Meetings

Cosmic Radiation and Space Travel

The problem of radiation as a hazard for future space travel has received much public discussion recently. Comments have been heard to the effect that (i) there is no need to put human beings into space, as necessary observations may be made better by instruments, and (ii) there is, in any case, no major danger from the levels of radiation that are expected to be encountered. Regarding the first point, it is certainly true that early observations not requiring the exercise of human judgment can be made much more simply by the use of instruments alone. However, it is virtually certain that man eventually *will* be put into space, and probably for prolonged periods of time.

On the second point, uncertainty about the nature and occurrence of radiations in space and about the biological effects of such radiations (particularly with respect to the heavy primary cosmic-ray particles) is such that much further study will be necessary, both on the ground and in flight tests, before the risk from these radiations can be fully assessed. One reason for this uncertainty is that there are no accelerators now available or even definitely planned, as far as we know, which would be capable of producing particles in the laboratory analogous to the heavier high-energy ones found in primary cosmic rays. Unlike most other phenomena involved in space travel (low gravity, high accelerations, stress, and so on) and except for the slower-moving ones, these high-energy radiations are a phenomenon that cannot be engineered out of a space vehicle by any technique presently known.

An informal meeting on "Biological Effects of Cosmic Rays and Accelerated Heavy Ions" was held 21 and 22 Jan. 1958 at the Donner Laboratory of the University of California for the purpose of discussing the present status of knowledge of biological hazards of cosmic radiations and of planning avenues of research leading to more definite knowledge of the fundamental biophysical processes involved and their relation to future space travel. The meeting was sponsored jointly by the Space Biology Branch of the Aero-Medical Field Laboratory, Air Force Missile Development Center, Holloman Air Force Base, New Mexico, and the Donner Laboratory of the University of California. The participants included the following: G. Adams, University of California Medical School; R. G. Allen, School of Aviation Medicine, Randolph Air Force Base; A. C. Birge, P. H. Flanders, H. B. Jones, H. C. Mel, R. K. Mortimer, H. G. Parker, C. A. Tobias, and D. C. Van Dyke, Donner Laboratory; C. D. Clemente, University of California (Los Angeles); I. Cooper and H. H. Mitchell, Rand Corporation; H. B. Chase, Brown University; R. Fox, E. L. Hubbard, and E. M. McMillan, University of California Radiation Laboratory; E. Goodpasture, W. Haymaker, and I. J. Lebish, Armed Forces Institute of Pathology; W. Hild, University of Texas Medical School; D. Mazia, University of California (Berkeley); E. C. Pollard, Yale University; H. J. Schaefer, U.S. Naval School of Aviation Medicine; D. G. Simons, Holloman Air Force Base; W. S. Stone, University of Texas; H. Yagoda, National Institutes of Health; M. R. Zelle, U.S. Atomic Energy Commission.

Discussion sessions were held on the following subjects: Physical nature, intensity, and variations of primary cosmic rays and experimental methods available for biological studies; effects (lethal, metabolic, developmental, and genetic) of cosmic rays and low-level radiation on unicellular organisms; effects of cosmic rays and low-level radiation on animals (acute and delayed physiological effects; effects with respect to carcinogenesis and longevity); nuclear rockets; effects of radiation on nerve and brain tissue; and future investigations with heavy ions.

The general recommendations of the meeting may be summarized as follows: Additional studies are necessary and should be made, both at ground level and in flight, on the physical properties, dosimetry, and biological effects of cosmic rays, fundamental work to be carried out first at ground level whenever possible. It is particularly important to have coordinated and simultaneously determined physical and biological measurements. Biological studies should be conducted on the unicellular, tissue, animal, and eventually human, levels, and both acute and chronic biological effects should be considered, the latter being perhaps the more important.

Previous studies suggest that radiation damage from cosmic-ray primaries may be of most consequence, or may differ most from damage from more conventional radiations, (i) in regions where damage to a few cells may be biologically amplified to affect many cells, as with germ plasm or when homeostasis is upset (from hypothalamic damage, for example); (ii) when the cells affected do not have the ability to regenerate (as in various parts of the central nervous system); (iii) where a single particle may inactivate a whole group of cells necessary for biological function (white hair formation on black mice is an example); or (iv) where partial cell irradiation may lead to an increased incidence of nonfatal but deleterious effects, such as carcinogenesis.

For making physical measurements on primary cosmic rays, vertical sounding rockets, balloons, and satellites all have their place. For measurements outside the earth's magnetic field, magnetic-polar-region flights or orbits several earth diameters distant will be needed.

