First Things
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Home Alone in the Universe?

by Fredric Heeren

As I first learned at a dinner table surrounded by new acquaintances, questioning someone's belief in extraterrestrial intelligence is like questioning his religious faith. My mention of doubt was met with gasps all around the table. The fierce stares told me, not just, "We disagree," but "You have blasphemed."

Don't get me wrong: I have nothing against curing cancer, heart disease, and AIDS, which advanced aliens could probably do. I'd be fascinated to hear an alien's perspective on the meaning and purpose of life. I'm all for immediate solutions to our war/crime/poverty problems, which a mature society is supposed to have solved. I even think that receiving all these blessings from above may follow logically from contact with a civilization that's survived for millions of years. But I also think that astronomers are now in a position to know that our chance of achieving such contact is very small.

There is a grim flip side to our zeal to find E.T.: If we learn instead that we're alone, alien enthusiasts will lose their best hope for finding the purpose of life. And for many educated people, the whole scientific revolution will come to a crashing halt. For me, the possibility of either company or aloneness brings up fascinating paradoxes beyond science's present ability to explain.

What Copernicus Began

Nothing drives ETI faith like the Copernican Principle, the idea that we do not occupy a privileged position in the universe. Many regard this as a necessary axiom for the continued success of the scientific enterprise. The practice of science begins, we're told, with the assumption that we are typical, not exceptional. We can't scientifically study a sampling of one, after all. Moreover, history suggests that Copernicus began an unstoppable progression: The world's greatest modern thinkers proposed and then proved that the Earth is not the center of the universe, that the Sun is not the center, that our galaxy is not the center, and finally, that there *is* no center.

Copernicus gave us the theory to take the first step, and Galileo demonstrated its truth. Einstein gave us the theory to take the last steps, and Edwin Hubble's observations of distant galaxies convinced the world.

Astronomer Robert Jastrow, founder of NASA's Goddard Institute, calls Hubble's achievement "the last great step in the revolution of thought regarding mankind's place in the cosmos that had been initiated by Copernicus." But today's Copernican Principle proposes, not only that the universe does not revolve around the Earth, but that the universe does not revolve around *us,* either literally or figuratively.

Having proved that our planet, sun and galaxy are typical, science has yet to settle the question about whether we ourselves are typical. We lack absolute certainty that we are not, in the most important sense, the center—until someone confirms the existence of intelligent beings elsewhere in the universe.

Yes, if you put it that way, Robert Jastrow agrees: the *final* step in the Copernican revolution has yet to be taken. But in my talks with him during the 1990s, he insisted that we are on the verge of taking it.

"I think that mankind is on the threshold of entering a larger, cosmic community," he told me during a visit to his home and then to California's Mt. Wilson Observatories, where he serves as Director. His words carried a kind of ecclesiastical authority, seeming to reverberate from the seven-story dome above him, the observatory he calls a "cathedral dedicated to mankind's quest for understanding of the Cosmos." Less loftily, he added, simply, "We'll be hearing from those guys soon."

Taking a seat on the wicker chair that Edwin Hubble had sat upon almost eighty years before, I pondered this possibility—and then promptly forgot it while playing with the controls that split open the ceiling to the night sky, that slued the 100-ton telescope across the room, that spun the entire cavernous structure around me.

Sitting there a mile above Los Angeles at the focus of the world's largest telescope, positioned at the helm of the entire scientific enterprise, Hubble felt tremendous power. Oddly, he was simultaneously struck with a sensation of puniness, being the first to fully understand how diminutive our place is in this enormous universe. While tweaking the controls over hundreds of cold nights through the early 1920s, Hubble provided photographic proof that our galaxy is but one of many. The nebulas, then understood to be wisps of gas among the Milky Way's stars, turned out to be more distant galaxies containing billions of stars of their own.

Now, having entered a new millennium, we're poised to make the final test of the Copernican Principle. And why should Robert Jastrow think our generation will be the lucky one to finally make contact, aside from the fact that his generation of astronomers can't die in peace until it happens? For one thing, over the next four years, new SETI (Search for Extra-Terrestrial Intelligence) telescopes and computers are being built with greatly enhanced sensitivity and coverage.

But Dr. Jastrow was thinking more about the signals we've been sending than those we hope to receive. "We're a very conspicuous part of the universe right now," he explained. "The TV and FM broadcasts—and the radar from our defense installations—are sending out a signal that there is life on this planet."

The SETI Institute's Robert Arnold agreed, saying: "These electromagnetic artifacts of daily commerce, entertainment and defense give the Earth a distinct radio frequency signature that is brighter than the Sun."

