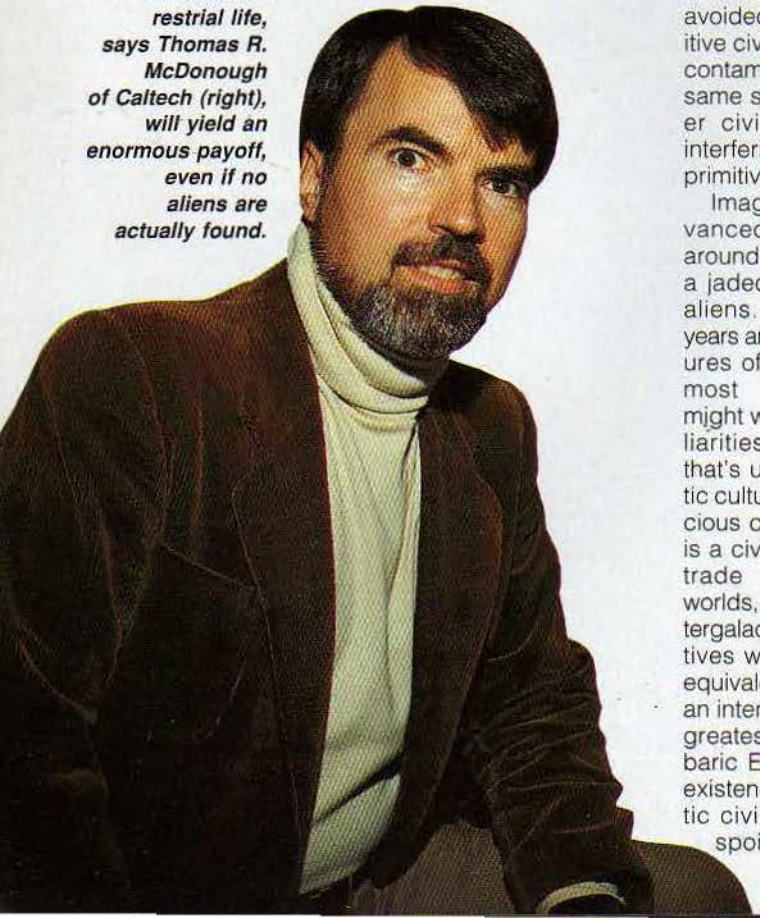
STARS

SWEET NOTHINGS?
Here are three reasons why E.T. has not yet phoned Earth

When Italian physicist Enrico Fermi sat lunching with physicist Edward Teller in 1950, Fermi ignited a debate that rages to this day. He asked simply, "If there are extraterrestrial civilizations, where are they?" In other words, if they exist, why aren't they obvious? Why don't astronomers see alien Coca-Cola signs flashing in the night sky?

Radio astronomer Frank Drake made a valiant effort to answer this question by creating an equation to estimate the probability of life arising in our galaxy. He broke it down into a series of steps: What are the numbers of planets around a star? What are the odds that life will sprout on one of those planets? What's the likelihood that intelligent life will arise? When we optimists plug our estimates into the Drake equation, we get numbers ranging from thousands to millions of technological civilizations that could exist in the Milky Way. When pessimists input their numbers, they get approximately zero. Ultimately, the burden rests on the shoulders of the optimists to explain why we have not yet discovered any proof of life on other worlds.



Talking head: The search for extraterrestrial life, says Thomas R. McDonough of Caltech (right), will yield an enormous payoff, even if no aliens are actually found.

To me, a Caltech engineering lecturer and coordinator of the Planetary Society's Search for Extraterrestrial Intelligence (SETI) program, the most appealing explanation for the apparent absence of E.T.'s is the quarantine hypothesis. Fans of the old *Star Trek* series know how the crew of the starship *Enterprise* always attempted to uphold "The Prime Directive"; that is, they steadfastly avoided direct contact with primitive civilizations in order to avoid contaminating the cultures. In the same spirit it's possible that other civilizations want to avoid interfering with the emergence of primitives such as us.

