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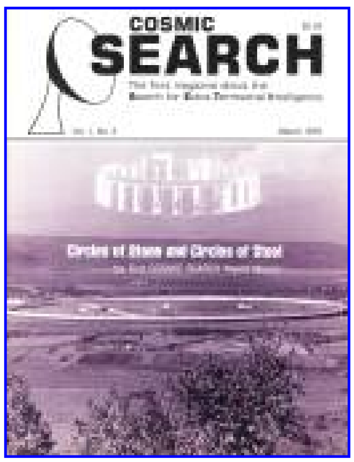

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The Case for SETI

By: Richard Berendzen

This article is a slightly abridged version of the statement Dr. Berendzen presented before the Subcommittee on Space Science and Applications of the U. S. House of Representatives' Committee on Science and Technology at Washington, D.C., September 19, 1978.

Mr. Chairman and members of the Subcommittee on Space Science and

Technology, I appreciate this opportunity to testify before you on the subject of SETI — the Search for ExtraTerrestrial Intelligence.

In the 19th century, Thomas Carlyle considered the stars and said: "A sad spectacle. If they be inhabited, what a scope for misery and folly. If they be not inhabited, what a waste of space." Or, as Lee DuBridge, Science Adviser to President Eisenhower, put it: "Either we are alone or we are not; either way boggles the mind."

The quest for mankind's kin invariably prompts philosophical speculations. But on the basis of modern knowledge, what actually do we know about this esoteric yet enthralling subject?

As recently as a generation ago, most scientists would have argued, often *ex cathedra*, that the likelihood is low that life exists beyond Earth. However, as Martin Rees has succinctly noted, "Absence of evidence is not evidence of absence." And accumulating evidence during the last two decades has convinced many scientists world-wide that extraterrestrial life probably does exist, possibly in enormous abundance. It must be noted, however, that incontrovertible proof has yet to be found: to date, the evidence is strictly circumstantial, but it is highly suggestive and possibly compelling. Today, the serious scientific search for extraterrestrial life commands the attention and respect of many of our most prominent, careful, and judicious scientists. SETI — in its sophisticated, modern form — is solid and sober, not tawdry or sensational.

Even for many informed skeptics, the question of the existence of extraterrestrial life has become not so much one of *if* as of *where*, and with regard to the search it has even become *when*, for ultimate contact may be virtually inevitable. This view was summarized recently in a report by the august U. S. National Academy of Sciences:

> Each passing year has seen our estimates of the probability of life in space increase, along with our capabilities of detecting it. More and more scientists feel that contact with other civilizations is no longer something beyond our dreams, but a natural event in the history of mankind that will perhaps occur within the lifetime of many of us ... In the long run this may be one of science's most important and most

profound contributions to mankind and to our civilization.

Life, yes — but in what forms? Extraterrestrial beings almost certainly will not be humanoids. It would be too extraordinary if this planet's conditions were duplicated precisely elsewhere. Our life resulted from a lengthy, delicate evolutionary process, which would have been permanently changed if any of a multitude of parameters had been different. Thus, although many scientists believe that life, even in advanced forms, probably is ubiquitous in the universe, they are equally convinced that there are no humans beyond Earth. In Loren Eiseley's words: " ... nowhere in all space or on a thousand worlds will there be men to share our loneliness ... Of men elsewhere and beyond, there will be none forever." Even in a fertile cosmos, life here remains unique and precious.

Biochemists believe that of the 100 plus elements known to man, only one can be the basis of life, here or elsewhere — carbon. Given that terrestrial life consists of aggregates of complex carbonaceous polymers, such an assertion may appear chauvinistic; actually it reflects nature itself. Carbon is the only known element capable of forming the intricate molecules so seemingly essential to anything approximating life as we understand it.

Earth from space (NASA)

