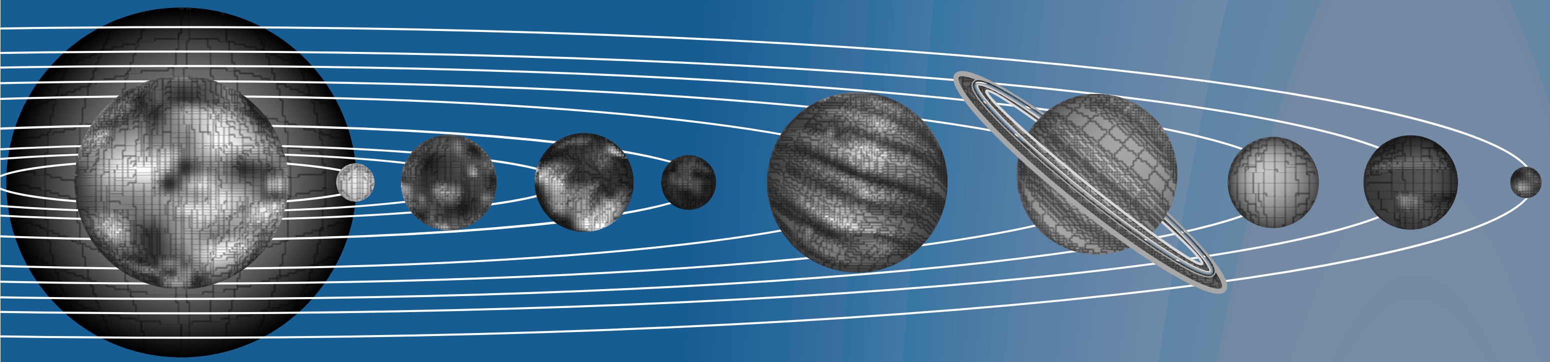

Man for the Cosmos:
Carl Sagan's Life and Legacy as Scientist, Teacher, and Skeptic

In this new remembrance of Carl Sagan, who died ten years ago, a noted planetary scientist and colleague (and former student of Sagan) recalls Sagan's immense contributions to planetary research, the public understanding of science, and the skeptical movement.

DAVID MORRISON

Carl Sagan was the world's best-known scientist in the late twentieth century, serving as our guide to the planets during the golden age of solar system exploration. He was both a visionary and a committed defender of rational scientific thinking. Sagan died on December 20, 1996, while only 62, and he has been greatly missed in the decade since. In addition to my own knowledge and insights about his scientific and skeptical contributions, I have made extensive use of the two excellent narrative biographies by William Poundstone (1999) and Keay Davidson (1999). Poundstone is stronger on Sagan's science, Davidson on his personal history. Neither, however, emphasizes his role as a skeptic.

Sagan was propelled on his academic and public careers by enormous talent, good luck, and an intensely focused drive to succeed. His lifelong quest was to understand the universe, especially our planetary system, and to communicate the thrill of scientific discovery to others. A natural teacher, he loved to explain things and never made a questioner feel stupid for asking. Although Sagan had broad intellectual interests, his pursuit of his career left little time for other activities: he did not play golf or follow sports, take up cooking or photography, sing or play a musical instrument, or join a church or synagogue. His first two wives complained that he devoted insufficient time to his marriages or his children (Davidson 1999). He focused on his career goals, and the world was enriched thereby.

As Sagan often noted, only one generation was privileged to grow up when the planets and their moons were little more than dim points of light in the night sky, and to see them emerge as unique worlds with their own geological and perhaps even biological history.

Many scientists would like to be able to communicate with the public about their discoveries. However, few become adept at explaining technical subjects in terms that are readily understood by the lay public. Even fewer are willing to take the time to answer journalists' questions patiently, to sit still for application of makeup for television appearances, or to return reporters' calls promptly even when they interrupt a meal or a lab experiment. They might like to be great communicators, but they lack the skills and the commitment. They also recognize that academic rewards generally come to the best researchers, with limited honor associated with excellence in teaching and even less for public outreach. Sagan was different. He recognized his talents as a teacher and popularizer and decided to make such outreach a major aspect of his career.