Imagine we belong to an advanced civilization that's been around for billions of years. We're a jaded group of near-immortal aliens. We have lived 1 million years and have sampled the pleasures of a thousand worlds. Our most refreshing experience might well be savoring the peculiarities of a brand-new world that's uncontaminated by galactic culture. Perhaps the most precious commodity in the universe is a civilization that does not yet trade information with other worlds, one where there are no intergalactic McDonald's and no natives watching Andromeda IV's equivalent of *The Cosby Show.* To an interstellar conservationist the greatest evil might be letting barbaric Earthlings know about the existence of an advanced galactic civilization. To do so would spoil Earth. Once Earthlings became aware of an alien presence, civilization would change, just as Papua New Guineans polluted by the outside world now listen to rock music, watch TV, and read *The New Yorker.*

Another possibility why aliens haven't contacted us is that their civilizations may have developed a method of inducing permanent ecstasy for their citizens through drugs, electronic stimulation of the brain, or computer-generated artificial reality. With automatic life-support systems, people could live happily ever after, blissfully unconcerned about the rest of the universe. It could be that there are whole worlds of slumbering little green men and women spending their lives in cosmic rapture. Maybe no one is particularly interested in signaling us. Suppose *you* could live in resplendent ecstasy for the rest of your life. Would you be interested in schlepping off to other worlds?

It's also possible that aliens have no more interest in us than the average human has in ants. After a few million years of evolution accelerated by their genetic engineers, they may have an intelligence as superior to ours as ours is to the ants'. What would they learn by contacting us? That's not to say they haven't left some subtle evidence for us to discover. Perhaps we, with our teeny ant brains, might still be able to detect the crumbs the aliens have left behind.

SETI has reopened a Pandora's box of questions, but at least it offers the *possibility* of answers. Throughout history, every time we've turned a new kind of telescope on the sky, we've always found surprises. So let's continue with the SETI search. At worst, we'll discover wonderful celestial bodies never before seen by human beings. And at best, we may find civilizations dazzling beyond our wildest dreams.

