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The Search for Extraterrestrial Intelligence

by Sally Stephens, Astronomical Society of the Pacific

Is anybody out there? On Oct. 9, 1992, the 500th anniversary of Columbus' arrival in North America, NASA will inaugurate a special program designed to answer that age old question. The program will look for messages from any technological civilizations on planets around other stars, the most comprehensive Search for Extra-Terrestrial Intelligence (SETI) ever attempted.

- How likely is it that there are other civilizations?
- What is the best way to contact other civilizations?
- What have been the results of previous SETI searches?
- Why is searching for such messages so hard?
- Are we sending messages, or just listening?
- What is NASA's new SETI program?
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How likely is it that there are other civilizations?

Many scientists think that given the right conditions and enough time, the development of life is likely, if not inevitable. We know that *organic molecules,* carbon-based compounds that form the building blocks of life as we know it, are scattered abundantly throughout the Galaxy. In interstellar clouds and newly fallen meteorites, astronomers have found complex organic molecules, including ethyl alcohol (the drinkable kind) and formaldehyde (embalming fluid). But a widespread abundance of these organic *precursors* does not, of course, guarantee that life is commonplace.

We know that life evolved here on Earth, a product of volcanic gases, organic chemicals brought by impacting comets and meteorites, and naturally occurring chemical reactions. We also know, from our robot spacecraft, that the other planets and satellites in our Solar System are unlikely habitats for complex life forms. Certain conditions apparently must be met, such as the amount of warmth obtained from the parent star, in order for life to begin. If there are planets orbiting other stars, as seems likely (see *The Universe in the Classroom,* no. 19), perhaps conditions on some of them are suitable for life as we know it to develop. But unless we undertake a search, we may never know if other intelligent life forms exist.

What is the best way to contact other civilizations?

There are really only two ways for us to make contact — visit them in person or send messages back and forth. Visiting them is, at present, not a realistic option. The distances between stars are so great that the time required for interstellar trips with any realistic technology is prohibitively long, requiring many generations for the crew. And the energy requirements for such trips are truly daunting. Bernard Oliver, Chief of the NASA SETI Program, has calculated the energy cost of a single one-way trip to a star ten light years

away (a close neighbor), assuming it would take 20 years and using a perfect spaceship, that is, one that does not waste any energy. His result — the trip would require about 500,000 years worth of the total energy consumption of the entire Earth! It is unlikely that Congress will be able to fund that kind of investment in the foreseeable future.

However, it is entirely possible to communicate with other civilizations by using waves that naturally travel through space at the speed of light. Among the many different ways we might try to communicate, radio waves — especially those called microwaves — are the most efficient at carrying messages. They can come through our planet's atmosphere and are less likely to be absorbed by the dust scattered among the stars; thus they can travel farther than other wavelengths. And there is very little background interference for radio waves, either from man-made or galactic sources.

One region of the spectrum, in particular, has attracted a lot of attention: the range of relatively noise-free frequencies (or channels) where hydrogen (H) and a hydroxyl molecule (OH) give off or absorb characteristic radiation. Because these are the ingredients of water, this area in the radio spectrum has become known as "the water hole.'' Scientists speculate that a species for whom water is important — like us — might relish the symbolism of using this quiet region of the radio spectrum to broadcast its message and "meet'' other life forms. It is important to remember that radio communication with another civilization does not necessarily have to begin with two-way conversations. Depending on how far away the other civilization is, it could take tens, hundreds or even thousands of years for radio waves to make the round-trip between question and answer. But if there are communicative civilizations "out there,'' they may already be sending out messages for their own purposes or to inform others of their existence. These are the types of messages SETI programs are designed to find. One interesting speculation your students might enjoy goes like this: If there are more advanced civilizations out there, for them, sending out messages to "beginner civilizations'' like ours might be the sort of interesting "science fair'' project a high school class would undertake.

What have been the results of previous SETI searches?

So far, there has been no successful SETI program, but that is not surprising since nearly all have been limited by inadequate technology and lack of funding and telescope time. The first search was conducted in 1960 by radio astronomer Frank Drake, using the 85-foot radio antenna of the National Radio Astronomy Observatory in Green Bank, West Virginia. He called it Project Ozma, after the queen of Oz, the mythical kingdom known for its wizard. Drake turned the giant radio dish to listen to two stars like the Sun, named tau Ceti and epsilon Eridani, both about eleven light years away, near enough that any signals should be easily detected. He observed the two stars intermittently from April through July, but no "intelligent'' signals were detected. Drake's experiment did, however, inspire other astronomers around the world to search for "intelligent'' signals from other stars.

Why is searching for such messages so hard?

Astronomers like to compare searching for intelligent radio signals from space to looking for a needle in a very large haystack. The problem is that there are many things about the message we need to know before we can "locate'' it. Among these are:

1. What star does it originate from?

Our Milky Way Galaxy alone contains an estimated 200 billion stars. However not all of these will have an equal likelihood of having an Earth-like planet.

