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**SCIENCE AND THE EXTRATERRESTRIAL HYPOTHESIS IN UFOLOGY**

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## SCIENCE AND THE EXTRATERRESTRIAL HYPOTHESIS IN UFOLOGY

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**ABSTRACT:** The literature relating to extraterrestrial intelligence (ETI) is surveyed to provide a basis for judging the extraterrestrial hypothesis to be an acceptable alternative concept for use in analyzing UFO phenomena. Other common issues facing ufology, ranging from the general argument about its scientificness to concerns about specific and puzzling characteristics of some reports are addressed.

### INTRODUCTORY REMARKS AND THE GROWING INTEREST IN ETI

The idea that extraterrestrial intelligence could be behind some elements of the great mixture of experiences lumped together under the term "UFO phenomena" has rarely been seriously discussed by the scientific community (Sagan and Page 1972; Hynek 1972; Condon 1969). It is natural that this silence has been taken by other academics and the educated public as an indication that the position is not worth taking seriously. Given the tenor of our debates upon extraterrestrial intelligence *elsewhere* in the galaxy, this is a peculiar and certainly inappropriate state of affairs. This paper will attempt an overview of the status quo of facts and hypotheses which are most relevant to the subject of ETI and the odds on life elsewhere visiting nearby space. It will try to place ufology and its extraterrestrial hypothesis into this context.

Since the 1960s, a growing group of scientists has directed a significant amount of thought and writing to the question of ETI. They have debated the odds of the existence of such beings, the possibility of their travelling between the stars, and the means of contact between them and ourselves. Carl Sagan and Frank Drake have become the leading proponents of the belief that our galaxy is teeming with intelligent life and technologically advanced civilizations (MacGowan and Ordway 1966; Shklovskii and Sagan 1966; Sagan 1973; Drake 1976).

Despite the intelligence and prestige of many of the leaders of this optimistic view, the vision had an air of complexity yet lack of concreteness which made it easy to disregard as unfocused speculation. Many conservative scientists felt that the field of study was not a field at all. The major tool which has swung the atmosphere of opinion has been the "Drake Equation," constructed as a heuristic device by Frank

Drake, and which has served well in generating discussion about specific issues where data of some sorts are available.

The Drake Equation is a mathematically simple string of multiplicative factors, as follows:

$$N = R_* f_p n_e f_i f_c L$$

The definitions of the factors are:

$N$  : the number of currently extant hi-tech galactic civilizations;

$R_*$  : the rate of galactic star formation;

$f_p$  : the fraction of stars which have planets;

$n_e$  : the number of earth-like planets per system;

$f_i$  : the fraction of earths which will form life;

$f_c$  : the fraction of ecologies which will evolve intelligences;

$L$  : the mean lifetime of an advanced civilization.

This mathematical "outline" has allowed discussants to split up the complex problem into more discrete bits upon which current science may have a say. Tentative conclusions from the last decade's debates are sometimes surprising in their concreteness and always interesting in their scientific, sociological, and psychological insights.

When one peruses the ETI literature, the following major discussions stand out:

- a) the Drake Equation factors  $n_e$ ,  $f_i$ , and  $L$ ;
- b) interstellar travel and "colonization waves";
- c) time scales and extremely advanced societies;
- d) ETI motivations and behaviors towards ourselves.

Taken as a piece, the literature tends toward the following vision: ETI occurs in great numbers of locations in our galaxy, and probably has the means and even the motivation for some degree of exploration and/or communication. A minority opinion holds that ETI is disinterested, paranoiac, rare, or non-existent. What follows is a review of the major facts and points of issue in this dialogue.

It is intriguing when placed against the backdrop of the UFO phenomenon.

#### THE GALAXY AND THE STARS-THAT-ARE-SUNS

Everyone agrees that the universe is vast and old and loaded with galaxies and stars. Almost nothing in science is more obvious. And because of this, and the foundation stone faith of science in the "Uniformity of Nature," almost no intuition is stronger than that the universe is filled with life. There are many people for whom all that is required to settle that question is one good look at the night sky. The methods and attitudes of science are more slow afoot, however, yet perhaps more

sure. The factor in the Drake Equation which takes "one good look at the night sky" is  $R_*$ .

$R_*$ , the rate of star formation in our galaxy, seems a straightforward matter, and in fact there is very little debate. If we have a reasonable understanding of starbirth, we can look to likely galactic locations and make a direct estimate. Or, if we have a reasonable history/timescale of the galaxy and a good starcount, we can divide stars by time and get another estimate. Both approaches have been taken and the results are given with an aura of confidence: our galaxy has averaged about 25 starbirths per year, and has perhaps slowed down to between 1 and 10 starbirths per year in its current mature stage of development.

This author prefers to alter the meaning of  $R_*$  to remove some of the confusion which enters later factor-analyses in the Drake Equation. Because some stars are never suitable for life-formation, and others become unsuitable as their life histories progress, it seems appropriate to settle the "star question" all at once at the beginning, and to eliminate unsuitable categories of stars now. This amounts to changing the concept  $R_*$  to  $R_{\odot}$ , the rate of "sun-formation" in the galaxy. "Sun" is here defined in its limited sense as a star possessing the proper lifespan, metallicity, and force-environment (re: Luminosity; stability; companion stars) such that a life-advancing timescale and planet-formation were at least possible.

*How many proper stars or suns are born in the galaxy per year? The question is less difficult than it may seem. In fact there is also little debate about it in the literature. The key assumptions are regarded as conservative:*

- a) Life in advanced forms needs a long time to evolve, perhaps 2 to 6 billion years. Any proper star should have a lifetime at least that long;
- b) Life in advanced forms needs a planet to develop upon. Any proper star should have arisen from a molecular cloud rich in heavy elements so as to make planet formation at least possible;
- c) Life in any form needs a hospitable energy environment, not involving wild energy swings and radiation bursts. Any proper star should allow stable orbits for rotating planets and planets beyond radiation flare zones.

Assumption "a" eliminates all fast-and-hot burning blue giant stars of the so-called O, B, A, and upper-F classes. Assumption "b" eliminates all so-called first generation stars, stars arising early in the history of the galaxy from the only available elements of that era: hydrogen and helium. Forming as they did before the building and dispersal (by supernovas) of the heavy elements, there was no heavy material to initiate planetary cores, ergo no planets, no base upon which to evolve ecologies.

Assumption "c" eliminates several categories of stars. No stars close to the galactic center are candidates due to extreme violent energy environments throughout the nucleus area. In fact it has been postulated that the nucleus

occasionally erupts violently in extreme forms of radiation outbursts, the waves of which would scour at least the near-nuclear systems of life (Clarke 1981). Such outbursts could be violent enough to destroy ecologies galaxy-wide unless their systems were shielded in the galactic arms when the "killer wave" passed by. On the other hand such shock waves could be the impetus for new star-system condensation and be ultimately a "biogenic" wave instead. Either way, the concept of the Milky Way as an occasionally explosive Seyfert galaxy brings an unknown but potentially time-synchronizing element into the discussion about the level of advancement of galactic ecologies.

Other stars are eliminated by assumption "c" as well. No small cool red-dwarf stars of so-called M and Lower-K classes are proper suns. Their relatively dim heat sources require planets so close as to be at risk from solar flaring and to be gravitationally locked (one face always roasting while the other freezes). A third category, multiple star systems, might be eliminated due to the planetary formation and orbital destabilization problems caused by the gravitational dynamics between the close stars. Many multiple star systems have been shown to allow stable close-in planetary orbits, however, and the estimates of acceptable multistar systems vary from 10 to 90% (Ksanfomali 1986; Gillette 1984; Dole 1964; Harrington 1977).

When we take our "good look at the night sky" with these restrictions in mind, we find that our galaxy has about 250 billion stars. Eliminating the mass at the nucleus and the non-heavy-metalead star systems of the halo, we are left with about 100 billion disk stars. Getting rid of the few large bright stars and the many small dim ones, and about half of the remainder which exist in multiple systems (keeping the other 50% of the sun-like multiple partners), we are graced with a total of about 6 to 15 billion "proper stars," or suns.

These are the later generation stars of the lower F, G, and upper K classes, most single but some in permissible double-star arrangements, and all in the galactic disk. If these stars formed at a somewhat regular rate across galactic history, there would have been about one per year. Because we are interested in the formation rate far back into the past (5 billion years ago when our solar system was being born) so as to estimate civilizations of our level of advancement or greater, perhaps this would be the most accurate figure to accept. Our system formed about halfway into the current lifespan of the galaxy. The use of  $R_{\star} = 1$  is, if anything, conservative, as there was certainly an initial period in galactic history when no high-metallicity stars formed whatever, and so the proper stars we count are probably more bunched toward our own time frame. But,  $R_{\star} = 1$  is an acceptable starting point...and 6 to 15 billion sun-like environments.

