February 22, 1961

Dr. Carl Sagan
University of California
Berkeley Astronomical Department
Berkeley 4, California

Dear Dr. Sagan:

Your letter arrived just after I had sent a set
of revisions to Dr. DuShane. However, I was sufficiently
swayed by your arguments to make still another revision at
the risk of incurring the wrath of the editor. You will
find it indicated in the enclosed letter.

I, too, had considered a combination of a spherical
and a planar distribution, as mentioned in my footnote 3.
Since I used a somewhat greater value for the thickness of the
galaxy, I obtained an even smaller difference between the two
models.

I agree that w would be smaller if the stars in
the solar neighborhood had been closer to each other at some
time in the past and if life had evolved very rapidly at that
time. However, the stars could not have been ten times closer
to the Sun than they are now, for otherwise the Sun would not
have retained its cometary belt. Moreover, if I am not mis-
taken, these clusters are usually quite small, on the order
of 10^3 stars. Therefore, such a cluster cannot contribute
much material, even if it is situated close to the Sun. For
example, if the 38 grams of cosmobiota all came from Alpha
Centauri, then w for that star would have to be 4.5×10^{21}
grams. Even if you placed 1000 stars at the distance of Alpha
Centauri, w would still have to be 4.5×10^{18} grams.

I also doubt whether extra-galactic biota could
ever have made a significant contribution to the lunar popu-
lation. True, the galaxies may have been much closer to each
other some time in the past, but the Moon is only 4.5 aeons
old, and if the present value of the Hubble constant is at
all correct, then most of the expansion must have taken place
before the birth of the Moon.

Your estimate of the ejection of soil by meteorite
impact is probably over-optimistic on several counts. First,
only crater-forming meteorites of at least several hundred
tons weight are likely to propel any material to the required
high velocities. On the other hand, the microorganisms will
reside only in the top soil, and since the depth of the crater
is approximately equal to five times a meteorite diameter, the
amount of top soil ejected by larger meteorites will go up
only as the 2/3 power of the mass.

Finally, the argument in my paper concerning lunar
craters indicates that the velocity distribution peaks below
2 km/sec with only a relatively small fraction at the circum-
lunar velocity. The small mass deficit of lunar craters
indicates that the integral of the velocity distribution
between 0 and 1.7 km/sec must be about 80 or 90%. If you use
these data to construct a Maxwell-Boltzmann or any other
reasonable kind of distribution, you will find that only a
very minute fraction, far less than 1% of the material, can be
propelled to the required high velocities.

I am sorry, of course, that I neglected to consider
the fascinating possibilities pointed out in your paper. I
hope the proposed revision meets your objections. However, I

feel that a decision concerning sterilization of lunar vehicles
should be made after careful appraisal of all pros and cons.
So far, only the pros have been discussed in the literature,
and I doubt whether any harm can result from a single con.

     I, too, hope that we shall have further opportuni-
ties to discuss this and other related problems. I shall be
in Washington at the Theoretical Division of the Goddard Space
Flight Center during March and April. Any hope of seeing you
there?

    With best regards,

           Yours very sincerely,

           Edward Anders

EA:mb
cc: Dr. Lederberg