A New Era in the Search for Life in the Universe

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Abstract. In this paper, we present a historical description of the emergence of a new science: "The Search for Extraterrestrial Life". We explore the circumstances and scientists that proposed several names for this new branch of science, over the last fifty years. We describe the origins of the International Astronomical Union Commission 51 and we make an account of the activities and meetings that were organized during the last 22 years. We explore the variation of the main of discussion as a function of topics time as well as Commission 51's relation to other scientific society (IAA, IAF, ISSOL, NASA, etc.) meetings.

1. Introduction: A New Branch of Science in Search for a Name?

The possibility that life, primitive or advanced, might exist in other places in the universe has occupied the thoughts of scientists, philosophers and laymen for thousands years (Crowe 1986; Dick 1982, 1996). It is only during the last 45 years, however, that we have entered the experimental phase of the search for extraterrestrial life and where a considerable progress has already been made.

We find now the field of bioastronomy growing in its scope and, as a result, so is the number of terms that describe its many facets of study. Terms such as *astrobiology, cosmobiology, exobiology* and *bioastronomy* are often used interchangeably, and the scope of their meanings overlaps. Just which term is used to describe this area of science depends on who you talk to. Surprisingly enough, many of these terms date back almost 50 years (Lemarchand 1998).

The history of science is marked with attempts to define emerging branches within novel areas of research. When vegetation on Mars seemed quite possible, Soviet astronomer, Gavriil Adrianovich Tikhov (1875–1960) suggested the establishment of a field that combined astronomy and botany *Astrobotany*, a field that would seek to understand the optical properties of terrestrial and martian vegetation. In 1947, the Astrobotanical Section of the Academy of Sciences in the Kazakh Republic of the Soviet Union opened.

In a lecture to the British Interplanetary Society in 1952, Irish physicist and science philosopher, John D. Bernal (1901–1971) extended his speculations about the origin of life in the universe, arguing that "the biology of the future would not be confined to Earth, but would take the character of *cosmobiology*," perhaps one of the first terms used to described a field that would study the possibilities of biological and life activities beyond our planet.

Strughold (1959) noted that the term *Astrobiology,* appeared as a book title in the Soviet Union, published by Gavriil A. Tikhov in 1953. In 1955, Russian-born American astronomer Otto Struve (1897–1963) pondered the use of the word *Astrobiology*, using it to apply to the broad study of life beyond Earth. The first director of the National Radio Astronomy Observatory (NRAO), Struve organized the Green Bank Conference in November 1961, where the Drake Equation was discussed for the first time. The term spread over the world and in Brazil, Flavio A. Pereira (1956) published a book in Portuguese with the same title. In June 1957, Lowell Observatory Director, Albert G. Wilson organized the first "American Symposium on Astrobiology". The use of this term has become fashionable again, particularly with the launch of the NASA's Astrobiology Institute and other international enterprises like the *Centro de Astrobiología* in Madrid and the Ibero-American School on Astrobiology, organized by the International Centre of Theoretical Physics (ICTP), UNESCO and several other organizations in Caracas in 1999 (Chela-Flores *et al.* 2000).

As early as the late 1950's, two main scientific groups were dealing in the scientific area of "extraterrestrial life": Panel 2 on Extraterrestrial Life of the Joint Armed Forces-National Research Committee on *Bioastronautics* and the Space Science board of the National Academy of Science's Panel on Extraterrestrial Life. Panel 2 on extraterrestrial Life, chaired by Melvin Calvin (1911–), included the participation of Carl Sagan (1934–1996). The National Academy group was originally divided into two sections on the east and west coast of the United States. In 1960, Panel 2 disbanded, merged the east and west coast sections, forming Committee 14 on *Exobiology*, chaired by prominent biologist and geneticist Joshua Lederberg (1925–). During these early days, topics such as the search for life on Mars and the development of devices on board the first planetary spacecraft fell into the domain of *Bioastronautics.*

Lederberg (1960) published a seminal article where he coined the term *exobiology* to describe what he called "extraterrestrial origin biology". Years later, also defined the term *esobiology*, referring to Earth's own biology. According to Lederberg, "The overriding objective of exobiological research is to compare the overall patterns of chemical evolution of the planets, stressing those features which are globally characteristic of each of them".