Born in 1934, Sagan grew up in a working-class Jewish neighborhood of New York and attended urban public schools in New York and New Jersey. The University of Chicago provided him scholarship support when he entered in 1951, and he continued there for graduate work, receiving his doctorate in astronomy in 1960. After two years as a postdoctoral fellow in biology at Berkeley and Stanford, he joined the Harvard College astronomy faculty as Assistant Professor. Denied tenure at Harvard, Sagan moved to Cornell University in 1968, serving as David Duncan Professor of Astronomy and Director of the Laboratory for Planetary studies until his death in 1996.

Astrobiologist David Morrison (NASA Astrobiology Institute), a Fellow of CSI, was one of Sagan's first doctoral students. He wrote a scientific update for the reprinting of Sagan's The Cosmic Connection*, and he was recently awarded the Carl Sagan Medal of the American Astronomical Society for his contributions to the public understanding of science.*

Research

Although best known to the public as a popularizer, Sagan first distinguished himself as a research scientist. His accomplishments in research made it much easier for his academic peers to accept him as a spokesperson for science. Sagan loved the research process, especially when it was combined with the exploration of new worlds. As he often noted, only one generation was privileged to grow up when the planets and their moons were little more than dim points of light in the night sky, and to see them emerge as unique worlds with their own geological and perhaps even biological history. Sagan helped define two new disciplines: planetary science and exobiology. As a leading consultant to NASA, he also helped chart the exploration of the solar system by spacecraft.

With training in both astronomy and biology, Sagan brought a unique breadth to the emerging new fields of planetary science and exobiology. At the time he received his doctorate, his thesis advisor Gerard Kuiper recognized that "Some persons work best in specializing on a major program in the laboratory; others are best in liaison between sciences. Dr. Sagan belongs in the latter group" (in Davidson 1999).

Sagan was an "idea person" and a master of intuitive physical arguments and "back of the envelope" calculations. He usually left the details to others, and most of his published papers were collaborations. Much of this work was done with students, many of whom went on to become leaders themselves in planetary science. On much of his later work, including the famous TTAPS paper on nuclear winter (more on this later), his name appears last among the listed authors. Throughout the 1970s and into the 1980s, he also edited the foremost professional journal in planetary science, *Icarus.*

Sagan's most important early research dealt with the atmosphere of Venus. Discoveries in radio astronomy made when he was in graduate school first suggested that this planet had a very hot surface, in contrast to previous speculation that the climate of Venus was more Earth-like. Part of Sagan's thesis consisted of the first computed greenhouse model for the atmosphere, in which the high infrared opacity of carbon dioxide and water vapor produced a surface temperature hundreds of degrees higher than that of an airless planet. Over the decade of the 1960s he improved these models, working primarily with his former student James Pollack, to develop and refine what remains to this day our basic understanding of the atmosphere of Venus.

Mars was another planet that interested Sagan, and with Pollack he modeled the atmosphere and developed the idea, later verified by the Mariner 9 and Viking spacecraft, that quasi-seasonal changes observed on the surface were the result of wind-blown dust. He also wrote a series of papers on Jupiter, focused on atmospheric organic chemistry.

From childhood, Sagan had been inspired by the mystery of the origin and distribution of life. This passion led him to study biology and develop collaborations with leading biologists such as Stanley Miller, and Nobel laureates Joshua Lederberg and George Muller. Early in his career, he received more encouragement from these biologists than from astronomers, many of whom considered planetary studies to lie on the fringes of respectable science, and exobiology to be beyond the pale. A number of his early publications were in exobiology, and at various times he speculated about life not only on Mars, but also on Venus, Jupiter, and even the Moon. In spite of his increasing role as a scientific skeptic, he permitted himself to indulge in this broad speculation, so long as his ideas remained within the realm of possibility. Sagan was also one of the founders of international interest in SETI, the microwave search for extraterrestrial intelligence, although he himself did not conduct any searches.

NASA valued Sagan's contributions to the spacecraft exploration of the planets during its "Golden Age" (roughly 1960–1990). He was a member of science teams selected for the Mariner 2, Mariner 9, Viking, Voyager, and Galileo missions, among others. With his quick mind and breadth of vision, he was always a welcome contributor to planning sessions and the "quick look" interpretation that followed the first receipt of spacecraft data. His former student Clark Chapman wrote in 1977: "A man of vivid imagination, he keeps alive a wide variety of conceptions of planetary environments. By suggesting often outlandish alternatives and challenging traditionalists to disprove them, he has inspired doubts about many accepted theories. Sagan's role is essential for healthy science because a bandwagon effect frequently leads to premature consensus among scientists before equally plausible alternatives have even been thought of, let alone rationally rejected."

