Space Medicine

Lecture by Dr. James Ryan
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1 hour, 12 minutes, 19 seconds

Speaker: Dr. James Ryan

Transcribed by: Sherry Yin

Time	Transcription
Part 1	
00:00	Marian Longstreth: I look forward each time to welcoming the students who come to the Meet the Scientist Lecture Series. Some time ago when we sent out a questionnaire to you asking what you would like to hear on this series, you replied in great numbers that you would like to have talks on medicine. So we feel very happy today in having persuaded the chief physician at Convair to come and talk to you on these lectures which are co-sponsored by the Scripps Institution of Oceanography, the Theatre and Arts Foundation of San Diego County, Convair, General Atomic, and Convair Astronautics. Our speaker today is a pioneer in the fascinating development that has occurred in medicine called space medicine. He has lectured and published many articles on manned space travel and its problems. He obtained his pre-medical degree at St. Thomas College in Saint Paul, Minnesota, and his degree in medicine at the University of Saint Louis's School of Medicine. He was in private practice until coming to Convair in 1951 and later joined Convair Astronautics in 1956. As chief physician there, his work has two aspects; one is looking after the 7,000 employees who are there and the other is space and radiation medicine. I take great pleasure in introducing to you Doctor James, Doctor James Ryan who will speak to us on space medicine.
02:00	[Audience Clapping]
02:08	Marian Longstreth: This is your [unclear].
02:11	Dr. Ryan: Thank you, Mrs. Longstreth. Our audience is still fairly well scattered out but perhaps that's because we're speaking of space medicine. For some time we've been seriously studying how we can give man a reasonable chance of survival in his first adventures into space. To many people, space travel seems like a very radical departure from the conventional modes of transportation, but I'm sure that the people a hundred years ago who heard scientists and imaginative people speaking of airplane flight thought that this was just as great a deviation from what they knew at that time. Spaceflight like airplane flight will be a process of evolution. We've already made tremendous strides during the past decade. This is the mode of travel which is unique for it's the first time in the history of man that extensive study has been made of the occupant or of the participant in a mode of travel before the mode of travel was realized. No one worried too much when the first man rode on a bicycle and the Indian said lazy white men walk standing up or walk sitting down. No one worried about the occupant of the first automobile excepting that they were very concerned because they felt that if he continued to travel for an hour or more at the tremendous speeds of 12 miles an hour, it would do something to his body which was dangerous.
04:06	Dr. Ryan: We've come a long way since then but now we are talking about protecting a man in a type of travel and a type we cannot call it flight, although it

frequently is so-called because this is not flight. We are talking about a mode of transportation. We're studying it. We're concerned about his welfare and the mode is not yet realized. If we are going to accomplish the development of this mode of transportation, we must settle down to some very hard work and experimentation and stop speculation. When we think about man in space, we think about a very fragile creature compared to the great expanses and powers of space itself. He'd die very quickly if he were left unprotected. But would he really die any quicker than the man who climbed the first mountain and went above the oxygen level or the man in the deep doing deep sea diving or any other adventuresome soul who depends entirely upon his survival upon his equipment? The equipment failure means certain death. So it will be with the man in space. If we can give him, however, a reasonable assurance of survival, I'm sure that he will be out of this world because the risk of death in the past has not stopped him nor will it stop him in the future.

05:46 Dr. Ryan: Now, we've been sending animals into satellite orbits for many, pardon me, correction - not satellite orbits - into space or into near space in rocket ships for some considerable years. But two years ago a man stayed at 100,000 feet, which is 99 and 44 100ths percent of space for a period of a day. At this time many studies were done which have helped us in understanding the effect of isolation and cosmic radiation. However, it was a short-term. It was not long enough to be much help. During the International Geophysical Year, the Russians have placed a dog in a satellite orbit. Now, it appeared to some that this was rather an adventuresome jump and we have learned very little from their feat. However, it did awaken the world to the need for further study of this interesting phase of space travel that is space medicine, the physiology of the astronaut. Now, I speculate myself why Russia has not done this again; it's almost a year and a half.

07:10 Dr. Ryan: We have to conclude one of two things, we may, we may not conclude that they did it and didn't tell us about it. That they did it successfully and didn't tell us about it. That is not a just assumption. We may not conclude that they have not tried because they are just as intellectually aggressive and as intellectually curious as we are. The fact they did it before us I think proves this portion of the point, so from this, I personally conclude that they have tried and that they have failed. This is no disgrace but I'm sure they've tried. I would even venture a guess that they may have tried to put man in space. They certainly are considering it as seriously as we are. If they have not successfully put more animals into space, into orbit, then they probably will not do any more than we would try to put man in space. If they had succeeded, I'm sure we would know because I think that they are, when they have done something successfully, they are very anxious to tell the world of their achievement.

08:38 Dr. Ryan: The next step in our advance is to put animals and even before that perhaps bacteriological cultures, microscopic organisms, and various things whose growth can be measured into space and then finally animals and finally man into an orbit. The reliability of such a vehicle must be proven before we in America can put a man into space. It must be proven to the point where the man will simply be a passenger. He will make observations and recordings and transmit information back to Earth and be able to eject himself in the event of an emergency. It will take considerable time and many other attempts before I believe we will let man have control of reentry and the place of recovery. I think this will be pre-planned and pre-controlled. When this has been done, we will be ready to take longer flights, and this, as those of you who read in the paper and listen to the radio, is projected into about 1961 in the Mercury project, in which these seven airmen engineers have been picked who are going through a long period of indoctrination over two years at Langley Field, Langley field and they there - come on down front gentlemen, there's - it's much easier to talk when the group is close together.

