The Origin of the Drake Equation
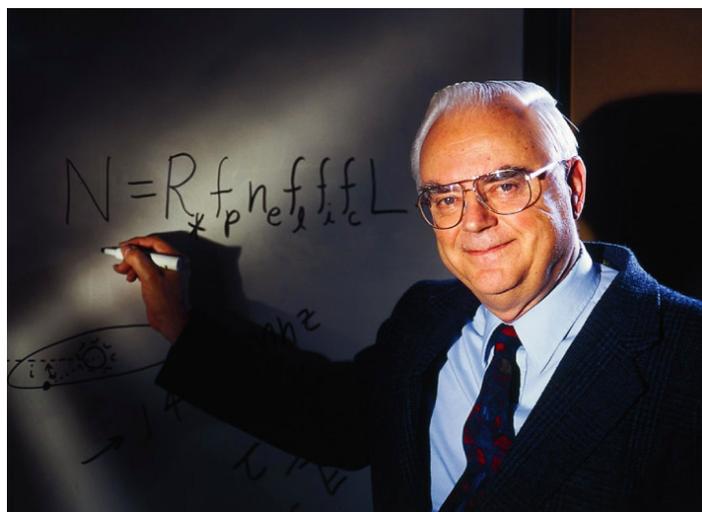
Frank Drake
Dava Sobel

Editor's Introduction

Most beginning classes in astronomy introduce their students to the Drake Equation, a way of summarizing our knowledge about the chances that there is intelligent life among the stars with which we humans might communicate. But how and why did this summary formula get put together? In this adaptation from a book he wrote some years ago with acclaimed science writer Dava Sobel, astronomer and former ASP President Frank Drake tells us the story behind one of the most famous teaching aids in astronomy.

Frank Drake with the Drake Equation *(Seth Shostak, SETI Institute)*

More than a year after I was done with Project Ozma, the first experiment to search for radio signals from extraterrestrial civilizations, I got a call one summer day in 1961 from a man I had never met. His name was J. Peter Pearman, and he was a staff officer on the Space Science Board of the National Academy of Science… He'd followed Project Ozma throughout, and had since been trying to build support in the government for the possibility of discovering life on other worlds.

"I conclude it's crucial that a meeting be organized as soon as possible," Pearman said, "to investigate the research potential. I wonder if I might count on you for help?" "Well, sure," I answered, not needing a moment to consider, "What can I do?" Pearman wanted two things he thought I could help him to get: approval to hold the meeting at the National Radio Astronomy Observatory site at Green Bank, West Virginia, since it was the site of Project Ozma, and the names of experts

to be invited.

Right then, having only just met over the telephone, we immediately began planning the date and other details. We put our heads together to name every scientist we knew who was even thinking about searching for extraterrestrial life in 1961. That turned out to be all of ten people, including Pearman and me….

The guest list included: Guiseppi Cocconi and Philip Morrison, who were the authors of the seminal paper in *Nature* on "Searching for Interstellar Communications;" Dana Atchley, a radio ham and electronics entrepreneur; Barney Oliver, the inventor and research magnate from Hewlett-Packard, who had flown to Green Bank during Project Ozma; astronomer Carl Sagan, who knew more about biology than any astronomer I had met; renowned chemist Melvin Calvin, who

had unraveled and explained the process of photosynthesis (and would, as it turned out, receive the Nobel Prize during our meeting); John Lilly, a neuroscientist and medical doctor, famous for his experimental interests in consciousness and communications; and Otto Struve, the Director of the National Radio Astronomy Observatory with an interest in the existence of planets outside the Solar System.

Otto Struve

I ran to see Struve the moment I hung up the phone. Now that Pearman and I had pushed the idea forward this far — the meeting had already grown into a three-day conference in our minds — I hated to think that Struve might object… In fact, Struve was delighted at the prospect of it, and immediately agreed to serve as the host… He suggested one more invitee: his former student Su Shu Huang, a Chinese émigré who had just joined the new National Aeronautics and Space Administration (NASA). Huang and Struve had collaborated in studies of the kinds of stars that might support habitable planets…

I took on the job of setting an agenda for the meeting. There was no one else to do it. So I sat down and thought, "What do we need to know about to discover life in space?" Then I began listing the relevant points as they occurred to me.

Surely we needed to know the number of new stars born each year — and not just any stars, but "good suns." These would be stars of medium and small size which maintained an almost constant brightness long enough for a technology-using civilization to evolve. This definition of "good suns" only ruled out the small fraction of the stars which are very massive and become giant, lethal stars too soon for technology to arise.

