stimulation which is absent. This occurs only when the sensory deprivation is acute and severe and only when a man is placed into a situation where he, in effect, can only vegetate. Where he has no useful function to perform, no useful job to accomplish. This is one part of the problem of confinement is a biological problem. When a man is confined, his activity is restricted, he gets less physical exercise, he becomes physically inactive, and under these circumstances undergoes a number of physiologic changes when can lead to reduced tolerance for reentry.

Many agree that the astronaut will not be without sensory stimulation, that even in the ominous silence of Space, there will be the interior sounds of the spacecraft and there will be chores to keep him busy. As the arc of exploration takes man deeper into Space, the astronaut will not be alone. He will have one or several astronauts along with him to talk to; and to, perhaps, quarrel with. Yes there is more to be considered than just the conditions of Space. There is the interaction of men. Lieutenant-Colonel Stanley White, director of bioastronautics at Brooks Air Force Base, looks at the longer journey.

> We are also at a point where we are talking about multiple crews. This means that we have a society that must be considered. It is not a matter of, in Mercury, where there was a single astronaut flying a single mission, the mission duration is relatively short. So, not only is the mission duration going up but, also, there are more than one. They must work together. There must be a command structure, or a governmental structure established. There must be an assignment of duties, there must be mutual confidence, there must be a way of being sure that these two men work as a team, they are cohesive, rather than repellent. We know that if the job is important enough, even people who do not like each other can get along and do a good job. But the key question is, how long?

In a 34-day space experiment, two men were penned up in a 17-foot-long box at the Philadelphia Aerospace Equipment Laboratory. It was an attempt to duplicate, as realistically as possible, the interpersonal conditions under which spacemen would be forced to live, perhaps for weeks on end. As the simulated flight moved into its 20th day, there were signs of irritation. In their words, they had become impatient provoked, even angry. Scientists say the two men saw themselves as stepchildren, not as important as another group of six men undergoing a similar experiment nearby. Although they had television with programs fed in at specified hours, they had to eat reconstituted food and they could take no baths. These factors, too, had a marked influence on their disposition for in answer to the question how dirty do you feel? An answer of “not very dirty” soon became, simply, “dirty.” As the test became two-thirds completed, their answer was curt and to the point: “Filthy,” they said.

> It is almost impossible for me to visualize two of our first seven astronauts, for example, after twenty days in Space getting into a fist fight because they couldn’t get along. These people are dedicated to the job that they are trying to do. They are mission-oriented. They generally consider themselves to be secondary to the mission and the fulfillment of the mission. For this reason, generally speaking, we have no evidence that there would be any personal interaction problems that would be expected to interfere with the success of the mission.

Even as Dr. Chiles expresses optimism, no one can really know the optimum mental stress the astronaut of the future might endure. At the NASA Manned Spacecraft Center, another psychologist, Dr. Robert L. Jones, wonders about the extended mission.

> I think when we get really long flights; you have a point here. Six, seven months? A two-week trip if probabilities are good and everything is riding well, all the feedback is good; no sweat. But I’m just like you are; I’m sitting here wondering, too, what it is going to be like when we fly for six months, straight out? This is going to be intriguing,

> and the intriguing thing is what is going to happen when we get other individuals, when we start manning these space platforms with many different individuals.

Yes. A point, to be sure. For flights of the future will involve doctors and scientists and men of many professions. No longer will test pilot criteria hold. No longer will they be able to count on hardened veterans of an adventurous past. So, as men dare to conquer the elements of distance in outer space, you wonder what the astronaut really thinks. Is there ever fear? The astronauts themselves say that the completeness of their training actually eliminates feelings of anxiety. Dr. W. Dean Chiles at Wright-Patterson feels that the question of fear is a matter of definition.

> For example, I don't do much diving off the high boards swimming and when I do climb up on the high board, and just before I'm ready to jump off, I think I can honestly say there's some element of fear involved. It is not panic or anything of this sort, but there is some element of fear involved. I'm sure there is something of this sort that occurs with the astronauts. But perhaps it is the kind of thing that we shouldn't call fear, because it is the kind of thing they're accustomed to.

Anticipation, perhaps as opposed to fear. The feeling a basketball player has before entering a big game. At the NASA Manned Spacecraft Center, Dr. Jones points out that the ever-present element of risk makes danger real, nevertheless.

> An astronaut trans-lunar might not be expected to have any more anxieties or existential separation from Earth, his old frame of reference, than any astronaut in orbit because the stress is there. As soon as he's been launched, death is just as real to him, and probably his probability of death.

The pursuit of Space has focused considerable attention on human stress, both physical and psychological stress.

> I think it has fostered a lot of research that eventually will be integrated into some kind of a theory on the effects of stress on man's behavior that is somewhat better than anything we have now.

The words of Dr. Julian Christensen, research psychologist and Chief of the Human Engineering Branch at Wright-Patterson Air Force Base. What sort of research? For one thing they're trying to determine a way to measure stress, and even to predict stress, in the individual. The effects of stress are individual. They know that heart rate, for instance, will not reveal a standard measurement of stress. For in times of stress, the pulse rate of some people may go much higher than others, while some may even experience a pulse count that is slightly below normal. Recently, at the University of Southern California, Colonel James P. Henry became interested in the correlation between stress and high blood pressure.

> We were very interested because I was also responsible for the flight of the chimpanzees in the Mercury series where they flew chimpanzees before the men. I was intrigued that these chimpanzees developed high blood pressure, some of them. These animals got high

> blood pressure, we think, because of the rigorous training schedule with the restrained situation that was imposed on them. They were made to sit in these little seats and work these levers. We were interested in determining their performance during spaceflight, during weightlessness, which we did successfully. But to our surprise, the prize chimpanzee who did best had a high blood pressure and it stayed high. It looked as if we had made him hypotensive just by the emotional distress caused by having to continually toe the line so much.

An astronaut, however, is more adaptable to psychological stresses of this type. Nevertheless, Colonel Henry's research may someday reveal a better understanding of everyday stress that accounts for the increasing number of heart attacks here on Earth. Meanwhile, at the NASA Ames Research Center, Dr. Evelyn Anderson, a medical research officer specializing in endocrinology, looked deeper into the prospect of utilizing a hormone called vasopressin to assess both emotional and physical stress.

> We call it here, just for the fun of it, the "stress hormone," because under many different types of stress, whether it is physical stress, emotional stress; like anger, nervous tension; physical stress, such as damage to the body, or heavy exercise or any abnormal condition, causes this vasopressin to be poured out in large amounts.

By tapping the flow of the hormone vasopressin in the bloodstream, Dr. Anderson would hope to establish a unit of measurement for stress.

Concern for the mind and the mission embraces more than moments of stress or even the endless hours of inactivity, but rather the routine of pilot performance as well. For the psychology of man is implemented in the actual mechanics of space equipment. Research psychologist, Dr. Julian Christensen:

> It is our job to see that the knowledge that we have regarding man's performance is introduced into the design and development of equipment and systems in such a way that the performance of those systems is most effective.

Deep though is our Universe only by plumbing the depths of the human mind can we possibly reach the innermost regions of that other world.

