SPACE

CONTACT

THE DAY AFTER

If we are ever going to pick up a signal from E.T., it is going to happen soon, astronomers say. And we already have a good idea how events will play out

By Tim Folger

Photograph by Grant Delin

The 100-meter-wide radio dish at Green Bank, W.Va., is the largest steerable antenna in the world. Astronomers use the dish as part of the search for extraterrestrial intelligence, a worldwide collaborative effort, to scan the skies for artificially produced radio signals.

Tim Folger has been writing about science for more than 20 years. In 2007 he won the American Institute of Physics science writing award. His work has appeared in *Discover, National Geographic, Science* and other national publications.

ONE DAY LAST SPRING FRANK DRAKE RETURNED TO the observatory at Green Bank, W.Va., to repeat a search he first conducted there in 1960 as a 30-year-old astronomer. Green Bank has the largest steerable telescope in the world—a 100-meter-wide radio dish. Drake wanted to aim it at the same two sunlike stars he had observed 50 years ago, Tau Ceti and Epsilon Eridani, each a bit more than 10 light-years from Earth, to see if he could detect radio transmissions from any civilizations that might exist on planets orbiting either of the two stars. This encore observing run was largely ceremonial for the man who pioneered the worldwide collaborative effort known as SETI—the search for extraterrestrial intelligence. As a young man, Drake had half-expected to find a cosmos humming with the equivalent of ET ham radio chatter. The elder Drake did not expect any such surprises from Tau Ceti or Epsilon Eridani. The Great Silence, as some astronomers call the absence of alien communiqués, remains unbroken after five decades of searching. And yet so does Drake's conviction that it is only a matter of time before SETI succeeds.

"Fifty years ago, when I made the first search, it took two months—200 hours of observing time at Green Bank," says Drake, who is now chairman emeritus at the SETI Institute in Mountain View, Calif. "When I went back this year, they gave me an hour to repeat the experiment. That turned out to be way too much time. It took eight tenths of a second—each star took four tenths of a second! And the search was better. I looked at the same two stars over a much wider frequency band with higher sensitivity and more channels, in eight tenths of a second. That shows how far we've come. And the rate of improvement hasn't slowed down at all."

Computer-processing power has roughly doubled every two years for the past 50. Drake and other SETI scientists believe that within 30 years or so, computing advances will allow them to sift through enough frequencies from enough of the 200 billion stars in our galaxy to have a reasonable shot at finding a signal from an extraterrestrial civilization. "My guess—and 'guess' is the right word—is that the number of detectable civilizations in our galaxy right now is 10,000," Drake says. "That means one of every some millions of stars has a detectable civilization." His estimate, he adds, assumes an average life span of about 10,000 years for a technological civilization. "In 20 or 30 years we will be able to look at 10 million stars. That's the challenge, even though it's based on a guess."

Drake may be too conservative, says Seth Shostak, senior astronomer at the SETI Institute. "If this experiment has merit, it's going to succeed within two or three decades," he says. "If it doesn't, then there's something fundamentally wrong in our assumptions. If it's going to happen, it's going to happen soon."

Drake and Shostak could, of course, be wildly off base. It is not hard to find astronomers who would peg the number of civilizations in our galaxy at one—our own. But if Drake and Shostak are right—if we are within a few decades of discovering that we are not alone in the universe—what then? What happens after we detect a signal from an alien intelligence? Could we even translate the message? How likely is it that the message might contain knowledge that would transform our culture? Would it be dangerous to respond and reveal our existence to beings from other worlds?

One thing that definitely *won't* happen if SETI scientists discover such a signal is a government cover-up or any sort of conspiratorial secrecy. The world will learn the news almost immediately. Shostak is certain of this. So is Jill Tarter, director of the SETI Institute's research center. They know exactly how events will unfold when they finally find a signal because on a June morning 13 years ago, they thought they had received one.

DRESS REHEARSAL

IT HAPPENED AT ABOUT 6 A.M. Tarter was at the Green Bank observatory when the signal came in. It was bunch of signals at discrete frequencies, with uniform spacing between them, which looked on a graph like a comb. "It was clearly an engineered signal," she says. Tarter and her colleagues at Green Bank followed their protocols to rule out false alarms. They swung the telescope away from the target star. The signal vanished. They aimed at the star again. The signal came back. Ordinarily they would have verified the precise origin of the signal with a separate telescope at an observatory in Woodbury, Ga. But lightning had recently struck that telescope and fried its hard drive.