10:37 Dr. Ryan: This group of seven engineer aviators will go through a two-year indoctrination program in order to determine if they are going to be able to react almost mechanically to any of the stresses that come up in their life. And this Mercury program, which is named after the Greek god obviously, Atlas will be the booster and the McDonnell Aviation Company in St. Louis will build a capsule. This capsule is being seen for the first time this week publicly in Las Vegas at the big show over there. There are some basic facts that we know about the requirement and problems of survival in space. There are other problems - incidentally, is this mic on? This one or this piece too? This one?

11:41 Marian Longstreth: Yes. It’s a loudspeaker and they need it for the loudspeaker and the other’s recording. Dr. Ryan, this is the loudspeaker and [unclear] recording.

11:50 Dr. Ryan: Ok. It’s in my way. There are other problem areas about which we can make fairly intelligent predictions. We know for instance that any manned space vehicle will need to carry all of the elements essential on Earth. Principally, these include oxygen, food, and water, temperature control, regulation of carbon dioxide of water content and of the, and control of water content of the atmosphere. Now for transportation from one point on the Earth's surface to another through space or for a brief two-orbital trip, these requirements do not impose undue penalties. A very simple system can be designed to take care of man during the four-hour twice around and recovery and this of course is what is the first proposal. The first consideration of man's flight into space and the first worry is his ability to withstand the very forces which take him there.

13:07 Dr. Ryan: Our present concept of this force is a three-and-a-half to four-stage rocket ship. The manned portion of this ship will be lifted from Earth at a velocity of approximately 6,000 miles per hour. Now, those of you who have watched the fire of a skyrocket or watched the picture of a rocket know that this speed is not achieved rapidly. A rocket starts very slowly, it is not a hot rod. It must lift its mass and we'll get to that in more detail in a minute but it will reach the velocity of 6,000 miles per hour. After separation of the booster, the second-stage rocket will increase this speed to about 13,000 miles per hour and finally, the third and fourth stages will produce the thrust to orbital velocity which is about 18,500 miles per hour depending on the altitude. At first glance, these tremendous speeds appeared to exceed man's tolerance, but study and tests which have been run many years ago proved that this is not true. People have always feared excess speed as the people we spoke of years ago saying that a man who travels 12 miles an hour in an automobile for over an hour would have his insides blow up or something.

14:13 Dr. Ryan: We thought the same thing when we spoke of going through the speed of sound, through the Mach, through the sound barrier. We thought that man would have a problem. But we know today and we can very very intelligently predict that up to, close to the speed of light, man can tolerate any speed providing he gets there in a manner which is safe for him, that is the change from one speed to the next that the change of velocity and this is what we're going to talk about considerably today. We must never lose sight of this fact when you think about speed, that it is not the velocity but the change of velocity that threatens man. Further, the rate of onset, how fast does it, how fast does this change take place. The rate of change, another factor, and the duration of change of velocity are the paramount things which affect the damage to man.

16:01 Dr. Ryan: There are two ways that we can produce change of velocity or change of G, which is a common term for this delta-V is called G. A - B - C - D - E - F - G for gravity. We can change velocity or give an increase G by a change of direction. The common instance is the dive bomber who pulls out and we all know the story of 9G. I take an airplane and test it in the post-World War I era, it should be tested to 9G. This meant that the aviator dove, pulled out at a time, at a speed when he increased his weight nine times, the weight of the airplane to see if it would fall apart. If it didn’t, it was passed. This 9G, he survived but he blacked out so he soon learned to wear a scarf around his neck and wear a tight band around his abdomen and he tightened his scarf up and he screamed at the top of his lungs to increase his intrathoracic pressure. He found he didn't black out. He found that if he put a band around his abdomen tight enough and held the blood from being pulled down into him that he would not black out even without screaming. So it was designed the pressure suit, which as the G load increases puts pressure on the man's body. It prevents blood from being drained away from his head. Now, this is one kind of G. Now, this is due to change of direction. You get the same thing when you're on a merry-go-round only if the merry-go-round went many times as fast and then we call it a centrifuge.

18:00 Dr. Ryan: You would have a change of direction G load and the G would be dependent upon which way you were facing at the time. The other, we have lots of experience in this change of direction G - airplanes, centrifuges, all kinds of things where this has been done. The, you've experienced it those who have gone to the state fair or to the Disneyland and, and ridden on these whips where you were violently thrown into the back and then to the front. You're thrown under G loads in different directions but G load which is brought about due to change of speed is much less common. We only experience it to a very limited degree. The starting of a car rapidly where you're pushed back into the seat, this would be transferous G. Stopping of a car where you're thrown forward, this would be transferous G. But this is relatively short experience, no long duration with the change of G, change of direction, you can continue a centrifugation for as long as you wish but with speed, it's difficult because you can't continue to go that much faster. So for the first time, we're going to experience this in missile flight but the physiological difference is, is zero, negligible. Let's look for a minute at the acceleration pattern of a spaceship. The figures I'm going to use are typical of those that are used in calculating rocket acceleration. Now, the acceleration of any rocket equals the mass divided by the force. Now, if the fuel is burning and the thrust or the force is constant, obviously the mass will be the least when it's near burnout.

