PROBLEMS COMMON TO ASTRONOMY AND BIOLOGY*

It is an interesting fact in modern science that border areas between well established specialties have become more and more important. This is evidenced by numerous examples, for instance, physical chemistry, bio-chemistry, bioclimatology, ecology, etc. Interdisciplinary studies of this kind are of benefit to both of the partner disciplines.

Recently, an intermediate field between astronomy and biology has taken shape under the name astrobiology or planetary ecology--which deals with the problems of life on other celestial bodies. Actually, the scope of the problems common to astronomy and biology is much broader when we include human physiology in planetary ecological considerations and the human factor involved in astronomical observations. This symposium is the first of its kind, to cover, in special papers, the area in which astronomy and biology can work together fruitfully. In the following I shall briefly outline this field as an introduction of the special papers of our panel.

Questions involving both astronomy and biology were posed for the first time when in 1877 Schiaparelli of Milan discovered features on Mars which appeared to him as canali.

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*Given at Symposium on Problems Common to Biology and Astronomy 18 June 57, Flagstaff, Arizona by H. Strughold, M.D.PH D.

This started the discussion of life on other planets which reached its climax in the books of Flamarion and of P. Lowell. The progress made in rocketry, space technology, and space medicine in recent years, has had a catalytic effect upon the occupation with this problem, and its discussion has been in full tide ever since with crests during oppositions of Mars. New publications have appeared such as S. Jones, Richardson, De Vaucouleur, Strughold and recently by Tikhof.

Astrobiology--or whatever you'd like to call it--is actually ecology, an extension from geographic ecology into a general planetary ecology. Ecology is a branch of biology. Physical ecology studies the physical conditions of an environment as to its suitability for life; physiological ecology studies the reactions and adaptations of li life to the physical conditions of an environment.

Planetary ecological considerations can be based on two assumptions: one, on the assumption of the kind of life known to us and based on carbon as the basic structural atom and on oxygen as the basic energy liberation atom, and two, on the assumption of other forms and processes of life unknown to us and based on other elements--for instance, on silicon as the basic structural atom. This extracarbonic biology would be a kind of parabiology and is beyond the scope of our discussion; we shall, therefore, base our considerations on terrestrial carbonic biology.

An approach to the question of life on the planets in our solar system, from the standpoint of general physical ecology, leads us to a zonal aspect. We find a zonal distribution of some fundamental ecological factor such as light, temperature, the presence of water and the chemistry of the atmospheres in the planetary system. The decisive factor responsible for this zonation of the planets with life--favoring conditions, is the intensity of solar radiation as the result of the distances of their orbits from the sun.

We find only in a narrow zone a biologically desirable illumination of the planets, a kind of euphotic belt surrounded by a hyperphotic and hypophotic region. Biologically acceptable temperatures too are found only in a certain distance range from the sun, forming a biotemperature belt in the planetary system. For the same region Harlow Shapley assumes a liquid water belt. And finally, a zonal distribution is evident in the chemical composition of the planetary atmospheres as the result of photochemical action of ultraviolet of solar radiation. The atmospheres relatively near the sun form an oxygen belt, those of the outer planets form a hydrogen belt with atmospheres of the protoatmospheric type. All of these belts: the euphotic belt, biotemperature belt, the liquid water belt and the oxygen belt, offer ecological conditions favorable to the kind of life now predominant on earth. Since all of these belts are found in about the same region, they are part of a general life zone which we might call the ecosphere in the planetary system. The earth lies in the most favorable region, Mars and Venus in the fringe areas of this ecological belt.

On the planets in the hydrogen belt microorganisms such as hydrogen bacteria, ammounia, methane and iron bacteria are conceivable--provided the temperatures were adequate, these organisms are the kind which were predominant on earth during its protoplanet stage some two billion years ago and which we still find today in the pores of the soil and other poorly aerated spaces. However, the low temperature probably excludes the outer planets from membership of the ecosphere.