Such a beginning springboard of the imagination could lead a prominent scientist such as Philip Morrison of MIT to state "it is both timely and feasible to begin a serious search for extraterrestrial intelligence," while almost simultaneously declaring about ufology: "I have now, after a couple years of fairly systematic listening and reading, no sympathy left for the extraterrestrial hypothesis" (quoted in Ridpath 1975).

As this is on the surface of things an extremely puzzling dichotomy of positions, and yet one which seems to accurately reflect establishment scientific thinking, we must proceed on in search of some explanation.

### PLANETS

Whereas there is almost no confusion about the vast numbers of proper stars, there is an apparent disagreement about planetary systems around them. This "debate" evaporates into a near uniformity of opinion once it is unraveled, however. Planet theorists and observational astronomers are arguing about whether clear evidence exists as yet for an extra-solar planetary system, leading some listeners, perhaps, to conclude that scientists think that planets are rare. Actually, astronomers are nearly universal in their belief that although planets are extremely difficult to detect with our current tools, they are commonplace, almost ubiquitous in the galactic disk. David Black, one of the most eminent planetary researchers, has stated that "Current planetary theories suggest that planets should be the rule rather than the exception" (Black 1987). In fact he asserts that if, once our technology improves, we cannot find *large numbers of other planetary systems, we will have to revise our whole theory of star formation.*

Confidence in numerous planetary systems is based upon more than pure theory. Several lines of research have indicated the overwhelming likelihood of such systems. They include:

- a) Since, in terms of the mechanism of formation, stars and planets differ from one another only in the amount of mass originally involved in their condensation, the formation of a *second* star orbiting about a primary is essentially no different than the formation of a big planet. Multiple stars are, therefore, planetary systems wherein at least one "planet" condensed from a lump of the cloud which was so large that it allowed nuclear fusion in the core, and the "planet" *became self-luminous, a second star.* We can see and count such "planetary systems" quite easily. About one half of our disk stars seem to be in such systems, and on that observation alone the phenomenon of a larger mass with smaller masses allied to it must be common. Unless there is something unforeseen unique about stellar-sized objects which favors their formation while blocking that of slightly smaller planet-sized objects, planetary systems must be at least as common as double stars.
- b) Our own solar system provides several, not one, examples of such systems. Not only do we have our system at large, but also several mini-systems in the moons of the Jovian planets. Large rotating centers-of-mass seem to naturally acquire secondary bodies revolving about them. An intriguing added fact that the elemental composition

of our solar system almost precisely matches the composition of the galactic disk leads to a further intuition as to the normalcy of our situation. Given similar basic materials and forces, what took place here should have taken place elsewhere in the galaxy as standard practice. Leading planetologists John Lewis and Ronald Prinn say:

"It is widely, but not universally, accepted that stars form from moderately dense nebulae comprising gases and dust with overall elemental abundances essentially identical to those in the Sun and in other normal (Main Sequence) hydrogen-burning stars" (Lewis and Prinn 1984).

- c) Several physical measurements have indicated the probable existence of planets around specific nearby stars. These measurements include gravitational tugs or wobbles caused by the pull of large unseeable objects on the stars, or infrared indications of circumstellar dust disks (expected accompaniments of planet-formation), or the slow rotational movements of stars (as if they had transferred some of their rotary motion to other bodies which now revolve about them) (Hobbs 1986; Hecht 1987; Gatewood 1987). Recent Doppler shift work by Campbell seems to confirm our positive expectations on the common occurrence of planets around nearby stars (Waltrop 1987).

The subsequent conclusions of almost all planetary theorists and astronomers are optimistic and eminently reasonable:

1. Planets are a natural ordinary feature of the cosmos;
2. Only our inadequate technology prevents us from directly settling the question.

To this position, the current author would add the following corollary, which is the view of almost everyone interested in ETI:

3. Probably *all* the sun-like stars in the galactic disk, as defined above, will have planetary systems. In the terms of the Drake Equation, the fraction of "suns" which are accompanied by planets is very close to unity ( $f_p = 1$ ). There are perhaps 6 to 15 billion sun-like disk stars with associated planetary systems.

#### EARTHS

Earths are defined here as rocky terrestrial planets which stably orbit their suns for long periods of time at a distance which allows a proper temperature/radiation input so as to keep the solvent-of-life, water, in its liquid state.

The frequency of occurrence of these objects has been the point of a quite intense debate, which is not totally resolved. The core material initiating the debate was provided by Michael Hart, who felt that certain facts and models indicated that our Earth was a very lucky, exceptional place, perhaps even unique (Hart 1978, 1979). The majority of the "pessimistic" commentators, however, seem merely to repeat Hart's conclusions, or, at best, build slightly off his basic model. The motivations of

this school of thought seem to range from a need to explain the "absence" of ETI visiting our solar system (a position which not only assumes the absence of evidence in the UFO phenomenon, but also ignores the obvious fact that we have not explored most likely locations in our system for evidence of present and past ETI), to apparently emotional concerns about humanity's place and future role in the universe. The most vocal of this school are enthusiasts for either human interstellar migration via advanced spaceships or for the "anthropic principle" as seen as "proof" that the universe has been designed particularly to evolve human intelligence as some sort of climactic pinnacle (Bond and Martin 1980; Martin and Bond 1983; Tipler 1980, 1981). If we scrape away the irrelevancies, the argument, as regards "earths," is still based on essentially one thing: Michael Hart's conceptualization of what he called the "Continuously Habitable Zone" (CHZ) for life-bearing planets.

To critique this issue we should begin with the standard version of what planetary theorists think would go on in the formation of a system around a sun. When a sunlike star condenses by gravity out of a heavy molecular cloud (a hydrogen/helium cloud littered with substantial amounts of heavier elements), other grains and lumps and centers of attraction also form. Such meteoritic or cometary lumps aggregate and condense into the cores of planets surrounded by the hydrogen-rich gas of the cloud. The cloud condenses, spins, flattens until there is a disk-like system with the proto-sun at the center and the proto-planets revolving in a flattened plane about it. An early super-bright phase of star-formation then blows the primaeval light gas of the original cloud from the rocky cores of the planets-to-be which are nearest the star. The cores continue to condense and heat-up as heavy elements engage in radioactive decay. Solids melt and metals sink to the center, while a lighter crust forms and floats. The crust fractures and gases escape to reform an atmosphere (more hydrogen and helium, but, more importantly, carbon dioxide, water vapor, nitrogen, and a few other components). The solar wind has now abated, and this new atmosphere becomes the true primordial atmosphere of our earth-like planets (Torbett et al. 1982; Lewis and Prinn 1984).

Now the planet cools. This is the critical phase. Will the planet cool enough to rain out its vaporous oceans-to-be? If the planet is too near the sun, it will not. Instead, insufficient liquid water will be present to dissolve the carbon dioxide.  $\text{CO}_2$  will pack the atmosphere as continued venting of gases occurs in the crust. This "greenhouse gas,"  $\text{CO}_2$ , will trap more and more heat until the atmosphere and surface temperatures are at a level unsuited for even elementary life. Such was the fate of Venus. Thus, some promising planets will be too near their star.

They can also be too far. On such a planet the rains will be complete and the  $\text{CO}_2$  will be dissolved. The processes leading to life may well begin. But as the primordial heat of the planet, insufficiently augmented by the incoming radiation of its star, continues to drop, liquid water freezes and glaciation begins. Such an early potential life-generating planet will die. This was probably the fate of Mars (Pollack et al. 1987). Even better placed life-generators may reach a later crisis caused by



atmosphere changes due to the biogenic release of massive quantities of oxygen. Such changes also result in less heat retention and potential irreversible glaciation. This last risk may be substantially modulated by the atmosphere controlling activities of the most primitive life forms in the oceans (the so-called GAIA force), however (Lovelock 1980; Margulis 1982).

Therefore, there is a life zone surrounding each sun-like star, a strip within which a planet must luckily form if it is to be a liquid-water earth. What are the odds that such a stroke of luck will occur? Hart and the school of minority opinion say that the chances are so slight that it is almost impossible to get a planet slotted into this narrow channel. Hart's models indicate that the galaxy is filled with Venuses and Mars lookalikes, and the Earth, the fabulous fluke, could be unique.

This position is now largely discarded or severely modified even by the pessimists. The reasons are several:

- a) The original atmospheric models have turned out to be overly simplistic and even directly inaccurate in some of what they did include (Schneider and Thompson 1980);
- b) The original models totally ignored the effect of life forms (microorganisms) in stabilizing atmospheres;
- c) More complex, and probably more accurate, modelling of early atmospheres predicts the probability of much wider liquid water zones, particularly on the "cold side" of the strip (Kasting et al. 1988);
- d) Our own Earth's history shows adaptation to widely differing solar energy inputs while maintaining remarkable temperature stability at the surface, a stability impossible if the pessimists' models were anywhere nearly correct (Schneider and Thompson 1980).

Newer models of atmospheres and temperatures point to life zones six or seven times wider than the Hart estimate. In our own solar system with the Earth at the reference distance of 1.0 astronomical unit, Hart's model pointed to a life zone between 0.95 and 1.01 AU. The new estimates increase the local life zone to between 0.86 and 1.25 (or greater) AU. Venus, for reference, is too hot at 0.72 AU. Mars is a bit too cold at 1.52 AU. With this wider zone what are the odds of an earthlike planet forming there? We do have some guides with which to estimate this answer.

