CONFERENCE REPORT

Life in the Universe
*Paris, November 19–21, 1979**

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(Received 2 May, 1980)

Abstract. A conference on Life in the Universe, organized by the Council of Europe, and held in Paris, November 19 to 21, 1979, brought together more than 100 scientists from different fields. The aim of this conference was to promote scientific cooperation in Europe, in conjunction with other countries, in fields related to the problem of Life in the Universe. Our knowledge concerning this problem was reviewed in three different sessions. The first session was devoted to the question of planetary evolution; the second session was devoted to the question of the origin and evolution of life, and the third session was devoted to the problem of evolution of intelligence and the search for extraterrestrial intelligence.

The Drake formula was the keynote of the conference. Each session tried to estimate some of the parameters of this formula, in order to examine the question: how many extraterrestrial civilizations with a level of technology at least equal to ours may be present in the universe? Even if no definite answer is given to this question, this meeting pointed out the need for more research.

An international conference on Life in the Universe was organized by the Council of Europe, in collaboration with UNESCO, the European Space Agency (ESA) and the French Space Agency, Centre National d'Etudes Spatiales (CNES) and held in Paris on November 19, 20, and 21, 1979 in the UNESCO Building.

Over time, the need to develop scientific cooperation between European and non-European countries in the fields relating to the problem of life in the universe, has become clear. The parliamentary Assembly of the Council of Europe established a Research Group on Cosmic Chemistry, Chemical Evolution and Exobiology with the organization of this conference as one of the many activities of the group. Dr. Y. Coeckelenbergh, Council of Europe, is the Secretary of the group and the Chairman is Dr. Alan Schwartz, University at Nijmegen.

At the Plenary Session, Mr. Gaetano Adinolfi, Deputy Secretary General of the Council of Europe recalled to the audience's attention the existence of the Research Group on Cosmic Chemistry, Chemical Evolution and Exobiology and asked the participants to show audacity and imagination during the conference. But, as he said, "human communication must not be ignored when extraterrestrial communication is discussed." Mr Amadou

* (Ed. Note. It is not the general editorial policy of the journal to publish conference and meeting reports. On occasion, the substance and discussions of a particular conference have such wide-ranging implications or touch so many concerns in the study of the origin and evolution of life, the editor will decide to make an exception to the general policy. This particular conference is one of those exceptions.)

Origins of Life 10 (1980) 371–377. 0302–1688/80/0104–0371 $01.05.

Mahtar M'Bow, Director General of UNESCO, conscious that "scientific research is becoming a parameter of understanding between nations" pointed out the new perspectives that European cooperation can give to the peoples of the world. Mr. André Lebeau, Deputy Secretary General of ESA, insisted on the very important role of the space agencies and finally, Mr. Roger Lesgards, Secretary General of CNES, recommended that the participants use strict scientific rigor when discussing problems related to space.

Fifteen countries were represented by more than 100 scientists of different fields, including astrophysics, planetology, radioastronomy, chemistry, physical chemistry, biochemistry, biophysics, biology geochemistry, and paleantology. The participants restated the question of the possibility of extraterrestrial life in three different sessions. The first, on Planetary Evolution, was chaired by Dr. A. Dollfus (France): the second devoted to the problem of Origin and Evolution of Life was chaired by Dr. A. Schwartz (Netherlands) and Dr. R. Buvet (France). The third session, Evolution of Intelligence and Search for Extraterrestrial Intelligence, had as its chairman one of the pioneers in this field, Dr. Frank Drake (USA).

Session I: Planetary Evolution

Are the planetary systems a general law in the universe? Since planets seem to be necessary for the origin and the development of life, the question of their formation and their presence is very important.

A review of our knowledge of our solar system – the only planetary system that we actually know – was presented by A. Dollfus. As described by M. Fulchignani (Italy), in his presentation on the formation of planets from the solar nebula, there is so far no acceptable model. D. Malaise (Belgium) in his paper 'Small Bodies and the Evolution of the Solar System' pointed out that if we examine the admitted scheme for the origin of the solar system, we find many contradictions.

Some data, however, on the primitive nebula are available. H. Reeves (France) in discussing the present vestige of primitive matter in the solar system showed, for instance, that the study of the ratio HDO/H_2O gives precious information about the temperature of the solar nebula. In his presentation on the evolution of the atmosphere of Venus, Earth, and Mars, J. L. Bertaux (France) pointed out that a possible scenario for the accretion of planets can be deduced from the study of the isotopic composition of Venus and Mars.