Sagan's own excitement with the process of scientific discovery is captured in the following quote (Sagan 1973): "Even today, there are moments when what I do seems to me like an improbable, if unusually pleasant dream: to be involved in the exploration of Venus, Mars, Jupiter, and Saturn; to try to duplicate the steps that led to the origin of life on an Earth very different from the one we know; to land instruments on Mars to search there for life; and perhaps to be engaged in a serious effort to communicate with other intelligent beings, if such there be, out there in the dark of the night sky."

Popularizer and Skeptic

At the same time he was building up an enviable bibliography (which grew to 250 pages by the end of his life) and a record of successful students, Sagan also established a growing reputation as a popularizer of science. His boyish good looks, resonant voice, and ability to explain scientific concepts in ways that lay persons and students could understand made him a popular teacher and public lecturer. He won teaching awards at Harvard and Cornell, and even in the busiest times of his life he tried to keep his hand in undergraduate teaching.

Carl Sagan with Immanuel Velikovsky at the 1974 AAAS debate. All photos by David Morrison.

In 1966 he first achieved some modest national attention with his book (with the Russian astronomer I. S. Shklovskii) *Intelligent Life in the Universe*. The following year, Sagan wrote an upbeat article on the potential of life on the planets for *National Geographic*, and he made a few brief TV appearances. Already it was apparent to some that Sagan sought a broader role than that of academic researcher, a concern that probably contributed to denial of tenure by Harvard University in 1967. Students loved him, but some colleagues bristled at what they perceived as self-aggrandizement and pandering to the public. Unlike Harvard, Cornell University was looking for faculty with a potential for stardom, and they provided Sagan an endowed chair and the solid academic springboard he needed for his future rise to fame and fortune.

Throughout his career, Sagan devoted himself to the quest to improve public understanding of the nature of science. He wanted every citizen to have a "baloney detector" as defense against sham in commerce and politics as well as science. He felt that it was the duty of scientists to face these issues squarely and publicly. *The Cosmic Connection* (1973), which includes extensive discussions of extraterrestrial life as well as more conventional astronomy and planetary science, even explores the UFO phenomenon and the writings of pseudocosmologist Immanuel Velikovsky. However, Sagan opposed tactics that demeaned pseudoscientific beliefs or attacked religion, refusing (for example) to sign a statement against astrology because of its authoritative tone.

His interest in popular misconceptions about science led him to organize two public symposia on fringe-science topics at meetings of the American Association for the Advancement of Science (AAAS). Both arguably concerned real scientific issues, not cases of fraud or religious extremism.

The first AAAS symposium, in 1969, dealt with the reality of UFOs. Like many scientists of his generation, in high school Sagan had been attracted to the idea that UFOs might

Sagan with colleague Toby Owen at JPL in 1976, examining recent Viking orbiter photos of Mars. Sagan and Owen played key roles in deciding on the landing sites for the Viking spacecraft.

be visiting spacecraft. At the AAAS, J. Allen Hynek and James McDonald defended UFO studies while Sagan, Donald Menzel, and Lester Grinspoon attacked this position. The proponents on both sides of the issue were scientists, although they took very different approaches to the interpretation of the anecdotal reports of UFO sightings. (The subject of alien abductions or direct contact with extraterrestrials, which has since become so common, was not an issue at that time; the AAAS symposium focused on the interpretation of moving lights in the sky and anomalous radar signals.)

UFO proponents argued that even though there was no individual sighting in which one could make a compelling case for extraterrestrial spacecraft, the sheer volume of reports justified continuing examination and study. In contrast, Sagan emphasized the unreliability of witnesses, the absence of physical evidence of UFOs, and alternative explanations including hallucination and self-delusion. He noted that "there are no cases that are simultaneously very reliable (reported independently by a large number of witnesses) and very exotic (not explicable in terms of reasonably postulated phenomena)," and he applied a skeptical standard that is often associated with his name: that extraordinary claims require extraordinary levels of evidence or proof.

