Teaching and Research in Space Medicine*

BY

HUBERTUS STRUGHOLD, M.D. PH D.
Chief, Dept. Space Medicine
SAM USAF Randolph AFB, Texas

The mission of the Department of Space Medicine is to study the human factors involved, and to provide protective devices required, in flights through the space equivalent regions of the atmosphere and into free Space. We use the term space equivalent for those altitude regions that show space conditions in one way or another or in all respects, but still belong to the atmosphere as it is astronautically defined. The area above 63,000 feet begins to become partially space equivalent, progressing step by step, to total space equivalence around 120 to 140 miles. This change in the qualities of the atmosphere as environment for human flight is caused by the termination of a series of atmospheric functions which are physiologically and/or technologically significant. The jet propelled planes of the Century Class and the rocket propelled craft of the X Class, operate today in these regions where space and atmosphere overlap. The record flight of Capt. Iven Kincheloe last October was a space equivalent flight to a very high degree. We are de facto

*Briefing for MEND, on 28 March 1957 (Annual Meeting) at SAM USAF RAFB, Texas in the transitional phase from aeronautics to astronautics. Almost all of the large aircraft corporations are today engaged to some extent in astronautics, as indicated by their advertisements in the various flight magazines. And, it is a sign-of-the-times that a Corporation like CONVAIR in San Diego has a Division of Astronautics with 6,000 employees, 20 percent of their total 30,000 personnel.

There is no question that an international race into Space is on. And concerning its significance for the program of MEND, I would like to refer to a speech of Major General Bernard Schriever at the first symposium on Astronautics recently in San Diego, in which he said (quote) "our safety as a nation may depend upon our achieving space superiority" (unquote) and (quote)"we should be spending a certain fraction of our national resources to insure that we do not lag in obtaining space supremacy."(unquote). An adequate alignment of the physiological medical and psychological lectures at the University to the requirements on this vertical frontier is therefore mandatory. But before I enumerate the various items that will require special consideration in your lecture program, I would first like to present a picture of the development in Rocketry of which we see at present only the beginning.

For this purpose let us imagine that we are placed into the future 30 years hence. A contemporary at that time can probably look back upon a whole family tree of rocket vehicles, just as the zoologist of today looks back into the paleozoicum and mesozoicum and speaks of a family of fish, amphibians and dinosauers. This picture shows you such a family tree, based on the jet propulsion principle.

The first descendant of the geneological tree of jet propulsion is the earthbound airbreathing jet engine. Its maximum altitude ceiling is about 20 miles. The rocket, independent of the presence of air--dynamically and chemically--is the space bound descendent of the jet propulsion principle. The first rockets as designed by Goddard and von Braun will be spoken of as the proto rockets. Their descendents are the intermediate ballistic missiles such as the class of the gods Jupiter, Thor, etc. and the intercontinental ballistic missiles such as the class of the giants like Atlas and Titan. The manned counterpart of the intercontinental ballistic missile will be an intercontinental manned rocket craft for long distance space equivalent flights. A logical development of the small research satellite will be a larger manned satellite vehicle and a space ship designed for lunar and planetary operations will be the final descendant of the family tree of rocketry.

According to this picture of present and future development we have, or can expect, the following flight operations: air operations, space equivalent operations, satelloid operations, satellite operations, lunar operations of several varities, and finally planetary operations.

You will have noticed that so far I have not used the word "space travel." This word --of which I am somewhat allergic--should, if at all, be used for the final remote phase of interplanetary operations only. The term "space flight" is to be preferred and if so no specification concerning durations is intended; the general term "space operation" is best fitted, especially in the realm of the Air Force. A good terminology can accelerate progress--a bad one can delay it. A sound and clear terminology is therefore required in lectures concerning the entire field of Space.