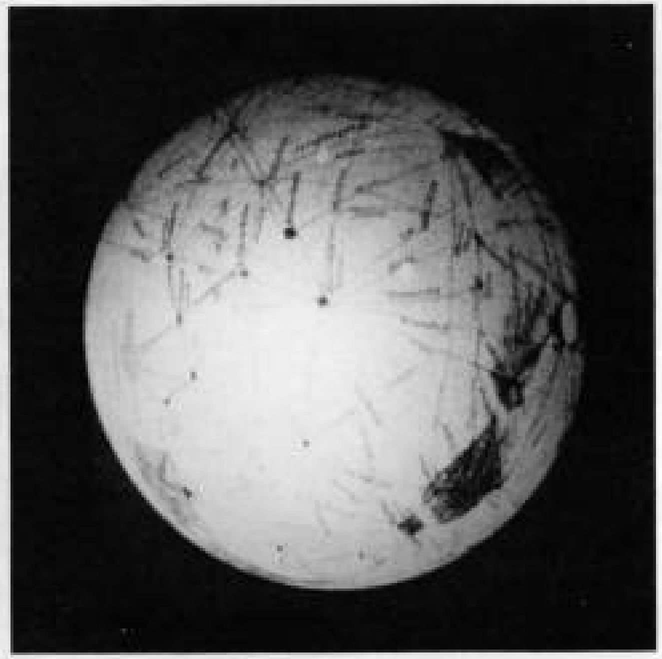
The insightful question about the genesis of life on Earth is not, "Was it miraculous?," but rather, "Was it unique?" In the 1920's, the biochemists Haldane in England and Oparin in Russia independently suggested that organic compounds could be produced from elementary inorganic molecules. Increased knowledge about the Earth's primordial atmosphere indicated that it had contained appropriate ingredients for the origin of life — hydrogen, ammonia, methane, water vapor. Then, in the early 1950's, Miller and Urey dramatically showed that these molecules would form amino acids if subjected to a laboratory simulation of the Earth's early conditions.

Subsequent research supports the conclusion that life likely will arise spontaneously, given the right initial situation. Of course, if we are wrong on this, irrespective of the cosmos's vastness, we could be alone. Even though terrestrial life now is hearty and adaptable, any one of a multitude of possible calamities could have prevented our development, such as inadequate supply of terrestrial water, severe irregularities in solar luminosity, major dynamical perturbations by the moon or planets, or collision with another astronomical object. Our biological beginnings may have been special, even unique; or perhaps no other suitable habitat exists. But besides the philosophical repugnance of this egocentric view, modern findings seem contrary.

Therefore, many of us believe that, under reasonable conditions, chemical and biological evolution will be inevitable. And, although the appearance of extraterrestrials may be wildly different from our own, their chemistry will be at least remotely similar. If this last assumption is false, then the following statements will constitute a conservative lower bound; *i.e.*, if non-carbon based life is possible, the overall prevalence of life will be even greater.

Of all the celestial objects, the one that for the longest time has prompted man to wonder if he is alone is the enigmatic Mars. Like Earth, it has seasons during which its polar caps shrink in the spring, while its equatorial regions darken as if vegetation were being nourished by melting liquids.

And in 1877, a leading Italian astronomer reported sighting long rectilinear features on the Martian surface — "canali," or channels. This innocuous term was later Anglicized to "canals," which implies intelligent intervention. At the turn of the century, the quest for Martian life was championed by Percival Lowell of the prominent Boston family; and, in the early 1920's Marconi reportedly detected Martian radio signals. Moreover, on the evening of 21 August 1924, as Earth and Mars passed exceptionally close to one another in their elliptical orbits, many radio stations worldwide ceased broadcasting for several minutes each hour in order that Martian radio signals might be detected.



Percival Lowell's map of canals on Mars made about 1900.

Another impetus to the Martian intrigue arose in the mid-1930's, when a clergyman read a story over British radio alleging that communists were invading the countryside. That this fictitious account should elicit widespread consternation prompted a perspicacious young American radio producer to employ a similar ruse but with creatures even more terrifying than communists — Martians. This led to the famous radio hoax in 1938.

Due to local atmospheric turbulence, ground-based astronomy from Earth cannot provide a definitive answer about the nature of Mars's surface; hence, an *in situ* experiment was needed. In 1971, our understanding of Mars changed dramatically as a NASA probe returned by far the best photographs seen of the planet until that time. Although they did not settle the question of Martian life, they revealed a fascinating world, with gargantuan volcanos and colossal canyons. The fabled canals were revealed to be nothing more than undulating natural depressions, and the equatorial darkenings were explicable without life forms.

Still we do not know about the possible presence of microscopic Martian life. The rigors of Mars would make life difficult although not insuperable. NASA's Viking mission has been stupendous but many questions remain. If even elementary life forms were discovered on Mars or elsewhere in the solar system, we would be emboldened, for the presence of two life-supporting objects about a single star would strongly imply prevalence elsewhere.

But our discussion today focuses on intelligent extraterrestrial life, and that unquestionably implies a search outside our solar system.

To proceed, let us assume that life will arise only, if not reside permanently, on planets, not in interstellar gas clouds or elsewhere. Again, if we were wrong on this, our estimates would be too conservative.