—Thomas R. McDonough

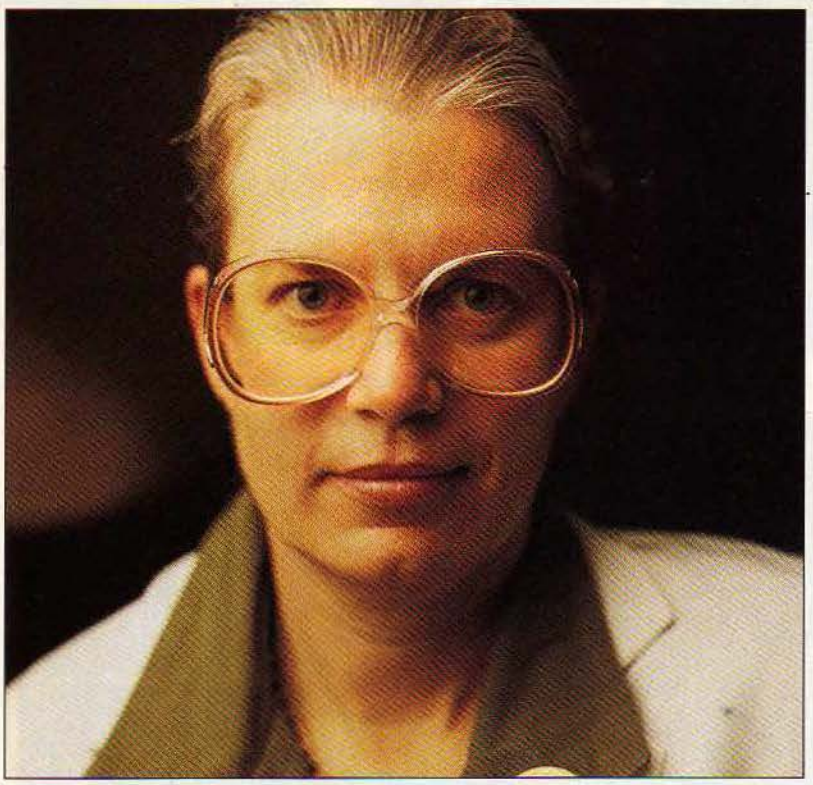
THE BIG EAR

ARTICLE

Giant new telescopes will step up the hunt for intelligent life in space

Extraterrestrials seem to like Jill Tarter. As a radio astronomer devoted to the search for life in the universe, she makes extraterrestrials her business—at least *some* extraterrestrials. Tarter is *not* interested in little green men in flying saucers who kidnap yuppies to Andromeda. Even so, that doesn't stop the tabloid variety from writing or phoning Tarter. Sometimes they even show up in person. As she pilots her black Saab Turbo

BY DENNIS OVERBYE



SCIENTIST JILL TARTER HEADS UP A RELENTLESS SEARCH FOR CIVILIZATIONS IN THE STARS

down very narrow streets past the six-story wind tunnels and blimp hangars that yawn cavernously in the bright Northern California sun, her blond hair pulled back in a pink ribbon, Tarter describes some recent encounters. One week, she says, a man arrived at the visitors' center of NASA's Ames Research Center, where she works, with documents purporting to prove his unearthly origins. "He wouldn't let us borrow them or Xerox them," she says with a straight face. Patient and tolerant to a fault, Tarter is no soft touch. All the physics that has been packed into her skeptical brain tells her the most she can expect is the dit-dit-dit of some interstellar Morse code falling like rain on a radio antenna from far out in the galaxy.

That faint radio tapping on the astronomical window would, of course, change the world. After ten years Tarter and her colleagues at Ames may get that opportunity. On Columbus Day, 1992, in California and Puerto Rico radio telescopes equipped with special receivers and computers capable of analyzing tens of millions of radio channels at once will switch on and sift the crackle and hiss of the heavens for the unique signs of intelligent life. NASA with its usual elegance has dubbed this earth-bound mission MOP, for Microwave Observing Project, but astronomers and enthusiasts everywhere know it as the Search for Extraterrestrial Intelligence, or SETI.

Generations of humans have raised their eyes to the night sky and wondered if there was anybody else in the universe. The news that the human race is not alone could come tomorrow, a thousand years from now, or never. It could come in the form of footprints in the methane goo of another planet, the indecipherable nameplate on a derelict spacecraft, geometric ruins crumbling beneath a brown or red sky; but if it comes in the next ten years, it will likely be in the form of radio waves. And it is to Tarter's windowless office, with its wall-size Saturn mural, that the answer to that cosmic question, wrapped in statistical uncertainties and radio noise, will wind. Here she and her colleagues will have to make the official verdict that humanity is no longer alone.

"It's an old question, 'Are we alone?'" says Tarter. "This is the first chance to take it away from the priests and the philosophers. There are four hundred billion stars in the galaxy," she adds brightly. "We're made of stardust, really common stuff. In a universe filled with stardust, it's hard to believe that we're the only creatures who could be."

