

# Extraterrestrial Intelligence: Where is Everybody?

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The most interesting scientific problem of our age involves the question of the existence of extraterrestrial intelligence.

## Mankind in the Universe

There are perhaps  $10^{11}$  galaxies in the known universe, some 80% of which are spiral. Our galaxy, the Milky Way, is a typical spiral galaxy, intermediate or ordinary in every property that we know how to measure or calculate. The Milky Way is not outstanding or special, although we suppose that it is unique in that no other galaxy is exactly like it.

The Milky Way contains some  $10^{12}$  stars and lots of other material such as gas and dust. Our star, the Sun, is intermediate or ordinary in every property that we know how to measure or calculate: size (mass and diameter), color (i.e., surface temperature), chemical composition, age, and location in the galaxy. In one respect the Sun might seem to be extraordinary: Although many planets around other stars are now being discovered, no other star is known to have a planetary system comparable to ours. But observing planets around other stars is extremely difficult. Although the near future promises notable improvements, extrasolar planets comparable to Earth would go undetected with our present technology. Speculation is, however, that many stars have such planets.

Among the Sun's nine known planets, our planet, Earth, is intermediate or ordinary in size (mass and diameter), temperature, chemical composition, age (all the planets in the solar system are probably about as old as the Sun), and location. In one respect Earth might seem to be extraordinary: No other planet is known to have life. But this is because of the relative fragility of known life forms, which require complex organic chemistry in

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a wet environment. No other place in the solar system now seems to be suitable for life to originate.

Among life forms on Earth, our species, mankind, is ordinary in some respects but outstanding in intelligence. The question of why we are thus outstanding may not be meaningful, but if it is, an answer may be that any significantly less-intelligent species is incapable of asking such a question. Or perhaps our seemingly unusual status is related to our failure to be aware of extraterrestrial intelligence (ETI, taken as plural). But here is a problem: Unlike extrasolar Earthlike planets, we should be able to interact with ETI, if any. Given a desire on their part, interaction should be easy. As Enrico Fermi originally asked: Where is everybody?

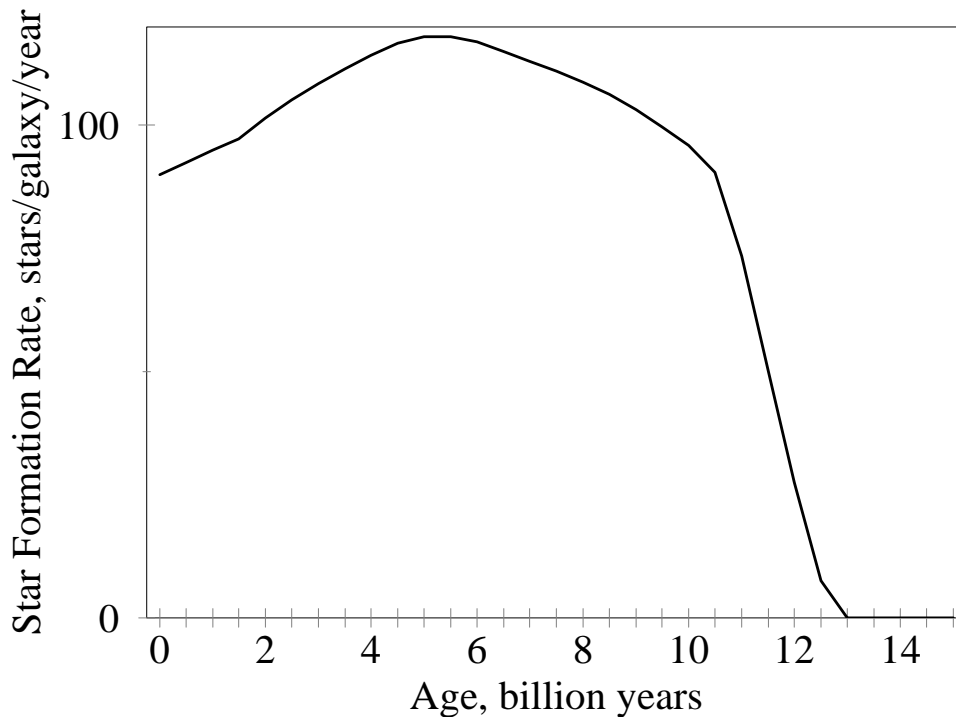
### **UFOs?**

I think that unidentified flying objects (UFOs or flying saucers) have nothing to do with ETI, but I might be wrong. If you can prove that I'm wrong, I'll be delighted! You should be delighted too, for you'll thereby win a lot of money in prizes and awards. I have this only as hearsay from a friend, but the total may be many million dollars (!) for finding physical evidence of ETI—for example, a piece of a flying saucer of extraterrestrial manufacture or, better, a little green cadaver. But there's no point trying to convince me; none of these prizes and awards hinges on my opinion. You'll need to convince, for example, the National Academy of Sciences, James Randi, or Phil Klass.

