

Feasibility of Laboratory Studies Concerning Life on Venus

CAPTAIN CHARLES A. SCHINDLER, M.S.C., U.S.A.F., THOMAS L. ROBERTS, M.S.
and E. STATEN WYNNE, Ph.D.

FEW SCIENTISTS unequivocally maintain that life can exist on Venus.^{6,11,20,28,32} In fact, several authors have questioned the plausibility of life on that planet.^{1,12,18,20,21} Impending manned space voyages increase the importance of conducting investigations into the possibility of life existing there, provided that such studies are indeed feasible and likely to produce information of value.

Unfortunately, scientists are not in agreement as to the environment on Venus (cf. reviews by Shaw and Brobrovnikoff³⁴ and Nourse²⁵). The planetary atmosphere has been investigated primarily by means of radiation received from it.^{8,9,27,30,33,36,43} There is general agreement that carbon dioxide is present in large quantities.^{5,13,29} Sinton³⁵ has suggested carbon suboxide, C_3O_2 , as a major constituent; however, this compound is so unstable that its occurrence in large quantities is hardly to be expected. Spectral wavebands of the dark side of Venus have been attributed to neutral (N_2) and ionized (N_2^+) nitrogen molecules;¹⁴ partial confirmation of this view has been reported by Newkirk.²³ Barrett's⁴ estimate of the Venusian atmosphere includes 75 per cent carbon dioxide, 0 to 3 per cent water and 22 to 25 per cent nitrogen. According to de Vacouleurs and Menzel,⁴² the atmosphere contains 90 per cent carbon dioxide, 9 per cent nitrogen and 1 per cent argon. However, Urey⁴⁰

claims that recent studies have not confirmed the presence of nitrogen. Allen³ lists the following gases, in cubic centimeters at STP, as presumably composing the bulk of the atmosphere: carbon dioxide about 100,000, oxygen less than 200, water less than 100, methane less than 20, and ammonia less than 4.

Water has been the subject of important controversy regarding the chemical composition of both atmosphere and surface of Venus. Menzel and Whipple believe the surface is covered with oceans of water; moreover, they maintain that the cloud cover consists of water vapor.²² Though Kuiper rejects the "ocean hypothesis,"¹⁶ Mayer¹⁹ contends that the upper atmosphere of Venus contains as much water vapor as the earth's atmosphere. Polarimetric observations indicate solid particles slightly over 2 microns in diameter, with refractive index comparable to that of water.¹⁵ The consensus^{19,31,40,} et al. favors the presence of water vapor in the Venusian atmosphere, although with widely differing views as to the concentration. However, some scientists deny the existence of water, since in an aqueous milieu carbon dioxide would react with silicate rocks and thus be removed from the atmosphere. The established high carbon dioxide content of the Venusian atmosphere has therefore led Tombaugh³⁹ and others to conclude that the *surface* of Venus is dry. Menzel and Whipple, in support of the "ocean hypothesis," suggest no effective contact between silicate rocks and carbon dioxide; however, this supposition is difficult to maintain in the light of current thinking regarding surface temperature.¹³

Since carbon dioxide is opaque to infrared,^{2,12} the high concentration of this gas in the atmosphere of Venus prevents securing information by

Captain Charles A. Schindler, MSC, USAF, is with the Armed Forces Institute of Pathology, Washington, D. C.

Thomas L. Roberts, M.S., and E. Staten Wynne, Ph.D., are in the Microbiology-Cellular Biology Branch, School of Aerospace Medicine, Brooks Air Force Base, Texas.

This paper reflects the personal views of the authors and is not to be construed as a statement of official Air Force policy.

infrared spectroscopy. Furthermore, infrared radiation from the heated surface is largely absorbed by the heavy blanket of carbon dioxide,^{12,19} so that surface temperature would be expected to exceed the boiling point of water.¹⁵ Actual estimates of surface temperature are difficult, but those obtained by measurements of radio frequencies are of the order of 300° C.^{19,26,29,36} The accuracy of these values is questionable;⁴ however, there is agreement that the surface temperature is probably much too high for the existence of life similar to terrestrial forms.

Because of lack of agreement of scientists as to environmental conditions on Venus,^{7,29} it is considered inappropriate at this time to attempt studies on survival of terrestrial forms of life under simulated Venusian conditions. Present knowledge is based on astronomic observations; distortions and obscurations introduced by the atmosphere of Venus handicap acquisition of more accurate information. Prior to any earth-bound laboratory experiment, it is essential to obtain—probably by a probe^{7,10,37,38}—a three-dimensional map of temperature and moisture on or about Venus, as well as characterization of chemical compounds at the surface. Such information would indicate zones where life as we know it might exist.²⁴

It is, of course, possible that forms of life completely unlike those on earth do exist on Venus; but we agree with Abelson¹ that our present microbiological methodology would not disclose such life. If such life exists, considerable ingenuity will indeed be required for its detection;¹⁷ its very occurrence would necessitate a redefinition of "life." Therefore, if the environment of Venus (when it becomes known) effectively eliminates organisms similar to those on earth, then samples from the planet should be subjected to simulated Venusian conditions.

