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Historical Perspectives: How the Search for Technosignatures Grew Out of the Cold War

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Abstract
This chapter focuses on the history of the search for extraterrestrial intelligence. It will explore the following questions: Why did SETI transition from a fringe idea to a concerted scientific effort in the 1960s? What were the different cultural, ideological, and technical approaches in the search? Why did SETI develop primarily in the US and Soviet Union as opposed to other countries? What challenges did early SETI pioneers face? In investigating these questions, I will focus especially on the collaborative efforts between US astronomer Carl Sagan and Soviet astrophysicist I.S Shklovsky as my main case study. This chapter aims to contextualize the current effort to search for technosignatures within its historical roots, with hopes this context will prompt a mindful analysis of how we utilize the artefacts from history in the ongoing search.

Keywords: SETI, technosignatures, history, history of science, radio astronomy, cold war, soviet union, Carl Sagan

1.1 Introduction

The search for and communication with extraterrestrial intelligence (SETI/CETI) [1.1] has largely been considered an internationalist scientific pursuit because of the "unifying" aspects of viewing humanity as a singular

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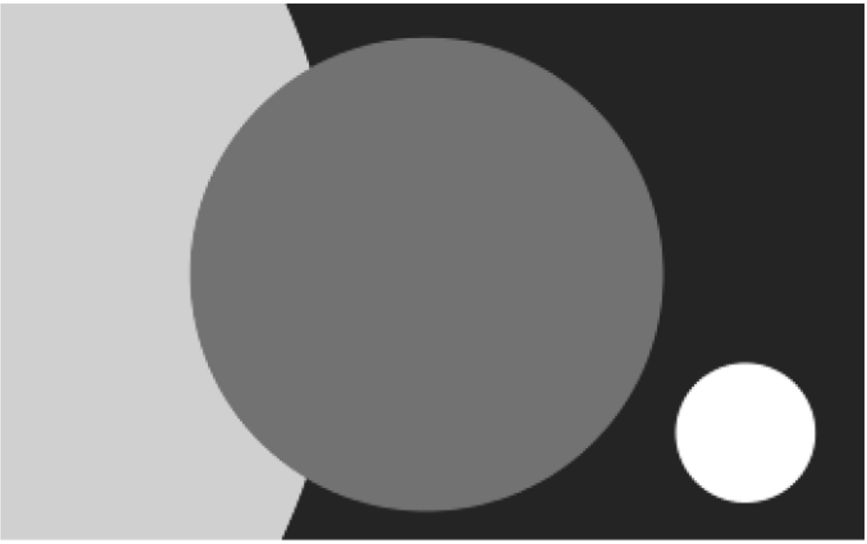

Figure 1.1 The flag of Earth, created in 1970 by James W. Cadle.

whole in a potential universe teeming with other intelligent civilizations. This hopeful scientific internationalism is reflected in much of the discourse and material culture surrounding the search for technosignatures; for example, the anti-national "flag of Earth" (Figure 1.1) flies in many places associated with the search, such as the Ohio State University Radio Observatory and the offices of the premier twenty-first century technosignature initiative, Breakthrough Listen. Indeed, many technosignature researchers, in studying the potential cultural impact of discovering extraterrestrial intelligence, have argued that the discovery of life on other worlds could possibly bring about global unity [1.2].

Despite the internationalist goals of the discipline, the early development of the search for technosignatures was deeply entrenched in the contentious geopolitics of its time, most notably in the tensions between the US and Soviet Union. Many introductory histories to SETI largely focus on significant events in SETI, such as the first SETI search in radio astronomy, Project Ozma, or introduce the major scientific contributors to the science. This chapter attempts to take a different approach; rather than focusing on key events and people, I will attempt to contextualise the origins of the science in the larger historical context. In doing so, this chapter will aim to answer the following questions: Why did CETI transition from a fringe idea to a concerted scientific effort in the 1960s? What motivated early CETI scientists to pursue their work? And why did CETI develop primarily in the US and Soviet Union as opposed to other countries? Answering these questions as they relate to one of the earliest efforts in the search for technosignatures will show that CETI was a direct product of the Cold War, primarily due to major government investment in scientific infrastructure and the influence of the Space Race on Soviet and American scientific and popular culture.

Additionally, CETI's development during the Cold War led CETI researchers to face specific challenges regarding communication and collaboration across the Iron Curtain. I will show here that although CETI scientists in the 1960s were preoccupied with finding and communicating with extraterrestrial life, they simultaneously faced great challenges meeting and communicating with one another. These barriers to communication included restrictions and censorship in publication, mail interference, travel restrictions, and ideological differences. We might describe these as difficulties transmitting and interpreting textual signatures, and I will suggest that their search for extraterrestrial intelligence was complexly related to the diverse dimensions of interterrestrial intelligence.

It is my hope this chapter will give the reader a greater appreciation for the tenacity of early CETI pioneers, especially those who contributed from the Soviet Union, as well as recognize the influence of the Cold War on the philosophical questions posed by CETI. To illustrate the crisis of communication with the "alien"—both those on other planets and on Earth—during the Cold War, I will focus especially on the interactions between US astronomer Carl Sagan and Soviet astrophysicist I.S. Shklovsky and their attempts at publishing the first popular CETI book in the mid-1960s. In exploring the history of the Cold War and relations between the Soviet Union and United States, a greater context for the development of CETI emerges, providing insight into both the cosmic and Earth-based challenges faced by CETI pioneers. Understanding that context will hopefully prompt a mindful analysis of how we utilize the artefacts from this history in the ongoing search for technosignatures.

1.2 The Extraterrestrial Life Debate Gets Technical

To understand the role of the Cold War in the development of CETI, it is first important to recognize how the intervention of technology revolutionized the approach to the question of the plurality of worlds. Up until the nineteenth century and the start of the Cold War, the question of humanity's place in the cosmos remained a purely speculative one, largely resigned to the musings of philosophers and theologians. In ancient Greece, atomist thinkers theorized on the plurality of *kosmoi* [1.3], and in early modern

Europe, physicists inspired by Copernicanism published tomes speculating on the existence of other planets, peopled just as Earth was [1.4]. These ponderings on the nature of the universe over the course of millennia are often referred to as the "extraterrestrial life debate".