The 1974 AAAS symposium, on the work of Velikovsky, was riskier, since Velikovsky himself was invited to speak under AAAS sponsorship, something he claimed as a vindication. While Sagan promoted the symposium, it was actually organized by historian Owen Gingerich and astronomers Ivan King and Donald Goldsmith. Velikovsky's thesis of global catastrophes caused by numerous planetary encounters within historical times was scientifically indefensible but had attracted a wide popular following. Unlike the UFO symposium, there were no scientists to defend these ideas, published in his 1950 book *Worlds in Collision* (dismissed by Sagan [1973] as a "speculative romance"). Rather, the 77-year-old Velikovsky confronted his debunkers personally.

Keay Davidson (1999) describes the symposium as part apology to Velikovsky for previous slights from astronomers, and part an effort to reassure the public of science's basic fair-mindedness. The confrontation of the patriarchal Velikovsky and his young, brash critic was a clash of egos on both sides. Sagan aimed his remarks, published in extended form in *Scientists Confront Velikovsky* (Goldsmith 1977), primarily at the public and science journalists. By most accounts he was the hands-down winner. Many people credit this debate as the beginning of the end for the Velikovsky cult, which is today reduced to a handful of obscure cranks.

However, Sagan's role earned him the bitter enmity of Velikovsky supporters. His greatest sin was his lack of respect for the old man, who steadfastly refused to accept any modification of his then quarter-century-old views. Sagan's critique of *Worlds in Collision* was also castigated by Velikovsky followers for its failure to address all of his claims, and for some slipshod calculations that were never corrected in Sagan's published remarks. This symposium has been extensively analyzed (e.g., Bauer 1984), and it still raises unanswered questions about the most effective ways to counter pseudoscientists. Similar scenarios are replayed today by scientists who debate creationists and defenders of intelligent design. I sometimes ask myself if Sagan would have ventured into this lion's den, and if so how a debate between him and, say, creationist Duane Gish, would have played out.

Both AAAS symposia were widely covered by the media and contributed to a growing public recognition. A further boost came in 1973 with the publication of *The Cosmic Connection*, described in *Science* (Hartmann 1974) as "thirty-nine genuine, vintage Sagan dinner conversations." This description was more accurate than the reviewer may have realized. This book, like all of Sagan's, was dictated. Creating his books and popular articles this way, Sagan simultaneously developed his unique speaking and writing styles. At his lectures, listeners were impressed by his carefully crafted sentences, and by the way his talks (delivered without notes) seemed to be so well organized. Dictation turned out to be the perfect way for Sagan to organize his thoughts and develop his prose style simultaneously. It allowed him to "write" while traveling or walking on the beach, and it never necessitated his learning to type. It also allowed him to derive multiple value from the same material, typically delivering his message in various lectures, writing it for a magazine article (for such outlets as *Parade*), and using it as the basis for a chapter in one of his books.

The Cosmic Connection helped open the door to a medium that Sagan seemed destined for: television. In November 1973, he was invited to appear on the popular *Tonight Show* with Johnny Carson (himself a skeptic). Handsome, articulate, informal in manner, yet enthusiastically discussing real science (and often bringing the latest photos from NASA missions like Viking and Voyager), he captivated both the audience and the host. Over the following thirteen years, Sagan appeared on *The Tonight Show* twenty-six times. No matter how pressing his other business, he was always willing to take a break and fly to Hollywood for Carson. He considered it "the biggest classroom in history."

In January 1974, *Time* did a cover story on life in the universe, in which it called Sagan "the prime advocate and perennial gadfly for planetary exploration." A few weeks later Sagan

published an article in *TV Guide*, the largest circulation magazine in the United States. Sagan was suddenly hot, receiving media attention normally reserved for a select few Nobel Prize winners. In August 1976, *Newsweek* put his smiling face on its cover, a rare accolade for any scientist. Their thumbnail sketch stated: "At 42, Carl Sagan has become the leading spokesman and salesman for the new science of exobiology, the search for extraterrestrial life. Lobbying in Washington, appearing on television talk shows, and teaching at Cornell, he is building fresh support for the space program and fulfilling his own fantasies of finding life out there." Two years later, he received the ultimate tribute for a science writer, winning the 1978 Pulitzer Prize for general nonfiction for his book about the human brain, *The Dragons of Eden*.