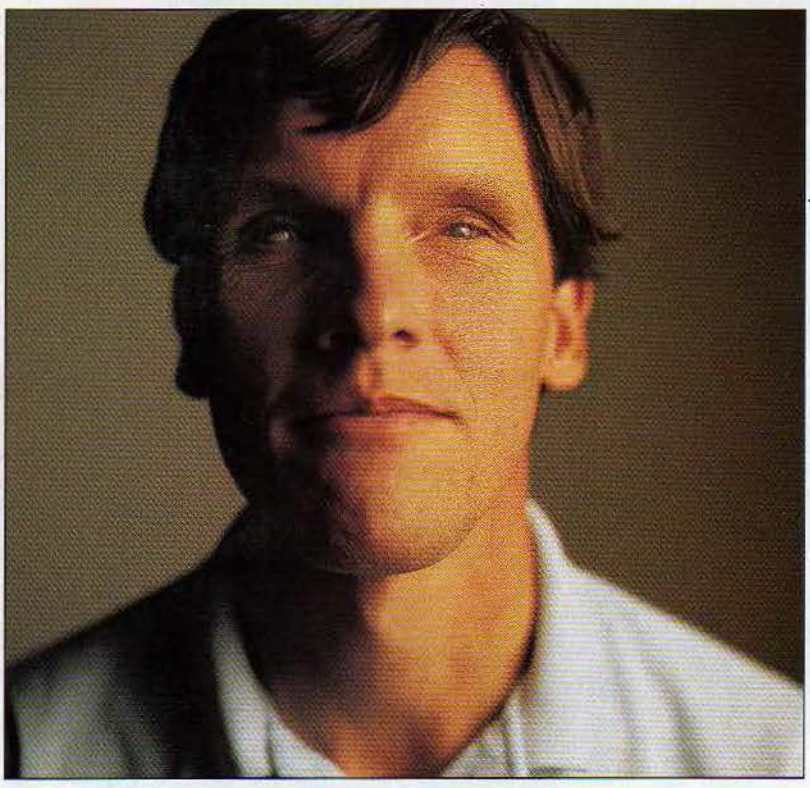
Why should aliens be broadcasting to us, or anyone else? Because it's a lot easier, cheaper, and faster than dropping by in person. A few dollars' worth of electricity can beam radar waves across the galaxy. The earth itself has been broadcasting news of humanity's existence in the form of stray radar and television signals for the last five decades. By now those signals have passed more than 1,000 stars.

While SETI scientists do not rule out the possibility of discovering what they call "leakage," unintended transmissions from some other planet, they think they'll find something like a radio beacon that is easier to detect. And the race or races that sent it probably will be older and more advanced than we.

The logic goes like this: If radio technology is the entrance requirement for the galactic club, then the human race has had the wherewithal for a mere 95 years. The other members are likely to have been there thousands or millions of years ahead of us. The galaxy, after all, is 10 billion years old and is full of stars and presumably planets, billions of years older than the sun and its entourage, on which life could have evolved long, long ago.

It is this kind of reasoning that leads Philip Morrison of MIT to call SETI the "archaeology of the future." These civilizations in some sense represent our future, at least technologically. The message we receive may be as obscure and difficult to interpret as the hieroglyphics over which scholars have scratched their heads in the past. Some scientists envision tapping into an interstellar radio and computer network that functions as a kind of galactic library, linking cultures across unbridgeable gulfs of space and time, broadcasting information about races that have been dead for millions of years. SETI pioneer Frank Drake has speculated that the most likely interstellar communicators would be races of immortals, who could wait nearly forever for return messages.

In 1959 physicists Morrison and Giuseppe Cocconi suggested that if extraterrestrial civilizations wanted to communicate with one another, the



most efficient and economical method would be radio waves. In the frequency range between one and ten gigahertz, they pointed out, background noise from the galaxy is relatively quiet and a signal could be heard a long way. Unaware of that paper, Drake started his so-called Project Ozma; for two months in 1960 he pointed a radio telescope in Green Bank, West Virginia, at a pair of nearby stars, hoping to detect a signal. Drake went on to invent an equation that—based on the fraction of stars with planets, the proportion of those that are habitable, and the lifetimes of technological civilizations—calculates the number of technical civilizations in the galaxy at any one time. Using Drake's equation, optimists like Carl Sagan and Drake himself have concluded that there could be 1 million civilizations in the Milky Way alone.

PHYSICIST KENT CULLERS DREAMS OF SIGNALS THAT WE COULD NOT PRODUCE OR EVEN UNDERSTAND

That was the beginning of the quest known as SETI. In the intervening years only 2,000 or so stars have been surveyed, less than one-millionth of the galaxy. Drake likes to say that the searches to date have been like trying to find a needle by walking past the haystack every now and then. NASA got into the act in 1971 when it sponsored with Stanford a summer workshop at Ames, led by Barney Oliver—an engineer and one of the founders of Hewlett-Packard—which concluded that the best way to comb the cosmic haystack was with a massive array of 300-foot radio antennas dubbed Cyclops.