In the nineteenth century, however, scientists began to explore the question of extraterrestrial life using scientific instruments such as the optical telescope, though their attempts remained largely rooted in conjecture and imagination, rather than systematic and empirical inquiry. For example, in 1906, Percival Lowell published a book titled *Mars and Its Canals*. In this book, Lowell, an American businessman and mathematician who had previously founded an astronomical observatory, asserted Mars was populated by intelligent life that had built intricate canals on the surface of the Red Planet [1.5]. Such assertions were not without some observational basis; Lowell had made countless observations of Mars in his observatory, and in 1907 published a mathematical essay in which he attempted to prove that the mean surface temperature of Mars was similar to an unseasonably warm winter day in England [1.6]. Still, even speculation rooted in some form of empiricism was inevitably unsubstantiated, and as a result, drew criticism and mockery from both the public and his scientific contemporaries. Alfred Russel Wallace, for example, published an entire book in refutation of Lowell's assertions, in which he sharply concluded: "Mars… is not only uninhabited by intelligent beings such as Mr. Lowell postulates, but is absolutely *uninhabitable*" [1.7]. Because of a hypothesis which lacked falsifiability, in addition to the eccentric characters who investigated it, such as Lowell, the extraterrestrial life debate had a dubious reputation within the scientific community in the nineteenth and early twentieth centuries. But in the mid-twentieth century there was a dramatic shift in the scientific perception of the extraterrestrial life debate, enabled by new technologies of radio communication and radar techniques.

Interest in using radio technology to communicate with extraterrestrials has been around for nearly as long as radio technology itself. In 1896, Serbian-American electrical engineer and physicist Nikola Tesla asserted that his new electrical transmission system could be used to communicate with Mars and soon after, Italian radio engineer Guglielmo Marconi claimed to have received radio signals from Mars. Although Tesla claimed to have used his radio experiments to become "the first to hear the greeting of one planet to another" in 1901, it was not until about two decades later that using radio technology to communicate with other planets became widely discussed in scientific circles [1.8]. In January 1919, the *New York Times* published an article titled "Radio to Stars, Marconi's Hope" [1.9]. It contained a summation of an interview the English journalist Harold Begbie had conducted with Marconi, during which Marconi discussed "the possibility of communicating by wireless with the stars" [1.10]. In the interview, Marconi speculated on the potential use of radio technology for interstellar communication. He said:

> Messages that I sent off ten years ago have not yet reached the nearest stars. When they arrive there why should they stop? … That is what makes me hope for a very big thing in the future… communication with intelligences on other stars [1.11].

The very next year, Marconi announced that he was investigating signals he postulated migh have come from Mars [1.12]. The *New York Times* once again published a lengthy article on Marconi's so-called "Mars signals". In Europe, Marconi's claims faced mostly ridicule; one French newspaper, for example, publicized Marconi's discovery under the headline "Hello, Central, give me the moon", referring sardonically to Marconi's wireless telegraphy system [1.13]. Yet the signals Marconi received, which he described as "distinct but unintelligible", generated much excitement in the United States. A newspaper in Minnesota, *The Tomahawk*, published an article titled "Hello Earth! Hello!", which jumped at the possibility of

Figure 1.2 Illustrations of Tesla and Marconi in an article titled "Hello Earth! Hello!" in The Tomahawk, March 18, 1920, Image 6. Digital scan held in the Library of Congress.

communication with extraterrestrial intelligence (Figure 1.2). In the article, Marconi is quoted as having said:

> If there are any human beings on Mars I would not be surprised if they should find a means of communication with this planet. Linking of the science of astronomy with that of electricity may bring about almost anything [1.14].

Still, despite interest and international conversation, these early investigations into the use of radio technology to communicate with extraterrestrials were rooted in conjecture and imagination, not rigorous scientific investigation, not unlike those of Lowell. For example, according to *The Tomahawk*, Marconi proposed Martians may use Morse code to communicate with Earth, which demonstrates that although ideas for interplanetary radio contact were forming, there was no serious scientific investigation into the problem of communication with extraterrestrial intelligence.

The advent of radio astronomy shifted the investigation of communication with extraterrestrial intelligence from a speculative one to a truly technical one because it gave scientists the opportunity to test their theories by making strategic radio observations of the cosmos. Although the science began as early as 1931 with Karl Jansky's discovery of the cosmic sources of radio waves [1.15], the formal discipline of radio astronomy was a direct product of World War II, growing out of the radar tools and techniques developed during the war. After the war, there was a great interest held by former wartime radio engineers in using the recently developed radar and radio communication technologies for scientific purposes, and scientists in the nations that had been involved in the war, especially Australia, Britain, the US, and the USSR, began to pursue research in the newly burgeoning field of radio astronomy [1.16].

Several years after the end of the war, however, as noted by historian Paul Foreman, US physics "underwent a qualitative change in its purposes and character", with increased government intervention and a new emphasis "in the nation's pursuit of security through ever more advanced military technologies" [1.17]. Radio astronomy had a unique dual purpose as both a tool for war and scientific pursuits, which led to heavy investment by governments in the infrastructure and institutions required. This dually motivated investment is perhaps best embodied in the establishment of the US National Radio Quiet Zone. In 1958, the Federal Communications Commission (FCC) had established about 13,000 square miles as the National Radio Quiet Zone (NRQZ), which placed restrictions on radio broadcasting in the area [1.18]. The principal reason given for this large-scale federal intervention was the opening of the first US national observatory for radio astronomy, the National Radio Astronomy Observatory (NRAO), which had been established a couple of years earlier, on November 17, 1956 [1.19]. Buried in the last sentence of the fourth line-item of the FCC's Docket No. 11745, amending the commission's rules and regulations to give interference protection to frequencies utilized for radio astronomy, however, was this statement: "additional coordination would be undertaken by the commission with the Department of Navy at Washington, D.C. with respect to the Sugar Grove facility" [1.20].

The FCC document goes into no further detail on the purpose of the Sugar Grove facility, and the National Reconnaissance Office still to this day keeps much of the documents from the planning and development of facilities in Sugar Grove classified. It is relatively well known from other sources, however, that soon after the establishment of NRAO, the Naval Research Lab began plans to build a 600-foot radio telescope for the purposes of gathering intelligence on the Soviet Union [1.21]. So while the US promoted the "pure science" purpose of the NRQZ, there was an undercurrent of military motivation. The advent of radio astronomy and CETI science during the Cold War is particularly interesting, then, because of the use of its technology for spying on both the unknown intelligence of the cosmos and unknown intelligence here on Earth. As this chapter will demonstrate, watching and being watched were intrinsic parts of collaborative scientific work during the Cold War, and CETI is a particularly revealing example of this fusion of scientific and geopolitical aims.