When we look at the spacing of the planets in our own system, we are struck with an intuition of a patterned array. The great rocks seem to lie in lanes of movement at "respectful" distances from one another, gradually widening the gaps as we look further from the Sun. The Bode-Titius equation hints at a regularizing mathematical physics which rules their positions, as if primaevial forces of gravitational resonance, collisions, available mass, or whatever, determined the design. As our theories of system formation become better at approximating the realities we see in our own planets, we are able to alter the initial parameters (star size, cloud metallicity, angular

momentum) and watch as our computers form alternative planetary arrays in moments. The arrays stay essentially the same: small rocky terrestrials in close to the star, a transitional zone, big Jovian gas balls further out, all gradually widening their gaps to their next further neighbor. Our own system should not be widely deviant from the others of the galaxy.

If the arrangement of our terrestrial planets was precisely the rule for our galaxy, it would be an easy task to lay down a grid containing the "too hot," "habitable zone," and "too cold" regions, and overlay the spacing of our four terrestrials on it. We could then slide the planets up and down and make a quick estimate of how often one would happen to fall in the zone. For our system, a planet falls in the life zone over 90% of the time (about 92.4% actually). If our system was average in this sense, then the vast majority of extra-solar systems would have a terrestrial planet in the zone. Our own spacing would allow a few systems (about 8.5%) to have two earths in the zone. The fact that the two numbers add up to something very close to 100 is not mysterious; it simply follows from the fact that our life zone's width (0.39 AU) is about equal to our average planetary spacing in the terrestrial zone (0.38 AU). This is perhaps just a coincidence, and maybe not even that true, given our future refinements of life zone width estimates. But it may also be just another intuitive reason to believe that earths are a natural product of the cosmos.

Such reasoning and the perusal of many computer-generated arrays has led researchers to estimate varying numbers for the amount of earth-like worlds. Planets do form and almost always one falls in the ecozone, but other concerns (axis inclination, mass, orbital eccentricity, and period of rotation) moderate many of the guesses. Depending particularly on what the model used says about planetary mass, estimates made upon widened (non-Hart) life zones would place earthlike planets with all the proper characteristics in the zones between one-third and two-thirds of the time for stars very much like the sun. Because most of the suitable stars will be smaller, perhaps calling for generally smaller planets as well, the odds may drop. Stephen Dole drops them by a factor of ten (to 1 earth in every 200 stars in the disk); Martyn Fogg drops them by a factor of fifty (1 in 1,000 stars); and the "Hart school enthusiasts" of Bond and Martin drop them by a factor of five hundred (1 in 6,000 to 12,000 stars). Bond and Martin, and even Fogg, used modified Hart models and their estimates would seem too low. Dole seems more legitimate and perhaps his guess is best for the moment (see Fogg 1986ab, for comparisons). If there are more determinant factors ensuring proper mass contents for terrestrial planets near the life zones (and other orbital characteristics), then the following more optimistic estimate by Sebastian von Hoerner of the National Radio Astronomy Observatory could well be true:

"Some astronomical estimates show that probably about 2 percent of all stars have a planet fulfilling all known conditions needed to develop life similar to ours. If we are average, then on half of these planets

intelligence has developed earlier and farther, while the other half are barren or underdeveloped" (quoted in Ridpath 1975).

#### THE RIGHT STUFF IN THE RIGHT COMBINATIONS

Will the right sort of planet revolving at the right sort of distance around the right sort of star produce life? The answer seems to be: yes, if it has the right sort of material to work with. Everything to date points to the conclusion that the right materials are automatically there. It is a conclusion practically without debate.

We have a convincing concept for the general formation of the elements (*everything heavier than hydrogen and helium*). They are formed ubiquitously in the galaxy in the cores and the death throes of stars. The larger stars disperse these elements to space in similar ratios wherever they destroy themselves in their titanic explosions. We have measured the composition of the resultant molecular clouds by spectroscopy. It is a pleasing revelation to find that the composition of the galaxy at large matches that of our solar system. The crucial fact seems assured: the elemental stuff that allowed planets, Earth, and life in our solar system was, and is, available everywhere else in the disk, once the galaxy went through its initial element-building and dispersing stage (Fowler 1984; Wood and Chang 1985).

We find, then, that the proper elements exist ready for further formation, and these elementals are already combining to form useful molecules. Some of these molecules are chemically active organics which could lead to biology. Especially creative scientists have even imagined life itself being pieced together in space on dust grains or cometary particles (Hoyle and Wickramasinghe 1980). Whatever the truth of that, it is almost a certainty that the chemistry-of-space produces important biological molecules such as amino acids, the monomeric units of proteins (Ferris 1984; Greenberg 1984). Such substances and others of importance have been found in carbonaceous chondrite meteorites (Engel and Nagy 1985; Irvine 1987).

"Around 4 billion years ago, showers of comets and meteorites may have carried the basic compounds of life to Earth. During their encounters with Halley's Comet, the Vega and Giotto spacecraft detected many of the elements necessary for life. Analyses of meteorites and cometary dust that have fallen to Earth have shown us that these interplanetary objects are often rich in organic material."—William Irvine, University of Massachusetts.

These discoveries are important in that they add three almost certain pieces to our vision of the formative days of planetary systems and earthlike worlds:

- a) chemical reactions between the elements are so programmed that massive quantities of organic chemicals are made in space and exist in the heavy molecular clouds from which planetary systems form;

- b) much of this organic substance condenses into chondritic dust and lumps which form the basis for early planetary cores, contributing ready-made organic chemicals to the neonatal planets;
- c) even after planet formation, more lumps and dust (a carbonaceous meteoric rain) continue to fall into the new environments of the "earths," seeding them with potentially biogenic compounds.

This should be happening, and did happen in the past, all over the galaxy: billions of earths soaking up a prebiological rain. The right stuff is present at the right time. Is this enough to ensure life?

When our chemists began to simulate the primordial atmosphere and energy conditions, they were delighted to discover that these original circumstances spontaneously began creating the chemicals of life. For two decades the advances have been continual and positive (Calvin 1975; Dickerson 1978; Hartman et al. 1985). The primitive conditions not only produce the right biochemicals but they seem to do so in a non-random way. Chemistry's products are determined, and not just anything is possible. Certain atomic arrangements (for example, just certain amino acids or nucleic acid bases) are strongly favored over other arrangements in the same biochemical classes of compounds. There seems to be a limited set of biochemical units out of which earthlike life, and presumably all galactic life, can be constructed.

The linking together, or polymerization, of these small units into the vital structures of proteins or nucleic acids is currently impossible to imitate in our labs in short time frames. Nevertheless, three lines of reasoning lead us confidently to suspect that such polymerization occurs in orderly, rapid and probably uniform fashions on Earthlike worlds:

- a) Several polymerization mechanisms have been researched and a few seem to work. They involve high-energy sources (e.g., UV-radiation, lightning, volcanic heat) and high-surface-areas for encouraging catalysis (such as on the bubbles of sea-foam or in the matrices of clay materials). All of these conditions should be available galaxy-wide. Related work, such as the melting of pure biochemical monomers together, and analyzing the resultant products, again shows that not just anything is possible. These melts yield a surprisingly limited variety of polymers.
- b) A second line of reasoning involves attempts to calculate the most stable aggregation of molecules, the molecular alliance which would have the best chance to persist in primitive planetary environments. The winners seem to be those aggregates which ally proteins and nucleic acid polymers, the same crucial alliance which lies universally at the basis of Earth's life (Eigen et al. 1981; Schuster 1984).

- c) The third line of reasoning is a deduction from a single observation. *Whatever* route the biochemicals took to form polymers and beyond to simple life, it was not difficult and it happened very rapidly. Life appeared in its simplest forms almost as soon as the Earth had cooled and settled enough to permit it (Groves et al. 1982; Ferris 1987; Gould 1978).

"On Earth, Life began almost as soon as the planet was cool enough to form seas. If this is typical, there may be as many as 10 billion Earth-like planets in our Milky Way alone. Today we contemplate a universe teeming with life, some of which may be intelligent."—Bernard Oliver, chief, NASA SETI program (1987).

More pieces of the prebiological puzzle continue to come to light. The discovery of microspheres, bilayered spherules which spontaneously form from certain proteins, is another important example. These structures behave much like cell membranes, creating differential electric charges on their surfaces and showing division behaviors uncannily like living units. Work with these microspheres and other simple pre-biological systems has inspired their discoverer, Sidney Fox (1984), to say: "The experiments suggest that evolution of molecular complexity was capable of occurring from simple beginnings very rapidly...in days or less" (quoted in Ridpath 1975).