For in Space, as on Earth, the human mind measures human achievement.

Eleven — The Human Element

The human brain is the focal point of man's five senses; consequently, scientists are seeking to understand its functions and its reaction to the hostile environment of Space.

> People are always anxious to draw analogies between electronic computers and the brain. At least, from my point of view, the two are so far apart that there is not necessarily ever going to be a fusion of the two in the sense that a machine would be constructed which functions specifically in a way that a brain does.

As indicated by Dr. Ross Adey, director at the U.C.L.A. Institute of Brain Research there is no real substitute for the human element. The human offers intelligence, reliability, particularly in view of unexpected developments. Astronaut James McDivitt can testify to that.

> We did lose the computer and we checked with the people on the ground; we were never able to get the computer back on-the-line, but people on the ground and Ed and I in the air discussed the technique we'd use to come down. We'd gone through this many times before on the ground, so it wasn't any big surprise; once we all arrived at the mutually satisfactory agreement. We performed the ohms retrofire at twelve minutes before firing our solid retro rockets; it was just as smooth as it could be. At retrofire, we had all four of our rockets fire just exactly the way they should have and it was it was a nice feeling. We knew we were coming down; not where, but we knew we were coming down.
>
> There wasn't a thing that was different from all the nominal simulations that we had. Of course, in our preparation, we look at a lot of non-nominal cases so we know how to handle them, but this this booster was fantastic.

Those who go return to tell of enchantment, enlightenment, and optimism. Yet each voyage into Space is but a child's step in traversing the great divide that is our Universe. Time and exposure are question marks, and men of bioastronautics must give pause in their predictions of human welfare and performance in the vacuum of Space. Only until more extended trips are made can medical authorities really be sure. In the meantime much of the future has to be fathomed by educated guess.

> There are, at the present time, no indications that seeing, hearing, taste, or smell, or the touch skills and capabilities are in anyway affected by the length that man is exposed to weightless period.

Dr. Siegfried Gerathewohl, staff scientist at NASA Headquarters feels that space exposure will have little effect on the five senses. Indeed, most authorities agree. Dr. Gerathewohl's reasons center on the simple fact that weightlessness is a mechanical condition.

> You do not know whether you're in a gravity field or no gravity field, if there is no mass involved. From the moment where masses are involved, you have changes in the mass-force-weight relationships. How, we are dealing with man; we're dealing with masses.

> So the masses are affected by it. On the other hand, functions which are not, in this sense, depending upon masses involved, as for instance chemical processes, or physiological functions which are based on photo-chemical process which occurs in the retina. This doesn't seem to be affected by weightlessness at all.

In the airless, endless void of Space, human sight is sometimes improved.

> I was quite surprised how much you really can see with just your unaided eye up there. I could look down into cities, both in the day and the night. I could see what I felt a much greater detail than I could just flying from an aircraft at 40-thousand feet.

Astronaut Ed White, reporting on the view from Space from Gemini 4.

> When you'd see a city, you'd see the outline and the details, and you could see the roads. And the seas, you could see the ships, you could see the wakes very clearly and if you used your imagination, I suppose you could almost see the ship. But I can't honestly say that I saw the ships. I could see the wakes very clearly. At night, I was quite impressed with the clarity that you could see the lights outlining a city when the atmosphere is clear. I went over a city in Australia, I believe it was Sydney, one night, it was very, very clear, and I looked down and it looked like almost fine, fine strings of lights where the street lights and the roads were lighted. It was like a fine, spider web.

Every astronaut has testified to the beauty of Space. John Glenn gave this graphic description:

> This is Friendship 7. Mark. At this present time, I still have some clouds visible below me. The sunset was beautiful; it went down very rapidly. I still have a brilliant blue band clear across the horizon, almost covering my whole window. The redness of the sunset, I can still see through some of the clouds way over to the left of my course. The sky above is absolutely black, completely black. I can see stars, though, up above. I do not have any of the constellations identified as yet.

Later, Astronaut James McDivitt defined the two-faced personality of Space in this observation:

> Another thing on vision; quite often, as we would go into the sunset or come out in a sunrise, we'd have one window with the light shining on it and the other window facing the dark side. You couldn't see a thing out the light side window, but out the out the dark side you could see all the stars. It is just like you're living in two different worlds; like someone had drawn a line through the middle of the spacecraft. One side was in pitch darkness, you could see all the stars; the other side you could see the horizon turning light blue, but no stars whatsoever.

Vision in space is vital. To judge distance and size is extremely important if astronauts expect to accomplish such intricate maneuvers as rendezvous and docking. While Space provides a clear, unobstructed view, there are no reference points to guide the observer. But it isn't the illusions of Space that concern doctors most, it is the illusions of man himself after being exposed to a prolonged period of Space monotony. At first, some thought there might be danger of hallucination. Dr. George Ruff, a psychiatrist at the University of Pennsylvania School of Medicine, explains the difference between hallucination and illusion.

> Hallucination is a perception of something that isn't really there. It is seeing something that doesn't actually exist. It is a little different from an illusion. An illusion is mistaking something for something else. Classically, a hospital patient who's delirious with a high fever may hear a ventilating fan and conclude that it is a train rushing up toward them. That's an illusion. But hallucination is hearing a voice where nobody's speaking, or seeing somebody when nobody's there.

Hallucination is usually associated with mental illness. But it could result for anyone who has been deprived of sensory inputs. Dr. Ruff adds:

> This has been thought of in relation to spaceflight because of certain experimental work and certain personal experiences of people who have been isolated alone for a long period of time where sometimes hallucinations do develop.

The empty wastelands of the artic, as a case in point, where loneliness crystalizes in the cold and silent air. Where endless night blankets the barren scene and stillness swallows the shape of sound and movement. Where time is tediousness and eternal moments hang heavy and harsh, where there is no one to talk to and very little to do.

Such real-life experiences have provided invaluable data in the study of sensory deprivation.

> In experimental chambers people have actually been placed in water where they had no light, they heard nothing, the water cut down on any sensation of touch, and actually buoyed them up to reduce the sensation of gravity. Under those circumstances people will hallucinate. It is a response of the nervous system to this extremely low level of sensory input.

> If you deprive the man of sensation through his eyes, and his ears, and touch, and so on, he needs a certain amount of stimulation, he'll provide this himself namely, his imagination. That it might be better to say that the man's imagination is quite active when you cut off everything else.

Dr. W. D. Chiles, research psychologist at Wright-Patterson Air Force Base, has added an explanation as to why people hallucinate. Is there danger then an astronaut might conjure up images that aren't really there? Most authorities think not. Dr. George Ruff explains it like this:

> But we're not expecting the astronaut to have that level of sensory deprivation. He is going to be allowed in subsequent longer flights, a certain amount of motion, he will have other people to talk with, he'll be in communication with the ground, he'll have work to do on his duty hours, and other material to use on his leisure hours. So I don't think the sensory deprivation problem is one that will probably produce hallucinations. I think it is

> more like the monotony and the boredom where people find it difficult to do their job efficiently.