20:07 Dr. Ryan: So maximum G or maximum acceleration would take place near burnout when the load is the least, where mass becomes nearly zero then it is divided into the, divided by the force, the number on top becomes larger. If we convert this to terms of G where 1G equals acceleration of 32 feet per second squared, we find that the number of G exerted equals the weight of the rocket in pounds divided by the number, divided by the thrust of the engine in pounds. Uh, you've heard people speak of these engines having 150,000 pounds of thrust, so if you used three of them, you'd have 450,000 pounds of thrust. So, therefore, the missile must not weigh more than that or it couldn't lift itself off the launching pad. So the missile weighs some little bit less than that, they ignite the engines as the fuel burns to make the engines burn and develop the thrust of the 450 pounds. The weight decreases rapidly, so then the missile is able to take off as this mass-to-force ratio changes. Another way of expressing G in a little more realistic term at least to me, rather than 32 feet per second squared, is to say 22 miles per hour per second or if we said a load of 7G would be equal to 150 or 154 miles per hour per second Then a man who is traveling under a load of 7G would be going 154 miles faster each second and as you see this grows up into a pretty big figure.

22:15 Dr. Ryan: Using correct positioning, man can sustain life and even useful consciousness under this kind of G load. I've got a couple of slides here that may help to clarify this. May we see the, have the lights on, and see the first slide, please? This slide appears and is rather complicated. I don't know whether you can even see it very well so I'll bore you by describing it. On this side are the velocities or change of velocities in miles per hour from 1,000 miles per hour to

100,000 miles per hour, that is in change. Across the top are listed seconds and minutes. The, any point where these two lines cross you could say that you could achieve. This dotted line for instance here, the dotted line underneath the 20,000 line would be a, would be orbital velocity - 18,500 miles per hour. You could achieve that velocity in any given length of time. Now across these, this background, I've put the white lines to indicate the lines of constant G, or constant acceleration.

23:56 Dr. Ryan: So that if we say that we, we spoke a minute ago about 7G, here it is here. It's this white line that's underneath or let's take six because it's a little easier to see. All right, if we say that we want to accelerate man at 6G to orbital velocity how long would it take? On this particular chart, you'd find that point orbital velocity being the dotted line, 6G being in a white line - they come together here and you can pretty well extrapolate that that would take about 150 seconds. In other words, between two and three minutes to go from zero to 18,000 miles per hour at 6G. Now, this is well within my man's tolerance. So across this already complicated deal I put the green lines. Now the green lines are the, what the charts for, threshold of useful consciousness. The bottom one is negative G, the force is going down the blood is going up into the brain. The second one is positive G, the aviator who goes into a power dive and pulls out. The force is up, the blood is drained away. Second from the top is transferous G with the force going from front to the back and the G load being from back to front, so that the eyes would be bulging out and the brain is not well supported.

25:38 Dr. Ryan: The best position is, is reversing that, the position that you're in when you start out in your car and given her the gun. This is the safest position for the brain and it's very well exemplified by showing that this, this is way above the rest as far as tolerance and useful consciousness. The pilot would be able to think and use his hands and use his brain very adequately. He would not blackout. He could reach orbital velocity within useful consciousness in 150 seconds of 6G and anything underneath that's perfectly safe. Okay, next slide, please. This is the same chart with survival, threshold of survival. Now obviously, this was not human experiments because in order to get to the threshold of survival you have to go beyond tolerance. You have to kill the animals in order to do it. This is based on animal experimentation and here as you see the loads are tremendously higher. Here was about the line of the useful consciousness at 6G and so on. Here we see that survival goes up as high as 40G. So that, when you hear about someone tolerating twelve and a half or 14G and blacking out but coming out of it fine, they are way down here. So we're well within survival level. Okay, let's for a minute look at the next slide.

27:18 Dr. Ryan: This is on the re-entry pattern. Now, all vehicles which are going to come back to Earth will have to re-enter the atmosphere. If they re-enter as nearly parallel as possible to the top of the atmosphere it's considered to be close to zero. Even this entry where they're almost flat to the atmosphere they will pull for a considerable period, this period up here, about seven and a half to 8G. Is this tolerable? Yes obviously, we just went over near the charts. It's well within the limit. Anything up to minus four, in other words coming in at, at a four-degree angle, coming in just below four degrees below the top of the atmosphere, below the level of the atmosphere would be tolerable and survivable because this only pulls 12G for about 60 seconds and this is tolerable. It's awful close, the fella I think would blackout but he'd survive. So in our design - may I have the lights again please and turn off the slide? In the design of any vehicle, man will have to consider re-entry pattern and re-entry control. It cannot just come sloppily back into, into the atmosphere.

28:43 Dr. Ryan: If it should tumble and not be stable, their loads would be unbearable. Now, during the period of time that a vehicle or man-carrying spaceship is in orbit, the centrifugal force which is forcing him away from the center of the Earth and - this would be due to the velocity of course - and the gravitational pull toward the center of the Earth would be equal. And this is commonly called zero-G, weightlessness, etcetera. None of these terms are technically correct but they're close enough to tell us a story. This is something we do not very well understand. We can't duplicate it on Earth. We can imitate it. We can come close to it in a high-flying airplane and for a few seconds, maybe seven we can get true zero-G, 45 we can go between 1G or towards zero and back to one again.