Sagan was a founding member of the Committee for Scientific Investigation of Claims of the Paranormal. CSICOP originated in 1976 in part to direct attention to egregious media exploitation of supposed paranormal wonders. (He was always supportive of CSICOP and the SKEPTICAL INQUIRER, and served as keynote speaker at two well-attended CSICOP conferences, Pasadena in 1987, Seattle in 1994, each of which led to a major article in SI: "The Burden of Skepticism," Fall 1987, and "Wonder and Skepticism," January/February 1995.) Sagan's own contributions focused less on critiques of the media and more on creating news, skillfully using the media to inform and entertain about science. He preferred the positive approach, talking about what was correct rather than exposing errors in others.

Showman of Science

In the later 1970s, between the Viking mission to Mars and the anticipated Voyager encounters with Jupiter, Sagan decided to test the capacity of television to bring science to a mass audience. In partnership with engineer and entrepreneur Gentry Lee, a Viking colleague, he formed Carl Sagan Enterprises and began marketing a television series modeled on Jacob Bronowski's *Ascent of Man*. They developed a script, raised several million dollars in support, and hired Bronowski's director, Adrian Malone. At the same time Sagan fell rapturously in love with Ann Druyan, with whom he worked closely for the rest of his life. He and Annie moved to Los Angeles, and production at KCET Public Television started in 1977 on the 13-hour series called *Cosmos*.

His commitment to *Cosmos* finally eclipsed Sagan's academic roles. His classes were canceled, and several graduate students who had come to Cornell to work with him chose other advisors instead. Colleagues complained, and there was an effort to force his laboratory out of the Cornell Space Science Building. In Los Angeles, clashes of will between Sagan and Malone almost derailed the entire *Cosmos* effort. *Cosmos* aired in September 1980, accompanied by a promotional effort that exceeded anything seen before in public television. Most reviews were enthusiastic, and suddenly Sagan became a celebrity. The series won the Peabody Award, and eventually more than 400 million people saw *Cosmos* in dozens of countries around the world. The accompanying book, also called

Sagan with Ann Druyan in 1980 during the filming of *Cosmos*.

Cosmos, was on the *New York Times* best seller list for seventy weeks and made him wealthy as well as famous.

In October 1980, Sagan appeared on the cover of *Time*, shown wading in the "cosmic ocean." *Time* described him as the "Showman of Science" and the "prince of popularizers." They wrote: "Sagan sends out an exuberant message: science is not only vital for humanity's future well being, but it is rousing good fun as well. Watching with wonder—and no doubt a little envy—the whirling star named Sagan, some of his colleagues feel that he has stepped beyond the bounds of science. They complain that he is driven by ego. They also say that he tends to overstate his case, often fails to give proper credit to other scientists for their work, and blurs the line between fact and speculation. But they probably represent a minority view. Most scientists, increasingly sensitive to the need for public support and understanding of science, appreciate what Sagan has become: America's most effective salesman of science."

Sagan moved back to Cornell after *Cosmos*, but he could not return to the anonymity of the campus. People stopped him on the street and interrupted his meals in restaurants to tell him how much they liked *Cosmos* or to ask for his autograph. He mused to me at the time how strangers felt comfortable approaching him, since after all he had been in their living rooms (on TV). He also received crank calls and death threats, requiring police patrols of his home and prompting the university to remove his name from his office door and from the Space Science Building directory.

Fame also had its rewards. He bought a spectacular home modeled on an Egyptian temple, perched on the edge of one of Ithaca's wooded gorges, and hired a personal staff. He received an unprecedented advance from Simon & Shuster of $2 million for a science fiction novel to be called *Contact*, before he had written a word. *Contact* was published in 1985, and later made into a successful film starring Jodie Foster.

Sagan's popularity did me a service at about this time. Driving across West Texas, I was stopped for speeding. As the police officer started to write a ticket, he asked what I did for a living. When I mentioned that I had been Carl Sagan's student, he put away his citation book and launched into enthusiastic praise for Carl and, by implication, for his friends and students.

Sagan at Cornell in 1974 with three former students (L to R): David Morrison, Joseph Veverka, and James Pollack.