Such optimisms about life formation abound in the cosmochemical and protobiological literature. The trend of the work to date supports such optimism. Given the right stuff in the right places (a situation which is the expected galactic norm), life will spontaneously and rapidly form. Returning to the Drake Equation, the factor " $f_1$ " is "1"; life does it every time, and quickly. It is the basic biochemistry of the universe.

"The elements required for life—carbon, nitrogen, hydrogen, oxygen, phosphorus, and sulfur—originate in the formation of stars. Then they evolve into larger organic (carbon-based) molecules in space between the stars. In primitive planetary environments they combine into the building blocks of life, evolve into enzymes and the genetic code, organize into complex and stable cell-like structures, develop self-replication processes, and grow from simple to complex living things."—Donald DeVincenzi, NASA Ames Research Center (1987).

#### BIO-ADVANCE

The subsequent two factors in the Drake Equation,  $f_i$  and  $f_c$ , which concern themselves with the advance of life in complexity until it achieves intelligence and tool-using civilization, are usually considered together, and often as arbitrary

benchmarks on an inevitable progression of bio-abilities. Some years ago opinions concerning biological advance would have been largely intuitive. Now the answer is essentially certain. Life inevitably advances in complexity. This insight is the gift of one of the twentieth century's great discoverers, Ilya Prigogine (1980; Nicolis and Prigogine 1977).

Prigogine solved the paradox of an evolving life-force in a thermodynamically dissipating universe by demonstrating the following:

- a) If an entity is both unstable (i.e., malleable, alterable, flexible, changeable) and self-organizing (i.e. capable of structuring and maintaining itself),
- b) and such an entity is "perturbed" (i.e. challenged, altered, stressed, damaged) by some force,
- c) then that entity will re-organize itself taking the perturbing force into account. It will tend to maintain its previous talents, while adding to them something which contends with the offending perturbation. It will become "more clever" in existing.

Such great insights always have the characteristic of being "obvious," once someone finally sees them.

Life forms are quintessential "unstable, self-organizing systems." Unless the perturbations they face are so disruptive as to kill, they will advance, they will evolve. Although this "advance," through extinctions and difficult times, is not uniform, the arrow of time and the arrow of bioevolution generally are in step.

All across Earth's surface and Earth's time, perturbations and restructurings have been taking place. Uncounted numbers of biological trials and errors have offered themselves up for testing by the physical and living environment. The winners have survived. Some writers have suggested that we make very risky judgments about advanced life in the galaxy when we base our thoughts on the "single case" of life on Earth. "Planetary chauvinism," Carl Sagan and others call it. Surely life fills the galaxy in unthought variations. Perhaps. But, whereas we are probably at great risk to apply specific macroscopic appearances from Earth forms to other galactic life, concerning the fundamental patterns of life there may be little or no risk at all. The patterns of design and basic structures of our life forms are neither random nor inflexibly linked to some peculiar or singular set of conditions on this planet. Our life forms do not represent "one case." They are the consummation of the experiments of billions of years to find the tools of survival, the structures and behaviors that work. And we have already seen how much alike the earthlike physical environments throughout the galaxy should be.

Support for the idea of common patterns of advanced life comes from more than intuition. Concrete evidence lies all about us. It is called convergent evolution. In isolated ecologies we see life forms which not only occupy similar niches but have also developed similar sizes, shapes, functional structures, and even behaviors. Life,

through all the experiments-to-exist, finds and refinds the paths to success. Convergence of form and behavior implies that "getting it right" involves a limited number of structures and abilities for each task. Our world separately evolved two kinds of bats, animals so alike that we didn't recognize their evolutionary separateness until very recently (Pettigrew 1986). We have marsupials almost indistinguishable from placentals. We have mammals (dolphins) looking like fish (sharks) looking like reptiles (mosasaurs). We have two dozen independently developed kinds of eyes. Some things obviously work and some don't. Some are so valuable that they are bound to arise many times. As biologists begin to take more and more physics into account in their discipline, it will be seen that the forms and abilities of organisms can not be infinitely variable in their basic patterns. And the same physics will operate throughout the galaxy (Reif and Thomas 1986).

There is little or no debate in the ETI literature about the general end-product of the advance of life. Complexity, great size, even intelligence and civilization are viewed as inevitable stages along the flow of evolution.

"Parallel or convergent evolution is a common phenomenon. Hence we see on Earth repeated, but separate, appearance of advantageous characteristics such as multicellular organisms, eyes, or wings. Such evolutionary developments are therefore not unlikely in living systems elsewhere in space."—John Billingham, NASA Ames Research Center (1986).

Intelligence, or encephalization, has been shown to be part of the strong trend of complication in bio-development as well (Russell 1981), and our own advanced intelligence is viewed as the product of a sequence of events which could as well operate on other life forms of our world should we have failed.

"The view that mankind's development was a lucky chance, and the only one, may perhaps be not quite right. It may well be that nature was making a number of experiments in homonization....It's quite conceivable that, given the same starting conditions, and given enough time and evolutionary opportunity, it could happen more than once."—Philip Tobias, University of Witwatersrand (quoted in Ridpath 1975).

Reflecting on these matters, David Attenborough argued that, if man became extinct and vacated the top of the intelligence niche in Earth's ecologies, there exists "a modest unobtrusive creature somewhere that would develop into a new form and take our place."

Without quibbling about the exact details of similarity between ours and other planets' life forms, the consensus of the literature upon the Drake Equation factors  $f_i$  and  $f_c$  is: once life begins on a long-existing earthlike planet, the advance to intelligence and tool-using civilization is inevitable.  $f_i$  and  $f_c$  are "1."

"Something like the processes that on Earth led to man must have happened billions of other times in the history of the galaxy. There must be other starfolk...these non-human creatures of great learning have doubtlessly been sending explorative expeditions through interstellar space for countless millenniums."—Carl Sagan, Cornell University.

#### SUMMARY OF THE DRAKE DEBATE

The ETI literature and related scientific research developments indicate good reasons for optimism about the amount of life, even intelligent life, which has arisen in the galaxy. As Frank Drake likes to put it: about one new intelligent civilization appears in the Milky Way a year. The question remains: how much of this intelligent life is still around? In the Drake Equation this refers to the final term,  $L$ , the mean lifetime of an advanced civilization. This current author has been quite impressed with the insights of modern science in casting light on all the other factors of the Drake equation. We know a great deal and we're advancing all the time. But this last factor,  $L$ , is almost a complete mystery. Sadly, all we can offer is a few tenuous guidelines.

Our galaxy was formed about 10 billion years ago, and it was at that time composed almost entirely of hydrogen and helium: no heavier elements, no heavy molecular clouds, no planets, no life. A significant but undetermined amount of time must have passed while the first generation stars built heavy elements in their cores, the larger stars exploded as supernovas, and these elements were dispersed to space. A great deal of this needed to happen before the "metallicity" of the galaxy would be high enough to allow formation of rocky terrestrial planets. For perhaps the first three billion years this process went on in the sterile galaxy. Perhaps seven billion years ago some solar systems outside the nucleus formed planets upon which the processes described earlier in this paper began. Two billion or so years later our own solar system was formed and we began the crawl up evolution's ladder.

If anything like the above picture was true, then some systems may have begun life-building a couple of billion years before our own. If so, and if Frank Drake's "one civilization per year" (essentially referring back to between one and ten sunlike stars per year) rule-of-thumb is anywhere near, then perhaps 2 billion civilizations have arisen before our own. The extremes are easily determined. If no civilization ever dies off (i.e.,  $L$ =lifetime of galaxy), then all 2 billion or so are still "out there." If civilizations execute themselves immediately (i.e.,  $L = 1$ ), then there is only one. So one can be either form of extremist: pessimist or optimist. For the optimists one must admit that nearby supernovas or huge galactic nucleus events may scour some systems of life. For the pessimists one must admit that even our own erratic selves have managed to make it forty-plus years past the invention of nuclear weapons and are still staggering into the future. Intuition, all that we have on this issue, would seem to say: some make it, some don't. Even the most pessimistic



scenarios would seem to be forced to the conclusion that there are advanced civilizations out there somewhere. And a little more faith in intelligence produces this:

"There may be abundant groups of  $10^5$  to  $10^6$  worlds linked by a common colonial heritage. The radar and television announcement of an emerging technical society on Earth may induce a rapid response by nearby civilizations, thus newly motivated *to reach our system directly* rather than by diffusion [emphasis added]."—William Newman, UCLA, and Carl Sagan, Cornell (1981).

#### THE QUESTION OF APPEARANCE

As we have seen, knowledgeable commentators on ufology do not object to the extraterrestrial hypothesis on the basis that there are no extraterrestrials. Some apparently learned commentators do object that any visiting extraterrestrials will not look at all like us, and that the anthropomorphic similarity of the described "ufonauts" is alone enough to disqualify those reports as fantasy (Simpson 1964; Dobzhansky 1972). But, whereas a precise identity to *Homo sapiens* in UFO reports would be very difficult to explain in any independent evolution scenario, a similarity of basic patterns of structure may be far more likely than is generally recognized.