NASA's attempts to follow up on the Cyclops study were consistently frustrated by Senator William Proxmire's opposition to SETI. Then last year the White House and Congress gave their blessing to a real search. After many years in the political wilderness, the SETI scientists are blinking at their emergence into respectability. NASA's search will last ten years and has two parts. One group of astronomers from Ames will build the special receivers and radio telescopes, particularly the 1,000-foot dish at Arecibo, Puerto Rico, to examine emanations from the 773 stars within 80 light-years of the earth.

Another group centered at the Jet Propulsion Laboratory in Pasadena, California, will use similar equipment placed on NASA's deep space tracking telescopes to survey the entire sky for signals that might be coming from between the stars or from far beyond the stars. As program scientist of MOP, Tarter is in charge of the long-delayed project.

It was during the outlaw era in the late Seventies that Tarter got swept up in SETI. Raised in Scarsdale, north of New York City, she decided when she was eight that she wanted to be an engineer.

Tarter studied engineering physics at Cornell—the only woman in her class—but after five years she'd had enough. "If engineering was as boring as my professors..." she groans. "I had a good education in problem solving, so I went looking for problems." She hooked up with Cornell astrophysicist Edwin Salpeter and wound up chasing a Ph.D. in astronomy at the University of California, Berkeley, a process made longer by the fact that she was then raising a daughter.

Tarter's first job at Berkeley was programming an old PDP-8S computer. "The *S* was for *stupid*," she jokes, but that old computer was to be her introduction to SETI. Years later a Berkeley astronomer named Stuart Bowyer, who had gotten enthused by Cyclops and wanted to equip the university's radio telescope at Hat Creek to do some searching, was given custody of the old computer. He set about looking for someone to run it, found Tarter, and gave her the Cyclops report to read. "That was it," she says.

Tarter learned early on not to hold her breath waiting for the Big Moment. In SETI most of the action is chasing false leads. She bends over backward to be conservative. "There's no poetry in my soul," she moans. "I'm afraid I'm so cynical that I'll throw the baby out with the bathwater." She recalls a tense observing session in France a few years ago in which she and her partner found a suspicious signal. *If I go to sleep*, she remembers telling herself, *my French colleague is going to call up* Le Monde, one of the largest French newspapers. After three nights they figured out the signal was coming from a Paris radar.

The bounty of nature is the biggest problem facing extraterrestrial hunters like Tarter. Besides the billions of stars or other places in the galaxy from which E.T.'s could be signaling, there are billions of frequencies on which they could choose to transmit. Moreover, artificial radio sig-

nals that humans or aliens created would tend to be very sharp in frequency, as opposed to natural radio sources, which are emitted over broad ranges of frequencies. The carrier signal for the *Voyager* spacecraft, for example, is less than a hertz wide, and television carriers are only about one tenth of a hertz wide. While this makes it easy to distinguish alien broadcasts from quasars—just look for a narrow-band signal—it also makes them harder to find. The receiver must be tuned to precisely the right frequency.

For the last few years NASA researchers have been testing an experimental receiver known as a multichannel spectrum analyzer (MCSA). Designed at Stanford, the MCSA can divide a radio signal into 74,000 frequency channels and examine them simultaneously for signals. That spectrum analyzer is the forerunner of an even more powerful 14.38-million-one-hertz-channel device that will form the very heart of NASA's SETI systems.

The MCSA is really a kind of supercomputer. Every second that a radio telescope is on the air, the spectrum analyzer will generate 120 million numbers during its six revolutions. Jay Duluk, founder of Silicon Engines, which is building the MCSA for Ames, says that with the receiver NASA searchers will be able to examine all of the several billion frequencies available to an extraterrestrial in a few hours instead of spending a few years looking at one particular star.

The MCSA is only half the story, however. What do you do with 120 million numbers a second? Only a computer could keep up with that flood. "Although we say we're looking for extraterrestrial intelligence, we can't define an intelligent signal," says Kent Cullers, an Ames physicist and expert signal processor. "We need to look for signals that can't be produced by any natural process that we understand. The amount of data processed is the equivalent to an entire *Encyclopaedia Britannica* every second. Those are random letters, and we're looking for the one combination that says, 'Hi there.' "

SETI is probably the one field of astronomy in which Cullers, forty-one and blind since birth, is not at a disadvantage. "I don't know of many blind astronomers," he says. His father was a physicist at Rockwell. "I got astronomy for bedtime stories."