### **SETI: Is Anybody Home?**

Suppose we want to estimate the number of other civilizations (OCs) that are within, say, a millennium of our development age and how far we might have to search to find any. An OC that is, say, a century younger than we are might not be able to communicate over interstellar distances; a century ago we couldn't. And an OC a millennium older than we are would probably be using a technology for interstellar communications, such as modulated gamma rays, that we humans haven't yet learned how to do.

We don't know enough about OCs to do such an estimate, but we know more about stars. Let's assume that OCs are born on Earthlike planets and that, like the Sun, stars, on average, each have about one planet suitable for the origin of life. (Some stars have none, but some stars presumably have more than one.) Let's also assume that OCs, on average, develop at about



the same rate as we, on Earth, have, so that we can equate development age and chronological age. Then we estimate the number of stars that are within a millennium of the Sun's age in our galaxy and a stellar density (stars per unit volume) in the Sun's neighborhood.

Figure 1 shows a guess at the star-formation rate, stars/galaxy/year, in our galaxy as a function of their age. Some points on this plot are pretty well known: Some stars are being born even as we speak, so the zero-age point is certainly not zero. The age of the Universe is some  $10$  to  $15 \times 10^9$  (10 to 15 billion) years, so no stars are older than that, but some stars, in globular clusters for example, are almost that old. At our Sun's age, about  $4.5 \times 10^9$  years, the curve is near a broad maximum. We can estimate the average star-formation rate in our galaxy as  $10^{12}$  stars (that's about how many there are, and that's the area under the curve in Figure 1) in  $10^{10}$  years (that's about how long star formation has been going on). This gives about 100 stars/galaxy/year, and this is a reasonable estimate for the present star-formation rate and also for the star-formation rate when the Sun was born about  $4.5 \times 10^9$  years ago. We estimate, then, that only about

one star in  $10^7$  is within a millennium of the Sun's age, but there are about  $10^5$  such stars in our galaxy and, by our assumption, about  $10^5$  planets in our galaxy within a millennium of Earth's age and candidates for talking with us.

The space density of stars in the Sun's neighborhood is about one per cubic parsec ( $1/\text{pc}^3$ ), or, in other words, the average distance between stars near the Sun is about a parsec. To find an OC to talk with, we'll need to search some  $10^7$  stars at distances up to 200 parsecs. (Near the Sun, there are about  $8 \times 10^6$  stars within a cube 200 parsecs on an edge.)

Radio-frequency searches for extraterrestrial intelligence (SETI) are based on assumptions and calculations such as these. Most SETI projects are looking for putative narrow-band beacon signals specifically intended to attract our attention rather than, say, eavesdropping on OCs' ordinary activities, which is much more difficult. No one has heard anything yet.

### Good Questions?

What are the crucial questions? Asking the right questions is sometimes remarkably important, and asking the wrong questions can sometimes lead one far astray. I feel that this is just what is happening to those who are asking: What experiment or observation can we perform to become aware of ETI? A better question, in my view, is: Why are we unaware of ETI? A premise of most searches is that ETI are trying to communicate with us, but we are not quite clever enough to see or hear them. I suggest, instead, that if ETI had chosen to announce their presence to us, we would be aware. Since we are not, I presume they have not.

Look for ETI on Earthlike planets? More likely an Earthlike planet is to ETI what an empty eggshell is to a bird. An Earthlike planet is a good place for advanced ETI to be *from* but not such a good place to be *at*. Some things that we regard as important—air, warmth, and gravity, as examples—are probably detrimental to OCs that are much more advanced than we are.

A civilization more advanced than mankind by a few eons might seem almost omnipotent and omniscient. Arthur C. Clarke's third law says, "Any sufficiently advanced technology is indistinguishable from magic."

