Some of the Preliminary Considerations [illegible]

Life Presented at an Informal Meeting on December 4, 19[illegible]

Among the participants were: Coryell, Doty, Gold, Kaplan, Kamen, Levinthal, Luria, Rossi, Sistrom, Strandberg, Watson and Whipple.

A. PURPOSE

In the next very few years space on both terrestrial satellites and martian (or venutian) probes will be available for biological observation. The purpose of the meeting was to discuss what kinds of biological questions it would be most profitable to ask. The meeting concerned itself with questions about the existence and nature of extra-terrestrial living things, not with the behavior of terrestrial living things in space.

B. THE PROBLEM

In considering extra-terrestrial living things four alternative hypotheses can be advanced:

1) Living things essentially identical to those found on earth exist on the planets (Mars or Venus).

2) Living things similar in their gross metabolic aspects to terrestrial forms exist. This is to say that processes such as fermentation, respiration, or photosynthesis occur. Interesting and important differences in the details of the processes and of the living things associated with them may occur.

3) Living forms exist basically different from terrestrial ones, possibly even based on a non-carbon chemistry.

4) There is some form of "proto-life" either extensive or perhaps marginal.

5) The planets are completely sterile; in other words, the physical chemical make-up of the planets has not led to the formation of any self-replicating molecular pattern.

6) Allied to this is the possibility that a presently sterile planet may harbor the remains of an earlier population of living things.

The very great importance of hypotheses (3) and (4) should be emphasized. If either situation occurs one can hope to make observations on biogenesis.

C. GENERAL APPROACH TO THE PROBLEM

The methods of getting information seem to fall into four groups:

1) Observations of the planets from the earth or from a near-earth satellite or balloon.
2) Observations of the planets from planetary probes or satellites.
3) Landings on the planets.

Experiments and observations on earth will be required both to perfect methods and instruments and to learn how to interpret the observations on other planets.

These approaches require transmission of information. The transmission is simplest when it is merely an answer to a 'yes-or-no' question, the question itself may be complex. Hence. the study of specific communication problems will have to follow the formulation of significant biological questions.

D. DANGERS AND CAUTIONS

Some of the approaches mentioned above entail a certain danger of disturbing the system under observation; the danger increases in proportion to the nearness to the system: thus (3) is much more dangerous than (2).

Not only must the obvious sources of contamination (bacteria and bacterial spores) be eliminated, but also the more subtle sources, such as dead bacteria and organic matter of any sort. It is essential to avoid unnecessary or thoughtless contamination. The only certain way of avoiding contamination would be not to approach the planets at all; this is obviously inadmissible. The best solution, therefore, is to have in advance a clear plan of attack on the problem. Thus all the observations which may reasonably be expected to be useful should be made by the least dangerous approach, before a more dangerous observation is attempted. Whenever an observation is made where there is danger of contamination, care should be taken to obtain the maximum of information at once and to remove the possible source of contamination as soon as possible.

E. TYPES OF INFORMATION WHICH MAY BE USEFUL

Many suggestions for possible observations were made. A brief summary of these follows together with some remarks concerning our present knowledge. Most of the suggestions implied a belief in the probability of hypotheses (1) or (2).

1. Present Information: (See Science, Vol. 128, page 89)

a) Temperature

(1) The temperature on Mars varies from about 300°K to 150°K; the maximum is certainly adequate for life and indeed is probably adequate for the marginal proliferation of known bacterial forms.

(2) Venus (at the surface) is much hotter: 600°K (?)

b) Atmosphere

(1) The total mass of the atmosphere of Mars is unknown. There is a large abundance of CO_2. Ice is known to present on the polar caps. Water vapor in the atmosphere is not much more than necessary to account for this. The spectroscopic evidence is consistent with the seasonal transport of this water from pole to pole via the atmosphere. No evidence for oxygen exists (oxygen could be 1% of the concentration in the terrestrial atmosphere). Nitrogen has not been detected, but could be present in large amounts.

(2) Venus has a heavy concentration of CO_2. Nothing is known about other gases. Clouds permanently obscure the surface.

c) Magnetic Field

(1) If Mars has a core, this must be small, therefore the magnetic field of Mars is likely to be weak, or perhaps zero. This, coupled with the low density of the atmosphere, leads to the presumption that the surface is very heavily irradiated with high-energy particles (as well as with intense UV).

(2) Venus has a mass and density similar to that of the Earth. Therefore the internal structure and magnetic field may be similar.

d) Direct evidence of life and/or organic material

(1) For Mars there is the behavior (seasonal waxing and waning) of the 'dark patches', as contrasted with 'desert areas'. Moreover, there is the spectroscopic evidence of Sinton showing the existence of a 3.46μ absorption band associated with the dark patches. This band is characteristic of C-H bonds in compounds heavier than methane. Its presence makes very probable the existence of organic matter on Mars, but does not imply the presence of living forms. It may indicate the existence of a "Miller-process" on a massive scale. Doty here raised the problem of the destruction of organic matter by UV-radiation. It is possible that a steady state concentration of organic material might occur; the possibility of a layering of the formed material and protection of the lower layers was mentioned.

(2) For Venus there is no information available.

II. Information Needed to Formulate Pertinent Questions

(a) More data on organic synthesis from inorganic compounds including models of planetary atmosphere, and studies on layering effects.

(b) Study of life correlates in the atmosphere and on the surface of the earth, and of their possible detection from an earth's satellite.

III. Information from Balloon and Terrestrial Satellites

Spectroscopic analysis of planetary atmospheres and and surfaces. Especially important are oxygen, nitrogen, and trace constituents. Also, a refinement of Sinton's observations on the 3.46μ band will be possible, and an extension of these observations into the visible spectrum, with special reference to chlorophyll.

IV. Information from Planetary Probes and Satellites

a) Photographic observations

b) Spectroscopic experiments such as mentioned under III, with the possibility of observing small regions.

c) Radar observations to determine the "roughness" of the planetary surface. On the earth the "roughness" is almost entirely due to vegetation.

d) Observations of free radicals. More information on feasibility and reliability of such observations is needed.

e) Chemical analysis from a probe entering the atmosphere or with instruments landing on the planetary surface. Particularly important would be the observation of optical activity.

F. LIMITATIONS OF PRESENT CONCEPTS OF LIFE

It is obvious that in order to arrive at an idea of the kinds of observations that would be most useful to make from planetary satellites (or even more by landings) much more thought must be given to the properties to be expected from the possible forms of living things. What, for example, are the kinds of energy metabolisms possible; what kind of activity might be associated with proto-life?