30:01 Dr. Ryan: When we, when man is successfully flown the course and the X-15, which I think will be very shortly, I think you will be under zero-G for five to six minutes. This is still a very short time, very short because you'll be very busy and I think you'll be very occupied and doing other things and observing his reactions. It will take the time until when we are really in space in an orbit before we'll have an opportunity to thoroughly study this. We expect that weightlessness would cause some confusion. I don't think it will for a matter of a minute or two but I think it would for 15 or 20 minutes. I think it would start to be a confusion reaction. It's perfectly possible that this can be suppressed by the use of drugs if we want to suppress it, but we may not want to. We may want to watch the reaction. We know that breathing and movement would be extremely easy, that since there'd be no weight to anything; you could pick up this room and move it or pick up this podium with your finger or anything else. There would be no weight so your arms would have no weight, your legs would have no weight. So moving would be easy from an energy standpoint but hard to control from a reaction standpoint.

31:36 Dr. Ryan: During the very first flights, these ones were speaking of 1961, I'm sure that man will not be moving around. He'll be padded in a, in a couch or in a contour chair of some type. There is no process in the body which I believe will be affected by prolonged weightlessness that is in weeks or months or possibly even years. I have speculated seriously on the possibility that in generations there would be a difference in cell growth. This is one of the things that I like to see done as soon as the space station can be established. And that is, to take unicellular organisms or small organisms which reproduce many, many thousands of times a day and study the growth characteristics on weightlessness compared to on Earth and this I think could be done most easily by bacteriological cultures. I think we could measure the production of, of glucose and other things by cultures and the use of oxygen without taking much weight and gain very rapid growth, without taking much weight to get him there. Once they are there, there is no weight.

33:10 Dr. Ryan: But the idea in this would be to study the effect of weightlessness, prolonged weightlessness, on growth. It should have an effect if our growing is in response to the pull of gravity and I think it may be. We really don't know. But when we evolved, or through the evolution from the amphibious or from the fish, we lost our gills. And from the amphibious, we lost other characteristics. And as the evolution of man has taken place, these things have changed. So that today, when we study the embryo of the human, we see evidence of the rudimentary gill slits. The rest of this as those of you who have studied biology have seen in animals even though they're no longer gilled animals. So I wonder in thinking, and this again is only thought-provoking conversation, I wonder what the effect of prolonged and I mean many, many, many generations, thousands millions of years of weightlessness, what effect it would have on growth for man. And one way we can predict it is to take other tissue which multiplies more rapidly and put it into the condition and watch it.

34:37 Dr. Ryan: Normal exercise under weightlessness would be impossible. Since there is no weight, there wouldn't be much point in weightlifting. Some form of, of resistant exercise, would be necessary. Now, elaborate plans have been made in all spaceships that are planned for any length of time to provide some form of artificial gravity. Not a 1G, that's almost impossible but maybe a tenth of a G, something so that at least things would fall and smoke would rise. As if you stop and think of it in weightlessness, if you lit a match, heat would not go up as it does on Earth. It would radiate down, out, and all over. That if you spilled a glass, it would just float in the air. These things you've seen in Disney in these other places, they've done a marvelous job. Disney's film on this is excellent and it's very, very accurate, the one on the weightlessness. It was produced two or three years ago. Heinz Haber was in on that and it's very accurately done. I don't want to get into that kind of speculation because I think that is not what we're here to talk about. I think we, I think there are more serious things.

36:14 Dr. Ryan: So the first important thing really after these first flights is to establish a space station. We've been talking and planning on these flights for so long they're getting a little bit old. I hope they happen pretty soon. But the next step and the one I really wanted to be interested in is in the space station where we can put something out there and keep it there for months and years and go to it and come back many times. Collision with a meteor is always brought up as a question. The odds of this someone said, and I like the simile, would be like trying to drop a BB down the stack of the Queen Mary sailing across the Atlantic Ocean if you were flying across the same ocean in an airplane someplace else. In other words, if you were flying across just any part of the Atlantic Ocean and the Queen Mary was crossing in the opposite direction just any place and you just dropped a BB out the window, the chance of hitting a smokestack would be about the same as a meteor hitting a satellite. This is a little far-fetched but it's a little bit like the number of grains of sand in the sea or in the shore. It's almost imperceptible or almost unimaginable, I can't think of it.

37:42 Dr. Ryan: Cosmic rays, these are a hazard. This is not as speculative, this is not as unrealistic. These are heavy protons which carry tremendous electron volt energy. The primary rays which don't reach the Earth do go through space. They do pass through tissue and we don't know how much damage they will do. We have evidence of it. We've seen effects of it on mice and other animals. We know that it tears a heck of a hole in the tissue almost like a bullet going through a glass of jelly. Isn't very wide, however, it's only 11 microns but it does do damage and enough of them would certainly have an effect. We know too since these recent studies were done on the high altitude explosions, nuclear explosions, that we will have to avoid the Van Allen Belts where the radioactivity is extremely high. If we should accidentally end up orbiting through these, we would be, the man would be in real trouble, will have to either be inside of them, outside of them or go through them quickly. By quickly I mean a matter of minutes.

39:00 Dr. Ryan: Now, this isn't in a missile taking off going out into outer space, this would be no problem because by the time it hits these areas, it would go through it and they're only a couple or 10-12,000 miles across. If we go through this very fast there'd be no problem there. Personnel equipment of a crew, there isn't much point in wearing a spacesuit inside a vehicle, as is always pictured, because unless you had the power to bring you back to Earth from a satellite orbit, there wouldn't be much point in getting out. You've got to have a row boat to bring it back. It'd be a little bit like jumping out of the Queen Mary in order to swim back. Unless you've got some way to get back and some power to bring it back to Earth, a space suit wouldn't be much help, only to repair damage to the ship and other things like this. There's a question I've thought a lot about, like to talk to you about it for a minute. As long as we have boys and girls the question of sex in a spaceship. What type of crew should it be? Should it be all men? All women? Mixed crews?