According to Jastrow: "That started in intensity, at the million-watt level, about thirty years ago, in the 1960s." *Jack Parr* and *I Love Lucy* are at a wave front, he said, that's spreading out into the cosmos. "Within thirty light-years there are some dozens of stars. And if they got the word thirty years ago, they would be sending a reply back to us. And those who are only fifteen light-years away will have sent a message back fifteen years ago, which should just about be reaching us today."

Other astronomers belonging to Robert Jastrow's generation recall the same kind of enthusiasm, but new concerns have since dampened it. "I used to rather enjoy thinking that the early civilizations would have set up an intercommunicating system," said Senior Astronomer Emeritus Eric Carlson of Chicago's Adler Planetarium. "Maybe laser beams or something full of information about all the other civilizations in the past history of the galaxy, and that this is all circulating around from star to star around the galaxy, and all we have to do is tap into it."

The actual likelihood that we'll hear back from anyone that close, of course, depends upon just how densely packed our galaxy is with civilizations—and upon how long those civilizations last. Today Eric Carlson frets about what might happen to any civilization in the course of a 10-billion-year-old galaxy. What will be left of human culture in a billion years, or even a million? "I tend to get this sense of a galaxy as being sort of like a garden," says Carlson. "You have the early spring flowers, and then you have the late spring flowers and so on, and you have life with consciousness springing up here and there for a while. And whether it's ever in contact at the same time, I just don't know."

The next generation of cosmologists might still say that the existence of extraterrestrial civilizations is "extremely likely," as cosmologist George Smoot (Lawrence Berkeley Laboratories) told me. "But I think the chances of there being life *near* to us is pretty low," he cautioned, "and whether there's life in our own galaxy, besides ourselves, I don't know."

Among the youngest astronomers to make a name for himself is Charles Steidel, the Caltech leader of an international team to discover ways of viewing 13-billion-year-old baby galaxies. His thoughts reflect the addition of 21st-century biological understanding to the equation: "The chance of there being life with which we would be capable of communicating, I think, is fairly low, because there are so many ways that things could develop."

Even Robert Jastrow, who has proved more relentlessly upbeat about alien civilizations than any other astronomer I've asked, appears to have had some second thoughts. When I was about to go to press with a book on modern cosmology, he asked me to make a small addition to a statement he had made in my chapter about SETI. Instead of saying, "We'll be hearing from those guys soon," he wanted me to change it to, *"If life is common,* we'll be hearing from those guys soon."

As we'll see, a number of challenges have been growing over the past decade to burst the ETI ebullience once so characteristic of astronomers.

Embracing Extraterrestrials

Most folks are oblivious to recent evidence bearing upon the ETI question, both pro and con. But the Copernican principle is firmly embedded in popular culture, understood in terms of "the awful waste of space" if aliens aren't out there. Any chatty taxi driver can tell you that there are billions of galaxies and billions of stars within each. The sheer numbers demand that there be millions of habitable planets in our galaxy alone, even if the percentage of tenantable star systems is small. To say otherwise is to expose one's lack of scientific education.

Contact is not a matter of *if,* but *when.* Our movies have given us progressively better special effects to prepare us for a day when the Earth will stand still, when we'll experience *Close Encounters of the Third Kind,* or when SETI will help us make *Contact.* Generation X and following has been entertained by more extraterrestrials than cowboys, Indians, and soldiers combined. It's probably not an overstatement to say that no movies have had greater influence on men under age 35 than the *Star Wars* films.

Incredibly, infatuation with extraterrestrials actually increased in the last decade. *The Rockford Files* became *The X-Files.* Mob-fighting "Untouchables" turned into alien-fighting "Men in Black," also spun into a children's cartoon series. The biggest hit in late night radio is a national show frequently featuring firsthand witnesses talking about their close encounters with aliens or their spacecraft.

For some people, real life is apparently taking too long to catch up to their media-led expectations—and they aren't going to wait any longer. During the 1990s, psychologists estimated that 900,000 people claimed to have been abducted by aliens in the U.S. alone, and the trend was increasing. In his book, *Close Encounters of the Fourth Kind,* C.D.B. Bryan reported "the emergence of a new psychological disorder," observed in people who have been conditioned to look to "alien saviors" who might give them the fulfillment they aren't finding on terra firma.

In my own experience, after I give talks about the latest space discoveries, I often find myself accosted by people who have personal stories to tell about their close encounters with UFOs, stories which are often accompanied by spiritual lessons.

Theoretical physicist Paul Davies claims that people are looking to extraterrestrials as "a conduit to the Ultimate." For many, the prospect of ETI has come to meet a need once met by religion. Even the SETI scientists say they are motivated by a nobler goal than the mere search for intelligence. Imagine, they say, the boost in knowledge, in morality, and maybe even in spirituality, to be gained from a *billion*-year-old civilization.