Accelerator work on dose response and relative biological effectiveness of the various radiations on a variety of biological materials should be continued and expanded, with nuclei identical to or closely analogous to those occurring in cosmic rays. It appears theoretically possible at present to accelerate artificially the very heaviest of such nuclei, and a long-range research viewpoint may eventually require this. To this end some of our very largest accelerators could be adapted to biological experimentation, or new accelerators could be built if the prospective work load for biological and physical experimentation required it.

For biological experimentation, continuation of balloon flights is desirable both for measuring the actual effects on special biological materials near the top of the atmosphere (including studies of carcinogenesis and longevity) and for gaining experience in handling techniques in problems of closed environment. Satellites offer some special advantages for longer experiments and will become increasingly valuable when satellite recovery becomes feasible.

A more detailed program of investigation was recommended for the near future. Work on certain of these projects is now, or is expected soon to be, under way. This includes studies involving use of the new heavy-ion linear accelerator of the University of California Radiation Laboratory, which is now producing beams of carbon, nitrogen, oxygen, and neon ions at 10 Mev per nucleon. Yale University now has a similar accelerator in operation, which may participate in this program. [For more information, see C. A. Tobias, H. C. Mel, D. G. Simons, Eds., *A Summary of the Berkeley Conference on Biological Effects of Cosmic Rays and Accelerated Heavy Ions,* Univ. Calif. (Berkeley) Radiation Lab. Publ. No. 8201 (10 Mar. 1958).]

As for hazards to personnel, a human being in a space ship removed from the earth's magnetic field might expect to receive mean doses of around 140 millirads per week. The relative biological effectiveness is not known for some of these particles, but since they have dense tracks one might find the primary rays many times as effective as low-energy x-rays, for at least some effects. Space flights of only a few weeks' duration probably will not involve a great radiation health hazard unless regions are found in space with radiations of unusually high intensity or effectiveness (recent press reports indicate that the Explorer satellites may have located some such regions). The use of nuclear-powered craft may also introduce a significant new factor of radiation exposure. In flights where long-time exposures are involved, such as in colonization of the moon and planets, the biological effects of cosmic-ray primaries may well be a limiting factor.

Because of the complexity of the biological and physical problems and the elaborate instrumentation involved in these investigations, they can be considered only as a large and long-term research effort. Furthermore, progress in this field must be based on cooperation and free exchange of information between scientists of several disciplines and various service groups.

C. A. Tobias
H. C. Mel
D. G. Simons
Donner Laboratory, University of California, Berkeley, and
Aero-Medical Field Laboratory, Holloman Air Force Base, New Mexico

Forthcoming Events

July

25–29. Chromatic Discrimination in Animals and Man, ICSU symp., Paris, France. (H. Pieron, Collège de France, Place Marcelin-Berthelot, Paris 5e.)

28–30. Regulation of Cell Metabolism, Ciba Foundation symp. (by invitation), London, England. (G. E. W. Wolstenholme, 41 Portland Pl., London, W.1.)

28–2. Home Economics, 9th intern. cong., College Park, Md. (Congress Director, American Home Economics Assoc., 1600 20 St., NW, Washington 9.)

28–8. Statistical Summer Seminar, Dedham, Mass. (I. Weiss, Bell Telephone Labs., North Andover, Mass.)

August

4–9. Microbiology, 7th intern. cong., Stockholm, Sweden. (F. C. Harwood, Soc. of American Bacteriologists, c/o Waverly Press, Inc., Mt. Royal and Guilford Aves., Baltimore 2, Md.)

7–9. Electron Microscope Soc., annual, Los Angeles, Calif. (C. M. Schwartz, Battelle Memorial Inst., 505 King Ave., Columbus 1, Ohio.)

10–16. Radiation Research, intern. cong., Burlington, Vt. (H. M. Patt, Argonne National Lab., P.O. Box 299, Lemont, Ill.)

11–13. International Mathematical Union, 3rd general assembly, St. Andrews, Scotland. (F. Smithies, Mathematical Inst., 16 Chambers St., Edinburgh 1, Scotland.)

11–16. Occupational Therapists, World Federation's 2nd intern. cong., Copenhagen, Denmark. (Mrs. I. Worsoe, Hvidklovervej 10, Aarhus, Denmark.)

12–13. Economic Botany Conf., New York, N.Y. (D. J. Rogers, New York Botanical Garden, Bronx Park, New York 58.)

13–15. Electronic Standards and Measurements Conf., Boulder, Colo. (J. F. Brockman, National Bureau of Standards, Boulder.)

13–15. Industrial Applications of X-ray Analysis, 7th annual conf., Denver, Colo. (W. M. Mueller, Metallurgy Div., Denver Research Inst., University of Denver, Denver 10.)

13–19. Seaweed Symposium, 3rd Intern., Galway, Ireland. (C. O. hEocha, Chemistry, Department, University College, Galway.)