In February 1963, a Symposium on *Current Research in Exobiology* was organized at the Jet Propulsion Laboratory (Mamikunian & Briggs 1965). In those early days, there was a discussion about the appropriate name for the new branch of science. In the preface to the proceedings of the meeting, Gregg Mamikunian wrote: "Biology outside the terrestrial environment has been named "exobiology" by Professor Joshua Lederberg of Stanford University, while others prefer the term "cosmobiology" to denote the biology of the solar system, the galaxy, and even extragalactic systems."

In 1964, another prominent biologist, George Gaylord Simpson (1902–1984), stressed that the development of the term *exobiology* was curious in view of the fact that the "science" has yet to demonstrate that its subject matter exists. Needless to say, Simpson did not share the euphoria among some of his colleague biologists some whom he considered "ex-biologists", which he converted to exobiologists (Simpson 1964).

However, over the years, many scientists have helped develope the new multidisciplinary field of exobiology, which involves the study of extraterrestrial environments for living organisms, the recognition of evidence of the possible existence of life in these environments, and the study of any nonterrestrial life-forms that may be encountered.

With the exponential development of radioastronomy, a new branch called *Interstellar Communication* appeared with the purpose of detecting radio signals from hypothetical extraterrestrial civilizations (Cocconi & Morrison 1959). In 1960, Frank Drake carried out the first experiment (Project OZMA), using the facilities of NRAO. The goal of these projects was the detection of artificial signals from distant stars, using the available radio telescopes around the world. Such detection would indicate that intelligent life that developed electromagnetic technology exits beyond Earth. During the sixties, several academic papers, books and meetings appeared under the denomination "Interstellar Communication" (Cameron 1963; Kaplan 1971; Ponnamperuma & Cameron 1974).

In 1965, in order to organize an international meeting on the problem of extraterrestrial civilizations, Prof. Rudolf Pesek (1979) devised the word CETI – an acronym for Communication with Extraterrestrial Intelligence. The choice was also connected with the well known fact that Ceti in Latin is the genitive of Cetus (family at which the Dolphins – species that humans were trying to communicate over the last four decades – belong) and that *Tau Ceti* was one of the two nearby stars (similar to our Sun) that Frank Drake observed in his Project OZMA. On 15 May 1965, at the seventh session of the International Academy of Astronautics (IAA) Board of Trustees meeting in Paris, Pesek proposed "CETI" as the subject of a three day IAA Symposium. After several meetings of the international organizing committee the recommended program was the following: (1) Astronomical Perspectives of Life, (2) Origin of Life and Life in the Solar System, (3) Evolution of Intelligence, (4) Evolution of Technical Societies, (5) Potential Sites for Extraterrestrial Intelligence and Search Problems, (6) Signal Acquisition, (7) CETI Impact on Mankind, (8) Prospects and Recommendations for Future Research.

This is, practically, the same agenda of modern international meetings on Life in the Universe. After years of negotiations, finally the symposium was replaced by a Soviet-American Conference on CETI (Byurakan, 5–11 September, 1971). The IAA CETI Organizing Committee canceled the planned conference and decided to organize a half-day "CETI Review Meeting" at the next International Astronautical Federation Congress in Vienna (1972). During the several international meetings that took place between 1965 and 1971 (in place of the canceled international CETI Symposium), the concept of "Interstellar Communication" was totally replaced by the new "CETI" acronym.

Ten years after the Green Bank Conference, C. Sagan, F. D. Drake and P. Morrison of the USA and V. A. Ambartsumian, N. S. Kardashev, I. S. Shklovsky and V. S. Troitsky of the Soviet Union, organized the first US-USSR conference on *Communication with Extraterrestrial Intelligence (CETI)*. The meeting was held in sight of the Mount Ararat, at the Byurakan Astrophysical Observatory (in the former Soviet Republic of Armenia) sponsored by the Academies of Sciences of both the United States and Soviet Union. Just as in Green Bank, the conference organizing principle was the Drake Equation (Sagan, 1973). In one

way of another, by these days the Drake Equation was considered the epistemological bases of the CETI research.

After a series of workshops organized by NASA, in the mid-seventies, some scholars worried that a hypothetical message from an advanced society might make us lose faith in our own, might deprive us of the initiative to make new discoveries if it seems that there are others who have made those discoveries already, or might have negative consequences (Morrison *et al.* 1977). Since we are under no obligation to reply to a received message, the organizers of these workshops decided to change the acronym *Communication* with Extraterrestrial Intelligence (CETI) to the *Search* for Extraterrestrial Intelligence (SETI). Since then, this term has been widely used for almost 25 years.