"I predict that, if a form of life is ever discovered in another part of the universe, however outlandish and weirdly alien that form of life may be in detail, it will be found to resemble life on

Earth in one key respect: it will have evolved by some kind of Darwinian natural selection.” —Richard Dawkins.

## Conceptualizing ETI

The human mind presented with difficult new concepts and problems usually needs to work with an analogy based on experience. Electromagnetic radiation, for example, is something like a particle and something like a wave but is really neither particle nor wave. We might be able to say that our relationship with ETI is similar to some other relationship that we understand. I suggest that we try this analogy: The relationship of mankind with ETI is similar to the relationship of some form of primitive Earth life (PEL) with mankind. But which PEL? And how useful is this analogy?

An argument based on relative time scales suggests that the appropriate PEL is an animal such as those in our Ordovician geological epoch, namely mollusks and trilobites. Now I can imagine talking with mammals and birds; indeed I’ve done it, although the conversation was on a pretty low intellectual level. But oysters? The point is that if this analogy is good for anything, then our relationship with typical ETI is probably nothing like the relationship of a primitive human tribe with technological man, which analogy seems to be in the minds of many who propose ETI searches, but instead is more like the relationship of an animal—a rather primitive animal—with mankind. The idea that we shall be welcomed as new members into the galactic community is as unlikely as the idea that oysters will be welcomed as new members into the human community. We’re probably not even edible.

Mankind should be able to take over our galaxy in a fairly short time—say a few hundred-thousand years—unless somebody else already has. But I think that there are many other civilizations, much older than ours, who might have taken over the galaxy eons ago. Where are they? Where is everybody? Why are we unaware of ETI? As you’ve probably guessed by now, I don’t know either.

## Categories of Answers

Anyone who really expects to learn about ETI from this note will be disappointed. I claim to know some good questions about ETI but precious few answers. The best that can be done for some questions is to classify all possible answers and estimate the likelihood of having the correct an-

swer in each category. Here are my ten categories of possible answers to the question: Where is everybody?

Category (1): There are no other civilizations (OCs). Earth is either unique—the only biosystem—or mankind is first in level of development. Michael Hart and Frank Tipler, for example, argue, in essence, that absence of evidence *is* evidence of absence. I regard this answer as unlikely because we seem to lack any special situation that would make us singular or outstanding. I feel, nevertheless, considerable rapport with Hart and Tipler: Although I think that their answer will eventually be shown to be wrong, they have asked the right question, and that's very important.

Category (2): Other civilizations exist, but they're very primitive. They don't know that we're here, but they might like to know. Their development has somehow been stopped at a level more primitive than ours. Category (3): Other civilizations exist at about our level of development. They suspect that we might be here, and they might like to talk with us. This hypothesis is called the *mirror view* because we seem to see that ETI are just like us. The mirror, I suggest, is not very far from the end of our noses, and it's blocking the view of other things. Category (4): Advanced civilizations exist and they know we're here. They would like to talk with us if they could just attract our attention.

Categories (2) through (4) are the popular views at least among my colleagues in radio astronomy. Categories (3) and (4) are the “consensus” views in the 1977 NASA report titled *The Search for Extraterrestrial Intelligence*. I think these answers are wrong primarily because they vastly underestimate the abilities of ETI. Surely they know we're here; for the Sun, the solar system, Earth, and mankind are all conspicuous. There's no way to hide. We'll certainly start studying and cataloging biosystems in the galaxy as soon as we're able; why should ETI do less?

Category (5) (of answers to the question: Where is everybody?): They know we're here, but they don't care; they're ignoring us. We pose no threat, we can't interfere with whatever they're doing, and we have nothing they want. This is a likely but a very *unpopular* answer, for it seems to downgrade mankind's importance, and we do like to feel important. We think we're pretty interesting; why shouldn't ETI think so too? Many of my colleagues refuse even to consider the possibility that our galaxy might be teeming with life, paying no attention to us, caring not a whit, and we are too primitive to notice.

The so-called *ants-in-the-jungle* hypothesis would have us unaware of ETI for the same reason that ants in a jungle may be unaware of people—no

# Spectrum of Possibilities

## Science

### Popular Views

- (1) There are no OCs. Earth is either unique—the only biosystem—or mankind is first in level of development.
- (2) OCs exist, but they're very primitive; they don't know we're here (but they might like to know).