40:20 Dr. Ryan: And of course, I have to come up with an answer. For short trips, it doesn't matter but I'm speaking of a three years trip to Mars and back. And I, this is one of the questions that I had answered a long time ago for the Air Force and I don't think there's any two ways about it. I think it should be one sex only because you're dealing with a closed ecological system. You can't run out to the store and get a box of Pablum or get an extra quart of milk or get an extra banana sundae. You have it with you or you don't have it. There's no milk delivery so that the possibility of the birth of a child would upset the closed ecological system. You are talking about five people perhaps, with just enough to get there and that's it. And a new birth in the environment would mean the sacrifice of life and someone else. So the answer, the only moral answer is to send only one, a crew of only one sex. Now, this is not a problem. Men throughout the, throughout the ages, historically have gone on adventures alone. [Christopher] Columbus had, had no women on board, neither did Leif Erikson, neither did many others. So this is not a real problem. It's, it's actually overrated but there is one thought I give you and that is that I think women would if it were all women, it would be better than all men.

41:58 Dr. Ryan: That's, I think worth thinking about. Why? For this reason. I think women properly trained as scientists have a better capacity to do repetitive work, to do things that are difficult and tedious, and even if I may say so, a little boring. They have a much better capacity to perform this type of task and I think this is what space flight would be at the end of the first two or three months. It'd be just nothing to do. Oh, you'd have television and you'd have a film library and you'd have books things like this, but there would be certain chores which would have to be done: reporting back to Earth, making observations, doing these, taking readings, doing repair work, this sort of thing - all of which women can be taught to do and I think they do a very fine job. I feel confident that it will be men that will go but I certainly have to go along with the idea that women could do it better. Let's take a look at the next slide. I've got a few slides here on a proposed spaceship or a space station, not a ship.

43:09 Dr. Ryan: This is, this is a centrifuge. This one we have out at [Convair] Astronautics. It's the largest privately-owned centrifuge in the world. It will take two tons to 100G in less than a minute. It's a lot bigger than it looks, you know, on here. This is the capsule here. It's about eight to nine feet long and about three feet across here, the arm is 30 feet across and the other end is simply a counterweight. Now when we proposed to put a capsule on the other end of this centrifuge and put a man in it to, to demonstrate some of these things but we couldn't get anybody to pay for it. Let's take a look at the next one. Oh, this is the proposal to put the this is the one that you saw in the other picture. This would be the man space capsule, the man capsule, not space capsule, which would be able to gimbal. Let's take a look at the next one, this is the gimbaling mechanism as it's attached to the arm of the centrifuge and it would be fixed so that it could pitch and yaw and rotate in various directions to put him under different G stresses. This may be done. It is not going to be done immediately but it may be done sometime in the future.

44:31 Dr. Ryan: There are other good centrifuges, centrifuge in the country. The one we have is principally built for equipment but it could be adapted to this for a tidy sum.

Heinz Haber likes to use the expression megabuck, that’s a million dollars. Well, one-and-a-half megabucks would do the thing here. Okay, let's take a look at the next slide. This is a, I think we are upside down and backwards. Can we, just upside down, can you flip it over, please? That's my fault because I set it in that way. When you look at these in space it doesn't really matter, the only thing is that my friend John Sunovak [sp] that did it, he might have a friend in the audience and if I didn't, if I didn't show his name down in the corner, he’d get mad. [Audience Laughing]. This is Atlas, the tank portion of it and this would be sending, the proposal is to send this into space and then to send up a second one with equipment near the top and so on and this one carrying the homing gliders and these would be rendezvoused in space in an orbit of about 400 miles. Next slide.

45:51 Dr. Ryan: This is a schematic idea of how they would have assembled this, this stuff. The station would actually be in the, through the nose cone and as you see they don't have to have it, they have no problem with lifting anything. They simply tie a static line onto it and let it float around because they're all going in the same speed. They're all going 18,000 miles an hour, everything. If you spit, it would go right with you. [Audience Laughing]. That's right, okay well. This, this may sound wrong to say this but it gives you a good idea. What happens when you throw a bottle out the window of a moving car? Does it go straight out and drop down? No, it goes forward. Have you ever watched it? Don't try it please but if you haven't done it, think about it and it'll make good sense. But if you throw a Coke bottle out of the window of a car straight out right as straight as you can, you'll see it will curve forward in the direction you're going before it starts to drop. Then what's the reason? The reason is that that bottle has the same velocity that you do, that the car does so that all of this is all moving at the same rate. Next slide. This one is right side up but the people are upside down. It looks a little easier to see when you do it the other way. This is the inside of the space station, the lounge areas, and so on. This is the, the hatch, the manhole only instead of a cover they put a basket around it so you can get to it and these are these supply gliders and the idea here is that this is a new crew coming in to take over and the old crew is going home.

47:35 Dr. Ryan: These are the, these are the lifeboats here that were brought up on the first, on ship number three. Now, this may sound pretty weird to you and sometimes it does to me too but I honestly feel that this is no more weird than some of the things that we were talking about in 1956 about putting a dog in orbit and putting a vehicle in orbit. Now we get so many of them floating around I can't keep track of them anymore. I think there are 14 that have been up. I've got a list of them but it's hard to keep track of which one is going which way. Now, they'll never hit there, the space is tremendous but it's hard to keep track and I doubt if anyone in this room could accurately tell me how many spaceships there are, I mean how many orbits, how many vehicles are in orbit today, how many parts there are because one's coming down and one's burning up and so on. It's hard to keep track of them. Is there another slide there?