Robert Jastrow imagines what it might do to our present religions. "When we make contact with them, it will be a transforming event," he says. "I do not know how the Judeo-Christian tradition will react to this development, because the concept that there exist beings superior to us in this universe, not only technically, but perhaps spiritually and morally, will take some rethinking, I think, of the classic doctrines of western religion."

Any signals we detect, according to SETI astronomer Jill Tarter, will come from long-lived civilizations. This fact, combined with the fact that religions cause so many wars on this planet, means that our first detected signals will come from beings "who either never had, or have outgrown, organized religion," she said at a recent science/religion meeting sponsored by the Templeton Foundation and held in The Bahamas.

Other scientists and theologians at the Nassau meeting thought that pantheistic religions could survive an alien encounter, but most assumed that Western religion would certainly meet its fate when meeting extraterrestrials. Science historian Steven Dick called SETI "a religious quest" that might help to reconcile science and religion. But he assumed this would occur at the expense of Christianity, which could not accommodate the implications of ETI.

It strikes me that today's scholars may be too quick to pronounce last rites over the faith that actually engendered most early ETI enthusiasts. Throughout the Middle Ages, well-read folks believed that a "plurality of worlds" was impossible, following Aristotle's arguments. In 1277, a council of bishops in France condemned this position, officially opening the way for many to take other worlds seriously.

Whether encouraged or discouraged by their churches, prominent Christians became the most prominent ETI promoters. These included Giordano Bruno and Nicholas of Cusa (15th century), Yohannes Kepler (16th century), American Puritan divine Cotton Mather (17th century), and Yale president/minister Timothy Dwight (18th century).

Whether aliens will deliver a knock-out blow to any particular religion depends, of course, upon exactly what aliens have to tell us about God. Materialists have traditionally assumed that Jews, Christians and Muslims, believing in a transcendent God, will receive bad news. And the Christian belief in Jesus' death for human sin seems particularly problematic to them. How could we reconcile Jesus' death for all with the existence of other intelligent creatures in the universe?

Christian ETI enthusiasts have not missed a beat, explaining their solution in one of three ways:

(1) Jesus' atoning sacrifice was a one-time event that covers aliens too. Oxford cosmologist E. A. Milne suggested that missionaries will eventually be preaching the good news to far-flung galaxies.

(2) Other civilizations may not have fallen into sin and so don't require salvation. Oxford don C. S. Lewis wrote science fiction fantasies about such alien societies.

(3) God has become incarnate in the form of alien flesh in as many places where his creatures have fallen into sin. Scholars and rock singers have taken this position. And in the words of hymn writer Sydney Carter:

> Who can tell what other cradle,
> High above the Milky Way,
> Still may rock the King of Heaven
> On another Christmas Day?

The New Case for ETI

Most ETI believers remain blissfully foggy about the best evidence to support their faith. Here are some of the recent scientific discoveries and trends I'd be sure to mention if I were to argue for the existence of ETI at my next dinner party.

Exoplanets

The Copernican Principle came through once again by predicting that we should find planets orbiting Sun-like stars. Waiting all their lives for this discovery, astronomers finally received word of it in 1995.

Until last year, no extrasolar planet had been observed directly, but rigorous measurements of the wobble in their host stars assured planet hunters of their presence. The first exoplanets discovered appeared to belong to freakish solar systems, not only because the pinpointed planets were huge—as expected, since these are easiest to measure—but they were orbiting close to their parent stars, very unlike our expectation of finding solar systems like ours, with large, gaseous planets farther out. Our solar system is beginning to look like the freakish one.

Astrophysicist Virginia Trimble (University of California, Irvine) typified the consensus *before* these discoveries, writing: “It is not a coincidence that the solid-surfaced, terrestrial planets are close to the sun and warm enough for liquid water, while the jovian (gas-giant) planets are in the outer, frigid reaches of the solar system.” Using “common sense and computer models,” she calculated that “the Milky Way probably still contains at least 10^{10} [that’s 10 billion] stars that could have harbored habitable, terrestrial planets for more than 5 billion years.” Our actual observation of unexpectedly different planetary systems now forces us to rethink our views on the commonness of earthlike planets.

Exobiologists have dubbed the habitable belt where water can exist in liquid form around a star “the Goldilocks zone,” because it’s neither too hot nor too cold for life. Those exoplanets that have been observed spending any time in the Goldilocks zone merely pass through it. Their orbits are extremely elliptical, meaning surface temperatures fluctuate from hotter than Venus to colder than Mars. The very fact that these massive planets cut through the habitable zone in their elongated orbits ensures there can be no smaller, more hospitable planets in this system, since the giants would destabilize their orbits.