The importance of the accretional processes appeared clearly from the papers presented by J. F. Minster (France), 'Dating of the Formation Processes of Planetary Bodies', by R. Meissner (Fed. Rep. Germany) 'Evolution of Planetary Body Interiors', and H. Wänke (Fed. Rep. Germany) 'Differentiation Processes in Planetary Bodies'.

We still know very little about the early terrestrial conditions, however, it seems reasonable to assume that the early surface of the Earth, before our planet evolved its own atmospheric environment, was very similar to the actual surface of the Moon and Mercury. This was discussed by Masson (France) in 'Evolution of Planetary Surfaces'.

According to C. Pillinger (U.K.) organic matter is present everywhere in the solar system and is also present in the interstellar medium. Life appeared on the Earth after a long period of chemical evolution beginning outside the stars where O, C, and N atoms are largely found. The presentation by J. M. Greenberg (The Netherlands) 'Laboratory Analog of the Formation of Complex Organic Molecules in Interstellar Grains – Their Contribution to Interplanetary Material' made the necessary connection between Sessions I and II. Greenberg is trying to answer the Question, 'Can interstellar grains be the source of the origin of life?"

Session II: Origin and Evolution of Life

For C. Ponnamperuma (U.S.A.), in reviewing our knowledge of chemical evolution in the universe, "the process of chemical evolution appears to be cosmic in nature", although several questions remain concerning the origin of life on our planet.

The first unresolved question concerns the composition of the early Earth's atmosphere. As pointed out by A. Henderson-Sellers (U.K.) in her presentation on the atmospheric composition and surface temperature of the terrestrial planets, "the concept of an early atmosphere on all the terrestrial planets is becoming the new orthodoxy". In essence it is frequently assumed that 4 billion years ago, the Earth's atmosphere was mainly composed of CO_2 and H_2O.

Before that time, as explained by E. Broda (Austria), in his presentation entitled 'Evolution of Bioenergetic Processes', the evolution of photosynthesis and respiration in the living systems on the primitive Earth started from a reducing atmosphere. However, an increasing number of scientists now believe that the primordial atmosphere of the Earth, before the origin of life, was also oxidizing, composed mainly of CO_2 (or CO), but without O_2.

Such a model of an oxidizing atmosphere is not at all efficient for the synthesis of organic precursors, as shown by G. Toupance (France), who reviewed what is known about the synthesis of organic molecules in gas phase reaction and the chemical evolution of aqueous solutions. He clearly showed that, if the precursors of most of the bionomers were produced from reducing model atmospheres containing CH_4–N_2–H_2O and H_2S, these syntheses are difficult when CO or CO_2 take the place of CH_4. Only a large ratio of H_2 in the mixture of CO or CO_2–N_2–H_2O could solve the problem. Such an amount of H_2 is too high to be realistic, as H_2 must have escaped very quickly from the Earth's atmosphere. The influence of this escape on the chemical evolution of the primitive Earth's atmosphere is currently being studied in G. Toupance's laboratory.

In his presentation at the Plenary Session, A. Schwartz noted that we could explain the origin of the organic matter on the Earth from a CO_2–N_2–H_2O atmosphere. First, the formose reaction allows the formation of HCHO from CO_2–H_2O, giving rise to sugars. Second, Schwartz pointed out some interesting new results concerning the UV irradiation of N_2–H_2O in the presence of a solid phase, giving rise to NH_3 thus allowing further incorporation of N atoms. However, Toupance concluded in the first part of his paper, so far "the incorporation of nitrogen in prebiotic organic compounds from non-reducing model atmospheres remains unsolved".

Let us consider another scenario and assume that primordial organic matter on the Earth does not come from the evolution of its atmosphere. Could it come from a seeding by the interstellar molecules or by meteorites containing complex organic molecules? A. Schwartz showed that only a very small concentration of organic matter could have reached the Earth from the impact of carbonaceous chondrites. Another suggestion, by G. Toupance and F. Raulin (France) is that the primordial terrestrial organic matter could have been formed during the earlier accretional processes, before the outgassing which formed the Earth's atmosphere. Thus, the primitive terrestrial organic matter would have the same composition as the organic matter found in some carbonaceous meteorites.