Our story now must turn to the planets's parents, the stars. Our Sun is one of more than 250 billion stars composing the Milky Way galaxy, in a universe containing tens of billions of galaxies. In fact, there are more stars in the heavens than there are grains of sand on the beaches of Earth. Of these multitudes of stars, which might make suitable parents for life-supporting planets? A candidate star should be moderately luminous, roughly like the Sun. Extremely luminous stars burn nuclear material so rapidly that their lifetimes are mere fractions of the Sun's; hence, life near them probably would have insufficient time to undergo the arduous process of evolution. In contrast, extremely under-luminous stars burn slowly, permitting biological evolution; but their ecospheres, or habitable zones, would be small, requiring potentially life-supporting planets to orbit so close that they would be forced to keep one face perpetually towards the star, thereby evaporating their atmosphere on one side while freezing it on the other. A candidate star should also be temporarily stable; it should not pulse in size, or erupt, or throw off gaseous shells, or spin frantically. Therefore, we omit as prime candidates such objects as variable stars, novae, planetary nebulae, and pulsars.

The planets themselves must not undergo dynamical perturbations. Roughly half the stars in our galaxy are members of multiple systems in which two or more stars lock gravitationally and orbit each other. Planets around a member of such a system might be perturbed by the other star. To be cautious, let us discard all multiple star systems as being dangerous abodes for life.

The next question is whether any of the suitable stars actually possess planets. Several independent lines of evidence suggest they do. Theory indicates that stars form by condensing gravitationally from the gas and dust that lace throughout a galaxy's spiral arms. As such a nebula contracts, apparently it can split into clumps of different mass: a large one with several small companions, leading to a single star with planets; or several of comparable size, leading to a multiple star system. In principle, a substantial fraction of the suitable stars could possess planets.

And planets appear to be observed orbiting some of the stars nearest the Sun. Interstellar distances are so vast that a Jupiter, much less an Earth, would scarcely be visible directly at even the nearest star. Planets can reveal themselves indirectly, though, by the minute wiggle their gravitational pull causes in the path of their parent star. After decades of painstaking observations, such perturbations seem to have been detected for a few nearby stars. (The measured size ofthese shifts, incidentally, is about the same as a hair's angular diameter as seen at one mile.)

The planets appear to exist, but are the requisite chemicals available? Even though chemical analysis of these planet's atmospheres lies far beyond our present capability, in the past few years radio astronomers have discovered numerous forms of interstellar molecules, including biologically significant ones. Considering that the planets formed in such an environment, it seems highly plausible that their atmospheres contain the substances necessary for biochemical evolution. Hence, we now strongly believe that the suitable parent stars exist, the planets exits, the chemicals exist, the necessary conditions exist. But does all that imply that extraterrestrial life exists?

Findings and conjectures such as these have prompted several bold efforts to estimate the number of extant civilizations that might be attempting interstellar communications within our galaxy. Even though such calculations obviously are plagued by unknowns, science can provide educated guesses for all the factors involved, save one — the length of time a civilization will spend in a communicative phase. The number of civilizations in the galaxy today turns out mathematically to be roughly equal to this time span expressed in years; *e.g.*, if advanced civilizations survive for an average of a million years, then about one million of them are extant in our galaxy. Paradoxically, the greatest uncertainty in this calculation may arise not from the study of nature but of Man.

Within the solar system we can search directly for non-intelligent lower life forms like ferns or bacteria. But outside our parochial environment, the hypothetical creatures must be communicative if we are to find them. The most dramatic way to communicate would be through direct contact; however, even using wild extrapolations of contemporary technology, deep space voyages seem highly problematic. If a rocket could burn with the efficiency of the solar interior, the energy requirements for a round trip even to a nearby star still would be enormous. Such pessimistic conclusions are based not on our ability in technology but on our understanding of nature. The distances between stars are characteristically light-years; yet, Einstein showed us that no craft can travel faster than the speed of light and even to approach that rate would require titanic expenditures of energy. Although perhaps ingenious solutions eventually can be found, most astronomers today concur that interstellar space travel will be untenable, at least for Earthlings, probably for generations to come.

Nevertheless, interstellar communication could be achieved immediately by using the fastest, most efficient mode known — the electromagnetic spectrum, of which visible light is only a small portion. In the 19th century, several imaginative but vain proposals were made for attempting visual contact. The mathematician Gauss, for instance, suggested planting a pine forest in Siberia in the shape of a Pythagorean triangle, as a detectable sign of terrestrial intelligence. And an astronomer proposed signalling by burning kerosene in a 20 mile-wide ditch to be dug in the Sahara desert.

Are we equally naive today? Undoubtedly! That unprofound observation, however, should not prevent action; if it were to do so, we would ensure the blunting of mankind's ingenuity. To paraphrase William James, only by risking do we live at all.