### SETI Views

- (3) OCs exist; they are about at our level of development; they suspect that we might be here; they might like to talk with us (“The Mirror View”).
- (4) OCs exist; they know we're here; they would like to talk with us if they could just attract our attention.

### Unpopular View

- (5) OCs exist; they know we're here, but they don't care; they're ignoring us. We pose no threat, and we have nothing they want.

### Zoo Hypothesis

- (6) OCs exist; we are of some interest to them; a few of their scientists are discreetly studying us.
- (7) OCs exist; we are interesting to them; they are studying us in some detail but inconspicuously.

## Philosophy & Religion

- (8) OCs exist; they are studying us and occasionally even dabbling in our affairs. (UFOs may be representatives of OCs.)
- (9) OCs exist; we are an experiment in their laboratory (“Petri-dish Hypothesis”).

### Popular View

- (10) A supernatural god exists—omnipotent and omniscient.

person has ever just happened by. People are beyond their *sensory* horizon. The *ants-in-the-city* hypothesis would have us unaware of ETI for the same reason that ants on Manhattan may be unaware of people—they just don't understand what being stepped on and run over implies. ETI may be beyond our *intellectual* horizon; some of the phenomena that we already see may be associated with ETI, but we don't understand.

Categories (6) and (7) (of answers to the question: Where is everybody?): ETI may be discreetly and inconspicuously watching us but not dabbling. This is the *zoo hypothesis*.

*Benign* may not be quite the right word; but if you believe that there is someone out there with the ability to squash us like a bug, and he has not—we're still alive and functioning—this implies either that we're more valuable to him alive than squashed, or at least that we're not interfering much with whatever he's doing. How could we interfere? We can't even get out of our own solar system—yet.

Now we must be wary of slipping off the craggy cliff edge that forms the boundary between the solid ground of science and the mists and vapors of philosophy and religion. Categories (8) through (10) in this tabulation are outside the realm of science. If advanced civilizations are dabbling in our affairs, then the results of our experiments and observations and the conclusions based on them are suspect, and the foundations of the edifice of our science crumble. But saying that a hypothesis is not scientific is very different from saying that it's wrong.

Various combinations of these categories are possible. We might have, for example, (10) together with any of the others; and we might have one civilization, say in category (7), another in category (2), and so on. Some such combination, indeed, seems to me to be the most likely answer.

## Summary

So what should we make of all this? As working hypotheses, I suggest, first, that mankind is neither alone nor number one. Advanced civilizations exist and exert some degree of control over the galaxy. Second, they're aware of us at least at some level. But are they concerned with us? We may be only an obscure entry in their tabulation of inhabited regions of the galaxy. Third, we're unaware of them because either they want us to be unaware—they're hiding (But this means that they care about us, else why bother to hide?)—or because we're not (yet) clever enough to know that they're there, but they don't care whether we know. These two possibilities depend on the



value of our civilization to them. I'm inclined to an intermediate position, namely number (6): Our biosystem and culture are surely of some interest; Earth is worth studying at least by a few of their scientists, but the faun on their street has never heard of us and doesn't care to. Our relationship to ETI might be similar to the relationship of *Eciton burchelli* to mankind: E.O. Wilson knows and cares, but Bill Clinton doesn't.

The history of science contains, one after another, a series of blows to mankind's anthropocentric ego. Egypt does not seem to be the center of the universe, nor Earth, nor our Sun, nor our galaxy. We humans seem to be only intelligent apes. I predict two further blows to our ego in the near future: We shall discover that our mental processes can be modeled, or even duplicated in detail, by a mechanism such as a computer. Thus vitalism, now living only in a few human minds contemplating themselves, will finally be dead. And we shall become aware of our relationship with advanced extraterrestrial intelligence. Will we then still believe that we are the chosen people of God?

To anyone who would do science related to ETI, I recommend these important areas: Search for Earthlike extrasolar planets, search for an understanding of the origin of life from non-living material, and try to understand what a civilization much more advanced than ours might be like. These are three outstanding unsolved problems on which progress might be expected within the next decade or so—perhaps with your help. Freeman Dyson suggests that “a reasonable long-range program of searching for evidence of intelligence in the galaxy is indistinguishable from a reasonable long-range program of general astronomical exploration.” I would add that biological exploration, especially trying to understand the origin and evolution of life on Earth, is equally important.