Commentators on advanced extraterrestrial life can agree on several foundation stone concepts. This life will be based upon the same primary elemental mix, the same solvent, the same basic chemistry, and polymers of amino acids and nucleic acids, and the energy systems utilizing phosphate molecules. The life forms will develop in relatively similar physical environments, including solar radiation, atmosphere contents, comparative planetary masses, temperature similarities.

Observing the apparently required sequence of evolutionary events, one must add to those similarities multicellularity, oxygen-use, sexual reproduction, large size, mobility, and, if a manipulative tool-user, evolved from a land-dwelling animal form. The large size (required of any intelligent evolved creature) demands several other crucial characteristics. The creature must be a large tube with an input end and an output end, a "head" and "tail." Nutritional intake, processing, absorption, and rejection proceeds most efficiently on a linear assembly line basis. Simple osmosis or other more passive mechanisms cannot deal with a large land-dwelling situation. For the same reason there must be a branching tubal circulatory system powered by a pump to reach all cells. The gas transport system should use the same tubes to avoid redundancy. The large mass will require a skeleton, which must be internal to allow mobility and flexibility. Such an animal will be bilaterally symmetrical along the line of the tube. The head end will concentrate the central nervous system and the major information-gathering senses, especially sight and sound. The brain must be seriously protected by some enclosure, and be directly and proximately attached to the major sensory organs.

These traits are recognized as required or determined by simple logic and physical laws. They are also recognized as being wholly dominant in all large land-dwellers and most large water-dwellers on Earth. This is not in any way an accident peculiar to our planet, but the result of limited sets of possible forms being tested and retested in the fires of universal physics, chemistry, and predator-prey relations. We are beginning to discover these limitations as biologists begin to apply physical principles to biological structures and systems. We are beginning to realize the power of certain structures or packages of characteristics as we learn more about evolution and its parallel or convergent production of similar traits. As is now commonly stated in reference to the two dozen or more independently evolved eye structures: some ideas are so important that they must independently reoccur many times. If ETI life forms did not have *very* similar visual organs situated close to the brain and above the food-intake orifice it would be an astonishing surprise.

The most convincing trend in biology which will indicate the likelihood of structural similarity of advanced life forms everywhere comes from the growing application of physical principles to biology. The field is still largely in infancy but the initial insights are impressive. Limitations on the variety possible in design turn out to be far more restrictive than most biologists suspected. The systems of fluid transport and filtration are based on only 5 and 6 design principles, respectively, no matter in which life form they appear. An interesting specific example of limited design is the "fibrewound cylinder," the commonest skeletal unit on the planet. This structure appears in plants, many lower animal forms, and some higher animal forms such as the swimming mammals. It allows lateral bending while resisting longitudinal compression, a useful combination of flexibility, mobility, and strength. A particular angle for winding the fibre around the cylinder is most efficient in balancing these traits. *This exact angle evolved several times*, let alone the separate evolution of the structure-at-large (LaBarbera 1986). Mathematics and physics will apply everywhere. So too will fibre-wound cylinders wound at "terrestrially-observed angles."

Even large biological categories, such as skeletons, have limited numbers of designs. A finite definable number of skeletal types has been described and related to earthly forms. Almost every type turns out to exist on Earth, most of them with many representatives (Reif and Thomas 1986). The message is this: physics, geometry, strength of materials limit the number of structural possibilities. Within these limits a dynamic ecology will inevitably fill each useful structural niche, usually many times over.

"We are not pretending that the outcome of evolution was fully determined or predictable, but we want to argue against the supposition that all things are possible. The same design elements show up again and again."—R.D.K. Thomas, Franklin and Marshall University.

A rather amazing case of structural determinism has been presented in the relationship between the capacity of mammalian bones to accept stress (before breaking) and the maximum likely stress those bones will be called upon to withstand in their owner's lifestyle. Investigators looked at small mammals such as rodents, at medium ones such as humans, at big ones such as elephants. All the ratios turned out to be *exactly the same*. Somehow the trials and errors of survival in nature have converged (Reif and Thomas 1986). Balancing all the differences of mass, activity, jumping, running, fighting, every type of mammalian bone became designed to achieve the same safety factor: they all can sustain three times the force they are likely to encounter in their lifestyles. This is another apparent example of a powerful order-giving trend governed by basic physical principles, which in this case makes all bony skeletal mammals astonishingly the same. Similar mathematical relationships exist for hydrostatic skeletal structures such as tentacles, tongues, and elephant trunks. Would these same principles apply elsewhere in the galaxy? It is difficult to conceive why not.

With these encouragements in mind let us address a prominent observable feature in advanced life forms which some scientists seem ready to doubt in an alien life form: the number of limbs, two arms, two legs. How really unlikely is it that advanced intelligent life forms evolving elsewhere will have this familiar morphology? A brief examination of our own development of this pattern may offer some grounds for more than a purely intuitive comment. Life here developed in the seas and moved to the land. Such a pattern must be the pattern elsewhere as well. Earthly life in the seas had a long period for advancement before the constitution of the atmosphere allowed movement to the land. Oceanic life was therefore quite advanced before any elaborate land life was possible. Given the time scale for such atmospheric change, this also should be the general pattern elsewhere. Many sorts of things can ultimately crawl up out of the sea to make a living on the land, but only the bony skeletal vertebrates were able to support the size, mobility, and potential for intelligence necessary to be a dominant advanced form. Again, and as we have seen, it is simple physics. It was therefore the fishes from which came the dominant land animals, amphibians, reptiles, birds, and mammals. But what determined the limbs? (Radinsky 1987).

Fish have fins, and it is from the fins that the four-limbed pattern of land-forms developed. Not all fins evolved. Fins along the midline of the animals simply disappeared in the land-forms. Why? They weren't useful anymore. They didn't help move the animal, and steering and stability in a dense fluid medium were no longer relevant. Fins distributed bilaterally in pairs were still useful. Primitive amphibious landlubbers could paddle and flop themselves forward using such fins in the way we might use oars in a rowboat. The more out-of-water time spent by the species, the more effective these fins needed to be as true walking structures. But why "four," and not six as in the insects, or eight as in the octopus, or any other number?

One might claim that the major reason for advanced land animals having four limbs was simply an accident of having evolved from fish having four bilaterally

paired fins, the pectoral and the pelvic. But fish were not always this way. The earliest forms had no fins. Later, all sorts of patterns appeared, including types with more than four bilaterally paired. Such experimentation by nature continued until the seas became dominated by the pectoral/pelvic pairs pattern. Accidental? Random chance? Almost no serious evolutionist utilizes such explanations today. This pattern became dominant because four was, on the average, more useful; it had a survival advantage. Can we understand what that advantage was?

Any such understandings, like all scientific queries which probe into the past, cannot be stated with certainty. We can, however, make some reasonable assessments based on our current knowledge. To start, since all advanced land life develops from bony vertebrate mobile ocean forms, and such forms are tubal and strongly "ended" in structure, these developed land forms will be tubal, ended, and bilaterally symmetric. The likely numbers of fins, which become primitive and evolved limbs, will be "paired": two, four, six, etc., rather than three, five, seven. For all of our advanced forms, the "answer" has been four. A large animal not yet possessed of a significant intelligence, might benefit on the basis of stability alone from more than two limbs. But the main reason is simply that having only two limbs nearly cripples the individual from doing more than one thing at the same time (e.g., standing while defending oneself). But then should not six or eight be better yet? There are two possible reasons why this may not be true, and as knowledge progresses, we'll probably know exactly why four is not only a useful number but a demanded one.

When an animal is large, every major structure of its body is a major genetic and energy expenditure, and a major site of risk. It is a place which can be hurt, infected, and cause death. Adding major structures to a species' form is a situation, therefore, which is carefully weighed by nature's struggle of survival. Six, eight, or multi-limbed organisms minimize their problems by strategies of dropping limbs or regrowing them, strategies inconceivable for a large advanced animal, given the energy and material commitment. Small creatures such as salamanders are probably at the limit of those which can afford such a luxury. Large land-dwellers need very strong supportive members. The problems of dispensing with strong joints and elaborative circulatory and nervous connections, and then restructuring it all later, make it obvious why such a large animal is "stuck with" the number of limbs it has in good times and in bad. More is, then, not necessarily better.

The main factor may be the nature of the brain. A big animal is, in a sense, in more than one place at the same time. Its brain must be able to independently and effectively control each of its limbs so as to avoid the most trouble and accomplish the most gain. The brain seems to be limited as to just how much of this it can do. Perhaps because of the stress of monitoring and station-keeping labor it does keeping track of bones, muscles, sense perceptions, and spatial relations in the limbs, or perhaps because of something even more fundamental about brain structure, the brain seems not to be able to properly focus upon 6 or 7 things at a time. Four things, four limbs, seem easily manageable. Five appendages as with prehensile tails or

elephant trunks, seem well-managed also. But six? At this point the brain seems to fail. The six-legged world of insects operates on a non-independent 3-up/3-down "tripod" walking pattern, most of the time. Very little independent control is possible for the minute brains of insects, and so the complex task of walking is simplified by a six-limbed robotic system with a stable tripod always on the ground. Instead of six, we might better consider their brain's task a task of controlling *two* sets of three during this apparently complex activity.