"It was rural Georgia, and it took about three days to get FedEx in there with a replacement drive," Tarter says. "In the

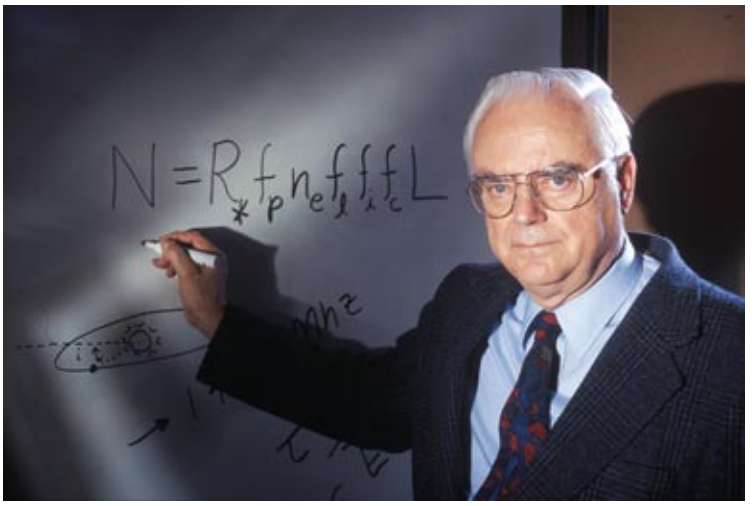
IN BRIEF

Within decades advances in computing power will allow astronomers to scan enough stars in our galaxy to have a reasonable chance at detecting a signal from an extraterrestrial civilization.

News of the discovery of an extraterrestrial signal will reach the public almost immediately. A conspiracy to hide or suppress the evidence of alien intelligence would be all but impossible.

The content of the signal may never be understood. The assumption that mathematics or physics could serve as a cosmic lingua franca among civilizations may be misguided.

Would revealing our existence to the universe at large attract the attention of hostile aliens? Such fears are probably groundless, despite the warnings of some prominent scientists.



Frank Drake first scanned for extraterrestrial signals 50 years ago.

COURTESY OF SETI INSTITUTE

meantime, we had telescope time in West Virginia"—SETI observations typically piggyback on other, mainstream astronomical research—"and we were going to use it. Without our second site, the only thing we could do was nod back and forth between two different stars."

Tarter, who had been scheduled to fly home to California at noon that day, canceled her flight and left a phone message for Chris Neller, her assistant in Mountain View, to tell her about the change in plans. By late afternoon the target star that was thought to be the source of the signal began to set below the horizon. That is when Tarter and her team realized something was wrong. Although the target star was setting, the source of the signal seemed to be climbing, its strength undiminished. The signal, they eventually determined, was coming from a NASA satellite, the Solar and Heliospheric Observatory, or SOHO.

During all the excitement, no one remembered to call the Mountain View office to tell them the whole episode had been a false alarm. Meanwhile Ann Druyan, Carl Sagan's widow, had by chance called Mountain View to talk with Tarter about something unrelated. Neller told Druyan that Tarter was delayed at the Green Bank observatory, studying what might be a signal from an extraterrestrial civilization. Druyan immediately called William J. Broad, a science reporter for the *New York Times*. Broad in turn called Shostak to confirm the story.

"The beauty of a false alarm is that you see what really happens," Shostak says. "It's no longer theoretical. Not a false alarm that lasts five minutes, but where for the better part of a day you think, maybe this is it. You have these nifty protocols, but what really happens? People don't follow protocols. It's not that people do anything mischievous or malevolent—you're so caught up in the excitement of the moment, the media are immediately calling you on the phone, people send e-mails to their friends."

In the event of a signal that survives initial scrutiny—one that is quickly verified by a second observatory—the astronomers who made the discovery would send an International Astronomical Union (IAU) telegram—now delivered as an e-mail—to observatories around the world. Astronomers use IAU telegrams to notify one another of time-sensitive observations: supernovas, comets or gamma-ray bursts. Tarter says a SETI observation would be treated like any other astronomical discovery. "If something like that happens, we'll want everybody who can to look at it right away," she says. "We'd like people to look in the signal's direction, with different tools, checking different frequencies, and try to figure it out."

VERIFYING THE MESSAGE

SETI SCIENTISTS THINK they know, in broad terms, what an ET signal will look like. To stand out as obviously artificial against a background of natural cosmic radio emissions, the signal would have to be narrow, with a lot of energy packed into a few frequencies. Natural phenomena, such as pulsars and interstellar gases, spew out radio emissions at many different frequencies. If an observatory ever receives a narrowband signal coming from an astronomical distance, the source would almost certainly be artificial.