In the late eighties, in order to obtain some institutional support from NASA Headquarters and the U.S. Congress, the NASA SETI Project received the name of SETI MOP (Microwave Observing Project). While, in the early nineties, for similar reasons the name was changed again to HRMS (High Resolution Microwave Survey), deleting in a definitive way the word SETI. Finally, in 1993 the U.S. Congress canceled any NASA involvement in a SETI program.

The acronym SETI is still in some sense misnomer. As of now, we have no means for directly detecting *intelligence* over interstellar distances. What we can do is to attempt to detect any manifestation of a technological activity, produced by that intelligence. Imagine that we find, in the middle of the ocean, a message inside a bottle. We may be unable to understand the message, but can surely make the *abduction* that an intelligent being created the bottle. Abductive reasoning accepts a conclusion on the grounds that it explains the available evidence (Pierce 1997).

Contrary to the traditional statement that the scientific grounds of the SETI project is based on the possible numbers of the Drake Equation; here we proposed a different epistemological approach. Using the hypothetico-deductive method (Popper 1959), we make the hypothesis that there should be other intelligent beings in the cosmos, using the *Lakatosian hard core* that we are living in a Universe where the *Principle of Mediocrity* (Sagan & Shklovsky 1966) is valid. In this way we do not need to make any kind of hypothesis about the different evolutionary paths and planetary or other cosmic environments that would lead the intelligence to appear. In order to test our original hypothesis or more appropriately to falsify it, we must develope a comprehensive Search for Extra Terrestrial Technological Activities (SETTA) program. The laws of nature will always place limits on any possible technological manifestation.

It is much simpler to distinguish the artificial origin of a technological activity than to establish a universal criterion to determine how to recognize the signature of life on other worlds. Based on our understanding of the laws of nature, we can systematically explore all the possible artificial signatures. In a first approach the SETTA cosmic haystack has 10^{29} different "cells". Until now, just a mere fraction of 10^{13} to 10^{14} cells have been explored and we are still unable to verify or falsify our hypothesis that there are other intelligent beings in the Universe.

For these epistemological reasons, and based on the fact that over the last 40 years there have been, in the scientific literature, several different proposals – not all of them radio astronomical ones – to detect extraterrestrial civilizations

by analyzing their technological spin-off, we propose to replace the acronym SETI with SETTA since this defines more adequately this scientific activity.

2. The Professionalization of the New Science: the International Astronomical Union and the Search for Life in the Universe

The active involvement of the International Astronomical Union (IAU) in the Search for Extraterrestrial Life was initiated by its sponsorship of the Joint Session on *Strategies for the Search for Life in the Universe* during the 17th General Assembly of the International Astronomical Union in Montreal, 1979. This meeting was jointly organized by three IAU Commissions, #16 Physical Study of Planets and Satellites, #40 Radio Astronomy, and #44 Astronomy from Space. An international organizing committee chaired by Michael D. Papagiannis (1980) carried out the preparation for the meeting. This meeting finished with an open session held in the large auditorium at the University of Montreal that was attended by more than 1,000 astronomers and guests, with standing room only, characteristic of the interest generated in scientists and laymen alike by the subject of Life in the Universe.

Following the success of the Montreal meeting, in 1982, at the 18th General Assembly of the International Astronomical union (IAU) in Patras, Greece, Commission 51 was established to devote an international effort to the search for extraterrestrial life, and to create a broader spectrum of life from its primitive to its most advanced forms. Its first officers, elected for the period 1982–1985, were Michael D Papagiannis, President; Nikolai S. Kardashev and Frank D. Drake, Vice Presidents. In 1983, Papagiannis initiated the publication of the newsletter, *Bioastronomy News*, for the IAU Commission 51 members, and with it, defined this area of science using a new term *Bioastronomy* or the astronomical search for life (bios) in the universe.

After the first IAU Commission 51 International Symposium in Boston in 1984, the name of the commission changed to "Bioastronomy: the Search for Extraterrestrial Life". The starting objectives of the commission targeted broad areas and included a number of researchers and institutions around the world (Papagiannis 1985). The objectives established at that time were the following:

- To search for planets in other solar systems;
- To determine the evolution of planets and their atmospheres;
- Investigate the ability of these planets to sustain life over cosmic periods;
- The search for biological relevant interstellar molecules and study their formation;
- To search for radio signals of extraterrestrial origin – both intentional or unintentional;
- To search for different manifestations of advanced civilizations;
- Pursue spectroscopic detection of biological activity of primitive forms of life around other stars;

Figure 1. A group of prominent IAU Symposium 112 participants. From left to right: Edward M. Purcell (1912–), Nobel laurate, co-discoverer of the 21 cm hydrogen line; Philip Morrison (1915–), co-author of the 1959 pioneering paper on SETI that ushered the experimental era; Carl Sagan (1934–1996) , distinguish scientist and author; Michael D. Papagiannis (1932–1998) founder and first President of IAU Commission 51 and SETI pioneer Frank D. Drake (1930–).