Journalist Joel Achenbach, in *Captured by Aliens* (1999), noted that once Sagan achieved superstardom with *Cosmos*, he became the public lightning rod for both the science and the pseudoscience of extraterrestrial life. As the "keeper of the gates" who effectively defined the border between science and pseudoscience, he was actively courted by many fringe figures who sought in his blessing a legitimization of their interests or beliefs. As an example, Achenbach reported this interview with Richard Hoagland, the popularizer of the "Face on Mars." Hoagland explained that in a public meeting in 1985, Sagan commented that those planning NASA missions to Mars should be open to discovering the unexpected. According to Hoagland, when Sagan made these remarks, he briefly made direct eye-contact with Hoagland, who was in the audience. In the weird world of pseudoscience, Sagan's innocent comment was interpreted as a coded message encouraging Hoagland to pursue his advocacy of an artificial origin for the Face—which he continues to this day, in spite of all the evidence to the contrary. (See some of Sagan's thoughts on the Hoagland/Mars Face matter in "Carl Sagan Takes Questions: More from his 'Wonder and Skepticism' CSICOP 1994 Keynote," SKEPTICAL INQUIRER, July/August 2005.)

Sagan's role is especially interesting because he himself was accused of straying beyond the limits of proper science in his pursuit of evidence for life on other planets and his defense of SETI. As Achenbach argues, it was precisely because of his apparent open-minded attitude toward fringe topics that many on the fringe became so bitter when Sagan turned against them.

Making a Better World

Sagan's rise to celebrity occurred simultaneously with Ronald Reagan's escalation of arms spending and cold war rhetoric. He told colleagues that he intended to return to the life of a professor, but he also felt he should use his new wealth and power to accomplish objectives of more global scope. As an early opponent of Reagan's Space Defense Initiative (SDI) or "Star Wars," he was able to rally vocal objections from the academic community that questioned both the technical basis for SDI and its potential destabilizing effect on the nuclear balance.

In 1982, an even more compelling opportunity presented itself, thanks to research involving two of his former students, Jim Pollack and Brian Toon (both at NASA Ames Research Center). With colleagues Rich Turco and Tom Ackerman, they were studying the influence of dust and atmospheric aerosols on global climate, working to understand the effects of martian dust storms and of the dust cloud that enveloped Earth following the asteroid impact that caused the extinction of the dinosaurs. In 1982, they had realized that smoke, especially from petrochemical fires, would have a much greater effect on global climate than naturally occurring dust. In fact, it appeared that the smoke from as few as 100 burning cities, when lofted into the stratosphere, could lead to severe global cooling (nuclear winter).

Turco and Toon flew to Ithaca in late 1982 to enlist Sagan's aid, for both the technical aspects of the research and as a means to overcome NASA objections based on the political implications of this work. This collaboration generated the TTAPS paper (named for the first initials of the authors, but with obvious symbolism) on nuclear winter published in *Science* in late 1983. The TTAPS authors concluded that even a less-than-full-scale nuclear exchange, especially if it were directed against cities, could cause global cooling and collapse of agriculture. The massive loss of life would hit victor, vanquished, or non-combatant nations alike.

Sagan used his prestige to argue that these new findings rendered nuclear war obsolete and undermined the concept of massive nuclear retaliation. The debate was international, including within the USSR, where it stimulated a rethinking of nuclear war-fighting strategies. But the pro-nuclear forces in the United States counterattacked vigorously, vilifying Sagan personally in the process. The *National Review* called nuclear winter "a fraud" and titled one cover story "Flat-Earth Sagan Falls off the End of the World."

Edward Teller, who at seventy-three was probably the second best known scientist in America, debated Sagan on nuclear winter before a special convocation of Congress. Sagan also led a delegation to meet with Pope John Paul II, who subsequently issued a papal statement against the build-up of nuclear arsenals. Many people credit this theory, and its advocacy by Sagan, as influential in the move toward nuclear disarmament and the end of the cold war.

Sagan oscillated between roles as scientist and political advocate. In this period, while attending a meeting of the imaging science team for the Galileo spacecraft, Sagan apologized to his teammates for his inability to commit more time to this mission, saying he was "putting most of my energy into saving the world from nuclear holocaust." Most team members agreed that this effort should indeed have a higher priority for Sagan than planning imaging sequences for the moons of Jupiter.