If there were planets out beyond the Solar System that were suitable for life, how many of them would actually become homes to living things? In other words, given a place where life *could* develop, how likely was it that life *would* develop? That was another important point.

Even granting that other worlds swarmed with alien life-forms, how many of those might be *intelligent*? What form would their intelligence take? Would we be able to detect them and communicate with them across interstellar distances?

All the places we might look for life would be very far away indeed. And in the universe, distance is time. The further away a star is, the longer their message will take to reach us and the more time will be required for our reply to get to them. Our chances of finding our alien counterparts would be greatly enhanced if civilizations, once they established themselves and became detectable, lasted a good long while… Indeed, the chances of a detection were just proportional to how long, on average, civilizations were detectable.

I looked at my list, thinking to arrange it somehow, perhaps in the order of the relative importance of the topics. But each one seemed to carry just as much weight as another in assessing the likelihood of success for a future Project Ozma. Then it hit me: The topics were not only of equal importance, they were also ut-
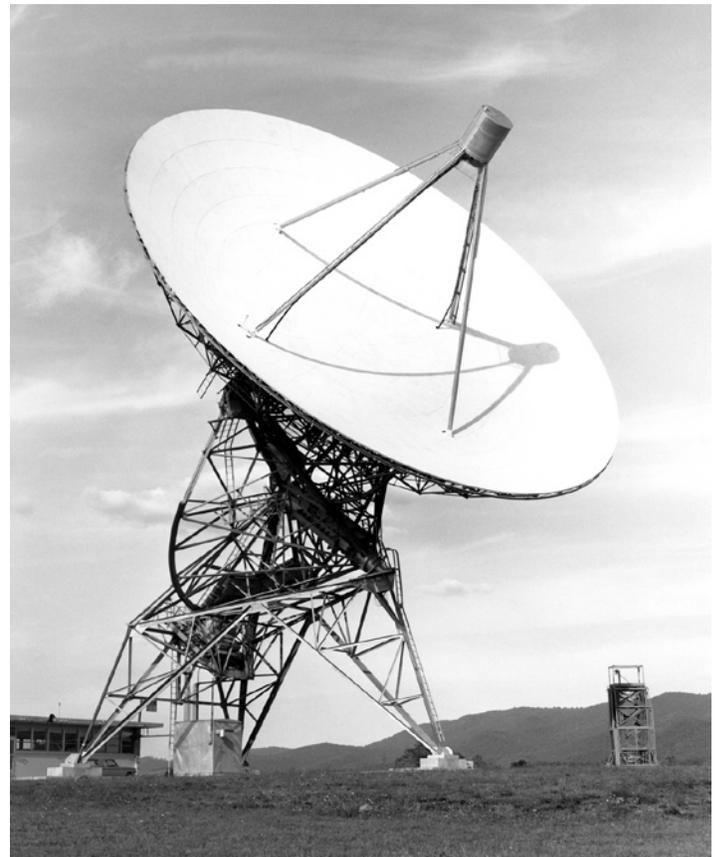
The 85-foot Telescope at NRAO Used in Project Ozma *(NRAO/AUI)*

terly independent. Furthermore, multiplied together they constituted a formula for determining the number of advanced, communicative civilizations that existed in space.

I quickly gave each topic a symbol, mathematician style, and found that I could reduce the whole agenda for the meeting to a single line, shown in the accompanying photo. Of course, I didn't have a real value for most of the factors. But I did have a compelling equation that summarized the topics to be discussed:

- The number (N) of detectable civilizations in space equals

- the rate (R) of star formation, times

- the fraction (f_p) of stars that form planets, times

- the number (n_e) of [its] planets hospitable to life, times

- the fraction (f_l) of those planets where life actually emerges, times

- the fraction (f_i) of those planets where life evolves into intelligent beings, times

- the fraction (f_c) of those planets with intelligent creatures capable of interstellar communication, times

- the length of time (L) that such a civilization remains detectable.

My agenda formula later became known as the Drake Equation. It amazes me to this day to see it displayed prominently in most textbooks on astronomy, often in a big important-looking box. I've even seen it printed in *The New York Times*. It was also made the focal point of an interactive exhibit at the Smithsonian Institution's Air and Space Museum in Washington, DC. I'm always surprised to see it viewed as one of the great icons of science, because it didn't take any deep intellectual effort or insight on my part. But then, as now, it expressed a big idea in a form that a scientist, even a beginner, could assimilate.