Now to familiarize the medical students with the present coming tasks of Space Medicine or Bioastronautics, the lecture program of my Department at the present time includes the following areas:

1. The physics and chemistry of the space equivalent and the true space environment. For this purpose the atmosphere in its entire material extension up to 600 miles as seen from the ground and from an observer in space, is discussed. Special attention is given to the various atmospheric photochemical reactions such as photodissociations, photoionizations and photoexcitations. One of the results of photodissociations and recombinations is the formation and distraction of ozone, the so-called ozonosphere extending from 60,000 to 140,000 feet. The existence of this layer might be a reason to use sealed cabins as low as 60,000 feet. Then the ionosphere between 50 miles and 250 miles, the most important result of photoionization, requires our interest with regard to radiocommunication in transionospheric flight. Only certain wave lengths of the radiospectrum can pass the ionosphere, most of them are reflected back to earth or back to space. Flights of research satellites and manned satellites without telemetering and radio communications are useless. Finally, photoexcitation and the effective photochemical process behind the occurrence of northern lights and night air glow are discussed.

Of particular interest for us now is the particle density and the free path between the air molecules in the upper atmosphere. As soon as the free path between the air particles is in the order of the wave length of sound, this is the case between 60 and 100 miles - sound transmission becomes impossible, i.e., we encounter the silence of space. The particle density is also responsible for aerodynamic support and drag of a craft and for aero-dynamic heating or for the heat barrier. Above 120 miles no effects in both respects can be expected. But still they will affect the lifetime of artificial satellites. The particle density is also the cause of scattering of light, producing the so-called skylight or blue day light. The rarification of the air particles in the regions between 80 to 100 miles leads to a disappearance of sky light, which results in the so-called darkness of space: a black sky with a bright sun with the stars visible all the time. The absence of skylight is the main difference between atmospheric optics and space optics.

Another novel feature is the fact that in the transitional zone between these two, the earth begins to appear to an observer as an illuminated, light reflecting celestial body, which means that the albedo of the earth enters the picture of the optical environment.

In Space and even down to 130,000 feet a vehicle is exposed to the cosmic rays in their original form and intensity, in contrast to the lower regions of the atmosphere where we encounter only secondary rays, which are splinters of these primaries. Our curriculum offers a special lecture on the energy, regional distribution and possible biological effects of those subatomic bullets from outer Space. There are also larger bullets of cosmic matter that must be reckoned with in Space flight above 75 miles: meteorites. Their kinetic energy, size and frequency is also discussed in our space medical lectures.

Besides these high kinetic pieces and particles of cosmic matter and a gas particle density of about 1 particle per 1 cm^3, space is almost a perfect vacuum. In such an environment of emptiness we need a completely sealed compartment in which the atmosphere for the crew must be provided artificially. In fact, such a space cabin is required even as low as 80,000 feet for technical and other reasons. Human engineering of the space cabin is another important subject matter in our lecture and research program. We have an experimental sealed cabin, a space cabin simulator in which we study the change of the atmosphere caused by the presence of occupants and the means to keep these changes under control. Human engineering of the space cabin is--to a great extent--an engineering problem, but space medicine must provide the engineers with the knowledge of the physiological requirements. We must know that the oxygen pressure should not fall below 100 mm Hg., the minimum permissible limit for efficiency, and it should not exceed the permissible maximum of 350 mm Hg. because oxygen concentrations above this level are toxic. On the other hand, carbon dioxide above 3 volume percent is toxic, too. To be on the safe side, it is advisable to keep its concentration below 1 volume percent or 10 mm Hg. by removing the excess with absorbing chemicals. We are also interested in optimal mixtures of nitrogen and helium, in such closed systems.

There is a natural process in our atmosphere which produces oxygen and consumes carbon dioxide. This is photosynthesis, found in green plants. Studies to utilize this process for the climatization of a closed system, and sponsored by the School of Aviation Medicine, are presently under way, being carried out by Dr. Jack Myers of the Department of Zoology, University of Texas, at Austin. So far it has been found that five pounds (fresh weight) of the alga chlorella pyrenoidosa can meet the respiratory requirements of one man. Recently another smaller alga--Anacystis nidulans--has been used which is three times more efficient.