1.3 Finding the 21-cm Hydrogen Line

Given the influence of the Cold War in developing both radio astronomy and CETI, it is surprising that prior histories of the search for extraterrestrial intelligence have largely neglected contributions from the Soviet Union. This is perhaps because of poor communication between the US and USSR during the Cold War, which meant Soviet radio astronomy had little reach or impact on the rest of the world [1.22]. In his introduction to the English edition of *A Brief History of Radio Astronomy in the USSR*, NRAO astronomer and historian Kenneth Kellermann noted that there were several instances in which Soviets would make a discovery before the rest of the world, but due to communication barriers, Western scientists would often receive credit for making the same discovery at a later date. One example was the case of the discovery of radio recombination lines, which Soviet astronomers at Pulkovo Observatory and Lebedev Physical

Institute (FIAN) [1.23] discovered as early as 1963 or 1964 [1.24]. Because of a lack of clear and consistent communication across borders, however, credit is usually assigned to Bertil Hoglund and Peter Mezger, who reported their own independent discovery in 1965 after observations made at NRAO [1.25]. In addition, while radio astronomy observatories in the US and most other Western countries were civilian organizations, Soviet radio astronomy was inextricably tied to state and military institutions and technologies, and therefore many of their publications were heavily redacted or censored, making it difficult for Western scientists to easily verify their scientific validity [1.26].

Another factor which made attribution of discovery a challenge was the poor exchange of journals and other forms of scientific publishing during this period. The Soviet Union did not join the Universal Copyright Convention, which by 1952 had been adopted by forty nations, including the United States and the vast majority of Western Europe [1.27]. Instead, the Soviet Union subscribed to its own internal copyright law, which granted the right to translate and publish any foreign work without the original author's or publisher's consent, and without the attribution of royalties [1.28]. Additionally, foreign works were also permitted to be edited and modified without the original author's permission, and this was commonly done with journals. The Communist Party control over scientific institutions was "almost absolute", so foreign scientific journals first went through a process of review, translation, and censorship before they were released in the Soviet Union [1.29]. As a result of this ideological stronghold, scientists usually had to expect delays in receiving new scientific results from the West, putting them at a disadvantage to their Western colleagues [1.30]. To make matters of communication worse, Soviet publications were practically inaccessible to Western scientists. As historian of Soviet science Michael Gordin has noted, in the late 1950s only 1.2% of American scientists could read Russian. Furthermore, in 1947 the Soviet Communist Party decided that "publication of Soviet scientific research abroad constituted a betrayal of native scientific resources" and as a result, the leading foreign-language publications were eliminated [1.31]. This lack of consistent sharing of information sometimes led to a difference in attribution of discovery in the West and the Soviet Union, leading to confusion that lasts up to the present day.

One example of this lasting confusing can be seen in historical documentation of the discovery of the 21-cm hydrogen line, the prediction of which is generally generally attributed to Hendrik van de Hulst, a Dutch astronomer and mathematician who published a paper in 1945 that suggested that the transition of neutral hydrogen at 1420 MHz should be theoretically observable using radio telescopes [1.32]. This was an incredibly significant insight in the development of radio astronomy, and later CETI, because of the abundance of hydrogen in the universe. Just a few years later, in 1951, Harvard University astronomers Harold Ewen and Edward M. Purcell became the first to observe the line. Since then, the hydrogen line has become a fundamental aspect of observational radio astronomy, allowing astronomers to map the structure of the Milky Way and other galaxies as well as the large-scale structure of the universe. So significant was its discovery to radio astronomy that it has even been memorialized in song form, with a chorus that reminds listeners that "Ewen and Purcell caught the radiation line/Of interstellar hydrogen, a most important find [1.33]."

When examining the historiography of the discovery of the line, however, another name besides van de Hulst's sometimes appears: Iosif Samuilovich Shklovsky, a Soviet astrophysicist. Several sources, including *The Biographical Encyclopedia of Astronomers* (2007) and Frank Drake's *Is Anyone Out There*? (1992), claim that Shklovsky predicted the existence of the 21-cm hydrogen line entirely independently of van de Hulst. This is a mischaracterization of what occurred, but a somewhat understandable one if unfamiliar with the issue of Soviet journal publishing. Astronomer and historian of astronomy Woody Sullivan, who conducted oral history interviews with Shklovsky before his death in 1985, notes in his book *Cosmic Noise: The History of Early Radio Astronomy* (2009) that Shklovsky was not able to obtain van de Hulst's paper in the Soviet Union because of the aforementioned publication issues. Instead, Shklovsky read a brief mention of van de Hulst's discovery in a review of astronomy published in 1947. The mention of this prediction in the review "lit [him] on fire", and inspired him to attempt to calculate the transition of the line on his own, without access to van de Hulst's original paper [1.34]. In 1949, the same year he received his doctorate, Shklovsky published a paper titled "Monochromatic Radio Emission from the Galaxy and the Possibility of its Observation" [1.35]. Shklovsky credits van de Hulst, with the first line of his Russian-language paper on the subject, asserting: "Van de Hulst was the first to point out the probability of the existence of monochromatic radio emission from the galaxy" [1.36].

Nonetheless, Shklovsky's semi-independent calculations of the 21-cm hydrogen line helped to establish him as a significant early contributor to the development of radio astronomy in the USSR. Yet there is another way the 21-cm line had an impact on Shklovsky's life. Once observed by Ewen and Purcell, the newly important status of this line to radio astronomy inspired two physicists, Philip Morrison and Giuseppe Cocconi, to propose its use in searching for extraterrestrial intelligence. Published in

Nature in 1959, Morrison and Cocconi's paper, "Searching for Interstellar Communications", advocated a search for artificial signals on the hydrogen line, becoming the first scientific publication to propose a CETI observational technique [1.37]. Their rationale in observing at 1420 MHz was that, if an extraterrestrial civilization wanted to send a signal at a frequency that Earth was sure to detect, it would make most sense for them to broadcast it at a frequency that is important to radio astronomy, where humans were already looking. Shklovsky was "greatly impressed" by Cocconi and Morrison's article, which added such great potential purpose to the line he had played a role in discovering [1.38]. Shortly after the publication of the Morrison and Cocconi paper (although conceived before it was published), Frank Drake, an American scientist at the National Radio Astronomy Observatory, conducted what is generally considered the first modern CETI search, using NRAO's 85-1 to search for an extraterrestrial signal near the hydrogen line. His search, named Project Ozma, was conducted in April 1960 and looked for signals from two stars—Tau Ceti and Epsilon Eridani [1.39]. Although the results were non-conclusive, Drake's Project Ozma excited the scientific community, including Shklovsky.