Another unresolved problem concerns the condensation of amino acids to produce peptides. "In spite of numerous efforts, it is known that the results are very disappointing, and we may wonder if polycondensation of amino-acids is a realistic way for the synthesis of peptides", according to G. Toupance. However, the condensation of amino acids can occur easily in absence of water, by heating. K. Dose (F.R.G.) showed that some selective interactions of amino acids give non-random polymers. This "emergence of order in amino acid polymers" suggests to Dose the possibility of evolution of biological information from some informative protoproteins. In addition, the thermolyzed amino acid mixtures, as presented by B. Heinz (F.R.G.) show some very interesting morphogenic properties with the formation of fluorescent cellular networks which are very stable and could contain flavine and pteridin structures. The importance of early amino acid polymers was also pointed out by A. Brack (France), who gave a discussion of the emergence of asymmetrical templates based on polypeptides able to orient and to catalyse the polymerization of amino acids and nucleotides.

More theoretically, the question of self-organization in chemical systems far from equilibrium is related to the concept of dissipative structures. A. Babloyantz (Belgium) reviewed this theoretical approach which provides a mechanism for self-organization in reaction diffusive system.

If now we go closer to the living systems, there are also several unresolved questions. The origin of chirality, for W. Thiemann (F.R.G.) is still unclear and needs refined laboratory experiments. This is also the case of the origin of the genetic code, reviewed by H. Kuhn (F.R.G.). For J. Ninio (France), in his presentation 'Molecular Evolution: a Walk in the Sequence Space', "selection may be acting not upon the gene alone, but upon the gene *plus* its neighborhood".

An interesting approach, based on steric considerations, was presented at two different levels. K. C. Bogdanski (France) discussed the properties of differentiation of self-regulating systems as a function of the dimension of the system. E. Schoffeniels (Belgium), in his paper 'Early stages of Biochemical Evolution', stressed also the dimensional problems, but from a biochemical point of view, pointing out that the spatial organization of metabolic sequences could be an early stage in biochemical evolution. Many observations argue in favor of such a principle of spatial correlation. Schoffeniels suggested that co-enzymes appeared early and even, in some cases, prior to the enzyme proteins.

Finally, G. Horneck (F.R.G.) pointed out the ease with which microbial living systems adapt in extreme environments, suggesting three different ways of adaptation: shielding, neutralization and toleration.

Session III: Evolution of Intelligence and the Search for Extraterrestrial Intelligence

In spite of the ease with which life adapts, it seems more and more likely that in our solar system, life is present only on the Earth. As noted by C. Ponnamperuma in his presentation 'Search for Life in the Solar System', "the absence of organic carbon on Mars is one of the points leading to the conclusion that, at present, there is no evidence for present or past life on Mars. Presence of liquid water may be the one factor which has made the planet Earth the only abode of life in our solar system". Ponnamperuma concluded that we must search for life beyond the Earth and outside our solar system.

The location of the closest planetary system remains problematic. So far, we have no direct evidence of any other planetary systems, even, finally, in the case of the Barnard's star. This was pointed out by G. Gatewood (U.S.A.) in his paper entitled 'Astrometric Survey for Extrasolar Planetary Systems'. However, the so far non-evidence of a dark companion for the nearest stars only means that those stars have no planets with radii of 2 to 10 times the radius of Jupiter. They may have smaller planets that we, with our present technology, have been unable to detect. P. Connes (France) reviewed critically the different technique which can be used for extrasolar planetary detection. Of the three indirect techniques, only two – astrometry and radial velocity – appear to be useful. The detection of eclipses, while theoretically interesting, is not practical. To Connes and Gatewood astrometry is the safest approach and one that should be tried first. Connes also postulated that direct detection, using the space telescope holds promise.

Let us now assume that the universe is crowded with planetary systems. During the Plenary Session, Drake estimated that the human civilization needs 10^6 times the total annual energy used in the USA alone to reach the nearest supposed planetary system. If we assume that life appears on a planet by necessity, as soon as the given physical-chemical conditions are present, and if we assume also that living systems may evolve toward an intelligent life which could develop advanced technology as happened on the Earth, we can imagine the existence of extraterrestrial civilizations having a level of technology greater than ours. For Drake, the nearest such a civilization could be very far from our solar system. In addition, assuming that interstellar civilization is wanted and useful only if it does not consume too much energy (that is, from an anthropocentric point of view if the consumed energy is less than the energy needed to have a level of 'good life'), Drake deduced that space colonization could take place only in a planetary system and not in the interstellar medium. Thus, it seems very improbable that search for extraterrestrial life by space exploration *in situ* could be successful. Drake's conclusion was that the only way of searching for direct evidence of extraterrestrial life appears to be interstellar communication between terrestrial and extraterrestrial civilizations, using electromagnetic waves.