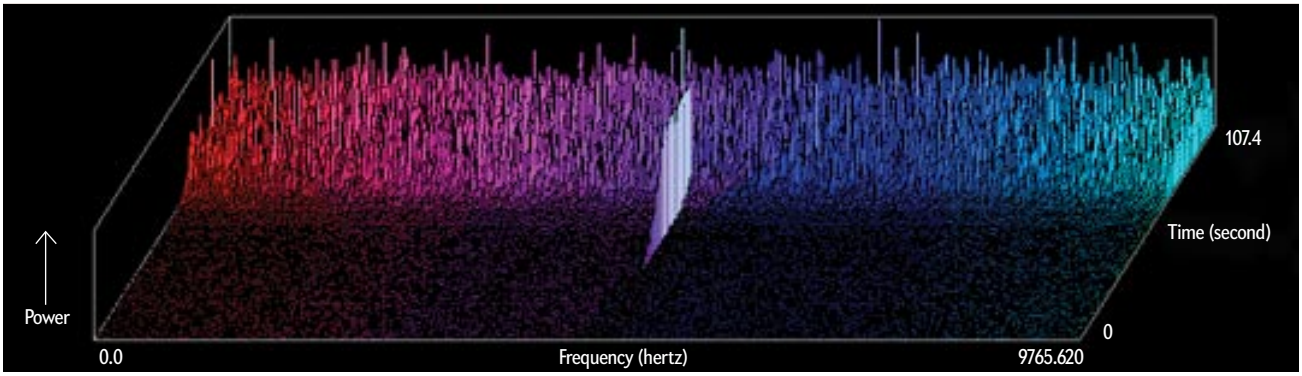
According to voluntary, nonbinding protocols adopted by SETI researchers around the world, if IAU astronomers confirmed a signal as genuine, they would then notify the United Nations and various world leaders. Tarter says that some generous SETI sponsors would also receive discreet thank-you calls. At that point the astronomers who made the discovery would be free to hold a press conference—if the story had not already been leaked. But even those modest constraints would probably be breached. "The protocols are just a nice idea," Shostak says. "They're like red lights in Naples, Italy," he laughs. "They're suggestions."

> The story of the discovery would monopolize the headlines for a while, but our collective attention span would inevitably move on while scientists sought to translate the message.

What happens next? A triumphant announcement, followed by headlines? Panic? New Age celebrations of galactic harmony? Probably none of the above, except for the headlines, if Douglas Vakoch is right. A psychologist by training, Vakoch has an office across the hall from Tarter at the SETI Institute and must have the world's most unusual job title: director of interstellar message composition.

"While we may be able to detect that there is a signal that at least initially appears distinctly artificial, I suspect even that claim would be questioned," Vakoch says. "There would be a lot of people trying to come up with natural explanations. I think the assumption that one day someone is going to announce that we've discovered extraterrestrial intelligence, and now the world knows, is a fallacy, because there's going to be much more ambiguity in the process. It might be similar to what was recently considered a plausible claim that there was evidence of fossils in Martian meteorites—interesting enough to consider, but now let's look at this over the next few months."

Even if the signal is confirmed as an authentic transmission from an extraterrestrial civilization, it is unlikely that astronomers would be able to extract any information from it for many years. SETI's instruments are designed to search for steady, pe-



ET's signal, astronomers assume, would arrive in a narrow frequency band at about 1,420 megahertz, the spectral frequency of common hydrogen. In the simulation above, the signal (*at center*) pokes through background noise.

riodic narrowband radio pulses—carrier waves powerful enough to be detectable across many light-years. The pulse itself would yield no information, other than its artificial nature. Any message content would likely be in the form of changes in amplitude or frequency buried within the pulse. Even a large radio telescope would need to repeatedly scan a small patch of sky to build up the signal pulse above background radio noise. In doing so, it would average out modulations on finer timescales that might contain a message. Resolving the message would require an antenna far more powerful than Earth's largest, the 305-meter dish at Arecibo, Puerto Rico.

"You would need something on the order of 10,000 times bigger than Arecibo," Shostak says. Rather than a single enormous dish, such a telescope would probably consist of many smaller antennas spread across a large area and linked electronically. Constructing such an instrument would require international collaboration and funding, with no guarantee that the message—if the signal contained one—could ever be deciphered. "That's not something you'd do overnight," Shostak observes. "That's a big project. I think we would do it, because—gosh darn it—we would want to know what they're saying."