Teachers and students learned from *Science News*: “Recent discoveries of giant planets orbiting within spitting distance of their stars have upset a central tenet of astronomers—that Earth’s solar system, where large planets orbit far from the sun, provides the model for planetary development everywhere.”

Of course, it’s too early to tell by these methods just how rare our Earth is. The technique is not yet refined enough to find smaller planets. Over the next two decades, NASA’s Origins Program is developing a series of space-based telescopes, hoping not only to detect the wobble produced by small, Earth-sized planets (2009’s Space Interferometry Mission), but to measure the chemical signature of life itself (2012’s Terrestrial Planet Finder).

In short, exoplanet discoveries probably provide the most important scientific gain in recent years to favor ETI existence, but this good news came at a price: the Copernican Principle cannot be applied so neatly to our own star system. Our solar system does not appear to be typical, and those that permit life, if they exist, must be the exception, not the rule—even among Sun-like stars.

SETI Strides

New search instruments coming on line in the near future may dwarf all previous attempts to pick up signals from distant civilizations. The argument can be made that earlier searches just didn't have the coverage required—either in sensitivity, frequencies or number of examined stars. And these shortcomings will shortly be remedied with instruments that are making great leaps in capability.

The SETI Institute of Mountain View, California calls its main search Project Phoenix, the best-funded search ever. Unlike others, this project carefully searches star by star, listening only to the likeliest candidates within a radius of 200 light-years. Project Phoenix has shuttled its Targeted Search System back and forth between the largest radio dishes in the world.

In September of 2000,, Microsoft's co-founder Paul Allen and his associate Nathan Myhrvold pledged $12.5 million dollars to the SETI Institute for the development of the Allen Telescope Array, a specially designed radio telescope that will be dedicated to the search for ETI. A small prototype is complete, and the full ATA, comprised of hundreds of backyard-type satellite dishes working together, is scheduled to come online in 2005. In the time it now takes Project Phoenix to survey 1,000 stars, ATA will check out 100,000, and might eventually scrutinize a *million* stars a year, looking out to 1,000 light-years or more.

"This telescope will do it," SETI astronomer Seth Shostak told me. According to Shostak, the ATA will scan so many stars with such speed that "even if we use the most conservative estimates about the number of civilizations out there, I think we'll find their signals within the next couple of decades."

Not wanting to wait that long, over three million volunteer enthusiasts are also partaking in the pursuit, either by joining a "distributed computing" network called SETI@home, or by building their own radio telescopes as members of the amateur SETI League.

"It gets the heart pounding," says Seth Shostak, anticipating the fact that we may soon be listening to alien wisdom. It's an experience several Silicon Valley legends are giving tens of millions to have. And amateurs are giving tens of millions of hours to try to bring us the experience sooner.

Some analysts of SETI projects argue that Project Phoenix is wasting its considerable resources on an outdated strategy. Nathan Cohen and Robert Hohlfeld, scientists at Boston University, point out that targeted search strategies assume that ET civilizations are much more abundant than recent observations allow. They favor scanning larger, star-rich areas of the sky, betting on the numbers rather than the long-shot chance of finding ETIs via nearby, star-by-star searches.

"Unless ETs truly infest the stars like flies (very unlikely)," write Cohen and Hohlfeld, "the first signals we can detect will come from very rare, very powerful transmitters very far away. The 1971 model, which lent too much weight to nearby stars, turns out to be a naïve case, the best that could be calculated at the time."

Slow Strides in Space Travel: A 2001 Space Oddity

Each new problem for space travel is a problem solved for SETI enthusiasts. Easy progress in our ability to zip around the solar system might imply our eventual ability to travel between the stars—and the ability of advanced aliens to do so. In that case, we shouldn't have to go looking for them; they should already be here.

But here we are, finally having passed 2001, the year when, according to Arthur C. Clarke's trend-setting classic of science fiction classics, humankind would make contact with more highly evolved beings (or at least one of their artifacts). At the very least, by this time we were supposed to be doing manned missions to Jupiter's moons. Clarke's expectation in the 1960s was not unrealistic, considering the fact that our new space program went from putting the first man in orbit to the first man on the moon in just seven years.

So why was that first small step for man the last great leap to be made in 20th century space exploration? Each passing year that delays the planning of a manned Mars mission reminds us of the exponentially greater distances—and difficulties—as we try to reach objects beyond our Earth-Moon system. And so these difficult-to-cross distances may explain why we haven't been visited.

The New Case *Against* ETI

If the public knows little about the best reasons to believe in intelligent extraterrestrials, it knows even less about the new reasons to doubt. Here's what everybody ought to know about the new case *against* the existence of ETI.