Sometimes, people who are unfamiliar with the scientific picture of cosmic and biological evolution think the equation is highly speculative. In fact, it is just the opposite, since each phenomenon it assumes to take place in the universe is an event that has already taken place at least once.

When the meeting took place, starting November 1,
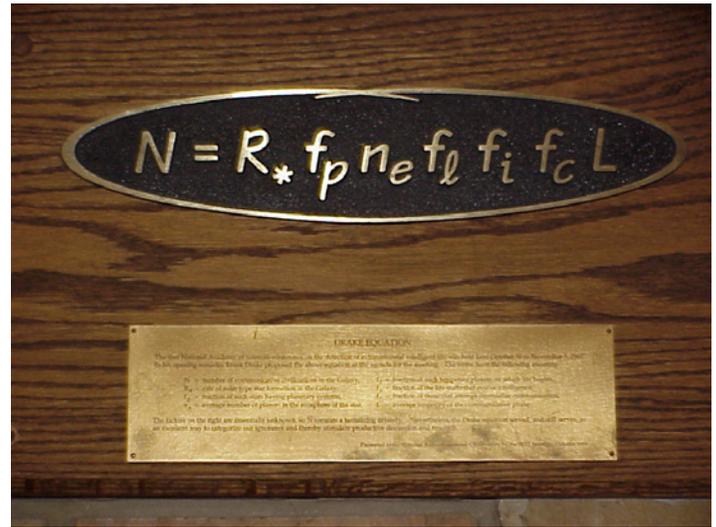
Drake Equation Plaque on Wall of Conference Room at Green Bank *(Paul Shuch)*

$$N = R_* f_p n_e f_\ell f_i f_c L$$

1961, we all gathered in a small conference room in the observatory's residence hall. Struve welcomed everyone officially, and then I got up and wrote my equation on the blackboard. I explained the factors as I went along. People started murmuring before I was halfway through it. Just as I had hoped, the formula gave immediate and pointed direction to our discussion… Where that blackboard stood at the National Radio Astronomy Observatory, there is now a commemorative plaque on the wall, bearing the equation with its description.

At the conference, we plugged in our best estimates for each of the factors, and found that the product of the first six factors on the right hand side came out to roughly the value of 1. Thus the value of N seemed to hinge solely on the value of L — how long intelligent, communicative civilizations could survive. At the end of the meeting, Struve offered a toast: "To the value of L. May it prove to be a very large number."

This excerpt has been adapted and updated for *Astronomy Beat* from *Is Anyone Out There: The Scientific Search for Extraterrestrial Intelligence* (1992, Delacorte Press) by Frank Drake and Dava Sobel. © 1992 by Frank Drake and Dava Sobel; used with permission.

About the Authors

Frank Drake served as Professor of Astronomy and Astrophysics and Dean of Natural Sciences at the University of California, Santa Cruz, after having been at Cornell and serving as the founding Director of the

National Astronomy and Ionosphere Center. He was the first president of the SETI Institute, and was President of the Astronomical Society of the Pacific during its Centennial. He is currently the Director of the Carl Sagan Center for the Study of Life in the Universe. He has always been a strong exponent of public education in astronomy and was the first recipient of the Education Prize of the American Astronomical Society.
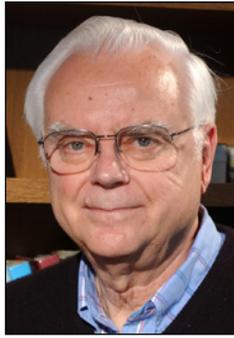
Dava Sobel, a former science reporter for *The New York Times*, is the author of such widely-praised and best selling books as *Longitude, Galileo's Daughter,* and *The Planets*. She has written articles on a wide range of scientific topics for magazines ranging from *Good Housekeeping* to *The New Yorker*. An asteroid discovered in 1994 by David Levy and Carolyn Shoemaker has been officially named Davasobel by the International Astronomical Union in her honor.

Resources for Further Information:

The full story of Frank Drake's SETI work is told in the book *Is Anyone Out There?* by Frank Drake and Dava Sobel (1992, Bantam Doubleday Dell.)

For more on the current state of SETI and Drake Equation research, see the web site of the SETI Institute at: http://www.seti.org

A Drake Equation calculator can be found at: http://www.pbs.org/lifebeyondearth/listening/drake.html

or at: http://www.msnbc.msn.com/id/30609189

Frank Drake discusses his modern view of what the values of the terms in the Drake Equation are in a lecture taped in 2005 at: http://www.astrosociety.org/education/podcast/index.html (scroll down to the last entry on the page). ✦