48:36 Speaker 1: Two more.

48:37 Dr. Ryan: Let's take a look at them. [Audience Laughing]. Well, this is a very difficult one to see but this is the completed space station. The living quarters are here all in one end. This is a nuclear power auxiliary power set up with its plate, a large plate here to disperse heat. This vehicle would, would rotate around a pivot point about in here by a very, just simply rotate - like I'm rotating this stick if you can see it, this way only going around around around. This would give one-tenth G down here in this end and of course, it's pretty well easy to figure out what's going to be down here. That's the head. Let's have the next one, please. So this is the living quarter on the front end of that ship: control room and lavatories, sleeping room, galley, recreation, and sanitary room. So this takes care of with the one-tenth G load going this way, this takes care of garbage disposal and you don't have to worry about it in space.

50:04 Dr. Ryan: Well, it's a realistic problem and this is the answer given the 1G, the one-tenth G would take care of many things. It would keep your papers on your desk, it would keep your hair on your head, and I mean many things. One-tenth G is a, is a wonderful thing. I don't think we appreciate what we have in G, in the load that we have, the attraction we have towards the center of the Earth until we start to think about some of the problems which are solved every day by G load, which we will have in space and have to find an artificial way. Now, all these things can be solved. You can use Brylcreem and you can make your paper out of, out of metal foil. I mean so there's always a solution but it's much easier to give one-tenth G. May I have the lights again, please?

51:03 Speaker 2: Dr. Ryan, what's the number of crew in space?

51:06 Dr. Ryan: Five. Why five? I don't know. I, I honestly don't know. I'm going to answer a few questions that haven't been asked, 'cause I'm asked them every time I speak. One is would suspended animation be of any help in space. The answer is, sure. If you can figure out a way to do it on Earth, tell us, we'll try it in space but we haven't figured out on Earth yet. And would hypnotism be any help in space? In other words, have a crew of five, three of them hypnotized, cut down on food consumption. Certainly, figure out a way to do it on Earth and we'll try it in space. But so far no one has done it on Earth for more than a few minutes or few hours but we're talking about months, years. These are two of the most common questions. Now, I'd like to hear some of yours because I'm sure you have some good ones and I'll try to answer them as long as they're on this subject. Yes sir.

52:03 Speaker 3: They have an idea for you. Put a man underwater, would that increase his ability to stand more Gs?

52:10 Dr. Ryan: The question is would submersion increase the ability to stand Gs? And the answer is, yes.

52:17 Speaker 3: Do you happen to know how much more?

52:21 Dr. Ryan: I can't give you a figure. I don't know a figure. My only, my answer is a much more practical one. How is he going to live? Well, this, this what you're speaking of goes back to intrauterine life and it goes back to the experiments that were done with mice that were completely submerged and I don't know how they got them oxygen. This work was done in Sweden and I talked to the man that did the work and then we, we laughed over it actually because it's so very unrealistic. It’s true, they survived the G but they drowned. [Audience Laughing]. So when you go into space, he would be able to tolerate it, yes but he need not tolerate it because you need not exceed. The second problem would be how are you going to get the water there. Water weight is high, extremely high. So in, in providing this protection, you're taking along a tremendous weight. It would be better not to put him under the G and I don't think G is a problem as I explained it. I think it can be tolerated. Anyone else? Yes sir.

53:33 Speaker 4: I would like to know if under weightlessness of conditions, would it have any difference on the body, in the blood system if like there, like for instance here on Earth we pulled out when we’re standing up or so forth?

53:52 Dr. Ryan: The question is would weightlessness have an affect on the, on the circulation of the blood? Yes, it will. I don’t think the effect will be major. There, the biggest incident of effect would be in the legs. And in the human being, in the leg veins, there are, there are valves which keep the blood from falling down. When those valves become defective, the veins become bulgy and they're called varicose veins. Not very close but varicose, meaning bulgy or swollen. So in space, these valves would not be needed since the weight would not have blood but the tissues themselves push. Did I say, [Audience Laughing]? Since the blood would not have weight, thank you. Thanks for the, thanks for the giggle because it picked me up. There would be no need for these veins, these valves, but they’d still be there. The blood would be returned to the heart by pressure and if need be, external pressure such as elastic pressure could wrap the body. The blood does not return to my heart from my hand as rapidly in this position because my veins become swollen and show. As I move my hand to the level of my heart, the veins disappear which means that there is no, the pressure is less. There is still pressure but it's less. As I come back down the veins become swollen again. I have no, I have no valves in my heart but the return of blood from these veins to the heart is not dependent upon gravity because as you see it comes from my hands to my heart in any position. I can lie on my back, hang by my toes, my heart still pumps, and this is greater weight. So it would have a long long-term effect in answer to your question, I think on the tissue fluid, on the osmosis of the tissue and this is one of the things I think should be studied but short-term no. Next. Yes, go ahead. I will get you next time.

56:25 Speaker 5: Do you feel that exercise would be necessary to keep the lymph fluid circulating?