Fermi's Paradox—Back in Style

Fermi's Paradox, a SETI-challenge that was tried and found wanting in the 1950s, has been given a retrial. This time, expert witnesses on propulsion technologies have been called in, claiming that if life sprung up in our galaxy many millions of years ago, then our galaxy should have been entirely colonized by now.

It all started over a Los Alamos lab lunch in the summer of 1950, when renowned Italian physicist Enrico Fermi had one of those napkin-scribbling epiphanies. His conclusion stemmed from the indisputable premise that there are billions of stars in our galaxy that are older than our sun, and that life routinely develops under favorable conditions.

Exhausted planet resources and dying stars would provide good motives for exploration and homesteading. Some cultures, like our own, would find other motives for colonizing, and it would only take one enterprising population to begin exponential expansion. Fermi showed that, even assuming modest speeds, every habitable star system in the galaxy should have been colonized within mere millions, not billions, of years. Complete colonization could take place in the relative twinkling of a cosmic eye, many times over, in a ten-billion-year-old galaxy like the Milky Way. “So,” asked Fermi, “where are they?”

Astronomers immediately developed solutions to the paradox, but as the years passed, each of these explanations have become problematic. Some suggested that perhaps the distances between stars are just too great for biological creatures ever to cross. But today, while still in our space age’s infancy, physicists and engineers at NASA envision propulsion strategies that should reach 10 to 20 percent of the speed of light, making trips to the stars feasible, even for short-lived biological beings like us.

Figuring on a cruising speed of 10 percent that of light and periods of 400 years’ settling time between migrations, astronomers say it would take just 5 million years for one colonizing group to reach every star system across the Milky Way’s 100,000 light-years.

In the 1970s, four astrophysicists—Michael Hart, David Viewing, Frank Tipler, and Ronald Bracewell—independently published studies concluding that the Fermi Paradox was difficult to escape. Today, as NASA lays the groundwork for new propulsion strategies, the thought that older cultures should have developed these long ago lends added weight to Fermi’s argument.

“The implication is clear,” wrote British astronomer Ian Crawford last year: “The first technological civilization with the ability and the inclination to colonize the galaxy could have done so before any competitors even had a chance to evolve.”

In the past, alien defenders turned to sociological factors that might have prevented interstellar travel. Perhaps aliens just don’t like traveling. Perhaps civilizations routinely blow themselves up after achieving nuclear capabilities. Or perhaps, according to the "zoo hypothesis," our solar system has been set aside as a primitive nature preserve, not to be touched.

But even SETI Institute astronomer Seth Shostak is skeptical about these scenarios, writing in his book, *Sharing the Universe:* "It isn't that we can resolve the Fermi paradox by arguing that *most* alien societies self-destruct or lose interest in expansion. *Every single one* of them must do so, for otherwise representatives of at least one society would be in our neighborhood."

Some of them, if not all, would have ample motivation to move when their host stars ran out of hydrogen and died. Hundreds of millions of solar-type stars in our Milky Way have already suffered this fate, turning any surrounding paradises into hells by puffing up into red giants or compacting into white dwarfs.

What are SETI proponents to do? Most have returned to pointing out the physical challenges of interstellar trekking. During the 1950s, astronomer Frank Drake decided that energy costs might make interstellar travel not just high-priced, but impossibly so. There's no guarantee that better propulsion systems are physically possible or that less costly energy sources can be tapped for higher speeds.

It's exactly here that believers in advanced ETI exacerbate the paradox. Part of assuming that advanced technological civilizations exist is assuming that their space travel technology and energy resources will also be highly advanced. After all, Carl Sagan and other SETI pioneers classified these advanced civilizations according to their abilities to harness the power of entire stars or galaxies. It doesn't sound like insufficient energy production would be the thing to hold back such societies from powering greatly increased transit speeds. In our own history, the cost of raw materials and fuels, relative to wages, has been dropping exponentially for the past 150 years. In 1983 Carl Sagan himself predicted that this trend would likely continue for another millennium.

New Analysis of SETI Results

Recent analyses of radio search findings have only tended to put severe constraints on the numbers and types of possible alien civilizations.

At the first SETI conference in 1961, Frank Drake proposed a list of factors to quantify the technological populations expected to inhabit our galaxy. Drake's associates assigned values to the rate of star formation, the fraction of stars with planetary systems, the number of planets suitable for life, the fraction of planets where life develops, and the fraction where technological civilizations develop. By multiplying the terms together, they determined that there should be about one million societies using radio waves in our galaxy. The scientists assumed, conservatively, that perhaps one percent of the civilizations would not blow themselves up shortly after achieving nuclear capabilities. Others have since assigned higher values to this and other factors, and have arrived at an even higher number.