The octopus is quite intelligent and seems to do a good job controlling its eight limbs, thus contradicting our theory. But despite its abilities as one of the Earth's best problem-solvers, the burden of controlling eight limbs severely limits what it can do. Tentacle movement is extremely complex and most of it must always be left to unconscious robotic control rather than focused intentionality. So limiting is this burden, that despite its high intelligence no octopus can learn a maze (Reif and Thomas 1986). The explanation for this brain-dependent preference for lower numbers of limbs is not clear, but it seems to be clearly true, and points to why we have four limbs and not six or more. Does this mysterious "mathematics" of our earthly brains apply only to our world? Maybe, but considering that the preference has held so strongly across time and types of species on Earth, one wonders if something more powerful and universal may be going on.

The point of the foregoing is not to prove anything but to show that, at the least, the facile dismissal of morphologically similar aliens needs a lot more work than authoritarian guesswork. A reasonable case can be made that common macroscopic designs happened here and elsewhere on the basis of simple physics, geometry, strength of materials, and whatever yet unknown processes limit the controlling abilities of central nervous systems. Further arguments might be made for four or five digits on hands and feet, the arrangement of facial features, basic advanced reproduction designs, certain patterns of sensory intake and brain processing. But there are also many areas allowing much room for variation within these larger structural designs: mass, size, relative dimensions of structures, colors, textures, secondary sex characteristics, aging and immune system patterns, consciousness cycles, etc. *Exact* duplication of an Earth-human by an independently evolved ETI is indeed inconceivable by any biologist. Such a UFO report would cry out for a *non-independent* relationship between the reported "alien" and the reporter. The first place a researcher would look for such a relationship would be in the imagination of the reporter. But a report of a morphologically *similar* but non-identical alien seems a totally different matter. It is intriguing in fact to note, that on the facts and reasoning discussed above, these reports tend to agree with those things deemed likely to be universal, while differing in those things we know may differ (Bowen 1969; Webb 1976). Such an "inspired" dichotomy might well be seen as a positive aspect of the reports rather than a reason to dismiss them.

"If we ever succeed in communicating with conceptualizing beings in outer space, they won't be spheres, pyramids, cubes, or pancakes. In all

probability they will look an awful lot like us."—Robert Bieri, Antioch College (quoted in Ridpath 1975).

#### TRAVEL AND BEHAVIOR

Other objections to the study of UFOs and the possibility of extraterrestrial visitation of Earth have occasionally been used as absolutist rejections of the concept. Of these, the commonest may be "the inadequacy of space travel technology" and the so-called "Fermi Paradox." Both of these have been rigorously and negatively critiqued, if not wholly dispensed with. A few remarks on each will be sufficient here, and will serve to develop some views particularly germane to the UFO phenomenon.

**A. Space travel.** Writings concerned with ETI almost always admit that interstellar travel is not only possible within the limits of what we know and can project, but that advanced civilizations could probably manage it if they were so motivated. It should be enough for us to learn from history about the absurdity of assuming that we know what our absolute technological limits are. But if vague intuitions about history aren't enough, we need only to look at the present. Any serious perusal of the writings of Robert Forward, among others, should convince a reasonable person that even extensions of today's technologies could achieve travel to the nearest stars in travel times of twenty to one hundred years (Forward 1984, 1985). Nuclear fusion designs and lightsails seem most concrete, and anti-matter engines are much written about as well (Forward 1982; Bond 1977; Winterberg 1983). Certainly we and others will uncover other methods as our knowledge progresses.

**B. The Fermi Paradox.** This conviction that there is little (technologically) to prevent ETI from traveling to the stars has inspired a "back door" argument that ETI doesn't exist. It is an argument of a puzzling sort. It is dominated with peculiar assumptions, even prejudices, and it fails the test of logic (Freitas 1983ab, 1985). Nevertheless, it has received an apparently serious hearing in the literature, giving one some concern about presumptions and prejudices playing overly important roles in scientific discussion. Perhaps, though, this is better viewed as a healthy willingness to explore new concepts, however unlikely.

The argument is called the Fermi Paradox, after Enrico Fermi, who allegedly first, even casually, formulated it. The thinking goes, in its briefest form: a) if lots of ETI exists, and b) if they can travel from star-to-star in any reasonable time-frame, then c) because the galaxy is so old and many of these ETI's comparably old with it, the earliest ETIs will have had plenty of time to travel to all the stars many times over. But, since we have no evidence of them visiting here, one of our assumptions must be wrong. Conclusion: since the case for possible space travel technology seems secure, it can only be that no such ETI existed in the first place (Tipler 1980; Martin and Bond 1983).

Most readers will have already spotted the flaws in this position, but, especially

for ufology's sake, it is useful to point out the major fallacies. The initial prejudice which is apparent to anyone even mildly conversant with the UFO phenomenon is the cavalier assumption that we have no evidence whatever which could be interpreted as ETI visiting this planet. Most serious UFO researchers would be willing to admit that we have no *conclusive* evidence for an extraterrestrial visitation, but to say that nothing in our recent, or even distant, history might be so interpreted bespeaks of a profound prejudice or ignorance of some kind. In a straightforward way, the whole thrust of the ETI literature should lead one to an intense research interest in the mysterious elements of the UFO phenomenon, as it is in these elements that the predictions of the Fermi Paradox reasoners would be borne out: that is, by every scientific line-of-reasoning, ETI should have visited our system. Any refusal of interest in investigating the UFO phenomenon, using an ETI concept as one working hypothesis, should surely be astonishing.

But, for the moment, we may set aside this problem and move on to a second, equally troublesome one. This second fallacy or unnecessary assumption was originally hidden between the lines, but is now openly discussed in the body of Fermi Paradox articles. The assumption begins with the view that, if ETI visited our solar system, the evidence of these visitations would be overt if not overwhelming. This rather "science-fiction" vision of ETI activity seems to pervade all thinking by the Paradox supporters. They seem to have grave difficulty imagining their ET-travelers as being anything other than colonizers.

When one speaks of "colonizing," giving "overt display," or "leaving obvious evidence about to be observed," we are talking about behavior, and we are talking about motivation primarily. Almost everyone addressing the topic admits that it is a dangerous game to guess what alien behavior and motivation would be, and *that* wisdom alone should place the "colonization hypothesis" into perspective as just one of many possible ideas. A certain sort of reflecting upon possible behavior and motivation is not dangerous however, if we display the proper attitude. Such reflection will be objective if we do not arbitrarily select just one motivation or behavior and then build absolutist conclusions out of that viewpoint. Some consciousness of alternatives is healthy surely.

**C. Alternative ideas on motivations.** We can imagine, probably, a nearly endless run of motivations for ETI meandering the stellar systems, but here we will briefly assess seven of the most discussed. We won't delude ourselves that we've covered the scope of possibilities, and we will hope that the discussion serves only to place ETI and the UFO phenomenon into useful alternative perspectives. The seven motivations are:

- 1) Colonization;
- 2) Material gain and power;
- 3) Threat at home;
- 4) Threat here;
- 5) Galactic kinship;
- 6) Religious conversion;

### 7) Curiosity and exploration.

The first of the list has already been mentioned as the motivation most debated (Hart 1975; Newman and Sagan 1981; Singer 1982; Fogg 1986ab). Although it is possible to envision "colonization waves" being driven by needs other than population growth, this is the factor which has dominated the discussion. This dominance is one more oddity in the discussion of ETI, as the choice of population pressure as a driver would seem to be one of the poorest choices we could focus upon.

If, as most feel, the moving of craft through interstellar space will involve a major resources and technology effort, then this is not something which will be done either casually or on a massive scale. A culture wishing for relief from population pressure will not find it by sending 300 citizens to the nearest star while 300 billion remain at home. Some other solution will be sought, like population control. Since on our own planet we have spotted the dangers of overpopulation even at this rudimentary stage of our development, and most of the advanced nations are vitally concerned with attaining stable population levels, it stretches credulity to think that advanced ETIs would not long ago have seen this problem and dealt with it. When you read the literature you get the intuition that the writers are using this particular motivation because it allows them to play "number games" (doubling times, filling times, expanding colonization waves) and so to make irrelevant "estimates" of how long it takes to saturate the galaxy based on a veneer of math and implausible assumptions. It reminds the reader of the drunk and the lightpole. The drunk spends all his time looking for his lost keys near the lightpole (despite the fact that he knows that he didn't lose them there), because it's the only place that he can see. The other more probable motivations do not lend themselves to the mathematical game, so they aren't often discussed.