In parallel with its escalation of the arms race, the Reagan administration cut back drastically on NASA's program of planetary exploration. In 1981 they threatened to close down the highly successful Voyager 2 spacecraft before its Uranus and Neptune encounters and to turn the Jet Propulsion Laboratory

into a defense contractor lab. After the space shuttle *Challenger* accident in 1986, the momentum seemed to have left NASA, just when Sagan was advocating an accelerated exploration program in his books and lectures. At the same time the USSR, under the influence of Mikhail Gorbachev's reforms, seemed more open to international collaboration.

Sagan saw an opportunity to achieve two goals of noble dimension. By working together on missions to Mars, the US and the USSR could build confidence and gain experience that would ultimately defuse the cold war and permit cooperation in other areas. By pooling their resources, these two space-faring nations could accomplish together what neither could afford alone—extending human presence into the solar system—and simultaneously ensure peace on Earth.

Sagan formed a close working relationship with Roald Sagdeev, the director of the Space Research Institute in Moscow, and together they opened up the Soviet planetary exploration program, with unprecedented live reporting of the Soviet flybys of Comet Halley in 1986. In Russia, he associated with Soviet cosmonauts and government officials as well as scientists. For a few years, under his leadership, anything seemed possible. Then the USSR disintegrated, and many of its space scientists found themselves unemployed. With the failure of Russia's last three planetary missions (all destined for Mars), both the motivation and the capability of Russia to partner in exploration of the solar system evaporated.

Disappointments

By the time of the final Voyager encounter with Neptune in 1989, it was apparent that Sagan's campaign to promote human expansion to Mars was doomed. His Russian friend Sagdeev was emigrating to the United States and marrying (of all people) Dwight Eisenhower's granddaughter. And after a decade of budget cuts, NASA seemed unable to summon the resources even to maintain a modest program of robotic space exploration. The high hopes of the Viking and Voyager era were gone. In a 1989 lecture at JPL, Sagan could not conceal his frustration and disappointment—the first time I had seen him unable to summon an optimistic perspective. However, worse personal blows were about to fall.

In the autumn of 1990, Sagan made his most serious scientific blunder. Threatened with military opposition to its invasion of Kuwait, Iraq threatened to set fire to the nation's oil wells. Sagan became concerned that the quantity of petrochemical smoke generated by these oil-field fires could generate a small-scale nuclear winter, endangering crops across Asia and threatening world food production. Of his four TTAPS co-authors, only Turco supported this hypothesis; Pollack, Toon, and Ackerman could not see how sufficient smoke could get into the stratosphere. However, Sagan went public with dire predictions. While he kept his predictions conditional, saying only that we could *not* show that massive oil-field fires *would not* have major climatological consequences (a "double negative" logic that he used frequently), his doomsday warning was widely reported. The oil fields were torched in January 1991, blackening the sky over most of Kuwait and disrupting the coastal ecosystem, but there were no climatic effects, even on a local scale. Sagan was widely criticized, and the episode had the further effect of undermining the credibility of the entire nuclear winter scenario.

Sagan with the author at a planetary science meeting in 1983.

The next year Sagan was nominated for membership in the National Academy of Sciences. Academy membership requires distinguished research scholarship, but that is rarely sufficient to ensure membership. Considerable weight is also given to public service, as well as more political factors such as where a nominee works and whom he or she knows. Most colleagues agreed that Sagan's research record was more than adequate (Shermer 1999), and that his additional journal editorship, government service, and contributions to public understanding of science should have ensured his election. But Sagan was blackballed in the first voting round, requiring a full debate and vote by the Academy membership. In the final vote he barely received 50 percent yes votes, far short of the two-thirds majority required for election to membership.

Two years later, the National Academy awarded Sagan its prestigious Public Welfare Medal, perhaps in partial compensation for his earlier rejection. The damage was done, however: not only a stinging personal blow, but also an attack on his credibility as a spokesperson for science. For all his accomplishments—or perhaps because of some of them—influential members of the academic "old boys" network never accepted him.

Other problems multiplied. In 1993 the NASA SETI program, which he had defended on critical occasions in the past, was abruptly terminated by Congress. His book on nuclear winter, written with Turco, sold only a few thousand copies; no one cared much any more about issues of nuclear war. Perhaps worst of all, a book that he and Annie put a great deal of themselves into, *Shadows of Forgotten Ancestors*, did not receive the enthusiastic welcome they expected. Although some reviewers consider it one of Sagan's best works, it was not a best seller. No longer a media star, Sagan was slipping from public consciousness.