Drake's first project to actually search for extraterrestrial radio signals became the forerunner of more than 70 grander radio searches by teams around the world, using the world's largest radio telescopes and most sophisticated computer programs to analyze the data. However, after forty years of null SETI results, astronomers are reexamining each of the factors making up the Drake Equation, concerned that the values of some may have been grossly overestimated. Most astronomers would no longer say that half of all stars have planetary systems, and most biologists would no longer say that intelligence develops a tenth of the time on planets that have life.

Charting the distances and radio powers that SETI projects have checked to date, Massachusetts physicist Andrew LePage has already determined which kinds of civilizations can be ruled out. These include nearby civilizations slightly more advanced than ours (called type I), as well as those at greater distances that are yet more advanced (called types II and III). "These are not trivial results," writes LePage. "Before scientists began to look they thought that type II or III civilizations might actually be quite common. That does not appear to be the case."

The Rare Earth Equation

Today the Drake Equation is being superceded by the Rare Earth Equation, as it was named by geologist Peter Ward and astronomer Donald Brownlee, both at the University of Washington in Seattle. Since the Drake Equation depends upon the number of Earth-like planets orbiting sun-like stars, Ward and Brownlee used the latest data to revise previous estimates concerning both—and to add many once-neglected factors, now known to be critical, to the equation.

These include the fraction of stars in a galaxy's habitable zone, the fraction of metal-rich planets, the fraction of planets with a large moon, the fraction of planets where complex animals arise (as opposed to bacteria or algae), and the fraction of planets with a critically low number of mass extinction events. In their 2000 book, *Rare Earth—Why Complex Life Is Uncommon in the Universe,* they remind their readers: "When any term of the equation approaches zero, so too does the final result." And they conclude: "It appears that Earth indeed may be extraordinarily rare." Here's why:

Special Gas Giant. Jupiter-like planets that orbit close to their host stars, or that orbit eccentrically, refuse to politely share their space with smaller, life-harboring planets. Habitable planets need to make circular orbits within the "Goldilocks zone." Gas giants making eccentric orbits will eject smaller neighbors out of the system or send them crashing into their sun.

Well-behaved gas giants, like Jupiter and Saturn, keep circular orbits at a respectful distance. In that position, they actually serves the necessary function of cosmic vacuum sweeper, drawing comets and asteroids to themselves, rather than allowing them to hit us (as when Comet Shoemaker-Levy 9 struck Jupiter in 1995). George Wetherill of the Carnegie Institution of Washington calculated that without Jupiter, comets would strike Earth between 100 and 10,000 times more frequently than they do, meaning that "we wouldn't be here."

Large Moon. Habitable planets, it turns out, need to be members of a double-planet system, as some astronomers call our Earth-Moon system. Most people don't realize that our moon is huge compared to the relative sizes of other moons in the planet-moon systems of our solar system. The Moon’s mass creates a stabilizing anchor for the Earth, preventing the Earth from undue attraction from the Sun or Jupiter, which would otherwise cause the Earth to tilt too far on its spin axis.

Discovering this, astronomer Jacques Laskar wrote: “We owe our present climate stability to an exceptional event: the presence of the Moon.” Without an extra-large moon orbiting at the right distance from us, scientists predict that Earth would be subject to a runaway greenhouse effect, as on Venus, or a permanent ice age, as Mars would experience if it had more water.

Worse, most astronomers now think that the Moon is the result of a freak accident, perhaps a one-in-a-million shot, when a smaller planet hit the forming Earth with a glancing blow that allowed the mantles of each planet to combine and end up in orbit around Earth. “To produce such a massive moon,” write Ward and Brownlee, “the impacting body had to be the right size, it had to impact the right point on Earth, and the impact had to have occurred at just the right time in the Earth’s growth process.”

Galactic Location. As in the real estate business, location is everything. Stars located much farther from the galaxy’s center than our Sun contain lower concentrations of heavy elements, necessary to form rocky planets like Earth. Stars much *nearer* the center of a galaxy reside in a denser neighborhood, exposing any orbiting planets to lethal radiation. Stars within a spiral galaxy’s arms have the same problem. Most stars traveling between the spiral arms won’t stay there, but our Sun is unusual for its circular orbit around the galaxy.

Plate Tectonics. A hospitable planet needs a critical amount of radioactive elements, such as uranium, to produce the heat that generates a magnetic field. Without our magnetic field, the atmosphere would soon drift out into space. The radioactive core also fuels plate tectonics, the movement of the planetary crust across its surface. Of all our solar system’s planets, this is found only on Earth.