56:33 Dr. Ryan: This is the point of the exercise. It's an answer to what we just said there. The tissue fluids, the lymph fluids, the osmosis of tissue fluids could be helped through exercise. This might be a help. Again, this is, these are things we are only trying to make guesstimates about, intelligent guesses, that's all. We can prove these I think in a space station. Yes sir.

57:01 Speaker 6: Would, would we like in the slide you showed there, the spaceship back when they are going back to Earth and other guys who are coming in. Well if we are out there in space and would you have to, could you move to your rocket ship without lines? I mean to the space station.

57:20 Dr. Ryan: The question is could you move in space without a static line? Yes, very easily and it was so, it's been used so much in the comic strips that I hesitate even mention it. All you need is an air gun or an Alka-Seltzer. [Audience Laughing]. Anything that will put out a little pressure. You can virtually spit and would go in the opposite direction. [Audience Laughing]. But the common way would be a, would be a gun, a compressed air gun, which would not push the air ‘cause there is no air. Do all of you know what makes a rocket go? You know it isn’t what comes out the back end or do you? How many think that what comes out the back end of a rocket makes it go? Don't be afraid to say so if you do. Okay, there's some of you that do who are afraid to say so. It's a pressure from within that is, that is not going out the back end that makes it go forward, otherwise, a rocket couldn't fly in space. It doesn't depend upon pushing out the back end. And the same way on this, the air gun, it isn't because the air pushes this air and pushes you away from the air. It's because of the force within which is always pushing in all directions like a balloon but only moves when one end is open like a balloon. So this is the easiest way to move and a small rocket, a hand rocket, all the stuff you see in the comic strips, this is, this is good, good legitimate. These little gadgets that Buck Rogers wears on his back that he turns on and it has a little rocket in it. This would be a good way to move around from place to place, okay?

59:08 Speaker 7: Is about the finance, the problem of financing space exploration hampering any or?

59:15 Dr. Ryan: Is the problem of financing a space exploration hampered any? Yes, I, I think it probably hampers it some. That's a real tough question to answer because if it weren't for the financing it wouldn't be where it is. It’s pretty hard to criticize something which has been done so very, very well in the last few years and is being done very well in the near future. I think an unlimited amount of money would hire a lot more people and build a lot more hardware. I think we can put a man on the moon in six months if we had about three billion dollars to do nothing but this one thing. I think we can put a man on the moon and bring him back. We have the power. We have the knowledge. But there's a lot of detailed stuff that has to be worked out. So yes it is, but I have to answer it without going onto another question, I've got to finish answering that. Who would want all of our resources put to this one thing? Let us go slowly. Let us learn as we go. Let us learn things of national defense importance as well as space exploration; let the two go hand-in-hand and the bill will be paid. But not all at once. And I think you gentlemen and your great-grandchildren would never get overpaying the bill. You won't anyway but it might, might be a little bit tougher to do if we tried to do it all at once. Let's get this boy in the back there or is that a boy? I can't see.

1:00:57 Speaker 8: Girl.

1:00:58 Dr. Ryan: It's a girl. Come on. [unclear]

1:01:02 Speaker 8: Will the living quarters in space stations be as cramped as the submarines are?

1:01:08 Dr. Ryan: Will the living quarters be as cramped as those in a submarine? Yes, I would say probably more so. We are talking about a room ten feet in diameter and that's not too small but it's not too big either. It's circular. It will have a low ceiling, probably padded. There will be three floors so to speak and hatchways or if you, if you take out the support structures and the hardware that holds the things together in the hatchway and take all this out of the ten-foot, of the ten-foot diameter room, it certainly cuts down the size. So I'd say yes. It will be very much more crowded. No more girls with questions? I'd like to hear the different, different, yes, you young man.

1:02:07 Speaker 9: What kind of diet would they have [unclear] on a long trip?

1:02:11 Dr. Ryan: On a long trip, they'd have meat and potatoes, and everything good. Ice cream, the works.

1:02:15 Speaker 9: [unclear]

1:02:17 Dr. Ryan: Yes, but it's very much - we've, we've gone into that. And the question is should you, question is should you give them a good diet, an inadequate diet, or just enough, or what? And when you start measuring the weight and the rest of the weight, the conclusion is that a good diet doesn't weigh that much more. In addition to that, their energy requirement would be small since they are weightless so that the energy requirement would be small. So, you can feed him pretty well and give him probably anything they wanted. I think there might be some inability to get some of the things that you cook at home or cooked at home probably. I think that one of the people on this ship would have to have that ability and of course, this crew must have multiple abilities. Each must know the other's job entirely. Yes, sir, you had a question.

1:03:12 Speaker 10: What are some of the chances of hypoxia in a spaceship?

1:03:15 Dr. Ryan: What are the chances of hypoxia in a spaceship? Well, they'd be the same as they are in this room if there weren't enough oxygen.

1:03:24 Speaker 10: Being that the air that they have in the spaceship isn't exactly the air that we have up here would there be any change in the respiration?

1:03:31 Dr. Ryan: Will there be any change in the respiration because the air wouldn't be the same as it is here? Well, the air could be the same as it is here, in the spaceship. However, this is unlikely because the air we have here is not very efficient. Here we have 21 percent oxygen and most of the rest of it is nitrogen with a little argon and a few other gases. I think in space we'd go to straight oxygen and helium because of the lesser weight of the helium and we'd have a much more efficient atmosphere in which to live. In addition to that, we'd increased the oxygen content probably up to 25 or 30 percent but there would be no more danger of hypoxia since that depends upon oxygen content of the lungs than there would be anywhere else. If there is hypoxia, the crew isn't going to live very long.

