Contamination of the Moon and Planets.

The Group decided at its meeting in February 1964 that a statement as reproduced in Ann. 3 be immediately communicated to COSPAR on behalf of the Group. This points out the extreme importance of undertaking for the time being only fly-by missions for the study of Mars.

Following the compilation of available literature on the subject a panel of the following specialists has met at Florence during the COSPAR Symposium in May 1964:

Prof. A. Brown, Dept. of Biology, Univ. of Pennsylvania
Prof. A. Dollfus, Astrophysics Section, Paris Observatory.
Prof. M. Florkin, Biochemical Laboratory, Univ. of Liège.
Dr. L. Hall, Bioscience Programs, NASA.
Prof. C.-G. Hedén, Bacteriology Department, Karolinska Institutet (CONVENOR)
Academician A. A. Imshenetskii, Inst. of Microbiology, USSR Academy of Sciences.
Prof. C. Sagan, Harvard College Observatory (RAPPORTEUR)
Dr. P. H. A. Sneath, British Medical Research Council.
Additional Russian member (not present).

The Panel has discussed the standards of sterilization which can be recommended for the protection of possible Life on Mars. Its report is enclosed in Annex 4.

The Consultative Group has considered the report of the panel and wishes to make a statement which is Annex 5. The report underlines the danger of contamination through accidental landing of fly-by missions and suggests definite steps to reduce this danger. The Group urges continued efforts in improving sterilization techniques and sharing of information concerning procedures designed to achieve space-craft with the desired degree of sterility.

Annex 3.

Text of the preliminary statement on contamination as drafted by the Consultative Group at the Geneva meeting and later slightly amended. The text reads:

"The COSPAR Consultative Group on Potentially Harmful Effects of Space Experiments has considered presently available scientific evaluations of the likely consequences of the biological contamination of Mars. There is consensus of opinion among scientific workers of the extreme importance of not jeopardizing the value of information that can be gained from studies of this planet about many crucial problems of biology and the evolution of life. Realizing that the technology of sterilization has many practical problems, the Group is endeavouring to establish through consultation with competent biologists the limits of permissible contamination of objects that may land on Mars. The Group moreover recommends that early discussions be held between specialists of launching nations to discuss techniques of sterilization and problems of technology involved in launching sterilized payloads. In the meantime, the Group urges these nations who presently have capability of attempting the exploration of Mars, to take steps to organize only fly-bye missions for the time being".

Annex 4

Report of the Study Group on STANDARDS FOR SPACE PROBE STERILIZATION

At the Florence meeting of COSPAR, the study group on Standards for Space Probe Sterilization considered data and expressions of expert opinion from a variety of sources, including those listed in the appendices to this report. The following statements represent a synthesis of the views of the members of the Study Group; it is suggested that they be made the basis of a position paper by COSPAR.

We reaffirm the conviction that exobiology should be a primary objective of activities in the space sciences. This view is justified for the following reasons:

(1) The detection and subsequent investigation of extraterrestrial life has profound scientific significance.

(2) Studies in planetary biology must, in large part, be completed before contamination is effected by unsterilized devices used in physical or geophysical investigations. The successful performance of physical experiments is primarily unaffected by previous biological experiments; because of contamination, the converse may be false.

(3) A study of the prebiological chemistry of a planet which proves to be sterile would nevertheless be of major biological significance.

We <u>believe</u> that space probe sterilization and trajectory control of flyby spacecraft are essential until further information gives strong indication that such standards could be relaxed without jeopardizing planetary studies. This policy is justified for the following reasons:

(1) A search for extraterrestrial life is essentially a search for materials with the properties of the known organisms on the planet Earth. Therefore all life-detection experiments will be capable of detecting viable terrestrial contaminants. Consequently the introduction of such contaminants (for example, by inadequate spacecraft sterilization) would render it impossible to decide whether positive results of a life-detection experiment are significant or spurious.

(2) Aside from such interference with remote life-detection experiments, biological contamination of a planet may lead to undesirable alterations of the planetary environment from the standpoints of both exobiology and physical studies of planetary surfaces. If the proliferation of terrestrial contaminants -- at some time after their introduction -- is <u>not</u> excluded, the extensive changes in the planetary environment which are possible as a consequence <u>could</u> inhibit or destroy our opportunity to
   (a) identify and investigate the indigenous biota
   (b) understand the ecological interactions of the original indigenous biota, and
   (c) investigate the prebiological chemistry of a planet which proves to be sterile.

It is difficult to estimate adequately the period of time which would pass before such undesirable consequences occur. As a simple example

of heuristic interest we note that a single viable organism deposited in an environment in which it slowly grows (general time, 30 days) would in the course of eight years produce a population of 10^{27} organisms, a number equal approximately to the bacterial population of the Earth. The calculation assumes zero death rate, and no interaction between indigenous planetary organisms and exogenous terrestrial contaminants.