1.4 The Role of the Space Race in Early CETI

The start of the Space Race deepened Shklovsky's fascination with the possibility of searching for extraterrestrial intelligence. In January 1959, shortly before he learned of the Morrison and Cocconi paper, the Soviet spacecraft, *Luna 1*, launched. After the glowing success of the first three *Sputniks*, *Luna 1* became yet another important achievement for the Soviet Union at the start of the Space Race: it was the first spacecraft to reach the vicinity of the moon [1.40]. There was a small dilemma, however: in 1959, the Soviet Union did not yet have a radio telescope capable of tracking its spacecraft launches. It is for this reason that Sir Bernard Lovell, then director of Britain's Jodrell Bank Observatory in Manchester, became a figure of much acclaim in the USSR. His Mark I telescope became the first telescope in the West to track the launch of Sputnik I in 1957, confirming the Soviet achievement to the rest of the world [1.41]. Without their own radio telescope, obtaining the exact coordinates of their rocket launches was a real challenge for the Soviets. For the launch of *Luna 1*, Shklovsky had proposed a solution. With the support of the "chief designer" of the Soviet space program, Sergei Korolev, Shklovsky and his team at Shternburg Astronomical Institute at Moscow State University designed what they called an "artificial comet" to aid optical observations of rocket trajectories [1.42]. This "comet" was composed of a luminescent cloud of sodium gas, which would be ejected from the rocket during launch and photographed, making the spacecraft detectable and therefore easier to track [1.43]. For his work on the *Luna 1* rocket telemetry, Shklovsky was awarded the Lenin Prize, the highest award for scientific achievements bestowed by the Soviet government [1.44].

This success put him on good terms with the president of the Soviet Academy of Sciences, Mstislav Vsevolodovich Keldysh, who was sometimes referred to as the "chief theoretician" of the Soviet space program, in conjunction with Korolev. As a result of his success, Shklovsky was invited to group meetings held in Keldysh's office for "regular [discussions] of space projects" [1.45]. During one such meeting in 1961, Keldysh reminded the group that the five-year anniversary of Sputnik I's launch was only a year away, and "should be properly celebrated". Shklovsky, whose imagination had so been swept up by the Morrison and Cocconi paper and the romance of the burgeoning space age that he felt "like a kid who'd fallen in love", eagerly proposed that he write a popular science book exploring the idea of extraterrestrial life [1.46]. Keldysh approved, but this meant there was only one year to write the book. What might have been a problem to some, Shklovsky saw as an opportunity.

That was because, in addition to the censorship of foreign scientific journal publication in the Soviet Union, there were also censorships placed on internal publications in the Soviet Union. In particular, any works regarding "space" during the Space Race were particularly challenging to get through censors [1.47]. The main organization of press censorship was called the Main Administration for the Protection of Military and State Secrets in the Press under the USSR Council of Ministers—or, "Glavlit" for short, an acronym for its Russian name [1.48]. Glavlit had an associated office called the Commission for Research and Exploitation of Cosmic Space which held specialized censors for space sciences. During the space age, "every book, article, radio or TV broadcast in any way connected with space flights must have an authorization from [that] censorship office" [1.49]. Because of the significance of publishing the book for the fifth Sputnik anniversary, however, Shklovsky suspected he "would have a better chance of escaping the embraces of the general censorship", as censors would have less time to review it [1.50]. Getting past censorship was particularly important for a book on the subject of extraterrestrial life. Although by the 1960s Lysenko's views on biology had begun to fall out of favor, the official end to the ban on criticism of Lysenkoism* was not lifted until the 1980s [1.51]. In writing about the development of life in the universe, Shklovsky intended to "demolish" the theories of Alexander Oparin, Soviet biochemist and "close confederate" of Lysenko, who researched the origins of life on Earth [1.52]. Challenging Oparin was a potentially dangerous undertaking, not to mention challenging. After all, it was difficult to find reputable books on molecular biology in the Soviet Union during the Lysenkoist period [1.53]. Nonetheless, Shklovsky's bet paid off. His book, titled *Universe, Life, Mind* made its way past the censors in its rush to be printed in time for the Sputnik anniversary and it was published in December 1962, despite some "uproar" [1.54].

Despite the initial challenges, *Universe, Life, Mind* became incredibly popular, due in part to the tremendous public impact of Soviet space activities. In the early 1960s, the Soviet Union had been dominating the United States in the so-called "race to space", as it had been labeled by President Kennedy

Figure 1.3 Gagarin waves from the car outside the headquarters of Amalgamated Union of Foundry Workers after receiving a medal, 12th July 1961. From the Daily Herald Archive/National Museum of Science & Media/Science & Society Picture Library.

in 1961 [1.55]. By 1962, the Soviet Union had become the first nation on Earth to launch a satellite into orbit, put the first living creature in space, put the first man in orbit, the first photo of the far side of the moon, launch the first space craft to reach the moon, and send the first probe to impact the moon. Characteristically, the Soviet government capitalized on these victories with great displays of promotional propaganda in the form of films, posters, and parades (Figure 1.3). Iina Kohonen, an expert in space-related visual propaganda and photojournalism in the Soviet Union, has argued that the Soviet space program was composed of a combination of "military aspirations, state propaganda and utopian thinking" [1.56]. It is the latter characteristic, "utopian thinking", which largely fueled Soviet public interest in space, and led to the success of Shklovsky's book, which painted an exciting future of human cosmic exploration. Soviet depictions of the future in space portrayed a universe in which communism had succeeded, the world was peaceful, and humanity dedicated itself to the pursuit of science and exploration of the cosmos. This mentality was not limited exclusively to the Soviet Union. Americans similarly created narratives about a human destiny in space—albeit with a US-centric bent. While Soviet literature espoused spreading a communist ideology throughout the cosmos, Americans viewed space as a "final frontier", an extension of the driving force of manifest destiny [1.57]. Therefore, in the United States, public interest in space exploration was also growing. The US had managed a rocky start in the competition, but especially after Kennedy's exhortation of the goal of a 'moon-shot', the US public imagination was captured by the space age.

1.5 Same Planet, Different Civilizations

Perhaps the most illustrative example of the role the Cold War played in the early development of CETI was Shklovsky's collaboration with a young American astrophysicist, Carl Sagan. While Shklovsky had been designing his artificial comet for the Soviet lunar program in 1959, Sagan was similarly involved in the race to space. At only 25 years old, he had been hired as a consultant to the newly established National Aeronautics and Space Administration (NASA) [1.58]. By August 1962, just a few months before Shklovsky's book was published, Sagan had just seen to the launch of NASA's Mariner 2 mission to Venus, which he had helped to design and manage. Like Shklovsky, Sagan had a fascination with the idea of searching for extraterrestrial intelligence. He was a member of NASA's Planetary Biology Subcommittee and hoped to find signs of life on other planets through his work on NASA missions [1.59].