Thus plate tectonics is crucial for life, and a string of other iffy factors, in turn, prove critical to the generation of plate tectonics. These include not only a radioactive core, but a crust of the right thickness and a mantle of the right viscosity, or flexibility.

Just-Right Crust. A fortuitous assemblage of two kinds of crust are necessary, with different densities, in order to allow one to slide over the other, and to allow the lighter one to maintain itself above the water to produce stable continents.

Timing the Warm-up. Exobiologists point out the necessity of a just-right host star, called a main sequence star. But main sequence stars increase their energy output over time, creating obvious problems for orbiting planets. In Earth's case, we now know that the era when the Sun heated up was timed to coincide with the era in which Earth's atmosphere gradually shifted from mostly greenhouse gases to the cooler mixture we enjoy today.

Biological Contingency

Even if we assume that there are plenty of planets in our galaxy that meet the right conditions, and that life develops routinely on them, the most important question remains: How many of them will develop *intelligent* life? The majority of biologists and paleontologists say that evolution works without direction or a "ladder of progress." Instead, the history of life on Earth shows that the path of evolution depends upon a series of unpredictable events.

What were the odds that dinosaurs would be wiped out by an asteroid impact 65 million years ago, paving the way for us? What are the odds that the Cambrian explosion, when all the modern body plans appeared on our planet within a short interval, will happen on other planets?

Rare Earth's Ward and Brownlee conclude that, though microbial life may be common in the universe, complex life (even as complex as a flatworm) is not. The Cambrian explosion of 40 new, widely separated, complex animal groups, they believe, didn't have to happen. Darwinism doesn't predict such an event. And the fact that no new major animal groups (called phyla) have evolved in the 530 million years since should give us pause.

Harvard paleontologist Stephen Jay Gould views the intelligence of *Homo sapiens* "as an ultimate in oddball rarity." The fact that only one species out of an estimated 50 billion developed it on this planet after 3.8 billion years of life suggests that high intelligence may not be the most natural result in the course of evolutionary events.

"If intelligence has such high value," says Gould's Harvard colleague Ernst Mayr, "why don't we see more species develop it?" The list of leading biologists and paleontologists on record for defending this position is impressive, including Simpson, Dobzhansky, Francois, and Ayala. British astronomer John Barrow notes that "there has developed a general consensus among evolutionists that the evolution of intelligent life, comparable in information-processing ability to that of *Homo sapiens,* is so improbable that it is unlikely to have occurred on any other planet in the entire visible universe."

Younger professionals in astronomy-related fields have also joined the trend. After writing an overview of what he calls the "bottlenecks on the road to intelligence," *Astronomy* magazine editor Robert Naeye concludes: "On Earth, a long sequence of improbable events transpired in just the right way to bring forth our existence, as if we had won a million-dollar lottery a million times in a row. Contrary to the prevailing belief, maybe we are special."

Bigger Questions

Ward and Brownlee tell us that if they're right about the rarity of complex life, then "there will be societal implications, or at least some small personal implications." They close their book with an appeal for Earthlings to stop causing extinctions, since we may be eliminating species, not only from our planet, but from the entire galaxy. An editor at the *Chicago Tribune* dutifully closes his review of their book with the question: "If we really are all alone in the universe, why aren't we taking better care of each other and this place?" So there's the moral to the story.

But what about those "personal implications"? Sure, it's fun to kick around speculations about aliens. But if intelligent life is so odd, the bigger question is, Why are *we* here?

In his book on extraterrestrials, British cosmologist and ETI enthusiast Paul Davies wrote that we have just three options when deciding why we're here: we either owe our existence to a very rare fluke, to unknown laws that make life a cosmic imperative, or to a miracle.

Davies rejects the fluke idea as the ultimate "just-so story." He rejects the miracle possibility out of hand, and warms up to the cosmic imperative notion. This gives him, he says, "a universe in which we're not alone." He hopes that perhaps we'll even find a billion-year-old society that will teach us how to solve all our problems. But if the evidence now points more plainly to the idea that we're not as common as flies, then it seems unwise to put our trust in a cosmic imperative.

In sum, we have no trustworthy principle to tell us what to believe about aliens. Worse, all three of our options for explaining life—laws, fluke, or miracle—require a leap of faith. This inference is a slap in the face to those of us who have put our faith in science.

The conviction that intelligent life is a cosmic imperative is not a scientific one, as we have seen, since actual data point in the opposite direction. Neither biologists nor astronomers see anything imperative about the many contingencies that had to be met, against all odds, for us to be here. Even Davies admits that the idea of laws slanted toward life and mind is "enough to make most biologists shudder," since it represents "a fundamental challenge to the existing scientific paradigm."

Though it strains our credulity, belief that we are a fluke at first seems more in line with modern science—until we realize that it runs directly against science's revered Copernican grain. What would Copernicus or Hubble say?