That trip of many weeks, perhaps of many months, may generate a routine that could cause concern. For boredom can eat into a man's ability to reason, can sap him of a desire to do constructive work. This too, says Dr. Ruff, is a form of sensory deprivation.

> It is a relative thing. With extreme sensory deprivation, we get hallucinations relatively quickly. With mild degrees of sensory deprivation, we don't usually see hallucinations but there are other effects. It is more like the kind of thing that the woman shows, who, after six months, just has to move the living room furniture around, or the man who likes to change jobs every few years. It is this this lack of variety and experience which tends to promote staleness and inefficiency in the job. That's also a form of sensory deprivation.

Space is a strange and unpredictable environment and some people are reluctant to discount certain possibilities of personal change that could occur after many days of exposure to deep space. The former Chief of the Human Factors Division at NASA, Dr. Frank Voris, feels that the astronaut may be affected by the extreme view of endless space.

> He may have an illusion of what we call space myopia; in other words, staring into space in which there's no reference whatsoever. The eye may relax to the point where that he would not readily compensate.

Even if his sight is not affected an astronaut's performance may suffer a lapse due to the endless hours of traveling through a void. A Federal Aviation Authority neurologist, Dr. John Seipel, compares this to a man monitoring a radar scope.

> If you have a man monitoring, say, a radar scope where he is looking for an unusual signal. After an hour or less, his alertness drops considerably. You can explain this on boredom; you can explain it on the basis of nervous system blanking; on anything you want to. If you then stimulate him with a different sensory modality, say, a sound that he's not expecting, or a shock or something of the sort, this generally re-alerts his whole nervous system, and from then on he will be monitoring with more accuracy.

In this modern age of computer and transistorized devices, the best of all memory machines, the human brain, is often taken for granted. Yet, here is the focal point of the five senses. Here, information is correlated, controlled, committed to action. Here, man functions and provides the measure of his worth. At U.C.L.A., Dr. Ross Adey directs an extensive program of laboratory study in his Brain Research Institute. As a part of the institute, Dr. Adey has established a space biology laboratory.

> A major facet of its activities centers around this space biology laboratory in the Brain Institute. Its activities go back now for a period of about five years to a time when, initially, it was a question of whether the forces encountered, say, in the boost phase of spaceflight where acceleration and vibration are major problems, whether these might

> have some effect on the function of the brain. The interest spread, naturally, into the entire spaceflight including the combination of stresses that are encountered in a long spaceflight where there is isolation, weightlessness, radiation and so on, all working together to hinder the normal functioning of the nervous system in ways that we can discuss.

Dr. W. Ross Adey is a lean, tall individual. Australian by birth. A leading Neurophysiologist. He will take you through the several floors of the Brain Research Institute, and relate the various experiments currently in process. He uses chimpanzees.

> Our experience with the chimpanzees suggest that his brain organization, for example, more closely resembles that of man than it does that of the monkey.

Dr. Adey explains how the experiments are conducted.

> We placed surface and deep brain probes in them. They have a little dental plastic cap about three inches in diameter on the top of their heads which is very firmly attached to the skull and on top of that little electrical plugs through which we can make connection to our recording amplifiers. In this way, we can record not only their brain patterns during wakefulness going over into drowsiness, going in turn into sleep of varying depths, but we can also record what are the brain reactions during the performance of a very subtle task for them. They've all been trained to play tic-tac-toe and this they enjoy doing. It is fascinating indeed to watch the changes in brain rhythms that occur in this time. In the same way for man, we have developed methods by which, for instance, inside the liner of the astronaut helmet, one can have a series of electrodes that merely touch the scalp in a light fashion, and nothing is actually stuck on the scalp. But through such a lite contact it is possible to record the electrical brain reactions of astronauts.

Utilizing methods developed by Dr. Adey, the NASA Manned Spacecraft Center and the Methodist Hospital in Houston assembled data from more than two hundred trainees. Under simulated conditions, much was learned of brainwave activity during various stress periods of spaceflight. Practical applications such as these studies have added tremendously to the growing research into the function of the human brain.

> The philosophy behind our studies is specifically the question of what it is that characterizes brain tissue in the storage of information. What are the characteristics about brain tissue that are involved in the memory function, for example. Although it is too early to say that we have discovered how the brain stores information, here and in other laboratories in this country, much work has been done that now sheds a great light on what are the processes underlying the storing of information in the brain.

What a marvel, the human brain! How little we know about it. But Dr. Adey will tell you, we're learning. Space has provided an abnormal existence by which brain function and efficiency can be tested. With each accumulation of data, a greater understanding of the human element to improve thought and action of some future kind, to make possible the achievement of distant worlds.

But what effect will Space really have on the functioning of the brain?

> The brain will be susceptible to any changes that occur in the blood that reaches it. If the heart doesn't function efficiently as a pump, then the brain will be affected. However, at least at this stage, we do not suspect that, except perhaps during the violent accelerations of boost and reentry, it is not likely that the blood supply to the brain is going to be grossly impaired. What is going to be vastly altered is the input from the muscles, the joints, the inner ear mechanism, our balance mechanism, in the weightless condition.

But experience in Space has been limited and one might wonder how the brain will respond to many weeks of weightlessness.

> Recently, in a quite detailed report the Russians showed that although the cosmonauts were able to use a Morse key with the same accuracy in Space as they had on Earth, the ability to write was impaired for the duration of the flight, and the handwriting became quite gross and was certainly substantially different from the individual's normal writing on Earth. So this raises the question of how the eye and the hand, being coordinated through the brain, can continue to function in Space.

Confronted with unknowns that are the challenge of Space, the biomedical community moves with care, asking a few questions of its own.

> The question that any cautious physiologist would ask in these circumstances is: Are these changes reversible, temporary, transient things that are merely a manifestation of the new exposure to a new and very unusual environment? Are they things to which the body will adapt perfectly well, so that man functions as well in Space as he does on Earth? Or, are they things which will progressively interfere with his performance or, more importantly, to his survival in Space?

So they're busy at U.C.L.A., and in hospitals and colleges throughout the country, wherever vital research is being accomplished in the continuing effort to analyze the intricacies of the human brain. Whether testing a chimpanzee playing tic-tac-toe, or measuring the brainwaves of an orbiting astronaut, it is a long and arduous task.

> One of the great sins of my field as a neurophysiologist in that they can line the walls of every house in the United State, I imagine at this stage, with these paper chart records of brainwave activity.

In recent years at the Aerospace Medical Laboratories at Wright-Patterson Air Force Base, there has developed a branch called "bionics." It involves the construction of machines that will act like living machines. While it is not difficult to imagine that one day a mechanical robot might be made to perform certain feats of the human being, its functions would certainly be limited without a brain.

You talk to the project director of engineering bionics, Mr. Cecil Guinn.

> Two ways that you could look at this brain problem. The first assumption you can make is the one that's just been made. If you assume this has something to do with heads, you can get yourself a head and open it up and look in there and see what's in there such as nerve cells and other things. Try to find out what they do and try to model this in some sort of hardware. But if you ask experts in this field, these experts being known neurophysiologists, you rapidly find out there is no theory yet which links this physiological structure with the psychological thing, such as learning, adaptation, and so on. These latter things are defined by psychologists, not by physiologists. So the other approach is to forget about heads and just watch what animals do and try to frame a theory of this, some mathematical theory, and make a piece of hardware that does this kind of thing. This, in engineering is often called "black box theory." You watch the inputs and outputs of the box, but you're not allowed to look inside to see what's there.