In April 1961, the year prior to the publication of *Universe, Life, Mind*, Sagan, like Shklovsky, was introduced to the radio search for extraterrestrial intelligence. The newly established National Radio Astronomy Observatory had just carried out the first search for extraterrestrial intelligence using radio telescopes, the aforementioned Project Ozma [1.60]. Although the project was not successful in detecting ETI, it had made a major cultural and scientific impact, inspiring many subsequent observations. As a result of the sudden interest in CETI, the Space Sciences Board (SSB) of the National Academy of Sciences (NAS) decided to support what they called a "quiet meeting" in the subsequent autumn, to discuss the possibility of making radio contact with extraterrestrial intelligence [1.61].

Although small, the first CETI conference was attended by an elite group of scientists from several fields, including NRAO director Otto Struve, future Nobel prize–winning physicist Charles Townes, Nobel prize–winning chemist Melvin Calvin, NASA astrophysicist Su Shu Huang, Project Manhattan scientist Philip Morrison, and John C. Lilly, a biologist who researched dolphin communication [1.62]. The scientists at the conference drew connections between Lilly's work and their own— the pursuit of communication with the non-human and with unknown intelligences. As a result, they dubbed themselves "The Order of the Dolphin", a semi-secret CETI society [1.63]. Sagan was the youngest scientist in attendance, perhaps invited mainly because of his connections with Melvin Calvin, who had written a letter of recommendation that helped him acquire his postdoctoral position at UC Berkeley [1.64].

The SSB outlined three major topics to be addressed at the conference. First, they wanted the attendees to consider the "estimates of limiting values for the probability of existence of planets on which civilized life is likely to have evolved". Second, they should determine whether this number was sufficiently large and decide whether present search methods were useful enough to make the search worth pursuing. And finally, the conference attendees were to make recommendations to the SSB for further study [1.65]. To address this issue of feasibility, Drake devised an equation which was henceforth known as the "Drake Equation". The equation was simple, a product of factors, the values of which were largely unknown at that time. The Drake Equation is represented as "$N = R^* \cdot f_p \cdot n_e \cdot f_l \cdot f_i \cdot f_c \cdot L$", with each variable defined as follows:

> "N = The number of civilizations in the Milky Way galaxy whose electromagnetic emissions are detectable.
> R* = The rate of formation of stars suitable for the development of intelligent life.

f_p = The fraction of those stars with planetary systems.
n_e = The number of planets, per a planetary system associated with one star, with an environment suitable for life.
f_l = The fraction of suitable planets on which life actually appears.
f_i = The fraction of life-bearing planets on which intelligent life emerges.
f_c = The fraction of civilizations that develop a technology that releases detectable signs of their existence into space.
L = The length of time such civilizations release detectable signals into space [1.66]."

Since the equation could not be reasonably calculated with their present knowledge, it was instead meant as a tool that the attendees of the conference could use to frame their estimates of ETI in the galaxy.

The final variable, *L*, has been the focus of many studies in technosignature literature, with estimates ranging from incredibly optimistic to deeply bleak [1.67]. As time has progressed and fields of study such as exoplanetary science have developed, many of the Drake equation variables have begun to fill in, but the answer to *L* has remained elusive and highly relevant. SETI anthropologist Kathryn Denning has argued that *L* is the variable in which "we are exceptionally emotionally invested", because "our estimates of *L* are intertwined with our forecasts for our own civilization's end" [1.68]. For that reason, Drake's inclusion of *L* in the equation is particularly revealing of the cultural climate in which CETI developed—after all, almost exactly one year following the first CETI conference in Green Bank, the world would experience its first nuclear standoff, the Cuban missile crisis. The question of *L* was inextricably tied to concerns about the role of technology in the destruction of life and civilization, concerns which were incredibly pressing during the height of the Cold War.

Shortly after the NRAO CETI conference concluded, Sagan wrote a paper titled "Direct Contact Among Galactic Civilizations by Relativistic Interstellar Spaceflight", in which he made an argument in support of his own estimate for the values in the Drake Equation, including the variable *L*. While he began his paper admitting that the "parameters are poorly known", he nonetheless came to the conclusion that there exists "~106 extant advanced technical civilizations in our Galaxy" [1.69]. Perhaps having heard of his interest in CETI from someone at the conference, Sagan sent a draft of this paper to Shklovsky in 1962, inviting his comments.

In response, Shklovsky asked Sagan if he might be permitted to incorporate Sagan's article into his upcoming book, which was to be published at the end of the year. He ended his letter to Sagan with a joke—wondering if perhaps they might someday meet, although remarking "the probability of this event is no smaller than the probability of a visitation of the earth by astronauts" [1.70]. Sagan agreed to have his paper incorporated into *Universe, Life, Mind*, and in return asked Shklovsky if he had any plans to publish an English translation of the book in the United States. If not, Sagan proposed allowing him to aid with such a publication himself [1.71]. Shklovsky agreed to the collaboration, but his prediction that they would work together without meeting was correct. The pair would not meet in person until well after the publication of the English book. This is largely because of constraints put upon Shklovsky because of his standing in the eyes of the Soviet authorities—yet another example of barriers to communication placed upon scientists during the Cold War period.

Although Shklovsky was held in high regard by his colleagues for his work early in the Space Race, his outspoken personality prevented him from experiencing the mobility and access granted to some of his peers. His letter to Sagan regarding the unlikelihood of their meeting reflected the personal resentment Shklovsky held towards Soviet bureaucracy for limiting his ability to collaborate with international peers. In a short autobiographical story published posthumously, Shklovsky recounted his first expedition outside the Soviet Union; a research trip to Brazil in 1947, to observe a solar eclipse. Shklovsky wrote of the time:

> I took it for granted that the forthcoming expedition to the Tropic of Capricorn, to a faraway Brazil as beautiful as anything in a fairytale, was just the beginning and that many more fine and soul-stirring things yet unknown lay ahead. After a poverty-stricken youth and the harsh suffering of the war years, the world had at last opened up for me [1.72].

Unbeknownst to him at the time, Shklovsky would not be allowed to travel abroad for another nineteen years. Despite his many accomplishments, including the aforementioned Lenin Prize for his work during the Space Race, Shklovsky often faced travel bans, and was never elected as a full member of the Soviet Academy of Sciences, which he resentfully concluded was because of his Jewish heritage and commitment to promoting human rights [1.73].