13–20. Insect Pathology and Biological Control, intern. conf., Prague and Smolenica, Czechoslovakia. (J. Weiser, Inst. of Biology, Nacvicisti 2, Prague XIX, Czechoslovakia.)

13–20. International Astronomical Union, 10th general assembly, Moscow, U.S.S.R. (P. Th. Oosterhoff, IAU, Leiden Observatory, Leiden, Netherlands.)

15–20. World Medical Assoc., 12th general, Copenhagen, Denmark. (World Medical Assoc., 10 Columbus Circle, New York 19.)

17. American College of Hospital Administrators, 24th annual, Chicago, Ill. (ACHA, 620 N. Michigan Ave., Chicago 11.)

17–21. Health Conf., 7th annual, University Park, Pa. (M. Cashman, Pennsylvania Dept. of Health, P.O. Box 90, Harrisburg.)

18–19. American Astronautical Soc., Western meeting, Palo Alto, Calif. (N. V. Petersen, Lockheed Missile Systems Div., Palo Alto.)

18–21. Conservation Education Assoc., 5th annual, Salt Lake City, Utah. (S. D. Mulaik, Biology Dept., University of Utah, Salt Lake City.)

18–21. Heat Transfer, AIChE conf., Evanston, Ill. (F. J. Van Antwerpen, AIChE, 25 W. 45 St., New York 36.)

18–22. Clinical Chemistry Workshop, Houston, Tex. (Division of Clinical Chemistry, Dept. of Biochemistry, Baylor Univ., College of Medicine, Houston 25.)

18–22. Occupational Medicine and Toxicology, 2nd Inter-American conf., Miami, Fla. (W. B. Deichmann, Dept. of Pharmacology, Univ. of Miami School of Medicine, Coral Gables, Fla.)

18–22. Plant Science Seminar, 35th annual, Big Rapids, Mich. (E. P. Claus, Div. of Pharmacy, Ferris Inst., Big Rapids.)

18–22. Semiconductors, intern. conf., IUPAP, Rochester, N.Y. (D. L. Dexter, Dept. of Physics, Univ. of Rochester, Rochester.)

18–23. New England Assoc. of Chemistry Teachers, 20th summer, Kingston, R.I. (J. A. Martus, College of the Holy Cross, Worcester 10, Mass.)

18–25. Religion in the Age of Science, 5th summer conf., Star Island, N.H. (Institute on Religion in an Age of Science, 280 Newton St., Brookline 46, Mass.)

20–23. Photofluorography, intern. cong., Stockholm, Sweden. (International Cong. of Photofluorography, P.O. Box 5097, Stockholm 5.)

20–27. Australian and New Zealand Assoc. for the Advancement of Science, 33rd cong., Adelaide, Australia. (J. R. A. McMillan, Science House, 157–161 Gloucester St., Sydney.)

20–27. Genetics, 10th intern. cong., Montreal, Canada. (J. W. Boyes, Dept. of Genetics, McGill Univ., Montreal.)

21–23. American Farm Economic Assoc., Winnipeg, Canada. (L. S. Hardin, Dept. of Agricultural Economics, Purdue Univ., Lafayette, Ind.)

21–23. Chemical Organization of Cells, Normal and Abnormal, Madison, Wis. (J. F. A. McManus, Dept. of Pathology, Univ. of Alabama Medical Center, Birmingham.)

21–24. Cenozoic of Western Montana, field conf., Missoula, Mont. (A. E. Wood, Soc. of Vertebrate Paleontology, Dept. of Biology, Amherst College, Amherst, Mass.)

23–25. Rural Sociology Soc., annual, Pullman, Wash. (H. F. Lionberger, Dept. of Rural Sociology, Univ. of Missouri, Columbia.)

24–28. American Inst. of Biological Sciences, annual, Bloomington, Ind. (H. T. Cox, AIBS, 2000 P St., NW, Washington 6.)

24–29. Atmospheric Diffusion and Air Pollution, intern. symp., Oxford, England. (F. N. Frenkiel, Applied Physics Lab., Johns Hopkins Univ., Silver Spring, Md.)

24–29. Mental Health, world federation, 11th annual, Vienna, Austria. (Miss E. M. Thornton, World Federation for Mental Health, 19 Manchester St., London, W.1, England.)

24–30. Prehistoric and Protohistoric Science, 5th intern. cong., Hamburg, Germany. (Büro des Internationalen Kongresses für Vor- und Frühgeschichte, c/o Fremdenverkehrs- und Kongresszentrale, Hamburg 1, Bieberhaus, Hachmannplatz.)

(See issue of 20 June for comprehensive list)