You wonder about decision-making. Can a machine be made to duplicate this quality of the human brain?

> Yes, there are ways of getting around this. There are certain types of learning machines that involve types of statistical decision-making. What it involves mostly is a game like flipping pennies and deciding what you want to save, head or tails. If you decide it is the heads, then you keep flipping the pennies and making them crooked in various ways to ultimately come up with the heads, which is what you wanted. This is an elementary type of learning machine. In this kind of black box, if you look inside it, you don't find anything resembling nerve cells and so on. But that's irrelevant; if you can make it act the same way, it doesn't matter what you put inside it. All you try to prove that if God had decided to make the machine this way, it might have worked this way.

The total wonder of the human brain remains a mystery that fascinates many fields of science. No organ of comparable size can provide the multiplicity of moods and applied creativity, that can transact intelligent response to unexpected developments. No known black box can replicate the reasoning powers and the versatility of the human brain. Dr. Ross Adey explains why.

> It appears that memory functions are very widely distributed through all the cells of the brain. This wide distribution is something that is not found in any counterpart electrical machine. There is a box that is the memory in the electronic computer. There's another box that is the arithmetic box and there are other boxes that serve logic functions. But it looks at this stage as though the individual logic elements of the brain; that is, the nerve cells individually can each support the functions of transmitting, transacting, and storing information. This baffles us when we try to build a machine in which the individual logic elements would do all three of these things in an equivalent degree.

Remarkable, isn't it? How eyes toward outer space can be, at the same time, focused on Earth.

But look, the lure of Space has prompted man to take stock of himself; to learn more about his world and his way. No greater impetus in our age has stirred the imagination of science, has inspired research, and has found the cause to measure the limits of mankind. The most exciting discoveries are yet to be made!

> The implication in the space field is that we stand to learn a great deal of fundamental information about the way the brain functions, merely by exposing it to the Space environment.

Twelve — Stethoscope in the Sky

The monitoring of man in space is an essential but difficult task as human physiology faces a new frontier of strange and unusual forces.

> There's a continual evaluation process going on and I think we in the pilot group realize that we can provide medical data. That if we are to prove to ourselves and to other individuals that spaceflight is possible, certain amount of this data has to be collected and it has to be done quantitatively so that we can extrapolate.

The first astronaut into space, Alan Shepard, acknowledging the need for medical data for purposes of research. Such information is picked up by sensitive instruments, sensors, they're called, and transmitted to Earth by telemetry, or radio waves. But medical authorities look upon bioinstrumentation as more than a research tool.

> The prime reason for monitoring the astronaut is that you're exposing him to an environment in which you would like to be assured that he is physiologically capable of performing. So we monitor him for flight safety purposes.

The Chief of Medical Programs at NASA Manned Spacecraft Center, Dr. Charles Berry.

> Well, you're sort of in a situation where you're trying to stretch your stethoscope a hundred miles away.

This is mission control, how do you feel? Do you read; how do you feel? Words of concern cross the universe and closely link the modern-day explorer with his planet Earth. But even before the man in space can speak, science has already assessed his state of well-being. For the art of telemetry and bioinstrumentation has been very revealing in measuring the biomedical dimensions of outer space Yet, doctors continue to be frustrated for there is so much more they would like to know about the condition of man in this strange and hostile environment.

Long before man traveled an arc that exposed him to the first rigors of Space, telemetry told the men of research what to expect.

> The National Aeronautics and Space Administration, in the early days of the Mercury program, was quite interested in finding out the exact effects that brief periods of high G, zero-G, and reversal of G would have on animals and also on humans. This was during the design of the escape system for the Mercury capsule. So we participated with NASA on several shots, using small primates as subjects.

Robert Adams is a research scientist in bioinstrumentation at Brooks Air Force Base. He tells of early experiments that challenged the imagination of both the electronics engineer and the medical doctor. He tells how animals, with special instruments attached, supplied the first data that pioneered the way in the conquest of Space.

Even today, telemetry is a vital instrument of research. A case in point: The study of brain function by Dr. Ross Adey, director of the Brain Research Institute at U.C.L.A. in California. Dr. Adey explains that they were led into the area of bioinstrumentation when a need became apparent for special equipment to record brain electrical waves.

> And this gave us the opportunity, for example, to record the brain activity of pilots on high performance aircraft who are on pursuit missions and encountering stresses that may endanger their lives. This, in a way, is a new philosophy in biology, because instead of the individual, man or animal, being taken to a laboratory the laboratory now moves out into the field and records on what we call a noninterference basis so many aspects of ongoing physiological activity and thereby, new base-lines are necessary. We no longer accept many important aspects of baselines for heart function, baselines for brain function, which have been gathered so many years ago in the laboratory, because we find that under the conditions of actual performance; a man flying a fighter aircraft, a man playing a game of football, is not the same individual that you have when you strap him down to something in the laboratory.

Dr. Ross Adey of the Brain Research Institute, emphasizing the value of receiving telemetered information from active people while actually engaged in their activity.

> We regularly record brain activity from people driving the Los Angeles freeways. Those of you who know the Los Angeles freeways will possibly sense that this is, if not exactly a hazardous pursuit, it is quite an exciting one.

Vital facts telemetered from Space have helped to illuminate the dark and unknown regions of that great void. At the NASA Manned Spacecraft Center in Houston, Dr. Lawrence Dietlein compares these findings with data taken of people in strenuous Earth-bound activities:

> Sports car racers have a much higher sustained average pulse rate and respiration rate than do the astronauts in spaceflight. The same is true of sky divers, ice hockey, mile runners and even bull fighters.

At Edwards Air Force Base, where NASA and the Air Force test such high-speed craft as the X-15, a test pilot-doctor, Major James Roman observed that:

> Our methods of getting information, from the point of view of instrumentation, are relatively crude because this is a new field, getting information under what we call dynamic conditions, in other words, people doing a job as contrasted to people in the hospital. The people at Houston with NASA have done an excellent job in coming up with better and more practical instrumentation for spaceflight, and we found this out in testing a lot of it in flight. Some of it is excellent, and certainly they have made breakthroughs in that respect. They at Houston and we here will continue to improve instrumentation. However, we also need to make a lot of progress, and we hope we're making some, in picking the kind of information that we want to go after. In other words, we're measuring things in flight now which routinely have been measured in hospitals, and that's the only reason we're measuring them in flight now. Not because they are

> necessarily the most meaningful things to measure, like blood pressure and electrocardiogram, but simply because they are traditional.

Dr. Frank Voris, formerly Chief of the Human Factors Division at NASA, and currently with the United States. Navy, feels that much of the monitored information is received too late to take corrective measures in case of some real emergency.