Actually, Copernicus would not have subscribed to the principle that bears his name, since he remained unabashedly anthropocentric while believing that the Earth orbited the Sun. And Edwin Hubble should be credited, not only for taking the final step in the Copernican Revolution, but for putting the kibosh on it. Shortly after discovering that our galaxy is one of many, he discovered that all the galaxies are fleeing from one another, demonstrating an expanding universe. Scientists had preferred to think of our epoch in time as a typical slice out of a changeless eternity, but their eventual acceptance of the big bang meant that our universe has changed over time. Our era turns out to be a special one that permits carbon life, contradicting the Copernican Principle that there should be nothing special about our time or place.

In their classic book, "The Anthropic Cosmological Principle," astrophysicists John Barrow and Frank Tipler call this discovery "the first failure of the Copernican Principle." And as we've seen, the Copernican Principle failed again by predicting that our solar system would provide a model for most others.

The principle Barrow and Tipler prefer, of course, is their Anthropic Principle, which doesn't try to explain away our privileged place or time, but instead says that the features of the universe are constrained by the need to permit observers like us. The less delicate way to put this is to say that the universe appears to have been finely tuned in its fundamental force strengths, particle mass ratios, etc., for our benefit.

Most scientists dislike the direction the Anthropic Principle points them, not just because it implies God as an easy answer, but because, once again, it commits heresy against Copernican dogma. "It seems to me a sort of hubris to think that God made the universe just for us," said cosmologist George Smoot. "It seems to me, I'd just make the universe full of life."

Theoretical physicists like Stephen Hawking have spent much of their energies looking for better explanations for the anthropic "coincidences," seeing red flags go up with each violation of the Copernican Principle. But surely, I thought, there must be a deeper reason for choosing one principle over another. Hoping to learn it, I decided to consult the cosmic oracle and asked Stephen Hawking himself. What grates him most about the Anthropic Principle?

“The human race is so insignificant,” he told me, “I find it difficult to believe the whole universe is a necessary precondition for our existence.”

Maybe that’s all there is to it: his fundamental lack of belief in our significance. Such disbelief comes easy for most people trained in science. We can’t be that important. Why waste all that space? The movie *Contact* had its characters raise this favorite SETI point three times. After all, we Earthlings don’t need all those other galaxies.

“Clearly the solar system is necessary,” continued Hawking, “and maybe our galaxy, but not a hundred billion other galaxies.”

However, Barrow and Tipler point out that we little Earthlings actually do require all that extra legroom. They say that the universe has to be as large as it is to host even one lonely outpost of life. Why? A stable universe with gravity must be expanding, or it will collapse. An expanding universe naturally becomes huge during the time required for stars to slowly cook the heavier elements life needs. By the time the first stars finish their life cycle, making life’s ingredients available through supernovas, the cosmos will necessarily be huge, whether it houses one population or billions.

As long as George Smoot and Paul Davies brought the possibility of God into this, what about that “miracle” option? “Miracle,” as I take it, doesn’t have to mean magical or instantaneous—but the word is up front about its demand for a non-physical explanation. As Edwin Hubble’s protégé, astronomer Alan Sandage, told me: “We can’t understand the universe in any clear way without the supernatural.”

Physicist James Trefil concluded his book about extraterrestrials and the conditions for life with the statement: “If I were a religious man, I would say that everything we have learned about life in the past twenty years shows that we are unique, and therefore special in God's sight.” Not being a religious man, apparently, he declined to make the leap.

Personally, I’ve never thought of myself as making a *leap* of faith, at least, not a leap that was any greater than the alternatives. If we do take this confluence of just-right conditions the way they sound, like someone had us in mind all along, then we don’t need aliens to keep us from being alone. Two-way communication with an Extraterrestrial Intelligence may indeed be available in our lifetime. Even better than appreciating our rarity, contact with our Superintelligent Creator could truly motivate us to take "better care of each other and this place."

Theistic believers have the same options as everyone else. Their alternatives are not restricted to faith in aliens or faith in God. If both exist, then the real question about aliens reduces to: Did God want separated creature groups to communicate with each other, or did He set them up so that they would develop independently?

Pleading ignorance but desiring knowledge, all of us can remain open to the possibility of aloneness as well as alien company. Either way, the truth must surely be a wondrous thing. With options fully open, then—in the true scientific spirit of letting the evidence lead us rather than our presuppositions—we may choose to fully support SETI's quest.

But given what we can know for now, we have little reason to hope for answers from E.T. in our lifetime. We'll have to solve our own problems with war, crime and poverty, make up our own minds about the purpose of life, and seek another "conduit to the ultimate."

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