In this collection of autobiographical stories, humorously titled *Five Billion Vodka Bottles to the Moon* (1991), Shklovsky also recounted his memory of the "astronomers purge" during Stalin's Great Terror of 1936-38, during which over two dozen leading Soviet astronomers were arrested, many of whom were later executed, or died in the Gulag [1.74]. The purge occurred in part because of an astronomy PhD student who failed his candidacy exam, and afterwards wrote a letter of denunciation of the astronomer who administered his examination, Boris Numerov [1.75]. Denunciations were common practice in the Soviet Union, most especially during the Stalinist era, and according to historian Sheila Fitzpatrick, largely fell into three categories of accusation: political disloyalty, "concealment of class identity", and "abuse of power" [1.76]. The state would investigate the accused, and punish those who they deemed guilty. This, however, led to the problem of individuals abusing the system by using the state to "settle personal scores or advance the denouncer's individual interests", as was clearly the case with the failed PhD student [1.77]. In his denunciation, he accused his examiner of having "foreign contacts", and shortly afterward the NKVD began investigating Numerov. After arresting and torturing him, he confessed "to being the organizer of a counterrevolutionary group of astronomers and geophysicists that had cooperated with German fascists and had engaged in wrecking, spying, and terror since 1929" [1.78]. In his confession, Numerov listed nearly the entire astronomy community as co-conspirators, setting off a chain of subsequent arrests and denunciations which historian and foreign diplomat Robin Mccutcheon argued led to the "disappearance" of approximately "10 percent to 20 percent of all astronomers in the Soviet Union in 1935" [1.79]. Only a graduate student at the time of the purge, Shklovsky avoided being arrested, but after his death, his account of the events leading up to the purge was published, a clear indication that the memory of the ordeal remained with him for the rest of his life [1.80]. Still, despite the threat of denunciation, Shklovsky often risked life and freedom by standing for what he believed in, and continually criticized the USSR for, among other things, its anti-Semitism and restriction of scientific freedom.

Even as his fellow physicists occasionally disappeared or died under mysterious circumstances, Shklovsky would defend mistreated colleagues and condemn what he viewed as ethical transgressions committed by the Academy or Soviet government. For example, in 1973, approximately forty members of the Soviet Academy of Sciences signed a document condemning Soviet nuclear physicist and political dissident Andrei Sakharov in a denunciation [1.81]. Shklovsky, on the other hand, sent in a strong letter of advocacy for Sakharov. As a result of this daring move, he was forbidden to appear at international scientific meetings he had previously been allowed to attend, such as the International Astronomical Union meetings. When asked by Western colleagues about Shklovsky's absence from international conferences, Soviet officials would reply "his health is too poor" to travel abroad [1.82]. An American colleague encountered Shklovsky in the USSR during this period of travel ban and enquired about his health, to which Shklovsky wryly replied, "Yes, I have diabetes. Too much sakharov" [1.83]. This was a joke because the word for "sugar" in Russian is "sakhar".

Although he avoided arrest during the Stalinist era, Shklovsky's dissidence sometimes still put his life in danger. One register of this was relayed much later by Sir Bernard Lovell, the aforementioned British physicist and radio astronomer who was involved in British tracking of Soviet satellites as an anti-nuclear tactic during the Cold War. Lovell, in his capacity as the director of the Jodrell Bank Observatory, went on an "unprecedented" scientific visit to the Deep-Space Communication Centre in the USSR in 1963, the year after *Universe, Life, Mind* was published [1.84]. The official reason for visit was because of a planned international scientific collaboration; the Jodrell Bank Observatory was to assist in upcoming Soviet-US communication satellite experiments [1.85]. During his stay in the USSR, however, Lovell learned that the Soviets were considering abandoning their moonshot, and his report upon return to the West played a key role in Kennedy's consideration of a joint Soviet-US moonshot [1.86]. Also during this visit, the Soviets attempted to convince Lovell to stay in the USSR and join the Soviet Academy of Sciences, perhaps because, as mentioned earlier in the chapter, Lovell was held in extremely high regard in the Soviet Union due to his role in tracking early Soviet satellites and probes, validating Soviet success in the West [1.87]. Lovell's refusal of their offer, alongside his newfound insight into future Soviet moon plans, may have led to the development of a dangerous situation. According to Lovell, Soviet colleagues attempted to assassinate him using a lethal dose of radiation while on his tour [1.88].

During his life, Lovell never spoke in detail about the alleged assassination attempt. He did, however, write an account of this event and gave it to the John Rylands Archive at the University of Manchester, where it was to remain unpublished until after he died, in 2012. It is unclear whether the events Lovell described truly occurred as he perceived them—it may well have been a product of Lovell's paranoia and the many myths and rumors enveloping the secretive state. Nonetheless, it is clear tensions were high, and the threat of danger was present, at the very least, in the minds of the scientists from both countries. Lovell's memorandum also detailed an encounter with an unnamed Soviet scientist who implored him to invite Shklovsky to his laboratory in England, for Shklovsky's life was "in great danger" [1.89]. The nature of the danger and the reason for it remained a mystery to Lovell, and there are no available sources that might explicitly explain the cause. It may have been the result of Shklovsky's open dissent to the treatment of Jewish academics, which likely cost him the ability to travel to the US between 1947 and 1967, or perhaps it was the biology controversy stirred up from his recent publication of *Universe, Life, Mind.* Either way, as evidenced by the tense Soviet political atmosphere, the fear the unnamed Soviet astronomer held for Shklovsky's safety was not entirely unfounded. Nevertheless, despite this danger, Shklovsky was able to make and maintain relationships with scientists around the world by extensive correspondence, including with Carl Sagan.

1.6 Making *Intelligent Life in the Universe*

Yet establishing these international correspondences did not come easily, and the road to the publication of the English translation of Shklovsky's book was rife with difficulties. When the US publishers, Holden-Day, wrote Shklovsky in January 1963 to confirm their agreement to publish the translation, they stated that they intended to "make every effort to publish the book in the shortest possible time and [estimated] that this could be done in three to four months…" [1.90]. Over eight months later, however, Shklovsky had no update from Sagan or the publishers. Feeling frustrated that he had not heard from Sagan within the few months the publishers had assured, an irate Shklovsky wrote to Sagan asking, "do you deny me the courtesy of informing of the status of the American translation of the book?" [1.91] Unbeknownst to him, however, Sagan had sent him several letters regarding the translation and its progress. Shklovsky had simply not received them—an example of yet another type of crisis in Earth-bound communication common during the Cold War: the unreliability of postal correspondence across the Iron Curtain.