> The normal physiological responses that we monitor react more slowly than the organism itself. We would like to be able to monitor, or develop systems and means of monitoring an individual, which will predict a failure or predict a decrement in performance. What we are monitoring now frequently trails a loss of performance and a loss of capability.

Major James Roman again.

> We simply at this stage of the game have no good clue as to how to measure automatically, objectively, how closely to his limit a human is performing at any one time. We can guess from the voice channel and we can ask him how he's doing, but objectively we simply have no way to do it at this time. Measurement of human performance and measurement of reserve, or safety factor, you might way, is an extremely important thing and we hope that someday we'll be able to contribute to measuring that type of thing.

So, between the search for new and effective ways to ensure astronaut safety and the cause for scientific curiosity, there is much indecision among the biomedical community as to what should be monitored and measured. Meanwhile, the astronaut endures the discomfort of skintight sensors that must be plastered to his body before he embarks on any given mission. At the NASA Manned Spacecraft Center, they are very conscious of this problem. Dr. Charles Berry:

> All of the fellows feel and we do, too, it is our ultimate aim certainly, to get rid of as many sensors as we can. In short, we would like to get the most information with the least amount of material stuck on the astronaut's body, and that's obviously an aim that we'd all like to work for.

One of the original seven astronauts, Scott Carpenter, spoke before a symposium on bioastronautics and urged the doctors present to get together on precisely what they wanted to monitor.

> We serve many disciplines in the manned spaceflight program and we have many requirements to measure or observe. We need you people to all get together and decide what are the most important items to be measured.

Scott Carpenter had a suggestion.

> We need to establish an order of precedence and then design one instrument that will measure all of these; it must be very compact and it must be very light. We have ten different instruments for ten different experiments, and there isn't space to carry them.

Certainly, more compact and comfortable means of securing biomedical data will be necessary as the astronauts move out on extended journeys into Space. Dr. Berry admits it is quite a problem.

> As we get longer and longer flights, this becomes a bigger problem, of course. Because you start talking about 14-day missions and then you got to worry about how are you going to keep electronics in place for fourteen days.

Would a doctor aboard a spacecraft solve most of these problems? Perhaps. To apply certain test equipment, a physician would be most useful. Of course, there is the advantage of direct observation but Dr. Berry raises the question: What can a doctor measure that is not already being measured?

> I'm not saying that we don't need a physician there, I think we do. I'm always hard-put, though, I'm asked this by the astronauts all the time. What are you guys going to do that we can't do? This is a hard question to answer. You can say, we can take your blood and you won't do that. That's always a good answer.

Eighteen miles south of Houston on sprawling Texas flatland, a box-like complex of modern buildings stand as the focal point of America's man in space effort. The NASA Manned Spacecraft Center. One building in particular becomes the eyes and ears of every manned mission that cuts the infinity of Space. This is the hub of command activity. This is Mission Control.

To find out about biomedical monitoring, you visit the NASA Manned Spacecraft Center. You stand in the Mission Control Center and you see several rows of button-clustered consoles, each facing a wide-screened wall that soon may show the waving trajectory of an orbiting astronaut. One console is marked for the flight surgeon. Your guide is Mr. Richard Holt, Chief of the Network Operations Branch at MSC.

> In any flight control business, whether it is aircraft or spacecraft or what it is, everybody that's on the ground monitoring what's going on would like to see just as much as they can and that aero-medical monitor down there, the flight surgeon, rightfully so, thinks that his job is the most important. If the astronauts don't survive, then the rest of the mission is no good according to him what isn't really all true. You talk to another guy, like the electrical and environmental communications system engineer that sits just on his right, down the row of consoles there and that guy's looking at things like what's happening with power supplies, what's happening with batteries, what's happening with the communications system on board. Is the environmental system that's providing the oxygen and what have you, is the carbon-dioxide eliminating equipment working properly? That guy says that if his systems don't work properly, then the mission's no good. So he wants as much as he can get. So it is always a compromise and we're a

> flight control division and we're always caught in the middle of this doggone thing, because these guys would like to get as much as they can and we'd like to give them as much as we can, but somewhere in there there's a balance of what you can provide.

On special screens, on television monitors, various facts of the mission in progress can be projected for visual observation, from the heartbeat of the astronaut to the temperature of the cabin. Sometimes, preflight information is shown for instantaneous comparison. Obviously, such displays must be readied in seconds and projected without error. The answer: Computers.

> We store in these computers a lot of information, prior to the mission even starting, that we can draw on. For example, what slide to select in the back area and this type of thing. It is all stored in the computers and it will get a command from the television system to pick out a slide back there, and it has to pull that out of memory and say that's the slide I want with that binary code on it, selected from the card files. So, as a result, we have got large demands on our computing system.

Dick Holt will tell you without computers, or television, or even air conditioning The Manned Spacecraft Center would be out of business. For in the matter of air conditioning humidity control is a vital factor for maintaining operational standards in the delicate equipment. From the spacecraft, biomedical data is provided in this way: The sensors monitor the body functions that are to be measured and convert these into electrical voltages. These pulses, along with other information, are picked up by tracking stations and transmitted to the control center in a single signal called a "pulse train."

> What we actually do is we have sensors on the spacecraft which pick off voltages, for example, of a certain thing that's happening on a spacecraft. This is changed into a coded signal which is sent back to the Earth in a pulse train. There are many bits of information in this big pulse train that's coming back. In fact, when you listen to it with just the naked ear it sounds like a solid sound as it is coming back from the spacecraft.

The pulse train is broken down and its various bite of information channeled to individuals who sit in specialized judgment. The medical material is sent to an adjoining room where as many as four doctors, perhaps even eight for an extremely complex or lengthy mission, receive and collate and record the data. Such information can be displayed, either on a TV screen or charted by the wavy line of a Sanborn recorder.

> Over in the corner, which you see, is a television camera in that overhead rack and a viewer on the right hand side. The purpose of this is, if this individual wants to show something to the aero-medical flight surgeon that's cut in the front control room, he can lay something on the surface of that table and that TV camera at the top will be taking a picture of what he's laid on the table. The guy out in the front room, if he knows what channel that's appearing on, there are thirteen of those in the building, but if he knows what channel that's appearing on, he can select that channel and this guy can then have a schematic drawn out, or maybe he's going to have a trace like this, because we don't have these out in the front room. He can take that EEG trace, the respiration rate trace, and zip it off of there, put it over there underneath that TV camera and be talking to the

> guy in the front room, saying, "Look at this R-wave, it is bad right from here there's something wrong with this guy it is not normal." Or you can have the trace that was made before the mission of that particular astronaut versus the trace that they made during the mission and say, "This guy's got heart trouble."

It is no simple matter, this stretching the stethoscope far into the formidable reaches of outer space. You realize this as Dick Holt explains the instantaneous communication between the worldwide tracking stations, receiving and sending a heartbeat in the seconds of real-time. As you look at the buttons and scopes and the scanning of pen of the chart recorder, you hear the challenge from Mr. Holt.

> You have to do three things; first of all, you have to know what you want to see. So the aero-medical people have to decide what they want to see on that astronaut. What kind of physical returns do you want indicated on your telemetry? Then, the second thing you have to worry about is can I get it? Do I have the equipment available? Then, after I have the equipment available, where do I display it, or how do I display it? Do I record it or do I display it?