Part 2

00:00 Dr. Ryan: Talk about putting in algae and they have to go. [Audience Laughing]

00:11 Ms. Longstreth: They're not being rude.

00:12 Dr. Ryan: I understand. I understand. I understand. I understand. I understand. If anyone else has a late, has an early date take off because questions like this can go on all night and I enjoy answering them and I don't mind staying but if you have to go, feel free to leave, please. If we get done so we're not more than a handful we'll go home. Um, but we're about through I think. Well, to answer your question, there has been considerable talk about using the algae chlorella pyrenoidosa, which is an oxygen-forming algae and absorbs carbon dioxide. And it can be suspended in water and 50 gallons of this suspension will take care of 1 man for one day. This is real fine and it looked like the solution. The only catch is the algae only grows to the depth of a quarter of an inch so that you'd have to have 50 gallons of water spread out all over this stage and this takes up a lot of space to have it at one inch deep. Now if we can find a way to grow the algae deep in the water and we can take a 50-gallon drum of water and get a more efficient algae and have it take care of five men, then we can get along without oxygen, liquid oxygen. But this is still hasn't been done and I like to stick with things that I know about that have been done and we know liquid oxygen works. This system is used in a B-58, B-36, B-52, B-47. I mean, heat conversion of liquid oxygen to breathing oxygen.

01:50 Speaker 11: What do they do with the carbon dioxide then?

01:54 Dr. Ryan: Carbon dioxide. What’s done with carbon dioxide? The carbon dioxide is absorbed usually through soda lime or carbon dioxide absorbers of one type or another. This is no problem. Well, pardon me. It's, it's, it's, it's an opportunity to do something. I mean it's always a problem, they're all problems but this is part of the control mechanism. Yes, let’s see. Let’s get someone who hasn’t had one. How about you back there? Behind this boy with the checkered shirt.

02:21 Speaker 12: [unclear] heart operations where they pack the body in ice, lowering the body temperature [unclear]. Could you do this in space [unclear]?

02:31 Dr. Ryan: Would, would refrigeration or hypothermia help to reduce oxygen need in space and food need in space? Yes, it would and again the same answer that I used for hibernation, hypnotism, and drug sedation over long periods - suspended animation - they're all the same. Prove to me that you can do them successfully on Earth for months at a time and we'll begin to talk about doing them out in space. But we don't want to go out with unproven things. I mean to me this makes, again I want to stick with what we know and hypothermia has been limited in my knowledge to 35 to 36 hours and longer I think in some cases. We know of this one girl in New York who by the unhappy coincidence of morphine, alcohol, and exposure to cold lived about 24 hours in subzero weather with very light clothing and survived. No one expected her to but the combination of morphine and the alcohol gave her enough energy. The morphine - which she was a dope addict incidentally - the dope addict lowered her metabolism and her heart rate down to about 25 a minute. Her respiratory rate went down to about six, which is typical of morphine. And in this very low metabolic rate, she was able to sustain herself in subzero weather without losing heat because loss of heat is the cause of people freezing to death. So hypothermia yes, it would be a good answer but let's prove it. Let's do it, you know before we start trying to do it out where we have other bigger problems. Okay. Yeah, go ahead.

04:35 Speaker 13: I’d like to know would they have a problem in maintaining the pressure as it would be here on Earth in a satellite.

04:44 Dr. Ryan: Would there be a problem maintaining atmospheric pressure within a satellite? Yes, there would be a problem. I think most of these things are problems but the same engineers were smart enough to get it there are smart enough to control it after it gets there. And this would be done. Your controlling of the atmospheric pressure would be done entirely through the helium, oxygen, water vapor, carbon dioxide absorption, the artificial atmosphere. This would become a closed system. It wouldn't be like the system like they had at Randolph Field where they had this airman sitting in a chamber. I mean he's all hooked up to the outside. I mean not he is, but all the equipment goes to the outside. This would be completely self-contained. Yeah.

05:38 Speaker 14: What's going to be tested with the X-15 [unclear] all the things discussed?

05:45 Dr. Ryan: Well, what's gonna be tested with the X-15? Practically anything you can think of. They're going to, they are checking on, this not only, X-15 is not only designed to check man, it's also designed to check systems, to check power, to check aerodynamics, and many, many other things that have nothing to do with the human. The human is just simply going along to bring it back. Frankly, they could get it most of the way by itself but it's kind of nice to have him around to land it. Otherwise, he wouldn't have to be there. He just goes for a ride because when he lights that fire or lights the fuse as we call it, from then on the X-15 is pretty much its own master. It's a lot of power and I don't think he'll have much control until it starts to return then he must land it. And they want it back in one piece. They want to measure the effect of heat on wing structure which they can't do except in miles. They want to measure the effect of, of fuel systems or any, practically everything you could think about, very little to do with man. We're just getting the stuff off the man because he happens to be a man and we can put a few gadgets on him and measure a few things too. But he's an old salt at this stuff and he's a pretty highly motivated individual and the reaction we get from him wouldn't be quite typical. I think we better cut it off, it's 5:20 pm.

07:26 Marian Longstreth: Yes. Thank you so very much.

07:29 Dr. Ryan: Thank you for being a fine audience.

07:31 [Audience Clapping]

07:39 Marian Longstreth: You've been so generous with your time, Dr. Ryan. [unclear] that's what he wants to do. Thank you so much for coming and we look forward to seeing you at our next lecture.