We believe , that the scientific desirability of sterility control is absolute; but the degree of sterilization required must be based on our judgements of the risks acceptable so planetary exploration will not be impossibly difficult. The probability that a single viable organism is aboard any space vehicle intended for planetary impact can then be computed as the solution of a waiting time problem in probability theory. Adopting values for the acceptable risk during approximately a decade of planetary exploration by landing vehicles, and for the biological and spacecraft reliability parameters involved -- values which we consider conservative -- we conclude that

(1) the probability that a single viable organism be aboard any vehicle intended for planetary landing must be less than 1×10^{-4}, and that

(2) the probability of accidental planetary impact by an unsterilized flyby or orbiter must be less than 3×10^{-5} during the interval terminating at the end of the initial period of planetary exploration by landing vehicles (approx. one decade).

We appreciate the considerable technical difficulties involved in realizing these probabilities in practice, but we consider that they are attainable by known means. The probabilities also apply to contamination by spacecraft propulsion and attitude-control systems. The probability of contamination by accidental impact of flybys and orbiters can be minimized by

(1) initial trajectory control,
(2) initial spacecraft sterilization, or by
(3) inclusion of programmed or commanded terminal precautionary systems for assuming non-intercept trajectories or for initiating destruction sterilization.

The probabilities given above are obviously subject to future revision as our knowledge of planetary environments, microbial ecology, and spacecraft design improves.

We feel that while our recommendations apply immediately to flyby, orbiter, and lander missions planned for Mars, the same recommendations should apply to any planet, which, on the basis of current information, cannot firmly be excluded as a possible abode of extraterrestrial life. The standards of space vehicle sterilization are, we believe, unrelated to the probability of indigenous life on the planet in question; except in the limiting case that indigenous life and the proliferation of terrestrial contaminants can both be firmly excluded. While there is a sizable probability that the surface temperatures of Venus are too high for either indigenous or exogenous organisms, this conclusion is based on indirect lines of argument. Also, we cannot entirely exclude the possibility of biological contamination of the cloudes of Venus. Until unambiguous astronomical information is available, we recommend that Martian standards of sterility control should also apply to Venus. In the case of the Moon, the surface

conditions are rigorous enough to reliably exclude biological contamination of the surface. We cannot exclude the possibility that conditions several tens of meters below the lunar surface will permit microbial replication. Such depths, however, are unlikely to be reached unintentionally during lunar landings. Accordingly, we recommend such less rigorous sterilization techniques as biocleanroom assembly and terminal gaseous sterilization of all spacecraft intended for lunar landings; but rigorous sterilization of drills designed for lunar subsurface boring. Our information about the conditions on other planets is insufficient to form a basis for definitive recommendations at this time.

To encourage broader consideration of the diverse means which can be employed to meet these recommended standards of sterility, it is suggested that an international conference be sponsored by COSPAR, possibly in cooperation with one or more other appropriate international scientific groups, to consider the technology of sterilization, and sterilization testing. To implement this suggestion, it will be necessary for COSPAR to endorse the proposed conference and to supply a budget for bringing it about. It is suggested further than the conference be held as soon as feasible, preferably in early 1965.

Annex 5.

Action suggested by the Consultative Group on Potentially Harmful Effects of Space Experiments concerning the contamination of planets:

Having studied — the available information, which includes comments by specialists and a report on contacts established with the National Microbiological Societies in 37 countries,

taking into account — the discussions of the Consultative Group in Warsaw (June 1963) and in Geneva (Febr. 1964) and the report by a special study group charged with recommending standards for space craft sterilization (Florence, May, 1964), and

considering — firstly the conceivable risks of interfering with possible extraterrestrial ecologies, secondly the importance of avoiding any action which may jeopardize future biological and chemical surveys, thirdly that the techniques available for space craft sterilization are continually improving, fourthly that there is a need for an advancement in this art before specimens can be returned from other planets,

the CONSULTATIVE GROUP ON POTENTIALLY HARMFUL EFFECTS OF SPACE EXPERIMENTS,
recommends the following action by
the EXECUTIVE COUNCIL OF COSPAR:

1. that it requests the UN to declare Mars a Temporary Biological Preserve. This will mean that in the exploration of this planet considerations of biological research receive priority over all other, and that the planet must be approached only by spacecrafts subjected to certified (see below) sterilization procedures. The declaration should remain in force until information returned from outer space will permit a change in policy on biological grounds.

2. that it recommends to launching nations that they plan only fly-bye missions, in the case of Mars, for the time being.

3. that it recommends to nations capable of launching moon probes that such probes are prepared and handled in such a way as to keep contamination to a feasible minimum and to give technical experience so that - in the future - no important planetary experiment will have to be rejected for lack of suitable sterilization techniques.

4. that it establishes a Study Group on Techniques for Space Craft Sterilization and instructs this group to:

   a. make possible an international comparison of sterilization techniques by devising an easily reproducible "mock capsule", incorporating basic probe elements suitable for standardized contamination - for instance by specified spores distributed on and between surfaces, under grease and paint films, in liquids, entrapped in solids and provided with different degrees of thermal protection.
   b. defining the term "certified", used in the first recommendation above
   c. draft an international code for space craft sterilization, based on the standards proposed by the special study group (Florence, May 1964)
   d. propose approaches to the problems involved in controlling the sterility level of space probes
   e. report to the Executive Council before a fixed date.