You marvel at the electronic efficiency before you and you remember the statement of Dr. Lawrence Dietlein, Chief of the Space Medicine Branch at the NASA Manned Spacecraft Center.

> First of all, we can't use off the shelf items. All this bioinstrumentation has to be developed and has to be miniaturized.

Not only custom-built, you understand, but so arranged to accommodate an increase in function for this control center will someday be the nerve center for missions that are today but dreams in the minds of foresighted men. The consoles are modular in design, the displays are computer programmed and can be revised in the twinkling of an eye. The signal will come in loud and clear from many millions of miles away as men move deeper into the darkening recesses of their other world.

Yet there are weaknesses in the system. At Edwards Air Force Base, you listen to Dr. James Roman.

> Sending the information from the spaceship to the ground is probably a million times more reliable than getting it from the subject to the telemetry transmitter. The big weakness in the link is, not electronic; we're way behind the state of the art in electronics, in medicine. We haven't even really begun to take advantage of everything that the engineers have provided for us. We're way behind. Most of the things we're doing in flight now; we could have done in the early 1940s. Sure it would have been with vacuum tubes the instrumentation would have been a little bigger and it would have generated more heat and consumed more current, but it could have been done.

And not only getting the information, but analyzing it can also pose a problem. Dr. Walton Jones, Chief of the Human Factors Division of NASA, explains it this way.

> You take the data down, and it is usually been done on paper tape, wiggly lines. You sit down and have to measure it with a ruler, very time consuming. You sit and talk to other people about it; you finally come to some decision that it is either pathological or it isn't or abnormal. But the condition that we run into here with these astronauts is a real-time proposition, you want to know right now, you don't have time to sit and cogitate and get your ruler out, and all this, that, and the other.

But the horizon is brightening and just as man has conquered the impossibilities of Space, he will in time master the problem of time. At the U.C.L.A. Brain Research Institute, Dr. Ross Adey holds a promising view for the area of data analysis.

> This question of data analysis is one in which a new field has grown up essentially around the problems of getting data from living man and from animals in ways that can subsequently be subjected to computer analysis. Our own work in this area has hinged around a laboratory that from its early days has enjoyed NASA. support in the provision of a quite large digital computer.

Dr. Adey notes the progress made in recent years.

> The computer can present you with a much condensed version of the initial experiment and often a very enlightening version. One of the great applications in our own area of brain function has been the ability to compress, in a meaningful way, very long epochs of brain activity into quite small and compact readouts. But additionally, the computer has revealed changes that relate to the correctness and incorrectness of decision in a way that we could not have anticipated even five years ago.

Who knows what progress will bring to the spaceflight of the future. As missions move deeper into the unexplored regions of this other world, ground control will diminish and men of Space will have to become more and more independent of planet Earth. This will affect bioinstrumentation. According to Dr. Frank Voris:

> I feel that the bioinstrumentation of the future the long-term spaceflight is going to require equipment whereby, not only can we here on Earth monitor and perhaps take corrective measures for the benefit of the astronaut, but that the astronaut himself will have a simplified method of determining his psychophysiological situation, his condition, to the point where he can then turn a knob and have the answer to what he should do to alter the situation in which he will then produce to his benefit. What I'm asking for is an automated piece of equipment to act as a physician.

Amid the sensation and the sometime controversy of far-away dreams that carry men beyond this globe into a great adventure, it is easy to lose sight of an immediate past that reveals earthbound prophets of this pursuit. Yet, hospitals have been making practical use of bioinstrumentation to monitor patients.

> The whole space program has given impetus to development within the bioinstrumentation area. So that all medicine, I think, is looking now at ways to measure things more accurately with smaller devices, which are less bother to the patient:

Comments by Dr. Charles Berry, the Chief of medical programs at the NASA Manned Spacecraft Center.

> Obviously in a hospital environment, if you have an ill patient, you have someone in bed in the hospital where you have a lot of control over what's going to be done; you can do a lot of things which we wouldn't think of doing in the space environment. But many of these devices are going back and forth; I mean, this whole push to develop these devices, I think, came initially from the space program and as a result, many parts of the body are being explored now by such devices and we're learning more about normals by individuals being monitored for long periods of time. We monitor normals and we spend our time looking at normal people in an abnormal environment; whereas, the doctor in a hospital does the reverse. He looks at abnormal people in a normal environment all the time. But we monitor these people for long periods of time, and we find out what normal people do. We look at hours and hours and hours of electrocardiogram, for instance, and we see this under fairly normal conditions, we see it under stress conditions, like on a centrifuge, or in an altitude chamber, in a pressure suit, what not. You learn a lot about an individual when you monitor this for hours and hours.

Observations by Dr. Charles Berry.

So medicine reaches to the sky to follow our men of the future on their path to the planets.

The vigil is kept in Houston, as astronauts face physiological unknowns in deep, outer space.

For as telemetry tells the Earth of this invasion of the great void, new knowledge is being recorded that will serve mankind for many ages to come.

Thirteen — The Far and Future Space

A new impetus in the constant search for knowledge has been inspired by Space, especially in the field of human physiology and medicine. Space provides a new dimension, a new perspective for the study of man.

Recently, after another successful venture into Space, the associate director of NASA, Dr. Robert Seamans, appeared before the press with these words.

> I'd like to stress, what I guess is well known, that this is a research and development program. That we have an objective with Gemini, as with all of our NASA projects: obtaining as much information as we can about Space from each one of our flights. As you'll see here, today we've learned a great deal about the space environment.

Yes with each turn of the clock, man is a little wiser about the Universe that envelopes his world. For his view now scans an ultimate horizon. Sooner than we think, the Earth shall feel the thunder of departure as the trim, tall rocket rises for a destination more than a half a year from home.

No greater mystery has intrigued man or inspired his ingenuity than the dark and distant vision of outer space. Each exciting discovery is a revelation that other unknowns still exist, as space scientist, Dr. Karl Schmidt, said recently of one such discovery:

> How important this in itself may be I don't know, but the interesting thing to me is that it indicates the possibility of other similar things, unpleasant surprises, that may await our people when they get out into outer space where no man has yet been.

Yes, like stars, question marks speckle the velvet void of Space. Yet, soon, technology will provide the path to some distant planet. Already space scientists are looking into the crystal ball of the future, fashioning a dream that defies description.

> There's a very fuzzy line between science fiction and the space world. Matter of fact, one is safer to lean toward what appears to be the fictional side; it is more likely to come true than being too conservative in that things change so fast.

But even as Dr. William Helvey, the manager of bioastronautics at Lockheed Aircraft, makes this observation it is quite clear that one thing will not change: the hostility of the space environment. As Lieutenant-Colonel Stanley White of the School of Aviation Medicine at San Antonio reminds us, the one other thing that will not change is man.

> We should keep in mind that our man has not changed really. He's still the same individual. He still has the same needs and it is a matter of trying to be sure that we do not default on meeting his requirements, regardless of what he's riding in, or on, or what the task is he's doing in this field of aeronautics or Space.