2. What channel or channels are they using?

Here on Earth, when you want to receive a message from your favorite radio station, you tune to the channel (or frequency) they have been assigned in the spectrum. For extraterrestrial messages, we have no idea what channel they might be using or how "wide'' their message might be (how many frequencies they are sending it out on). In other words, are they "narrow"-casting or "broad"-casting?

3. How faint is their message?

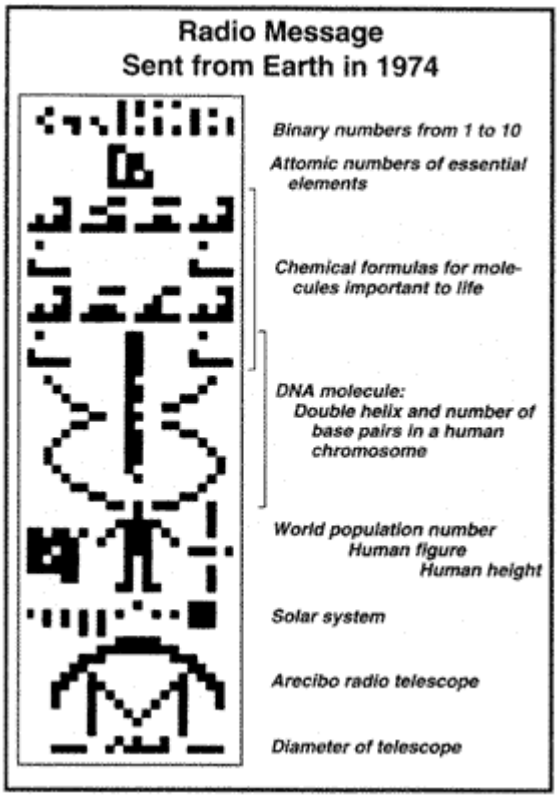
We all know that for receiving radio messages on Earth, the power of the sender is often a crucial consideration. On a car trip, the weak radio stations fade out long before the really strong ones. We may

similarly miss an extraterrestrial message even while pointing our antenna in the right direction if our receiving equipment is not sensitive enough to pick it up.

4. What method have they used to code information into the radio waves they are sending?

It would be wonderful if we could rely on all alien civilizations knowing Morse code, for example, but this is not very likely. We need to be prepared to examine a variety of ways in which messages might be coded (so that we can recognize a signal when we receive it).

In past searches, astronomers have had to guess at many of these message characteristics, a process that can be compared to poking your hand into the haystack at random, hoping you've guessed right and will feel the elusive needle. The importance of the upcoming NASA search is that it will search a much broader range of possibilities than has ever been attempted.



Are we sending messages, or just listening?

Since the early part of this century, we have been *unintentionally* transmitting signals into space — radio, radar and television — creating a "bubble'' of radio energy expanding outward from Earth at the speed of light. By the end of the twentieth century, this bubble will be over one hundred light years in diameter, and any technological civilizations within that radio sphere may be able to learn that we are here.

Some popular accounts of SETI have joked that one reason that extraterrestrials are not visiting us is that they have listened to our radio and television broadcasting, and, so far, see no sign of intelligent life on Earth. To be precise, however, while our neighborhood may appear brighter in radio waves that it would naturally, as a result of our broadcasting technology, it is unlikely that any *program content* would be decipherable many light years away.

A few (mostly symbolic) messages have also been sent *intentionally*. In 1974, Frank Drake and his colleagues used the gigantic radio telescope at Arecibo, Puerto Rico to beam an elaborate coded message in the direction of a globular star cluster (a cluster of millions of stars) called M13. However, because of the cluster's great distance, it will take the message 25,000 years to get there. The message, coded in the binary notation of ones and zeros, contained 1679 bits of information (that is,1679 ones and zeros). 1679 is the product of two prime numbers 23 and 73, which should suggest to an alien to break the message up into some combination of those two numbers. If the message is arranged in 73 columns of 23 bits each, no discernible pattern results. But if the message is arranged in 23 columns of 73 bits each, and the zeros and ones are replaced by white squares and black squares, respectively, an interesting pattern emerges (see figure). Coded into this pattern are (from the top down): binary representations of the numbers 1- 10, atomic numbers of the five elements essential to terrestrial life, the chemical formula of the DNA molecule, numbers for the average human height and the world's human population, images of the human form, the solar system (with Earth displaced to indicate it is the planet from which the signal originated), and the transmitting radio telescope, with its diameter indicated. Although it will be tens of thousands of years before the message reaches the target cluster, its transmission did serve to remind us of the kind of information an interstellar message can contain.

What is NASA's new SETI program?

NASA has developed sophisticated new radio receivers and computers to carry out a SETI survey of unprecedented sensitivity. A number of radio telescopes around the world will be employed in the search, including the giant antennas of NASA's Deep Space Network which normally track distant spacecraft.

A key element of the program will be its ability to search more than ten million channels simultaneously over a broad range of frequency and to use computer software that has only become feasible in the last few years

to pinpoint a variety of complex signals that would not be readily apparent to the human eye or ear. Among the signals the program will be able to find are those that "drift'' in frequency; this is important because we expect that we and the senders are each moving in orbit around a star, and that radio signals would thus tend to shift in frequency due to the *Doppler effect* (which also causes the familiar drop in pitch of a police siren as it comes toward, passes and then begins to move away from you).