Astronomers now study the heavens with radio waves as well as with visible light, and such bands now seem to offer the uniquely rational mode for interstellar communication: They are easily transmitted and received, propagate over interstellar distances without being absorbed, stand out against background stars, and travel at the maximum speed in nature — that of light.

Coincidentally, we on Earth inadvertently have been sending out such signals for the past few decades, through our use of radio and television and of military and scientific radar. At present, mankind's major interstellar emissary is commercial radio and TV.

Pine forests planted around a 16 kilometer Pythagorean triangle, proposed by the famous mathematician Karl Friedrich Gauss about 1820 as a way of indicating to extraterrestrials that there was intelligent life on the earth.

But to communicate this way, we should follow a play on Biblical dictum: In the case of SETI, it is better to receive than to send. We fail to know not only exactly *where* and *how* to send but also *when*. Even if we knew that a certain star had a habitable planet and that radio was the proper medium, our message might not arrive there at the proper epoch: It could come before the inhabitants had evolved to the level of radio technology or after they had passed that era or even after they had annihilated themselves. If we were to receive a signal, such problems would vanish. On the other hand, if each civilization were to follow such logic, none would transmit, at least until it could do so without being exorbitantly consumptive. Because our radio ability is in its infancy, we are as technologically primitive as a civilization can be and yet achieve interstellar communication. Thus, if we make contact, the other beings must be as scientifically advanced as we, and possible eons ahead.

On 8 April 1960, the first serious attempt by man was made to intercept signals from other beings, when a radio telescope was tuned to 21 centimeters. (1420 megahertz) and pointed at a Sun-like star about 10.5 light-years away. (See "A Reminiscence of Ozma" by Frank D. Drake in the January 1979 COSMIC SEARCH). Since then other searches have been made in the United States and abroad, looking towards a handful of nearby candidate stars, usually at 21 centimeters, because interstellar hydrogen emits at that wavelength, producing a prominent natural marker presumably known to all advanced beings.

The attempts to date have been negative, as one would expect considering the range of unknowns involved. Nevertheless, it is sobering to realize that today the world's largest radio telescope — the 300 meter diameter surface at Arecibo, Puerto Rico — would be capable of communicating with its twin, if one existed, even in a distant part of the galaxy.

Contemporary science is already able to identify candidate stars and likely wavelengths, and contemporary equipment could detect the signals if they were transmitted with devices no more powerful than our own. These are but a few of the reasons why many serious scientists treat the search with new respect: Science fiction is rapidly becoming science fact.

Presumably, the initial discovery of life elsewhere will be made one-way and at-a-distance; that is, we will infer the existence of life on another planet by detecting non-natural, quasi-coded radio emissions from it. Such signals could be intentional messages or inadvertent radio noise, revealing the other planet's advanced technology. Of course, other scenarios probably will occur, especially among advanced beings, but irrespective of the details, inhabitants here seemingly will have at least these options: to avoid response; to return a radio signal that can be readily detected and decoded; or, possibly, to launch spacecraft towards the other planet. Clearly, if Earth ever discovers such a radio emission, mankind will face monumental decisions.

Regardless of the wisdom of making initial contact, it could occur serendipitously: At our modern level of technology, we might accidentally discover other civilizations or vice versa. Although we can only poorly affect the ability of others to detect us, we can strongly influence our capability to find them, by making concerted searches. But should they be made?

Science fiction is replete with tales of potential hazards, a common one being the invasion of Earth. But such holocausts would require the other beings to be aware of us, as well as we of them; also, it assumes the feasibility of interstellar space flight. As another danger, the beings elsewhere could subvert us intentionally with their seemingly beneficent broadcasts, playing on our ignorance. Obviously mankind would have to proceed carefully, guarding against impetuosity or gullibility. And there is the serious possibility of culture shock. Just the realization that we truly are not alone might be traumatic, but would it threaten our egos or shatter our institutions? Even the converse could happen: At last the commonality of all Earthlings might become more apparent. But suppose the messages we received were both benign and voluminous, enabling us to leap centuries in knowledge. Would that celestial umbilical cord rob us of our own ingenuity, or would it inspire us to new heights?

The most frequently cited benefit to come from contact would be instant technological gain. Even though this might occur, the immense distances militate against lively repartee. A two-way conversation would require tens or possibly hundreds of years, even using radio and anti-cryptography (that is, readily readable messages based on parameters in nature). But if information could be transmitted and deciphered — from an advanced, friendly civilization to us — it might enhance our understanding not only of science and technology but also of arts and humanities. Perhaps it would provide us with new aesthetic forms, raising our consciousness and making life more rewarding. And the very existence of such long-lived civilizations would prove that the rigors of survival are not inevitably debilitating. In short, we possibly could join what has been called the "galactic heritage".