We must first ask what is the probability for such advanced civilizations to exist and if these extraterrestrial living systems have developed intelligence and technology. It is difficult to give a quantifiable, scientific definition of intelligence, but D. Russell (Canada) has tried to analyse the evolution of intelligence on Earth, by studying the evolution of the rate of ancephalization. The origin of life seems to him much more probable than the origin of higher intelligence. However, he thinks that a high level of ancephalization allows better adaptation to environments, and he concluded that extraterrestrial space colonization by organisms of human or greater level of intelligence is plausible. The study of the evolution of technology on Earth, as presented by B. Campbell (U.S.A.), may also provide precious information on the possibility of technological development elsewhere in the universe.

Thus, the assumption of the existence of technologically advanced extraterrestrial civilization seems theoretically plausible, and the search for extraterrestrial intelligence (SETI) by looking for extraterrestrial radio signals, reasonable. J. Tarter (U.S.A.) reviewed the several experiments of radio SETI which have been carried out. Since Project Ozma, in 1960 about 15 other unsuccessful searchs have been undertaken. However, Tarter pointed out that those negative results could be attributed to several technical constraints, such as the use of instruments not specifically designed for SETI and the very limited amount of available listening time. With a new program which has been proposed using a SETI-specific system, these technical problems should by solved. In addition, as clearly shown by Tarter, the portion of the multi-dimensional parameter space which has been explored is very small, when compared to the portion that the new SETI program will be able to explore. Of course, the choice of wavelength is very important, and even the range of 'magic wavelengths' is quite wide. F. Biraud (France) proposed the use of wideband signals for interstellar communication, in place of searching for quasi-monochromatic radiowaves.

Conclusions

The keynote of this conference was the formula, proposed many years ago by F. Drake, to estimate the number of technologically advanced civilizations in our universe:

$$N = R \cdot f_p \cdot n_e \cdot f_l \cdot f_i \cdot f_t \cdot L,$$

where R is the rate of formation of stars similar to our Sun; f_p: the fraction of those stars which have a planetary system; n_e: the number of planets which are suitable for life in those planetary systems; f_l: the fraction of those planets where life effectively appeared; f_i: the fraction of such inhabited planets where life evolved toward intelligence; f_t: the fraction of the intelligent civilizations who develop advanced technology; and L: the longevity of those technologically advanced civilizations.

On the basis of the reviews and discussions carried out during each of the three sessions, the participants tried to estimate some of the factors of this equation. Dollfus, for instance, suggested that the formation of a solar system is not exceptional and f_p could be very high. He added that ne is very difficult to estimate, because of the many parameters involved. For many participants, the origin of life on the Earth could be a 'non-unprobable' event and f_l could be closed to 1. On the contrary, f_i and f_t are extremely difficult to estimate because of a lack of data. Drake proposed that L could be very high, if we assume that technologically advanced civilization may develop a kind of auto-conservative behavior.

It must be noted that, in general, the estimate of the parameters ranged over a large scale in order of magnitude. For a majority of participants, this range was smaller than it *could* have been, generally less than 10 decades and may reflect a general optimism. It could also reflect a better knowledge of the different physical laws corresponding to those parameters.

During the final Plenary Session on November 21, the conclusions of the three sessions were summarized by the Chairman, A. Schwartz.

1. The process of planetary formation is generally believed to be a general phenomena in the universe.
2. Some of these planets could possess an environment similar to that of earth.
3. The formation of organic material structurally related to biological material is observed astronomically by studies of meteorites and by laboratory simulation experiments. The origin of life on earth may be related to that process. Both physical and chemical evidence suggest that this is a general phenomena in the universe.
4. Extraterrestrial biology based on biochemical pathways similar to those on earth seems plausible.
5. The evolutionary history of the earth suggests that the evolution of intelligence should not be a unique event.
6. We consider appropriate the developments of multi-disciplinary research on the origin and evolution of life and the possible existence of extraterrestrial life, by such means as laboratory experiment, biological studies and all techniques of astronomical observation.

At the end of the meeting, a public forum was organized by SETI-France. This gave scientists, involved in the study of life in the universe, the opportunity to present their thinking about the possibility of extraterrestrial life to the public,

Acknowledgments

The author wishes to thank A. Bossard, J. J. Kemper, C. Ponnamperuma, and G. Toupance for their assistance in the preparation of this report.