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January 30, 1961

Dr. Joshua Lederberg
Stanford University Medical Center
Palo Alto, California

Dear Dr. Lederberg:

Thank you very much for bringing the error in my manuscript to my attention. I had read your paper rather carefully last August, immediately after its publication, and thought I could trust my memory. However, it seems that I wrongly attributed to you statements by other authors. I am therefore offering to revise the first sentence of my paper to read as follows:

"Several authors have discussed the possibility that the Moon might serve as a repository for microorganisms from outside the solar system, or "astroplankton" (1a,b,c,d)".

The references in question are:

1a C. Sagan, Proc. Nat. Acad. Sci. U. S. 46, 396 (1960).

1b C. R. Phillips and R. K. Hoffman, Science 132, 991 (1960).

1c J. B. S. Haldane, "The origin of life", in New Biology (Penguin, London, 1954) vol. 16.

1d J. Lederberg, Science 132, 393 (1960).

The term "astroplankton" is used in your paper on p. 397. Although Haldane does not give a complete definition of this term, it is clear from the context of his discussion (especially pp. 25 and 12) that he meant spores from interstellar space. It would seem to me that while it was wrong for me to say that you have "emphasized the importance...", it is still true that you have "...discussed the possibility..". I hope the present wording meets with your approval.

I also propose to change the penultimate paragraph of my paper (pp. 6-7) to read as follows:

"...a factor of 3.3×10^6. Hence a search for extra-terrestrial biota has overwhelming odds against it, but, as pointed out by Turkevich (9) the Moon may well yield samples of now-extinct

terrestrial microorganisms. At the observed frequencies of meteorite infall (10), crater-forming impacts of the required magnitude may be expected at 10^5 - 10^6 year intervals, and a fraction of the debris ejected from the Earth may ultimately reach the Moon, after transit times ranging from a few days to $\sim 10^7$ years. Indeed, the latest addition to the Moon may have taken place in this century, after the fall of the Tunguska meteorite (or comet) in 1908.

It would seem that these facts should warrant a reconsideration of the goals of the lunar biology program. The principal remaining objective would be a test of the panspermia hypothesis, as provided by the presence or absence of terrestrial microorganisms (1d). If a positive result could be predicted with certainty on the basis of present knowledge, the sterilization of lunar probes would no longer seem as imperative as has sometimes been supposed (1b), although a strong case could still be made for the sterilization of planetary probes."

I agree that some delicate policy issues hinge on a clear understanding of this problem. I am sure that you will find most physical scientists anxious to cooperate with you once they become convinced of the need for sterilization. To arrive at an informed opinion, they need to know all pertinent facts. In my paper I have tried to clarify one particular aspect of the problem.

I hope these changes meet your objections. As I tried to indicate in my letter, I sent you the manuscript in order to give you an opportunity to spot any errors and misrepresentations before they appear in print. I dislike polemics at least as much as you do, and therefore regularly distribute preprints of my papers to about 150 workers in the field. In the present case, I shall include an errata sheet with the above changes.

Thank you again for your comments. With best regards, I am

Cordially yours,

Edward Anders

EA:mb
cc: Dr. Carl Sagan
Miller Inst. for Basic Research
U. of Calif.
Berkeley 4, Calif. (with preprint)

2/61

THE MOON AS A COLLECTOR OF BIOLOGICAL MATERIAL

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ABSTRACT

The Moon is not likely to contain detectable amounts of microorganisms from outside the solar system, since this would require, on the average, the intact ejection of twice the mass of the biosphere from 10^{11} planets in the Galaxy. The ratio of terrestrial to extra-solar-system biota on the Moon should be $\geq 8 \times 10^{11}$, and the addition of terrestrial biota by meteorite impacts on the Earth is likely to take place at intervals of 10^3 - 10^6 years.

Lederberg (1) has recently emphasized the importance of the Moon as a possible repository of microorganisms from outside the solar system. It is the purpose of this note to discuss some quantitative aspects of this idea.

The first question to be asked is, what amount, W, of microorganisms needs to be ejected from an average planet in the Galaxy to give the minimum detectable density of 1 microorganism per square meter of lunar surface (2), or 10^{-12} g/m^2. Assuming a perfectly uniform distribution of this