The program, called the *Microwave Observing Project (MOP),* consists of two separate surveys that will run simultaneously. A targeted search will listen for signals from 800 stars like our Sun within 80 light years of Earth at more than a billion separate radio frequencies. Radio telescopes will look at each star for long periods of time, making the targeted search billions of times more comprehensive than any previous attempts. A second "all sky'' survey will search for signals with less sensitivity than the targeted search, but will cover the entire sky. Scientists have tested their new equipment by searching for the faint signals from the *Voyager* and *Pioneer* spacecrafts, which, over the past decade or more, visited Jupiter and Saturn and are now billions of kilometers away, heading out of the Solar System. The NASA systems were able to acquire the signals and successfully recognize that the signals were technological, not natural, in origin.

On Oct. 9, 1992, NASA will "turn on'' the two surveys during special ceremonies at the Arecibo (Puerto Rico) radio telescope and the Goldstone (California) antenna of the Deep Space Network. The program is expected to last ten years, at a cost of roughly $10 million per year. That works out to less than a nickel from each American each year. Not a bad investment if it can help us answer one of the most fundamental questions we, as a society, can ask — is there anybody else out there?

Activity: Message to Space

by Gregory L. Vogt, NASA Lewis Research Center The *Pioneer* 10 spacecraft, after a close encounter with the planet Jupiter, is on its way out of the Solar System. *Pioneer* 10 is on a course heading toward the constellation of Taurus. After 40,000 years, it will have traveled nearly the distance to the next nearest star: 4 light years.

It is conceivable that *Pioneer* 10 could eventually pass near intelligent life forms living in other parts of our galaxy. On the chance that such an encounter could occur, a message has been placed on *Pioneer*. The message is carefully designed so that aliens might decipher what we have to say, even though they will not speak our language or necessarily use the same units of measurement that we do. In the best case, aliens might even learn from the message where the spacecraft came from, when it was launched, and even a little bit about the creatures who sent it.

Procedure (students can work in teams of 3 to 5):

1. Design a different message to space to go inside a larger spacecraft. This message could be two- or three-dimensional, but can't require audiovisual equipment.
    1. Make a list of all the things you would initially want to tell aliens about ourselves and our environment.
    2. Choose a medium for your message and explain.
    3. Design the form of the message.
2. Construct the message, or a model of it.
3. Show your message to someone else (or another group) and ask them what the message says. (In some schools, this has been a project or contest in which several classes participate and prizes are awarded.)

Pioneer 10 Plaque

This plaque was designed to show scientifically educated inhabitants of some other solar system — who might intercept it millions of years from now — when *Pioneer* 10 was launched, from where and by what kind of beings. The design is etched into a gold-covered aluminum plate, 152 by 229 millimeters (6 by 9 inches), attached to the *Pioneer* spacecraft's antenna support struts. The radiating lines at left represent the positions of 14 pulsars, compact, ultra-dense rapidly spinning stars. As the pulsar spins on its axis several times a second, a powerful pulse of energy sweeps by the Earth, rather like an interstellar lighthouse beacon. The period of the pulses (the time between each pulse) decreases steadily over time, as the pulsar ages. The

pulsars on the plaque are arranged to indicate the position of the Sun, the home star of those who launched the spacecraft, relative to the pulsars. The "1-'' symbols at the ends of the lines are binary numbers that represent the arrival times of the pulses from each pulsar at the time of the launch of *Pioneer* relative to the frequency of the hydrogen atom shown at upper left. The hydrogen atom is thus used as a "universal clock,'' and the change between the period of the pulses observed when the plaque is found compared to the periods listed on the plaque will enable the aliens to determine the time that has elapsed since the *Pioneer* spacecraft was launched. The hydrogen atom is also used as a "universal yardstick'' for sizing the human figures and outline of the spacecraft shown on the right. The hydrogen wavelength — about 8 inches — multiplied by the binary number representing "8'' shown next to the woman gives her height - 64 inches. The figures represent the type of creature that created *Pioneer*. The man's hand is raised in a gesture of good will. Across the bottom are the planets, ranging outward from the Sun, with the spacecraft's trajectory arcing away from Earth, passing Mars, and swinging by Jupiter, before leaving the Solar System for interstellar space.

Some SETI Resources for Teachers

Books

- McDonough, T., *The Search for Extraterrestrial Intelligence,* 1987, John Wiley. Good, basic primer.
- Bova, B. and Preiss, B., eds., *First Contact,* 1990, New Amer. Libr. Collection of science articles and speculation.
- Goldsmith, D. and Owen, T., *The Search for Life in the Universe,* 2nd ed, 1992, Addison-Wesley. A readable textbook.
- Poynter, M. and Klein, M., *Cosmic Quest,* 1984, Atheneum. An introduction for younsters.

Organizations for More Information

- Astronomical Society of the Pacific, 390 Ashton Avenue, San Francisco, CA 94112
- The Planetary Society, 65 N. Catalina, Pasadena, CA 91106
- The SETI Institute, 2035 Landings Drive, Mountain View, CA 94043