- The coordination and promotion of all these activities at the international level, and the collaboration with other international organizations (astronautical, biological, chemical, etc.) that share common interests in these objectives.

After this meeting, the IAU Commission 51 Executive Committee established an international meeting should be arranged each three years.

3. A Demographic Account of International Bioastronomy Meetings

After the original IAU General Assembly Joint Session, held in Canada (Montreal, 1979) there have been six "Bioastronomy Meetings" organized by the IAU Commission 51. Three of them were organized in the USA (Boston, 1984; Santa Cruz, 1993; & Hawaii, 1999), one in Hungary (Balaton, 1987), one in France (Val Cenis, 1990) and one in Italy (Capri, 1996). There are plans to hold next 2002 Bioastronomy Meeting at the Great Barrier Reef in Australia. Table 1 presents a short account of the main characteristics of each IAU meeting, for example: date; IAU Status (e.g., symposium, colloquium, none); location; name and nationality of the chairman of the scientific organizing committee (SOC) and local organizing committee (LOC); number of registered participants; number of papers (for the 1999 meeting we include the number of all presented papers and not the number of published ones) and the names and nationalities of the proceedings editors.

Only 50 % of the six bioastronomy meetings got IAU official support. Considering that the IAU is an international organization and that the bioastronomical research needs a global perspective, it is interesting to note that all the Chairmen from the SOC were from the USA (and only one is a woman). Again, only one woman was elected as chair of the LOC. Sixty four percent of the editors are from the USA, while Argentina, France, Hungary, and Italy hold one editor each (9 %). Of the eleven editors only one (Karen Meech) is female. The number of participants (with the exception of the IAU GA JS) range from 80 to 192, while the number of presentations range from 68 to 144.

Table 1. Main characteristics of the "Bioastronomy Meetings".

Date	IAU Status	Location	SOC Chair	LOC Chair	No.†^{a}	No.†^{b} Pap.	Editors†^{c}
8/15-16 1979	IAU GA Joint Sess.	Montreal (Canada)	M. Papagiannis (USA)		35	21	M. Papagiannis (USA)
6/18-21 1984	IAU Symp. 112	Boston (USA)	M. Papagiannis (USA)	P. Morrison & Purcell (USA)	159	82	M. Papagiannis (USA)
6/22-27 1987	IAU Colloq. 99	Balaton (Hungary)	J. Tarter (USA)	G. Marx (Hungary)	∼80	68	G. Marx (Hungary) (1988)
6/18-23 1990	None	Val Cenis (France)	M. Klein (USA)	J. Heidemann (France)	107	87	J. Heidemann & M. Klein (France, USA)
8/16-20 1993	None	Santa Cruz (USA)	S. Gulkin (USA)	F. Drake (USA)	122	59	S. Shostak (USA) (1995)
7/1-5 1996	IAU Colloq. 161	Capri (Italy)	S. Bowyer (USA)	C. Cosmovici (Italy)	182	86	C. Cosmovici, S. Bowyer & D. Werthimer (Italy, USA) (1997)
8/2-6 1999	None	Hawaii (USA)	J. Rummel (USA)	K. Meech (USA)	192	144	G. Lemarchand & K. Meech (Argentina, USA) (2000)

†^{a}: Number of Participants; †^{b}: Number of Papers; †^{c}: Proceedings' Editors;

If we take a short look at the distribution of nationalities among the members of the Scientific Organizing Committees of the seven meetings we realize that there is a strong participation of members from the USA (45.24 %), while USSR/Russia has 10.71 % and France 9.52 % (see Fig. 2). The rest are distributed among members of Argentina, Australia, Canada, Czechoslovakia, Hungary, Italy, Japan, Sri Lanka, Switzerland and UK. In this group, only the representatives from Argentina are from a developing country (the member from Sri Lanka is Arthur C. Clarke, who was born and received his academic education, in the UK). In all these cases, there was a very little female participation.

It is interesting to note that besides the fact that while the population of China and India represents 38 % of the whole planetary population, none of these countries were represented in any of the international scientific organizing committees. Both countries have very qualified IAU members that may represent these regions.