Let us stretch the population problem scenario to its limits by assuming that the ETIs have developed some absolutist position such as a "sacred priority of propagation," and are, therefore, mindlessly spewing out citizens and somehow surviving all the crises this creates. Even this scenario does not demand colonization of all Earth-like planets or Sun-like systems in ways that require readily recognizable extraterrestrial presence. For instance, such a civilization would surely do the easier task of colonizing its own system thoroughly, prior to launching to the stars. In doing so, it would learn to live efficiently in space colonies or cities. Should such a civilization later decide to colonize other systems, eventually entering our own, such a colonizing group might easily choose to settle in space with the readily accessible solar energy and asteroidal minerals rather than at the bottom of a difficult gravity-well on our planet's surface. They might not even want to risk immersion in our alien biosphere any more than necessary. In short, they could have been here many times, and could still be in the solar system, without ever setting up housekeeping on Earth. And, at our crude level of solar system exploration, it could be many years into the future before we suspect what has been going on nearby (Papagiannis 1978ab).



"Following life's innate tendency to expand into every available space, technological civilizations will inevitably colonize the entire galaxy establishing space habitats around all its well-behaved stars. The most reasonable place in our solar system to test this possibility is the asteroid belt, which is an ideal source of raw materials for space colonies."—Michael Papagiannis, University of Boston (1983).

The point of this speculation is that being absolutist about any of these scenarios makes no sense. Many possibilities are readily imaginable. The second scenario, *material gain or power, is really an analog of the population problem. If it is truly difficult and expensive to travel star-to-star, then this possibility makes even less sense than the first.* Mass freighting of some relatively abundant universal constituent seems inconceivable, and the specialty freighting of some rare commodity (*genes? humans?*) seems a poor return on the investment if this is some economic game. And could some power-mad tyrant want to go out and conquer star-systems just for the kick of it? Maybe. But if such existed, how many would be required to saturate the galaxy? And, each would have to spawn generations of power-mad successors to keep the "power wave" expanding for several millions of years. And, how does one hold "The Empire" together with the most isolated chains-of-command imaginable? Most tellingly, we *know* that this bizarre idea is irrelevant for us anyway. Despite Hollywood, no conquerors have arrived.

A third possibility is threat-at-home. This we can divide into two: a specific threat prejudicial to a small group, or a cosmic threat against the whole system. Hi-tech pilgrims in their fusion-powered Mayflowers may leave the stifling repression of home worlds for freer spaces, but this is a piecemeal effect not likely to give us the sustained continuity of expansion necessary to cover the stars of the galaxy. And our space-faring pilgrims may also be no more interested in planetary surfaces than our generic colonizers discussed earlier. A more certain occurrence would be the flight occasioned by rare but inevitable coincidences of an advanced civilization lying about an unstable sun. Would such a civilization meekly accept its end or make a heroic effort to reach safe havens in the stars? Of all the mass movement scenarios this seems the most necessary, although the cosmic coincidence needed to inspire it should be exceedingly rare. Such people would be a reluctant group of colonizers seeking a long-lived star, and stopping their expansions after one great wrenching jump. If one's own Sun did not happen to be the nearest stable neighbor to such a tragedy, there is little reason to expect visitors from such a cause (San 1981).

What if *we* comprise a threat of some sort? Such may seem another bit of human egocentrism, but perhaps not. We are constantly reminded that we are competitive, xenophobic, and violent. We are also curious, inventive, and risk-taking. We *understand nuclear power and the rudiments of space flight. We have been very fast to accelerate into a high-technology lifestyle. How fast and how far will we go?* Recently there has been talk of "relativistic rockets," devices which might approach

the speed of light. Science fiction? Maybe, but who knows when we will "turn over the right rock" and discover the key secret to make it a reality? Such a device would participate in the relativistic effects of objects moving at very high speeds, including tremendously increased mass. Relativistic rockets have been called "planet crackers," a doomsday weapon, the "gun" that makes all civilizations equal (Pelligrino 1986).

If you were living around a nearby star, you might well want to know what we, your neighbors, were like. Once you found out, you probably would want to keep track of us, while keeping a low profile yourself. Depending upon your level of interspecies ethics, you might be sitting "out there" right now, weighing our existence in the balance, hoping that we learn how to behave properly, or just paranoically biding your time until you give up on us and pull the trigger. Many such paranoia scenarios might be possible, but they all call for one alien behavior: ultra-secrecy. The last thing a worried civilization wants to do is give itself away. A larger organization of civilizations might not feel as threatened, but still be concerned. In such a scenario more genuine concern over the survival of dangerous but fledgling species could be evidenced out of both self-interest and a sort of cosmic morality.

This leads us to a possibility of some galactic kinship group, oft termed the "Galactic Club" (Bracewell 1975). Such an alliance is pictured as an association of advanced civilizations who oversee the maturation struggles of species such as ours. This overseership could be driven by anything from total self-interest to total "moral duty-to-others." Within that spectrum can be imagined any amount of overtness, ranging from nearly-total quarantine (the so-called "leaky embargo" hypothesis) to blunt intervention. Once again the point is: this possibility allows an ETI presence in the Solar system in a variety of levels of covert activity with, however, some purposeful interaction or manipulation (Tough 1986).

Only certain extremes of alien motivation would *demand* overt display, and one such extreme relatable to the above is the sixth scenario: religious mission-work. It has been reasoned that if interstellar travel is as difficult as it seems it should be, then only extreme survival pressures or powerful "matters of the spirit" would motivate ETI to engage in the task. One of the things that has made blood run hot here on Earth has been religion and the desire to bring one's truth to others no matter what the sacrifice. Such an interstellar apostolate is quite conceivable, but it is difficult to conceive as other than an overt interactive mission. Since nothing like that is happening, we are left only with the unlikely situation of a "conversion by stealth" to an alien thought-system. Subtle persuasions through hidden means: an excruciatingly slow method for evangelization. This possibility, despite the claims of some UFO contactee groups, seems irrelevant to reality as we currently find it.

The last possibility is the one this author finds most congenial and most likely, hopefully on more than purely intuitive grounds. This seventh scenario is motivated by curiosity: the desire to explore. It is a motivation that strikes a responsive chord in most of us because it is the motivation which has primarily driven our own space

excursions. There is little question upon listening to our spacecraft designers and "high frontiersmen" that if (when) *Homo sapiens* goes to the stars it will be because we want to know what's out there. Curiosity, for us, is a powerful "matter of the spirit" which is one of those irrational urges which disregards economics, security, and other practical values and plunges forward anyway. Curiosity is the driving force of Discovery. As such it would be the same motivator that pushed any technological civilization forward in the development of its elaborate tools.

But is there any reason other than intuition and the history of our own species to give better validation to this idea? Perhaps there is. First let's try logic. Imagine any life form in any situation. To be able to behave appropriately (to survive), the life form must have some means of either altering its situation to move toward (become more involved with) something, or of altering its situation to move away (become less involved with) something, or of maintaining its present situation. We might call such abilities "exploration," "flight," or "stasis" in common language, or, if we were psychologists, "novelty seeking," "harm avoidance," and "reward dependence." For an intelligent species, the triggers for these instincts would be located in the brain and serve as the foundation of behavior. It has been said, loosely and without any depth of analysis, that alien intelligence would never share any behavioral similarities with our species. Yet logic, simple deductive reasoning, indicates that the foundation stones of behavior *must* be the same three universals, one of which is closely related to, if not identical with, curiosity (Cloninger 1988).

Now that the tools of science have advanced enough to let us probe the physics and chemistry of the brain, psychologists are moving beyond the limits of external observation of behavior and are beginning to apply the physical sciences to their discipline. Some of these researchers have already shown that a chemical trichotomy serves to facilitate the three foundation stone behavioral drivers just described. These researches delineate a "Behavioral Activating System," related to impulsive and exploratory activity, driven by the critical consciousness-alerting hormone, dopamine. A second "Behavioral Inhibiting System" relates to caution and shyness, and is driven by the major sleep-state controlling hormone, serotonin. The third "Behavioral Maintenance System" relates to dependency and conservatism, and is inversely driven by the main energizing hormone, nor-epinephrine (Cloninger 1988).

We have known that these three neurotransmitters (brain hormones) are vitally important to behavioral stability for some time. Imbalances in these chemicals have been accused of producing certain schizophrenias, depressions, hyperactivity, and neuroses. We are just now realizing how fundamental they are. They go to the roots of behavior, and one of them is the activator of what we see as a biological essential relatable to the ETI story: curiosity, exploration, novelty-seeking. Species everywhere should seek novelty, avoid harm, and conserve the good. If we were to assume the absence of a powerful curiosity and exploration instinct in ETI, we assume that they are missing one of the three required instincts of life forms. Would their level of curiosity be strong enough to take them into the stars and ultimately to

us? No one, of course, can say. But if they do come, they will come with curiosity and a sense of exploration among their other instincts.

#### UFOLOGY AND SCIENCE

The discussions of this paper have argued for the following:

- a) There are billions of proper suns, planetary systems, and life-bearing worlds in our galaxy.
- b) It is extremely probable that many of these systems evolved intelligent life-forms, some much earlier than our own.
- c) It is extremely probable that some of these civilizations still exist, and possible that all of them still do.
- d) It is extremely probable that some, if not all, of these life forms are based upon a physical structural format similar (though not precisely identical) to our own.
- e) It is extremely probable that some, if not all, of these advanced civilizations have the means, albeit with difficulty, of traversing interstellar space.
- f) And, it is essentially a certainty that these advanced life forms have several instincts/motivators/behaviors in common with *Homo sapiens*, one of which (curiosity) may be particularly germane to such journeys.