So there's the challenge. To explore the far regions of our Universe, men of space must know what to expect. They must learn what they can about this strange environment and about the needs of man. Colonel White points out:

> Fortunately, we are in pretty good shape. When the manned space programs began to break loose, as far as manned support, we have used up a tremendous amount of that information. Now the challenge is to try to refill the cupboard again; to get ready for prolonged, multi-manned flights that we can anticipate or envision that would be practical for the future.

So the space age provided an impetus for special kind of research.

> In the last several years there has been a real increase in tempo, broadening of program, in understanding what is normal in man. This has been rather revealing.

So medical science took a new tact to the study of human physiology. Space had provided another opportunity to observe normal people in an abnormal environment. Baselines of normalcy had to be established. Now, man could learn more about man.

> The human tragedy that is constantly about us, you realize that at least one reason for this is that man doesn't know enough about man. He doesn't know enough about himself. We're sort of on a knife's edge here, civilization is. I suppose every generation feels this way. But we have learned to control enormous sources of energy. I'm speaking of nuclear fission and so on. As one individual put it, and I believe it was Schweitzer in Africa when he was interviewed by Stevenson of the U.N., I think it was he, and I'm paraphrasing here, but said essentially that, "Man has learned to control these enormous sources of energy before he has learned to control himself."

Research psychologist, Dr. Julian Christenson at Wright-Patterson Air Force Base, emphasizing the far-reaching effects of space research. Applications to our everyday existence became obvious. Naturally, centers of learning and research joined in this quest for knowledge.

> With the space age, there has been much broadening. For example, now the universities have gotten interested. Now there was a small nucleus of universities prior to the space age that had been involved. Primarily, it was sort of an adjunct, or a little splinter group, that was working in their physiology department or something of this kind.

Suddenly, a new perspective presented itself. New possibilities became apparent and a growing emphasis in general research for the space effort unfolded in laboratories and classrooms throughout America. One such place is the University of Southern California. The chairman of the Department of Physiology, Dr. James P. Meehan, puts it like this.

> The technological development has been going on at a very rapid pace. Perhaps some other areas of human endeavor have not received the same attention that they should have received. The space business is making us look a little farther than our own immediate laboratories and this is a real healthy event.

Out of an aeronautical past NASA foraged the fundamentals of human physiology and applied them to space. This saw an original six astronauts span the initial acres of our Universe. Our flying services, the Air Force and the Navy, along with the aircraft industry added to a growing stockpile of data concerning man's welfare in the throes of high altitude flight. But Space was unique. Exploratory probes had already revealed a strange environment, unnatural, unpredictable; even deadly. This called for special research into some very special problems.

> This is a unique environment to which very few people have been exposed for any length of time. What we have to do is to make assumptions based on knowledge gained here on Earth as to what changes are most likely to take place during prolonged weightlessness.

As the chairman of the pathology department at New York Medical College, Dr. Bernard Wagner, suggests new methodology must be applied in the difficult task of deciphering the mysteries of outer space. Step by step, then, NASA's manned space program has gingerly tested the wiles and evil attitudes of this unusual environment.

> From a space medicine point of view we must approach it in this step-wise manner in order to be safe.

An opinion by the Director of Life Sciences at the Garrett AiResearch Corporation, Dr. James Waggoner.

> One of the Soviet scientists, Dr. Valory Parin, was pressed for an answer as to how far their five-day mission Vostok 5 will allow him to extrapolate would be safe for future cosmonauts. He would not go past seven days in his predictions. He said, "I think our five-day mission will be satisfactory to say that they'll be all right for seven." They pressed him about ten days and he wouldn't buy it. He said, "Seven is all I'll go." This is about the way we must go in this field. It is a big crumb cake and we've got to get an awful lot of crumbs together before we can bake that cake.

In putting together the concept of outer space and man's ability to cope with its multitude of stresses, many things have been learned, not only of the Universe, but of man himself. For instance, at the Naval Aviation Medical Center in Pensacola, Captain Ashton Graybiel points out:

> The vestibular organs, the semicircular canals and the otolith organs just, by tradition, these two quite different sensory organs have usually been lumped together and they've said, "These are the organs of equilibrium."

But in his search to seek the answers to man's possible disorientation in Space, Captain Graybiel has attributed distinctive functions to the various parts of the inner ear.

Already, the immensity of magnificent dreams are silhouetted against the sunlit Floridian sky.

Soon, you shall see the tall Saturn, two-thirds as high as the Washington Monument, emerge from that huge concrete building. There, supported by a great gantry of skeleton steel, the mammoth rocket will be moved to its site of launch on a special assembly platform. This will be the beginning of our day of destiny in Space. Of course, man will be ready to go.

But there was a time when uncertainty clouded the issue with doubt. When cautious men of science tempered hope with actual laboratory proof. Out of an era of scant information came a number of new techniques thought necessary for man to traverse the great expanse of Space.

Hypothermia has been considered. This is the reduction of body temperature to a point of hibernation, so that a human might endure severe stresses of extended travel in Space. Because there would be a reduction in energy expenditure, this would minimize the intake of oxygen and food. Once at his destination, the frozen man would, in a sense, be defrosted, hopefully, with no ill effects and could therefore assume his role as a space explorer. While hypothermia has been used with success in many hospitals for the freezing of selected tissues, it hardly seems possible or even necessary now, to freeze the whole body for an extended journey into outer space.

Hypnosis has also been considered to minimize stress encountered during space travel. Indeed, two scientists at Wright-Patterson Air Force Base are experimenting with hypnotic influences which reduce the sensation of pain, or as Dr. Abbott Kissen puts it, distracting stimuli.

> There could exist many stresses of the environment that are the so-called extraneous type of stimuli. They are certainly not desirable; in other words, pain from cold, or something like this, discomfort from an existing environment. All that this can do is simply deteriorate the performance of a man who is supposed to be doing something else. If one could eliminate the distracting and the inhibitory effects of the environment, he might be able to do the tasks that he’s supposed to do better.

Dr. Kissen and Major Victor Theler discovered that with self-imposed and personally controlled hypnosis, an individual could withstand extreme cold without pain or visible signs.

> Hypnosis for the protection of man, particularly against hypothermic conditions and radiation, is nothing more than reducing the metabolic state of the individual himself, throwing him into a basal metabolic state. This may be done with more reliability, later on, with drugs.

This view by Dr. Frank Voris, a Navy Captain who once headed NASA’s Human Factors Division, brings up the controversial subject of drugs. From the very start of the space program drugs were held in suspect, for dangerous side effects seemed inherent in their use. For the Mercury program, NASA established the policy that drugs would be used only in an emergency such as unusual fatigue or motion sickness. Also, that each drug should be first tested on the man while he was still in training. Many scientists see in drugs the potential answer to many untenable, and perhaps unexpected, situations men of space might have to face. The research director at the Navy’s Aviation Medical Acceleration Laboratory in Johnsville, Dr. Karl F. Schmidt, was for twenty years head of the pharmacy department at the University of

Pennsylvania Medical School. You talk to him about the possible need for drugs in the conquest of space:

> The decision as to what is going to go into the medicine chest for these prolonged spaceflights, when two or three men are going to be in Space for two weeks, four weeks, and eventually for months on end, is going to be quite a major decision. On what basis is it going to be made? Who's going to make it? On what kind of information?