We can organize the themes discussed in all the meetings under the following classifications:

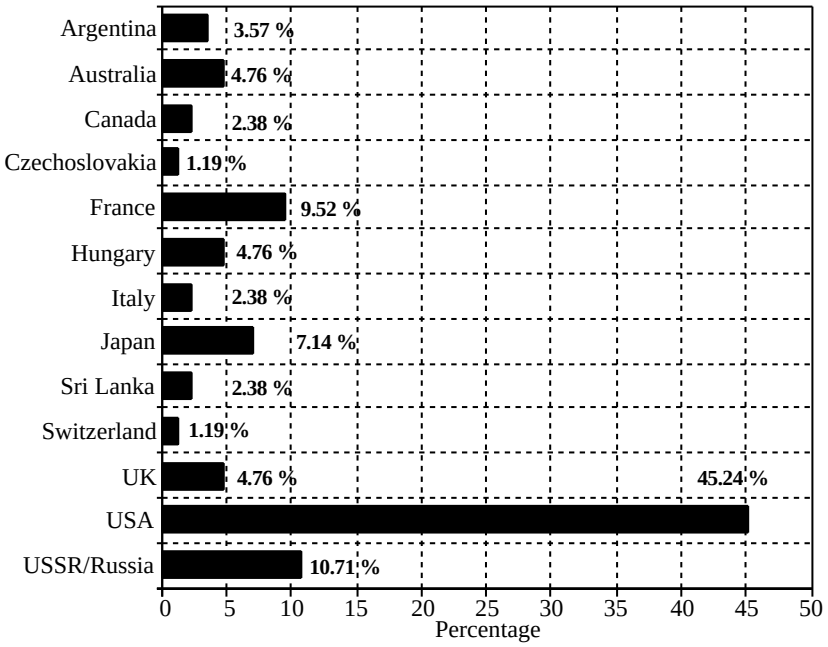

Figure 2. National distribution of the members of the international scientific organizing committees of the Bioastronomy meetings (from 1979 to 1999) organized by the IAU Commission 51.

- *Cosmic Evolution:* stars, chemical elements, the interstellar medium, molecular clouds, the solar system (planets, moons, comets, meteorites, and catastrophic impacts), evolution of planetary atmospheres.
- *Extrasolar Planetary Systems:* origin and evolution of planetary systems, protoplanetary disks, the search for extrasolar planets, etc.
- *Biogenesis:* organic and prebiotic evolution, early chemical evolution on Earth, origins of life, origin of biological information, the search for early life in the solar system, potential of life in other planetary systems.
- *Evolution of Life:* early life (blue-green algae and stromatolites), panspermia theories, evolution of complexity, geological co-evolution, climatological co-evolution, distribution and evolution of life intelligence.
- *SETTA (Search for Extra Terrestrial Technological Activities):* search for electromagnetic extraterrestrial artificial signals (radio and optical signals), the search for extraterrestrial astroengineering (e.g., Dyson Spheres), the Search for Extraterrestrial Artifacts (SETA) within our solar system (e.g. space probes), prospects for interstellar flights, detection systems, data analysis, RFI, etc.

- *Societal Issues and Reviews:* studies and analyses of the possible impact of the discovery of life beyond Earth (primitive or advanced), international political and legal frames on how to announce the eventual detection signal and how to organize a possible response. Educational tools related with the life in the universe topics and reviews of the conferences.

Figure 3 shows the distribution of topics among the seven conferences.