That the climatization of a space cabin must also include barometric pressure control, temperature, humidity, and odor control, can be mentioned only briefly.

Last year my co-workers, Dr. James Gaume and Dr. Emanuel Roth, carried out an experiment of a 24-hour duration; we are now able to extend the time to days, or even weeks. These experiments of long duration must include psychological studies in closed systems and day-night cycling, because in space there is no natural sequence of day and night.

~~In Space and even down to 150,000 feet~~ So far I have discussed the environment of Space and the artificial microclimate within this environment of emptiness. I would now like to devote the last minutes to the process of movement through this environment.

In atmospheric flight, motion takes place under the continuous acting power of propulsion from takeoff to landing. There are only slight variations in gravitation and only slight additional accelerations and decelerations The process of motion is more or less uniform during the whole flight. It is in the nature of rocket propulsion that the fuel expenditure takes place during the first few minutes, only followed by a period of coasting without power, until the vehicle again enters the atmosphere.

This phase between launching and atmospheric entry is flight by inertia; during this period the vehicle is not supported by a material medium like the atmosphere but rather exclusively by forces, namely, by inertial forces acting in the opposite direction of the earth gravitation. Under these conditions the vehicle and crew are weightless. Weightlessness is perhaps the most revolutionary feature in the coming development of flight. We now experience in proxy that Mass and weight are not the same. Mass is an intrinsic property of matter, weight is an xxxxx extrinsic property of matter, depending upon external forces. And this property of matter, ever present on earth, is removed in Space Operation. Weightlessness therefore plays an important role in our lecture program. The discussions about weightlessness are no longer purely theoretical in nature. Remarkable progress has been made in this field, experimentally, during the last two years, despite the fact that we can produce the state of weightlessness only for about 40 seconds during xxx parabolic flight maneuvers in jet planes. These studies, as they have been carried out by Dr. S. J. Gerathewohl and Major H. G. Stallings, here at the School and by Major D. Simons in Holloman, include general tolerance of the human body to weightlessness and sensory functioning under weightless conditions.

In the latter point we must not only consider the otolith organ but also the involvement of the peripheral mechanoreceptors or gravireceptors such as the pressoreceptors of the skin, the tensile recepters in the muscles, and pacinian corpuscles in the connective tissue. In this respect a comparison between floating in water and weightlessness in space flight offers an interesting subject for discussion. Such comparative studies have been carried out recently in a swimming pool here at the School by Major Leon A. Knight and will be published soon in the Journal of Aviation Medicine. The problem of weightlessness is a very urgent one because, in the new planes like the X-15 this condition will be encountered for minutes and in other rocket propelled vehicles, coming soon, for half an hour or longer. In this coming development of weightless flight, our attention will shift from the atmosphere to the earth's gravitational field or more precisely to the sphere of predominant gravitational attraction which we might call briefly "gravisphere", which extends as far as 1 million miles. The gravitational attraction of the earth must now be discussed in the lectures for a better understanding of the energy required to project artificial satellites into orbits and for a better understanding of their orbital velocities and periods of revolutions I must conclude this discussion before we escape into Space.

Summarizing: In the lectures at the medical schools concerning space flight, special attention should be given to the following areas: In addition to the physics and chemistry of the atmosphere in its entire extension, and of Space-

I. Human engineering of the Space Cabin

II. Protection of the crew against cosmic rays and meteorites.

III. Psychological problems in closed systems

IV. Motion into, in and back from Space; Tolerance and sensomotoric control.

V. Space Optics

VI. Physiological Day-Night Cycling

VII. Telemetering and communication from beyond the ionosphere.

VIII. Toxicity of Rocket Fuel.

These are some of the medical problems on our vertical research frontier, which need consideration in the MEND teaching program.

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