REFERENCES

1. ABELSON, P. H.: Extraterrestrial life. *Proc. Natl. Acad. Sci.*, 47:575, 1961.
2. ADAMS, W. S., and DUNHAM, T., JR.: Absorption bands in the infra-red spectrum of Venus. *Pub. Astron. Soc. Pacific*, 44:243, 1932.
3. ALLEN, C. W.: *Astrophysical Quantities*. University of London: Athlone Press, 1955.
4. BARRETT, A. H.: Microwave absorption and emission in the atmosphere of Venus. *J. Geophys. Res.*, 65:1835, 1960.
5. BIRNBAUM, G., MARYATT, A. A., and WACKER, P. F.: Microwave absorption by the nonpolar gas CO₂. *J. Chem. Phys.*, 22:1782, 1954.
6. CALVIN, M.: Origin of life on earth and elsewhere. *Proc. Lunar Planet. Exposit. Coll.*, 1(6):8, 1959.
7. DOLE, S. H.: The Venusian atmosphere. *Proc. Lunar Planet. Exposit. Coll.*, 1(5):12, 1959.
8. DUNHAM, T., JR.: The spectra of Venus, Mars, Jupiter and Saturn under high dispersion. *Pub. Astron. Soc. Pacific*, 45:202, 1933.
9. VON HARKANY, I. B.: Recent investigation of the physical nature of Venus, Budapest 1930. *Stella-Alamanch*, 6:181, 1930.
10. HOROWITZ, N. H.: Astrobiology session. *Proc. Lunar Planet. Exposit. Coll.*, 2(1):2, 1959.
11. HEUER, K.: *Men of Other Planets*. New York: Pellegrini and Cudalig, 1951.
12. JONES, H. S.: *Life on Other Worlds*. London: English University Press, 1955.
13. KAPLAND, L. D.: A new interpretation of the structure and CO₂ content of the Venus atmosphere. *Planet. Space Sci.*, 8:23, 1961.
14. KOZREV, N. A.: In recent studies of the known physical characteristics of the moon and the planets. Kiess, C. C., and Birney, D. S., (eds.). Georgetown College Observatory Monograph No. 15.
15. KIESS, C. C. and LASSOVSKY, K.: Known physical characteristics of the moon and the planets. Georgetown College Observatory Monograph ARDC-TR-58-41, 1958.
16. KUIPER, G. P.: The atmosphere and cloud layer of Venus. In *The Threshold of Space*. Zelnoff, M. (ed.). New York: Pergamon Press, 1955.
17. LEDERBERG, J.: Exobiology—Experimental approaches to life beyond the earth. In *Science in Space*. Washington, D. C.: Natl. Acad. Sci.-Natl. Res. Council, 1960.
18. LYTTLETON, R. A.: *The Modern Universe*. New York: Harper and Brothers, 1956.
19. MAYER, C. H.: Radio emission of the moon and planets. In *Planets and Satellites*. Kuiper, G. P., and Middlehurst, B. M. (eds.). Chicago: University of Chicago Press, 1961.
20. MOORE, P.: *Guide to the Planets*. London: Eyre and Spottiswoode, 1955.
21. MOORE, P.: *The Planet Venus*. London: Faber and Faber, 1956.
22. MENZEL, D. L., and WHIPPLE, F. L.: The case for H₂O clouds on Venus. *Pub. Astron. Soc. Pacific*, 67:161, 1955.
23. NEWKIRK, G. A., JR.: *Space Science*, 1:32, 1959.
24. NOVICK, A., and LEDERBERG, J.: Challenges to biology. *Bull. Atomic Sci.*, 17, 1961.
25. NOURSE, A. E.: *Nine Planets*. New York: Harper and Brothers, 1960.

26. PETTIT, E.: Planetary temperature measurements. *In Planets and Satellites*. Kuiper, G. P. and Middlehurst, B. M. (eds.).
27. PETTIT, E., and NICHOLSON, S. B.: Temperature on the bright and dark sides of Venus. *Pub. Astron. Soc. Pacific*, 67:293, 1955.
28. PFEIFFER, J.: *The Changing Universe*. New York: Random House, 1956.
29. REFERENCES: *In Known Physical Characteristics of the Moon and Planets*. Kiess, C. C., and Lassovsky, K. (eds.). Georgetown Observatory Monograph No. 12, 1958.
30. RUBASHEV, V. M.: New data on the physical conditions on Venus. (Studies of the atmosphere of Venus). *Sitzungber. der pressi. Akad. der Wissenschaften. Physikal-Mathematic. Klasse*, 383, 1931.
31. SAGAN, C.: Technical Report No. 32-34. J.P.L. Calif. Inst. Tech., 1961.
32. SHAPLEY, H.: Extraterrestrial life. *Astronautics*, 5:32, 1960.
33. SHARONOV, V. V.: The probable structure of the atmosphere of Venus. *Astronomicheskii Tsirkuliar*, 125:8, 1952.
34. SHAW, J. H. and BROBROVNIKOFF, N. T.: Natural environment of the planet Venus. *WADC Phase Technical Note 847-2*, February 1959.
35. SINTON, W. M.: Dissertation. Johns Hopkins University, 1953.
36. SINTON, W. M.: Recent radiometric studies of the planets and the moon. *In Planets and Satellites*.
37. SMITH, F. A.: The Venus probe. *J. Brit. Interplan. Soc.*, 17:42, 1959.
38. STRALY, W. H.: Mars or Venus? *Proc. Lunar Planet. Exposit. Coll.*, 1:4, 1959.
39. TOMBAUGH, C.: The Moon, Mars, and Venus. *In Lectures in Aerospace Medicine*, 11-15, January 1960. USAF School of Aerospace Medicine, Brooks AFB, Texas.
40. UREY, H. C.: The Planets. *In Science in Space*. Natl. Acad. Sci.-Natl. Res. Council, 1960-61.
41. DE VAUCOULEURS, G.: Remarks on Mars and Venus. *J. Geophys. Res.*, 64:1739, 1959.
42. DE VAUCOULEURS, G. and MENZEL, D. H.: Results of the occultation of Regulus by Venus, July 7, 1959. *Nature, London*, 188:28, 1960.
43. WHIPPLE, F. L.: *Earth, Moon and Planets*. New York: Grosset and Dunlap, 1958.