This general ecological probing or screening of the planets confines our interest to the planets Venus and Mars. The latter, best known concerning the climatic conditions down to the surface, offers presently the best planetary object for an astrobiological study. Ecologically, Mars seems to be an underdeveloped planet, probably has always been so, and undoubtedly will always remain so. The climatic shortcomings permit only lower and cold resistant organisms of the kind we know on earth in the form of lichens and mosses as suggested in numerous publications. However, we must consider not only the climate as a whole but also the so-called microclimate near, on, and below the ground influenced by surface and subsurface features, snow coverings, etc., which usually moderate the extremes of the macro-climate. And then, there is the physiological ecological side of the problem as manifested in the enormous capacity of life to adapt itself to abnormal climatic conditions. With regard to the specific environment on Mars, we should consider the possibility of oxygen photosynthetically produced and stored in intercellular space structures such as we find in terrestrial plants, especially in underwater plants, storing of carbon dioxide in intercellular fluids, and water stored as in our desert plants. As a means of temperature control and of protection against ultraviolet we should absorbing power of the plants surfaces for infrared and a shift in the revlecting power toward blue. The pronounced bluish tint of the green areas on Mars might offer a hint in this respect. Tikhof devotes a considerable part of his two books "Astrobiology" and "Astrobotany" to such adaptive optical properties of plants. Moreover, protection against frost xx could be imagined if the martian plants were able to develop as a metabolic by-product some kind of antifreeze such as glycerol. We know, that even terrestrial animal cells can survive temperatures as low as -70°C when placed in glycerol solutions. When searching in the botanical literature for clues in this respect, I found that some of our terrestrial lichens de facto contain erythrol which belongs to the same family of chemicals as glycerol.

Concerning this whole problem of vegetation on Mars, comparative spectroscopic studies of the green areas on Mars and of chlorophyl carrying terrestrial plants represent an interesting border field between Astronomy and Botany.

Naturally, we can simulate the climatic conditions on Mars in special chambers and study the behavior of microorganisms in such artificial Martian environment. Studies of this kind are not only interesting for Astronomy and Astrobiology but also for our knowledge of life in general.

The development of the rocket has brought about the realization of space operations. The final phase of such space operations will be interplanetary space flights and the first of these will probably be an expedition to Mars Of primary interest from the standpoint of the astronaut then will be the question: what kind of an atmospheric environment would he find on Mars with regard to himself, especially what protective measures must he take concerning respiration. This involves astronomy and human physiology

First, atmospheric entry will pose fewer aerodynamic, aerothermodynamic and pertinent physiological difficulties than are encountered in the terrestrial atmosphere because of the lower air density. On the ground the space ship will be surrounded by an air pressure of about 70 mm Hg. maximally. This pressure corresponds to an altitude of 55,000 feet in our atmosphere. Barometrically, this altitude is so-to-speak the Mars equivalent level in the earth atmosphere. Our pilots flying in these regions must wear a pressure suit. The same then would be required for an astronaut on Mars, when he leaves the sealed compartment of his space ship. However, an air pressure of 70 mm Hg. lies just in the critical border range in which pressure suit or simple oxygen equipment with pressure breathing are a matter of dispute. The latter may be sufficient for shorter periods of time. B. Balke, after spending six weeks at a height of 14,800 feet in Morococca, Peru, for acclimatization purposes--was able to withstand an altitude of 58,000 feet in a low pressure chamber for three minutes, applying pressure breathing only. Be that as it may; a terrestrial explorer on Mars, wearing a pressure suit or pressure breathing equipment must always retreat after half an hour or so, into the more comfortable sealed compartment of the ship. In the event of a leak in the sealed compartment or in the pressure suit, the astronaut would encounter the same rapid decompression effects, including anoxia and aeroembolism as the pilots in our atmospheric region at around 50,000 to 55,000 feet. He would not, however, be endangered by "ebullism" a term suggested by J. E. Ward for the so-called boiling of body fluids. This effect becomes manifest on Mars at an altitude of 13,000 feet, which corresponds to 63,000 feet in our atmosphere. The critical pressure in this respect is 47 mm Hg.

A factor which might facilitate the problem of oxygen requirement, and the mobility of the astronaut, might be the relatively low gravitational force on Mars (38 percent of terrestrial gravity). So much for a problem involving astronomy and bioastronautics or space medicine.

A similar problem arises which concerns the astronomer himself should he intend to ascent into the higher atmosphere in order to avoid the turbulence of the air disturbing astronomical observations. Such undertakings are now possible with the development of sealed gondolas for high altitude balloon flights up to 100,000 feet, which should offer ideal "seeing" and the possibility of avoiding the masking effects of the earth's atmosphere in spectroscopic studies of the chemistry of planetary atmospheres.

With this question we have already touched upon the border field between astronomy and physiological optics.

In this field during the past 20 years considerable advances have been made by physiology and psychology and aviation medicine. In aviation night vision, color vision, radar observation, etc. is of vital importance and consequently extensive research has been devoted to these fields. Some of the results might be of some interest and usefulness to the astronomer just the same as the "personal equation" conceived by Maskelyn, London and Bessel in Koenigsburg have had a great influence upon the concepts of latent time of perception, recognition time, reaction time as developed by Donders in Ulrecht, Helmholz in Heidelberg and Eckner in Vienna in the second half of the 19th century.