The issue of Soviet interference with the post is well documented. In the 1980s, for example, there was a concerted effort by the US government to address the issue of deliberate interference with the flow of mail between the US and USSR. A 1989 report on the history of mail interruption prepared for the US Committee on Post Office and Civil Service of the House of Representatives examined what they described as a "long existing problem" [1.92]. The report claimed that over many years, a "significant number" of items of communication sent from the US to USSR had "disappeared, or were opened, inspected, and/or confiscated by officials of the Soviet Union, without the proper notification given to mailers" [1.93]. Mail interruption was described as a "violation of human rights" by the authors of the report, who also presented data which indicated the rate at which letters were not delivered. For example, in 1985, non-delivery of letters was at approximately 12 percent [1.94]. Given that 1985 was the year *perestroika* began, it is reasonable to assume earlier decades might have faced higher rates of mail interruption, although data to support this hypothesis is difficult to attain.

It would be naïve, of course, to assume the problem of mail disruption existed exclusively on the side of the Soviets. As Edward Pessen, historian of American history, has pointed out, "what a nation's leaders call its policy is after all only its stated policy" [1.95]. Although United States policy was purported to be emblematic of a "free" society, there is also evidence of US interference with postal communication. As Pessen points out, "in blatant violation of the law creating it, the CIA kept files and spied on American citizens, tampered with and opened the mail of hundreds of thousands" [1.96].

What differed between the US and USSR, however, were the populations targeted by mail disruption. For example, both the authors of the 1989 report, as well as an earlier congressional hearing on disruption of mail service in 1984, argued that Soviet Jewish people were disproportionately impacted by mail disruption [1.97]. The report argued that these obstacles were indicative of an effort to "isolate the Jewish community in general, and the 'activists' in particular, from any contact with the outside world" [1.98]. The Soviet Union practiced anti-Zionist campaigns throughout the latter half of the 20th century, fueled in part by its negative relations with Israel during the Cold War. Anti-Zionist propaganda (Figure 1.4) promoted historically anti-Semitic representations of Jewish people, which in turn provoked anti-Semitic attitudes within the Soviet Union, leading to negative impacts on Jewish Soviets [1.99]. In a state where denunciations on political or social loyalty could lead to deadly consequences, questioning Jewish loyalty through anti-Zionist campaigns was no small accusation. As both a Jewish man and someone who might have been perceived as an activist, it is not unreasonable to assume anti-Semitism might have been a reason for Shklovsky's difficulties with international correspondence. Perhaps it was in part this discrimination that later led Sagan to reflect, in his science fiction novel *Contact* (1986), that human beings may have difficulty effectively communicating with extraterrestrial intelligence so long as they continue to create aliens among themselves through the process of othering and oppression [1.100].

During the publication process, further challenges had been presented regarding the illustrations in *Universe, Life, Mind*. As noted earlier in this chapter, the Soviet Union did not join the Universal Copyright Convention, and therefore did not need to receive permissions from creators outside the Soviet Union to reproduce them in print. The United States was a member

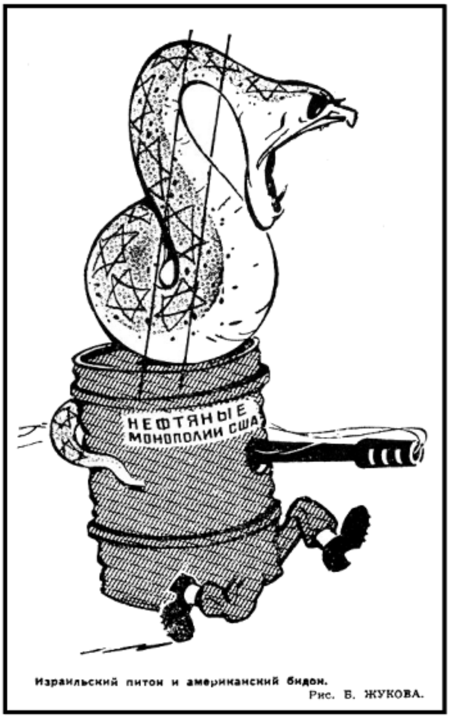

Figure 1.4 'The Israeli python and the American barrel,' B. Zhukov, Pravda Vostoka, Feb. 11, 1968. (From The Israeli-Arab Conflict in Soviet Caricatures, 1967–1973 by Yeshayahu Nir, Tcherikover Publishers, 1976).

of that convention, however, and therefore it was a hefty task tracking down and gaining permissions to reproduce the illustrations in the US. Although this caused delay, it was not the main reason the book was not yet ready for publication.

In an earlier letter to Sagan, under the mistaken impression that he was a trained biologist, Shklovsky commented that Sagan was welcome to make changes and additions to the biological and genetic sections of the book, adding that he believed he would be much more competent in these matters, especially since Shklovsky had limited access to biology texts due to Lysenkoism [1.101]. Decades later, Shklovsky claimed that Sagan "interpreted my request broadly", which, given what happened, might be considered an understatement [1.101]. In the introduction to Intelligent Life in the Universe, Sagan explained the delay, stating that he felt it was necessary to include explanatory addenda in order to make the book more accessible to Western readers [1.102]. In his attempts to slightly modify the book for a US readership, however, the young Carl Sagan claimed he "found [himself] unable to resist the temptation to annotate the text, clarify concepts for the scientific layman, comment at length, and introduce new material", until the English translation had about doubled in size [1.103]. This came as a shock to Shklovsky, who upon receiving the finalized copy of the English translation in the post, noticed that "on the cover were crammed the names of two authors: Shklovsky and Sagan" [1.104].

Shklovsky might have been understandably annoyed by this but said of Sagan: "[he] showed a certain integrity; he left my text unchanged and set off his with little triangles" (Figure 1.5) [1.105]. By "little triangles", Shklovsky was referring to the fact that Sagan, in his attempts to be clear about what was Shklovsky's original wording in *Universe, Life, Mind*, and what were his own contributions, enclosed his added text within inverted delta signs. As a result of Sagan's attempts to distinguish his own words and thoughts from Shklovsky's, the English edition, which was titled *Intelligent Life in the Universe* (1966), reads in a somewhat clunky manner. It was neither a conversation between two scientists, nor a streamlined narrative, but instead, as described by Sagan, "a peculiar kind of cooperative endeavor" [1.106]. The disjointed organization highlighted the different perspectives of the two scientists, which served an extremely valuable purpose. On the one hand, it gave readers an insight into the different ways a Soviet and

> ▽ The appearance of a supernova in the spiral galaxy NGC 4725 may be seen in Figure 7–1. The top photograph was taken on May 10, 1940, when the supernova exceeded in brightness all other regions of the spiral arms of this galaxy, except for the galactic nucleus; the bottom photograph was taken on January 2, 1941, when no supernova was evident. Figure 7–2 shows a less spectacular but more common variety of supernova; this occurred in the nearer galaxy M101. Here too, we have a "before" and "after" sequence, with the arrow indicating the supernova △
>
> Despite the infrequency of supernovae in the Milky Way, a number have been recorded in historical times. On July 4 ▽ sic! △, 1054, a "guest-star" appeared in the sky; it was duly reported by Chinese scholars. This star was so bright that it could be seen during the daylight hours. It surpassed Venus in luminosity; only the Moon and Sun were brighter. For several months this star was visible to the naked eye; then it gradually faded from view.