THE FALLOUT

TAKING INTO ACCOUNT political debates and the time needed to build a telescope sensitive enough to analyze the signal, years would pass before astronomers or cryptographers could begin to attempt to decipher a message from the stars. So whereas that first contact with another intelligence would in itself be one of the most important scientific discoveries of all time, the lack of any further knowledge about the nature of that alien intelligence would limit the immediate cultural impact. The story of the discovery would monopolize headlines for a while, but our collective attention span would inevitably move on while scientists sought to translate the message.

"I have no doubt that the receipt of such a message would be a huge and genuinely exciting moment," says Charles T. Rubin, a political philosopher at Duquesne University who studies the social issues raised by SETI research. "But I don't think it would cause a great cultural shift, because the notion of extraterrestrials is common both in popular culture and in scientific circles. It would confirm what many already suspect to be true."

If some nation or group of nations decides to build an instrument that would give us a shot at cracking an extraterrestrial message, how likely is it that we would succeed? Sagan, an early advocate of SETI, imagined that we might receive an *Encyclopedia Galactica,* filled with the accumulated wisdom of many advanced extraterrestrial civilizations. Some SETI researchers assumed—and still assume—that the language of science might provide common ground for communication. Kathryn Denning, an anthropologist at York University in Toronto and a member of the SETI Post-Detection Taskgroup, is less sanguine.

"We run into an irreducible problem with communication that isn't face to face, and that is the problem of establishing a referent," Denning says. "If you and I speak different languages, and we're in the same room, I can point to a table, and I can say 'table,' and you infer that 'table' is my word for that thing, and then we can go from there. That's the time-honored way of learning languages. If you're not in direct contact, if you can't do that kind of pointing exercise, there's always this question of what you're referring to in these initial communications. Scientists—physical scientists and mathematicians in particular—tend to be more prone to thinking that because we'll be dealing with the same physical structures in the universe, we can use those as our Rosetta Stone, so to speak, and build up from there—send each other the value of pi, and then we're off to the races. But anthropologists tend not to be so comfortable with that. Errors can take place right at the get-go. For example, if I give you a signal—beep, beep, beep—is that three or two? Are we counting the beeps or the spaces? We have fundamental assumptions built in."

Stephen Hawking said that transmitting messages could be dangerous. He warned of the possibility of predatory aliens ravaging the resources of world after world.

John R. Elliott, a researcher at Leeds Metropolitan University in England who studies artificial intelligence and the structure of languages, is already preparing for the day we receive the first extraterrestrial message. Even if it proves impossible to directly translate the message, it might be possible to discover patterns that Elliott suspects are fundamental to all languages. Those patterns might reveal something about the nature of the beings who sent the message, particularly how their level of intelligence compares with our own.

COURTESY OF SETI INSTITUTE

Elliott has devised a computer program that compares any unknown language with a database of 60 human languages. All languages, he says, share what he calls functional elements—words such as "if," "and" and "but"—that break up the complexity of a language into manageable chunks. The length of those chunks—the nouns, verbs and other words contained between the functional elements—provides a measure of our cognitive abilities. "It opens a window on our way of embedding information, the way we structure our sentences," Elliott notes. "It shows the constraints on us as intelligent authors."

Elliott says his computer program shows that the functional elements in all human languages are typically separated by no more than about nine words. Assuming an ET signal arrives as a binary stream of ones and zeros, his program would search for patterns in the message and attempt to identify the occurrence of functional elements. The program would, ideally, give us a rough measure of alien IQ by comparing the average interval between our if's, and's and but's with theirs. "Anything above 10 means it would exceed human cognition," he says. Elliott thinks he could determine whether a signal bears the characteristics of a language within a few days; he might be able to tell if it contains images. "For the semantic side? We might never interpret it."

WORTH THE RISK?

SOME SETI PROPONENTS suggest we should do more than passively wait for a signal. They believe we should transmit messages and let anyone who might be listening know that we are here. Last spring, in a Discovery Channel series, Stephen Hawking of the University of Cambridge said that transmitting messages without knowing what is out there could be dangerous. He warned of the possibility of predatory aliens ravaging the resources of world after world. "If aliens visit us," he said, "the outcome would be much as when Columbus landed in America, which didn't turn out well for the Native Americans."