If there are scholars who do not agree with the arguments upon which the above conclusions are made, they should at least agree that each of the points is possible, not inconsistent or forbidden by scientific information as we know it. A perfectly congenial scientific working hypothesis might be: advanced extraterrestrial visitors have reached our solar system and may still be here. Though not identical, they have much in common biologically and psychologically with our species. They are partly motivated by curiosity and (scientific) exploration.

This is the classical "ET hypothesis" from ufology. When stated simply without the extensive previous discussion, it is often disregarded ad hoc or even derided. However, we have seen that it is an eminently defensible and scientifically respectable beginning hypothesis. We see its respectability in the growing interests of scientists in closely related research. There is the large upsurge in interest and programs for detecting ETI by radiotelescopy by the Drake-Sagan school of explorers. Other astronomers have suggested that an intensive exploration of the asteroid belt, looking for space colony-dwelling ETI, is in order (Papagiannis 1983). The famous "Face on Mars" and the "Pyramids of Elysium" are intriguing (DiPietro and Molenaar 1982). Some established scientists have mused that they are probably natural but just maybe not (Sagan 1980). Another researcher has scanned the Earth-Moon Lagrangian gravity-well points for possible alien artifacts (Freitas

1983ab; Valdes and Freitas 1983). No true scientist disapproves of these investigations as being outrageous, laughable, or beneath scientific dignity. Nearby stars, the asteroid belt, Mars, the Lagrangian points: how much closer does "respectable science" have to come to Earth itself before UFO research is accorded equal dignity?

"The supposition that we are alone in the solar system is based essentially on the assumption that if others were here they would have made contact with us, or at least we would have become aware of their existence. Neither of these assumptions, however, is true, though it is possible that some of the thousands of UFO sightings might deserve some further consideration."—Michael Papagiannis, University of Boston (1978a).

The ET hypothesis is an acceptable concept to be weighed alongside others in the analysis of UFO phenomena. UFO phenomena, like any other natural (physical, biological, psychological, etc.) events, are acceptable subject materials for research. The only question can be: is this research being pursued properly?

As J. Allen Hynek was fond of saying, the science of ufology is the analysis of UFO reports (and any attendant artifacts or other remanent features). As in any fledgling science, the primary duties of researchers have been data-gathering, data-clarification, and pattern-finding. These are the classical first steps of the scientific method and much of the effort in ufology has been directed properly to just this work. Many patterns were found (e.g., times of sightings, population density relationships, witness numbers and types)(Hynek 1972). Some patterned subsets were discovered. Some of these led to known but somewhat unsuspected phenomena (e.g., rocket booster re-entries). Some of these led to rare or possible new natural phenomena (Persinger and Lafrenière 1977). And some led to intriguing unsolved puzzles (e.g., motor vehicle engine interferences, Rodeghier 1981; and ground markings, Phillips 1981).

Beyond the pattern-finding step, scientific methodology requires testing or at least some form of pro-active observation to proceed further. However, as in many non-laboratory sciences, variables were difficult to control and replication was not possible, in general. Occasionally, as in photographic analysis work, labwork has been possible, and has often been pursued with high standards (Maccabee 1988). Scientific deductions based upon the available patterns are possible in part, but as the phenomenon is idiosyncratic regarding time of appearance (and as no one seems to be able to produce the phenomenon on demand) only the crudest predictions can be made and checked (see Persinger 1981 for a creative attempt at this).

On the other side of scientific methodology (researching causal agencies, rather than patterned behaviors or "laws of nature"), hypotheses for "why" the experiences are as they are obviously can and have been made. The ET hypothesis has been one of many hypotheses weighed in the pursuit of explanations. "Lying,"

"misperceptions," "confabulation," "psychiatric problems," and "unknown natural phenomena" are several of the other hypotheses always taken seriously by the better UFO researchers: a fact proven by the vast majority of UFO reports being explained by those same researchers. True control of variables is not possible in all of the hypotheses (especially the more extraordinary ones such as the ET hypothesis). As such, testing and scientific deduction aimed precisely at these possibilities has not yet been fertile. However, in any given case, all of the hypotheses are theoretically falsifiable, and, in each explained case, all but one has been falsified. And this is not a trivial point in a fledgling science wherein one case bears no necessary relationship to any other. Science must permit piecemeal testing of cases or no new field of science could begin.

Beyond this, some cases have resisted explanation by the array of "mundane" or "ordinary" hypotheses, and yet are consistent with extraordinary ones like the ET hypothesis. They do not *prove* the hypothesis, as "hard," unambiguous lab-testable evidence does not exist for any such case. Such cases, therefore, present the scientist with flaws. By definition, since they are unexplained, they lack sufficient data. They may lack data because the data was not able to be uncovered, or because the witness or the researcher were not clever enough to uncover it, or because the methodology used in the case has somehow clouded the data. Certainly all of these situations exist in the vast numbers of cases in the field. But the conclusion of a scientist should be this: if cases exist, flawed or not, which resist explanation in ordinary ways, and which are consistent with extraordinarily interesting alternatives, these reports constitute an area worthy of scientific research. Even if all of the reports and all of the past researches are flawed in some form or another, this statement still stands. Ufology is, after all, a difficult field to "surround," and thereby difficult to research. It is eminently interdisciplinary, and taxing for the narrowly trained investigator. Its complexity should be recognized and approached with proper humility by the skeptical commentator as well. But the difficulty of the field is not a reason to abandon the field or to oppose the reasonable work of those who choose to pursue it.

Comparing the scientific approach of J. Allen Hynek to the scientific charade of the so-called *Scientific Study of Unidentified Flying Objects* headed by Edward U. Condon (Hynek 1972; Condon 1969), an outstanding U.S. scientist wrote in *Science* (the journal of the American Association for the Advancement of Science):

"On balance, Hynek's defense of UFOs as a valid, if speculative, scientific topic is more credible than Condon's attempt to mock them out of existence. The fact that Hynek was granted no NASA or NSF support at all for study of UFO's can be regarded as a rather dismal symptom of the authoritarian structure of establishment science. It is also disappointing that *Science*, which has earned the respect of U.S. scientists and occasionally the enmity of U.S. bureaucrats by providing an independent forum for controversial views, failed to publish a responsible rebuttal to the Condon report, treating it instead as a news item. As a result, the

substantial criticisms raised by Hynek now were not adequately aired then. Thus, from this juror's point of view at least, Hynek has won a reprieve for UFO's with his many pages of provocative unexplained reports and his articulate challenge to his colleagues to tolerate the study of something they cannot understand."—Bruce C. Murray, *California Institute of Technology* (1972).

In the view of this current author, this situation has not appreciably changed. Hynek's articulate wisdom and his cases remain, the public attitude of official science has remained cool to hostile, and Dr. Murray's enlightened tolerance has not been followed by his peers.

#### SUMMARY

There have been many goals of this paper and many issues treated. The following general positions have been defended:

- a) The UFO phenomenon is a proper field of scientific study.
- b) Some UFO researchers have proceeded with the elementary first steps of the scientific method in a proper fashion.
- c) Some UFO researchers have pursued the more advanced steps of the scientific method properly, albeit with the difficulty expected in a complex, uncontrollable, de novo science.
- d) The ET hypothesis is a proper alternative hypothesis for use in evaluating UFO reports.
- e) Reasonable scenarios within the ET hypothesis are consistent with debated and puzzling characteristics of many unexplained UFO reports.

And, concerning the possibility that an advanced ETI civilization could be visiting our planet, it is easy to conceive why the following specific characteristics of the UFO phenomenon would follow:

- f) UFO experiences would not be able to be controlled or easily predicted by Earth scientists.
- g) UFO experiences might be deliberately made confusing whenever total secrecy was not possible or desired.
- h) "Good" (related to ETI) UFO cases would be relatively rare, buried within a multitude of mundane experiences.
- i) Some UFO experiences might appear to be deliberately "staged" to accomplish some specific purpose.
- j) "Magical" or "impossible" characteristics of some experiences might rather be manifestations of ultra-advanced technology accord-

ing to the "Clarke Law" of the impact of such technology on relative primitives.

- k) Occasional awarenesses or subtle programmed information might be transferred, but never concrete physical evidence.

These last comments are highlighted simply as a reminder that the rejection of some reports, or the whole study area, on the basis of "absurd or confusing content" is another inappropriate attitude in this ETI context. Such a list as above may be a bit depressing for the scientist who would much rather be the controller than part of the controlled, but it is a possibility well within our concept of the universe and what could be going on around us.

"I cannot presume to describe, however, what UFOs are, because I don't know; but I can establish beyond reasonable doubt that they are not all misperceptions or hoaxes."—J. Allen Hynek (1972).

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