Figure 1.5 Excerpt from *Intelligent Life in the Universe* (1966). Sagan made contributions to Shklovsky's original text by interjecting between "∇∆" symbols. In the second paragraph above, Sagan inserts a tongue-in-cheek 'sic erat scriptum' to poke fun at the unintentional reference to the American Day of Independence.

an American astrophysicist approached the problem of extraterrestrial communication. But additionally, and perhaps most crucially, it prevented Shklovsky from facing problems in the Soviet Union for what it would have viewed as undesirable arguments deployed within the book. Shklovsky was able to get the first edition of *Universe, Life, Mind* past censors because of the fortuitous circumstances outlined earlier, but the new edition, with all of Sagan's cultural additions, would face greater problems. Sagan pointed out in the introduction to the book:

> As the reader might expect for a book written by two authors, one in the Soviet Union and one in the United States, there are occasional ideological differences. I have not tried to avoid these problems, but I also have not tried, in what is primarily a scientific work, to rebut each ideological assertion. When Shklovsky expresses his belief that lasting world peace is impossible while capitalism survives, or implies that lasers are being developed in the United States for their possible military applications alone, I have let the content of these statements stand, despite their political intent [1.107].

Shklovsky later noted the benefit of Sagan's approach to distinguishing their words, later claiming he realized "that my American 'coauthor' had done me a priceless boon in distinguishing his text with triangles. Otherwise our vigilant official "readers" could have made things tough for me" [1.108]. Clearly, the challenges faced by Shklovsky and Sagan in their attempts to work with each other across the Iron Curtain demonstrates that the difficulty of communicating on Earth posed nearly as large a challenge as communicating with extraterrestrials.

1.7 Conclusion: Returning to L

Intelligent Life in the Universe also addressed the *L* variable from the Drake Equation that had been introduced to Sagan at the 1961 Green Bank conference. As noted earlier in the chapter, *L* referred to the longevity of any given intelligent extraterrestrial civilization. The inclusion of this variable in the Drake Equation was telling for both the period and the culture in which it was presented. In 1961, when the equation was presented, Cold War tensions were reaching their height. In the 1960s and 1970s, the United States alone possessed 1,054 nuclear missiles [1.109], over ten times more than necessary to make the Earth hostile to human life [1.110]. For the first time in human civilization, human beings had the capacity to destroy their entire species in a nuclear war. This realization led Sagan and Shklovsky to consider the following in *Intelligent Life in the Universe*:

> Another question of some relevance to our own time, and one whose interest is not restricted to the scientists alone, is this: Do technical civilizations tend to destroy themselves shortly after they become capable of interstellar radio communications? [1.111]

This question, posed by a Soviet and American, is demonstrative that CETI's reach extended far beyond physics and cosmology, and promoted questions of a philosophical, historical, and sociological bent. In 1971, a few years after the publication of *Intelligent Life in the Universe*, Sagan and Shklovsky held a joint US-USSR conference on the topic of communication with extraterrestrial intelligence [1.112]. Among those invited was a historian, William McNeil, who had achieved notoriety for his earlier publication of *Rise of the West* (1963), which argued that contact and communication between foreign civilizations was the primary driver of human history. The presence of a historian whose expertise was in the rise and fall of civilizations reflected the pressing concern *L* held in the minds of CETI researchers. This preoccupation with the destruction of civilizations led Sagan, less constrained than Shklovsky in speaking out against nuclear weaponry (which in part had led the aforementioned Sakharov to exile), to dedicate much of his effort to anti-nuclear activism. In 1983 he published an essay titled "Nuclear War and Climactic Catastrophe: Some Policy Implications" in *Foreign Affairs*, where he argued that if the US and USSR did not reverse their arms race, "there is a real danger of the extinction of humanity" [1.113]. The aforementioned Philip Morrison, co-author of the paper which had inspired Shklovsky to pursue CETI, had served as a leader on the Manhattan Project and oversaw the assembly of the bomb which would detonate above the city of Nagasaki. After viewing the devastation in Japan as part of the Manhattan Project's survey team, Morrison became an adamant anti-nuclear activist and founded the Federation of American Scientists and the Institute for Defense and Disarmament Studies. In addition to his activism, he dedicated much of his life after the war to CETI and chaired the early NASA SETI workshops and studies [1.114]. At least in part, the search for intelligent life on other worlds had prompted its practitioners to fight to preserve civilization on Earth.

It will be surprising to some, in opening a chapter of a book on technosignature research, to find that this chapter did not concern extraterrestrials. Rather, this chapter demonstrates that the history of CETI largely concerns humans and their beliefs, cultures, and biases. As a science, it was also inextricably tied up in the Cold War, posing many communication challenges to the scientists involved, but also forcing them to confront larger philosophical questions. In some sense, the search for technosignatures as we know it today could not have existed without the enormous investment by US and Soviet governments into major scientific projects, such as the establishment of NRAO, the funding of conferences, or the support for the publication of books. Similarly, without the Space Race, there might have been far less public support and individual interest in pursuing the CETI problem. Furthermore, it was the Cold War mindset that influenced CETI scientists such as Frank Drake to pose the question of longevity of civilizations, and that led others, such as Sagan, into anti-war activism. Although the Cold War played a role in the establishment of CETI, it also presented many challenges to those who pursued it and highlighted the cultural and communication barriers between scientists in the US and USSR. In striving to overcome interterrestrial cultural and communications difficulties, and in recognizing the existential dilemma posed by the Cold War, CETI scientists in some sense engaged far more in philosophical and historical problems than they did technical ones. Understanding the historical context in which CETI developed is fundamental to the continued pursuit of the search for technosignatures and communication with extraterrestrial intelligence, as scientists to this day continue to pose philosophical questions which are influenced by our present cultural and geopolitical circumstances.

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[1.1] A note about terminology: Historically, the search for technosignatures was called CETI (communication with extraterrestrial intelligence) in the 1960s and early 70s. It slowly transitioned to SETI (search for extraterrestrial intelligence) shortly after a US-USSR conference in 1971. Today, the term "technosignatures" is becoming favored, as a compliment to the term "biosignatures" in exoplanetary research. For historical accuracy, this chapter will predominantly use "CETI" when discussing work conducted in the 1960s.

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