The SETI community seems to be divided about the wisdom of sending messages versus quietly biding our time. But in any case, it is probably too late. Radio and television signals have been leaking from our planet for decades now. "*I Love Lucy* has already passed 10,000 stars," says Dan Wertheimer, a SETI researcher at the University of California, Berkeley, who helped to develop the SETI@Home project, which allows anyone to download software to a home computer to help process SETI data. Moreover, there is no reason why an extraterrestrial civilization couldn't spot Earth using the same—or better—techniques that terrestrial astronomers are already using to find planets around other stars. Geoffrey W. Marcy, an astronomer at Berkeley who has played a leading role in the discovery of dozens of extrasolar planets, says that by the end of this century, space-based telescopes will enable us to map the continents and oceans of these worlds. And if we will soon be doing that, it is likely that extraterrestrial civilizations—if any exist—are doing it, too.

FIND AN ONLINE POLL
ScientificAmerican.com/jan2011/seti

"Aliens who have a mere 1,000-year head start on us could listen to our conversation right now," Marcy says. "They could read our lips. So this passive versus active thing makes no sense to me. We can't hide—that's crazy! Any more than ants can hide from us humans. It would be like one ant talking to another ant, 'Oh, we'd better not talk because the humans would know we're here, and they might step on us.' No, sorry, guys, you ants can't hide from us!"

Drake believes Hawking's fears are unfounded, largely because interstellar travel may be practically impossible, which he believes also answers the Fermi paradox, named for Enrico Fermi, the Italian physicist who first posed it: If extraterrestrial civilizations exist, why haven't we seen them yet? Given the age of the galaxy, and its 200 billion stars, surely at least one civilization should have colonized the galaxy by now. Drake demurs.

"To give you an idea why even a very small mission won't work, just imagine a spacecraft the size of a 737 airplane, with perhaps 50 passengers. Suppose the nearest star with a habitable planet is only 10 light-years away, which is quite close—there are only a few stars that close. And assume you can go 10 percent the speed of light. Why that number? It never gets mentioned in all these discussions about space travel, but if you're going a little faster than that, about 12 percent the speed of light, if you impact a pebble, the energy in that impact is equal to what that same mass would release if it was used in a nuclear fusion bomb. It would blow up the spacecraft. One pebble in the whole trip ends the mission." But Drake believes that SETI's limited funds should go to searching, not broadcasting.

Marcy says the Fermi paradox presents a genuine problem for SETI researchers, and he sees only three possible solutions. "The fact that aliens haven't landed tells you they're rare, or that space travel is very hard, or that it's not just worth doing."

Perhaps Hawking's fears say more about us than about any aliens we might encounter. Given the history of our own species, who would have more to fear from contact, humans or extraterrestrials? SETI, unavoidably, reflects our own dreams and night terrors about our place in the universe. In postulating the presence of civilizations on other worlds, we are extrapolating wildly from a single known example—our own fragile, remarkable existence.

Realistically, though, the quest to make contact will be an endeavor that spans centuries—if our own civilization lasts that long. SETI is, perhaps, the strangest and most profound experiment in the history of our world. One of the founding fathers of SETI, the late Philip Morrison, a physicist at the Massachusetts Institute of Technology, likened the SETI project to the medieval and Renaissance recovery of the knowledge of classical antiquity, in which scholars labored for generations. The patient transcribing of ancient texts revealed a world that had been lost and eventually transformed the world the scholars thought they knew.

One day we may learn that we are not alone and, indeed, that intelligence is common in the universe. "If SETI succeeds, then intelligence happened in at least one other place," Shostak says. "So it probably happened in lots of places. In astronomy, the only numbers are one, two and infinity. So if you get two, there are probably lots more. It's like finding two elephants." SA

MORE TO EXPLORE

The Eerie Silence: Renewing Our Search for Alien Intelligence. Paul Davies. Houghton Mifflin Harcourt, 2010.

A debate between Carl Sagan and Ernst Mayr on the chances of finding E.T. life: www.planetary.org/explore/topics/search_for_life/seti/seti_debate.html

For aliens only! An informal group of 100 scientists, artists and futurists put together an open invitation to all E.T.s in an early attempt at planetary outreach: **www.ieti.org**

The International Academy of Astronautics quantifies the significance of possible E.T. signals: **www.setileague.org/iaaseti/rioscale.htm**

The SETI Institute's home page has information on telescopes, essays on E.T. signals, podcasts, and more: **www.seti.org**