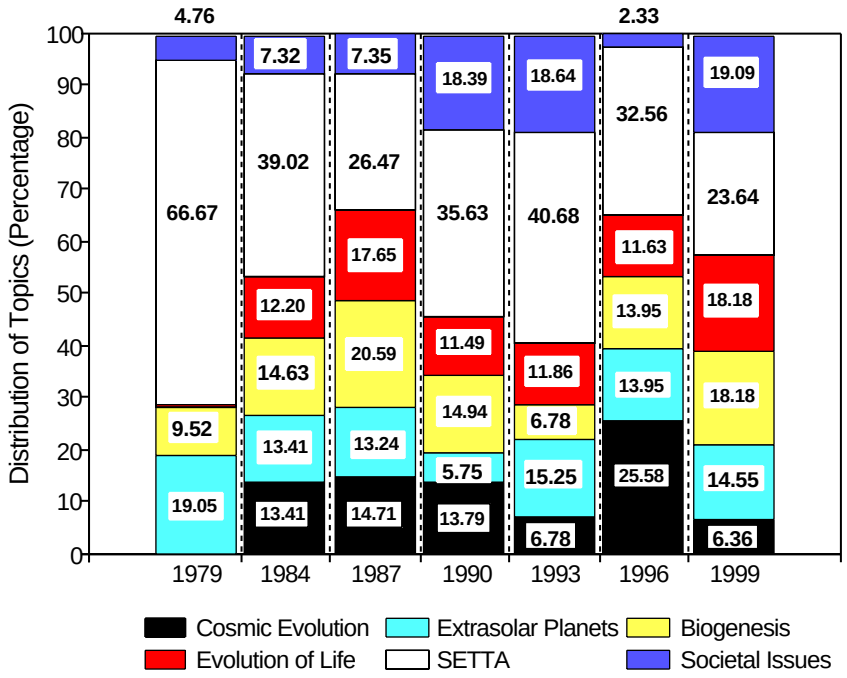

Figure 3. Distribution of topics at each conference: Montreal (1979), Boston (1984), Balaton (1987), Val Cenis (1990), Santa Cruz (1993), Capri (1996) and Hawaii (1999).

The average among the seven conferences gives the following figures: (a) Cosmic Evolution: 11.5 %; (b) Extrasolar Planetary Systems: 13.6 %; (c) Biogenesis: 14.1 %; (d) Evolution of Life: 11.9 %; (e) SETTA: 37.8 % and (f) Societal Issues and Reviews: 11.1 %. Clearly, the topic related with the Search for Extraterrestrial Technological Activities was, on average, three times more represented than the other themes.

4. Conclusions

After the first section, it was clear that there are two main groups dealing with the problems of extraterrestrial life. The first one (exobiologists, cosmobiologists or astrobiologists) is mainly formed by trained biologists and chemists who are focusing their research on the biogenesis and evolution of life on Earth and the

possible life within our Solar System (e.g., Europa, Titan, Mars). Most of them are members of the International Society for the Study of the Origin of Life (ISSOL) that sponsors sessions on exobiology at its triennial meetings. In 1957, Alexandr I. Oparin (1894–1980) organized, in Moscow, the first International Conference on the Origin of Life on Earth. Since then eight more international conferences were organized on the origin of life by ISSOL, as well as several *Gordon Conferences on the Origin of Life* and NASA Conferences on the Chemical Evolution and the Origin and Evolution of Life.

The second group is mainly composed of trained astronomers, physicists and engineers that are focusing their work in the search for extrasolar planets, the evolution of planetary atmospheres and geology and the radioastronomical search for extraterrestrial signals. After the 1961 conference in Green Bank, there were a couple of similar conferences in the Soviet Union during the sixties (Kaplan 1971). In 1971, the first Soviet-American Conference on SETI was organized in Byurakan (Armenia) and then repeated in Tallin (Estonia) in 1981 and in Santa Cruz (California) in 1991 (with a periodicity of ten years since the Green Bank Conference).

Under the leadership of Rudolf Pesek, the IAA has maintained a group on CETI/SETI since 1965. Beginning in 1972 it held annual reviews of developments in interstellar communications, SETI and interdisciplinary issues related with the possible impact on humanity of the detection of an extraterrestrial message (e.g., the detection and transmissions "protocols").

During the seventies, eighties and early nineties, NASA (both at JPL and Ames) played a very important role sponsoring a series of workshops and research and development groups that initiated in 1992 a huge observing program. As it was already mentioned, in 1993, the U.S. Congress cancelled all the funds for SETI research. The first private initiatives were supported by *The Planetary Society* in the early eighties and since 1994 by the *SETI Institute*.

In the last twenty years, the "Bioastronomy" meetings organized by the IAU Commission 51 have created an excellent environment to bring together scientists of both groups. Representatives from the cosmic evolution, extrasolar planets, biogenesis, evolution of life and intelligence, SETTA and several Societal and Educational issues, debated topics of common interest.

The international scope of the IAU is very important in that it gives the opportunity for scientists from less developed countries to participate and meet several world specialists in one meeting.

In the last twenty years, we evolved from the multidisciplinary to the interdisciplinary research on *life in the universe*. Our next step will be the creation of a new transdisciplinary science, passing the incommensurability problem that we have when we work with people trained in different disciplines who see the object of study in different modes. I hope that the next Bioastronomy meetings will continue to us the creative environment to finally reach the milestone where we will be able to find the evidence that we are not alone in the universe.

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