And with our ability to comprehend comes a yearning to explore, to move out of Cradle Earth, even to know our kin beyond. If the estimates of scores of modern scientists are correct, at this instant there may be thousands if not millions of advanced civilizations, whose radio transmissions are passing not merely through space but even through our very bodies. If we only knew exactly where and how to look and had the will to do so, life on this planet might at last reach childhood's end.

Rarely, however, do major triumphs come easily. Requiring monumental ingenuity and resolve, this search would be like virtually no other effort known before. What we contemplate here would challenge our imagination and wisdom with unprecedented effort in diverse disciplines; moreover, it would test our fortitude, possibly spanning not only terms of Presidents but also lifetimes of scientists and even of nations.

But irrespective of the pros and cons of searching, would the inquisitive human mind be willing to forego the quest? Within the next few decades we will have explored most of the "ghetto Earth", as our planet might be viewed in its present state of cosmic quarantine. Will humankind limit its vision over astronomical time periods to this minute locale, especially with the ability to do otherwise at hand?

The sternest arbiter of all is not the President, the Congress, or even the People; it is

Time. Before that unforgiving master, how will our judgments stand? As we sit in the Court of Ferdinand and Isabella, will we give Columbus his ships? Are we willing to look through Galileo's telescope? Dare we join Darwin on the *Beagle*? How long will we tarry at Newton's seashore, while the ocean of truth lies undiscovered?

Only in exceptional epochs do we face such decisions. Now is one of those times. Even though the issues here perhaps seem vague, implausible, and futuristic, their ultimate significance possibly could dwarf the Apollo Project, if not the entire space program.

But about this search we are fearful — of appearing naive, of venturing imprudently, of proceeding hastily, of squandering resources, of confusing priorities, even of achieving success. Yet, as Bronowski has noted generally: "We are all afraid — for our confidence, for the future, for the world. Yet every man, every civilisation, has gone forward because of its engagement with what it has set itself to do."

- Our root questions here come down to these:

1. Are our reasoned suppositions and circumstantial evidence misleading or wrong? Given that we cannot know the answer precisely, are we yet confident enough to proceed? If not, when will we be—at what stage of discovery, with what degree of certitude?

2. How much are we willing to pay to achieve contact—in terms of money, time, and commitment—especially if for decades the search were unsuccessful?

3. And even if the search is practical now, do we actually want to know if there is life beyond Earth? Do we want to make contact?

- Each person must answer individually:

1. For myself, I am impressed by the current evidence, even if not entirely convinced. That the modern findings are inconclusive and incomplete is unarguable, but so too is the unmistakable fact that they cannot be ignored. Science never rests. Contrary to popular belief, science is not an immutable body of

absolutes — codified, comprehensive, and final; rather, it itself is a growing, evolving process. And that generic truth holds for the case here. Instead of only lamenting about our ignorance, let us also rejoice at our knowledge; while steadfastly recognizing our limitations, let us likewise acknowledge our achievements. And of late, they have included the piecing together of a wondrous mosaic — spanning eons of time and leaping millions of light-years in distance, ranging from stellar core to atomic nucleus, from primordial egg to human gene. The data are not all in, nor will they ever be. But from what we do know, a reasonable person could reasonably conclude that we likely are not alone.

2. Any responsible search should include, at core, cutting-edge science and technology; accrued benefits should be both potential and immediate. Like in any pursuit, the suitable level-of-effort in this one should be simultaneously frugal and adequate, commensurate with the task. But would even modest funding for such a search be extravagant or wasteful? In short, would the search be worth the cost, however low? If contact eventually were achieved, the $24 purchase of Manhattan Island would pale in comparison; and even if the search were not successful, the ancillary scientific and technological benefits alone would justify it.

3. I believe Mankind's desire to know if we are alone and to make contact with life elsewhere is instinctive, innate, indelible. If not now, then soon, a methodical search *will* begin. If not by the United States, then by other nations, it *will* be made. And I believe *here* and *now* to be the proper place and time. To me, the answer is clear and irrefutable: Yes, let us proceed!

Richard Berendzen is University Provost of the American University, Washington, D.C., and a member of the Editorial Board of **COSMIC SEARCH**. For the premier issue (January 1979) he contributed an editorial "Science and the Multitudes" and also an article "Time and a Cosmic Perspective," a biographical sketch accompanying the latter.

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- *"Contrary to the Biblical dictum: In the case of SETI, it is better to receive than to send."*

- *"SETI may be one of science's most important and profound contributions to mankind and our civilization."*

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