Figuring there was no future for a blind astronomer, Cullers studied the effects of radar on the ionosphere and got a Ph.D. from Berkeley in physics. He started begging the Ames SETI group to give him a job after meeting Jill Tarter at a wedding and persuading his wife, an economist and writer, to read the Cyclops report to him. She read for 24 hours straight. "It was an astounding document," he says. He joined Ames in 1980 and has been there ever since, writing computer programs to search for signals.

According to Cullers, an alien "Hi there" would most likely take the form of a continuous tone at some narrow-frequency band or a series of pulses. His programs are designed to recognize either kind among the cosmic noise and confusion.

Our own civilization is only marginally within the bounds of detection by the SETI system, adds Cullers. Earthly television transmitters are only about one tenth as strong as they would need to be to be detected at the distance of the nearest star. The early warning defense radars of the United States and the Soviet Union are strong enough to be picked up from 100 light-years away, but the direction of their beams changes constantly as the earth rotates.

To most SETI people the quest is its own reward, whether the answer is out there or not. "It would be incredible, fantastic, to succeed," says Tarter. "It's pretty fantastic just to search." She compares it to the green revolution. "Talking about SETI to people makes them feel different," she says. "They realize they're a small entity in a large universe. This is a milestone, a major achievement in social stability. As far as I know, this is the first time we've taken on a task that could last for generations, just because we're curious. We're signing on for this of our own free will."

THE SETI PROTOCOL

Lately a lot of people have been taking seriously the possibility that NASA's or some other group's search might eventually succeed. In 1986 during the International Astronomical Federation's (IAF) annual congress in Innsbruck, Austria, scientists, lawyers, philosophers, and diplomats attended a session on "Legal, Political, and Social Implications of the Detection of an Extraterrestrial Intelligent Signal." The following year the IAF drafted a protocol on what to do if a signal is received. Its guidelines stipulated that any discovery should be confirmed independently before it was announced; once a signal had been verified, information about it should be disseminated through regular scientific and public channels to all the world; and no response to the signal should be sent without "appropriate international consultations."

The International Academy of Astronautics and the International Institute of Space Law approved the document. The goal is to have it signed by the various institutions and individuals involved in or affected by the search. NASA meanwhile has developed its own protocol for handling potential discoveries. "Being NASA, we have to have a plan for everything," Tarter says, smiling, "even success." The protocol is designed to minimize the chance that some strange interference, or worse, a hoax, will pass for the real thing. "We've had people ask us, 'Would you like a test signal every now and then?' " she says with a look of dread.

To begin with, both the operation of the radio telescopes—moving them from star to star—and the analysis of the incoming data will be completely automated. Even if a human could keep up with 20 million random numbers a second, the pain of the tedium hour after hour, night after night, month after month, would be cosmic. A human operator will make sure that everything is working and then go to bed. Upon reception or recognition of a suspicious signal, the computer will perform a series of tests, checking the source of the signal against a catalog of satellites and other causes of radio interference, wiggling the telescope on and off the star to see if the signal goes away when it should, and other exercises that Tarter won't describe, in order to keep hoaxers off guard. Only then will the computer wake up the operator, who will check again to make sure everything is working right and begin monitoring the source.

Finally, the operator will call a special officer at Ames, who will arrange for another NASA SETI station to observe the star. "If the other site verifies the signal, we'll notify headquarters," Tarter says. According to her plan, the discovery site, the SETI office, and NASA headquarters in the person of the associate administrator for the Office of Space Science and Applications would share in the official announcement. After that, the technical details of the discovery would probably go to the International Astronomical Union's Central Telegram Bureau, which alerts astronomers worldwide to fast-breaking events that need to be observed. "Nobody has signed off on it," Tarter admits. "We can make a lot of plans in advance. You can imagine that people who take responsibility for this will have strong opinions."