Yes, and as man moves deeper into Space, he will encounter new and difficult problems. Drugs may be called upon to meet the crisis.

> So this problem of trying to decide on what to do with drugs is one of trying to use chemical substances of relatively low mass to play off against man's biological weaknesses in such a way as to make him endure these hazards of spaceflight, as he couldn't have done before and particularly protect him against miscalculations, or unexpected emergencies, and bring him back alive and safe at the end of these flights.

But as Dr. Schmidt would warn drugs cannot be expected to provide miracles.

> It is a little too much to expect to find any miracles in the shape of drugs here. It is an axiom in pharmacology that drugs do not introduce any new functions; they can only increase or decrease functions that already exist.

Dr. Walton Jones, who heads the Human Factors Division at NASA Headquarters in Washington, sums up present policy in these words:

> After we get there and we find there's some problem we can't solve in any other way, then you fall back on drugs. This has been the procedure in the past; I'm sure it'll be the procedure in the future.

To travel among the stars no stone must be left unturned here on Earth. So lights burn late in the laboratory. Space medicine spans the gamut of many areas, many disciplines, for to pave a way to other planets, we need to know more about life as it exists here at home. A fascinating field, this bioastronautics, for it breeds curiosity and concern and it creates avenues for a more complete understanding of human physiology. The Chief of the bioastronautics laboratory at Brooks Air Force Base, Dr. Hans Clamann, observed that:

> All of a sudden the biologist is much more respected by the engineer because he holds many of the answers. Zoology and botany play much more of a role in all these questions. This we call "comparative zoology." We compare the functions of various animals. Some animals are far superior to us in this respect. Many animals can hibernate or sleep without food over quite a span of time. Some animals can stand tremendous heat, tremendous dry-out. Some animals can exist without free water. In studying such systems is has a name of a new science, which is very young, called "bionics."

At Wright-Patterson Air Force Base, you stop in at the bionics laboratory. You ask Mr. Cecil Guinn about his new science.

> Bionics is the attempt to ultimately construct machines which in some way act like living machines. They either model some function of a living machine, like its ability to see or its ability to hear, or even more ambitiously in the future, some of the thinking abilities shown by living machines.
>
> For instance, take a little cockroach, a millimeter long, you may not respect it very much. But if you think this animal can move like lightning! Try to catch one, you'll find out! It can fly. It can hear. It can see. What is it? It is a drop of water contaminated with a little bit of minerals and protein; without any metal. This thing does all this better than our best microphones and best photocells!

Is there no limit to man's accomplishment? Look! Wherever you go wherever Space is the target you can see and hear and feel the optimism. There is no doubt in Des Moines, Houston, or the Mojave Desert. There is no question in Albuquerque, no concern in Philadelphia. They know in Los Angeles, in St. Louis, in San Francisco. People are positive that their other world is in the palm of their hand!

But not yet. For they know, too, that there is much yet to be done. Optimism must not be mistaken for overconfidence. Dr. Karl Schmidt, for instance:

> We're pretty close to the limit of the state of the art in just putting up a man, or two men, or three men with suitable protecting and bio-support mechanisms. Any ounce that can be saved is so much more for the success of the mission. When you consider that man is the limiting factor in these missions, the hardware problem is a relatively simple one. When you put a man into this system, his biological weaknesses are the thing you have to play with.

Yet, they'll tell you: "It is not impossible." The men of space, the engineers, the astronauts, the men of science and medicine, they have eyes for distant goals.

> I'm old enough so that I can remember when television was considered more or less impossible, at least by me. So you can't say. I think the completely closed ecological cycles still need a little work at least. But, even if they could do that. . . . Yes, I think distance in Space is going to limit man. Or time, or whatever you want to call it, or time-space, if you so wish.

Dr. Ursula Slager is a pathologist at the Orange County Hospital in Los Angeles and the author if a text titled *Space Medicine*. She has mentioned a closed ecological system, a system of recycling or converting waste products into useable products. Certainly, a system of this sort would be essential to provide the oxygen and the food and the water for prolonged trips of many months. As she has indicated, no system like this has yet been perfected. But the search continues, and soon some answers will be found. As Dr. Hans Clamann declares:

> We're looking much further ahead in the future. We're looking ahead twenty years and more.

So they are. At the NASA Manned Spacecraft Center, Dr. Charles Berry, Chief of medical programs, speaks of plans and how they become accepted schemes in the space program.

> The long-range plans we talk over with a lot of people. We end up clearing these out with our people at headquarters because they have to be coordinated with other branches within NASA. We also coordinate them with other agencies like the Air Force, people who are interested in this area. We make sure that we are not wasting effort going down a certain road. There are too few people in this area to waste a lot of effort duplicating things. We try and make sure that everybody is doing something different and trying to get all the information we possibly can.

Though time will tell, there seems little doubt that man will be ready to go, once the far and future rockets are ready for launch. The dark frontier of man's current goal, Space, offers many intriguing opportunities. In the future, a manned orbiting laboratory will be circling the heavens and interplanetary travel will be an accepted feat. But some, like Dr. James Van Allen, for whom the belts of radiation were named, feel that routine business and pleasure travel in Space may yet be a long way off.

> That strains my imagination to foresee that, if for no other reason than the immense expense involved. But I certainly feel it is reasonable to expect scientific expeditions, certainly to Mars and to Venus, to be, if not common, at least not uncommon during the next ten to twenty years.

Space is no longer a page in fiction. Science has seen the light and through research has extended the realities of our Universe in terms of human conquest. Somehow, the planets seem nearer. The way seems easier.

But lest your eyes be drawn entirely to those far-away worlds; look about you! Here at home, you can witness a wondrous revolution in scientific activity. For Space has provided a proving ground to test theories and concepts of human behavior It has offered inspiration for research and development in the field of human physiology and medicine. But most importantly, it has created the impetus to reach deep into the fundamentals of our existence to form the basis for later and more fruitful research. In the words of Dr. Karl Schmidt:

> The main thing is, this is looking toward the future as with any pure research. If they have already paid off in some way, fine. Whether they're going to pay off in the future, who shall say? I think we can say this, however, that future advances are not going to take place in any other way than this; than by trying to push back the frontiers and advance fundamental knowledge.

Their Other World
a documented study of bioastronautics

Produced by the Indiana University Radio and Television Service for the National Aeronautics and Space Administration.

The program was written and directed by LeRoy Bannerman.

and featured William Kinzer as the narrator.

Production assistants were: Art Freeman and Ken McGlon.

Technical operator: Howard VanDeventer.

Recording engineer: James Rolfe.

Consultants: Dr. Stuart Bondurant, of the Indiana University School of Medicine and Dr. Robert Bullard, Department of Anatomy and Physiology, Indiana University.

John Dimmick speaking.

This has been a presentation of the Educational Programs and Services Office of the National Aeronautics and Space Administration.