A Candle in the Dark

Sagan's most important contributions in his final years were in the struggle against pseudoscience. Throughout the last decade

of the millennium, this scourge of public irrationality grew, as astrology, alien abductions, alternative medicine, and any number of other New Age and "millennial" fads and cults gained in popularity. Sagan fought back, and after the death of his friend Isaac Asimov, his was the voice most often heard in defense of scientific reason in the United States.

His most influential platform was provided by the weekly newspaper-supplement magazine *Parade*, one of the two most widely read publications in America. His column appeared there regularly for more than a decade, providing a unique opportunity for outreach and education. He discussed the latest discoveries in science, debunked the purveyors of flimflam, and also delved into sensitive topics of public concern such as abortion and animal rights. His articles in *Parade* provided the basis for many chapters in his final three books, *Pale Blue Dot*, *The Demon-Haunted World*, and *Billions and Billions*.

The Demon-Haunted World, subtitled *Science as a Candle in the Dark*, was a passionate defense of science against pseudoscience and irrationality, as illustrated in the following quotes. "It is far better to grasp the Universe as it really is than to persist in delusion, however satisfying and reassuring [that may be]. . . . Superstition and pseudoscience keep getting in the way [of understanding nature], providing easy answers, dodging skeptical scrutiny, casually pressing our awe buttons and cheapening the experience, making us routine and comfortable practitioners as well as victims of credulity. . . . [Pseudoscience] ripples with gullibility. . . . The tenants of skepticism do not require an advanced degree to master, as most successful used car buyers demonstrate. The whole idea of democratic application of skepticism is that everyone should have the essential tools to effectively and constructively evaluate claims to knowledge. . . . But the tools of skepticism are generally unavailable to the citizens of our society. . . .Those who have something to sell, those who wish to influence public opinion, those in power, a skeptic might suggest, have a vested interest in discouraging skepticism" (Sagan 1995).

While vigorously advocating the concepts of scientific skepticism, Sagan also raised questions about strategy. He wrote that "The chief difficulty I see in the skeptical movement is in its polarization: Us vs. Them—the sense that we [skeptics] have a monopoly on the truth; that those other people who believe all these stupid doctrines are morons." He was especially troubled by anti-religious attitudes. While not a believer himself, Sagan had constructive interactions with religious leaders, including the Pope and the Dalai Lama. He wrote "There is no necessary conflict between science and religion. On one level, they share similar and consonant goals, and each needs the other."

Although more demanding and hence less popular than his books about astronomy and planetary exploration, *The Demon-Haunted World* is arguably his most mature and valuable publication. Expressing his concerns about the irrationalism that pervades modern society, he wrote: "I know that the consequences of scientific illiteracy are far more dangerous in our time than in any time that has come before. It's perilous and foolhardy for the average citizen to remain ignorant about global warming, say, or ozone depletion, air pollution, toxic and radioactive wastes, topsoil erosion, tropical deforestation, exponential population growth. . . . How can we affect national policy—or even make intelligent decisions in our own lives—if we don't grasp the underlying issues? . . . Plainly there is no way back. Like it or not, we are stuck with science. We had better make the best of it. When we finally come to terms with it and fully recognize its beauty and power, we will find, in spiritual as well as in practical matters, that we have made a bargain strongly in our favor."

Sagan's example has contributed to increasing efforts by scientists to reach out to the press and the public. For the first time in the 1980s, such professional organizations as the American Astronomical Society and the American Geophysical Union appointed full-time press officers and began sponsoring press conferences at their annual meetings. NASA missions also undertook to identify and encourage project scientists to speak with the press, both informally and as official NASA spokespersons. In the late 1990s this extended to welcoming commercial HDTV crews into high-level NASA meetings and spacecraft encounters. Breaking with tradition, the space agency was now anxious to show the human side of scientific exploration. In the 1960s, Sagan was almost alone in his work with the press, but such activity had become relatively common among space scientists two decades later. None, however, has approached Sagan's level of charisma or public name recognition.

Cornell's President Frank Rhodes, speaking at Sagan's sixtieth birthday celebration, summarized his impact: "I want to salute Carl Sagan . . . as the embodiment of everything that is best in academic life . . . in scholarship, teaching, and service. . . . Carl is an inspiring example of the engaged, global citizen . . . . [He is] a master of synthesis, and he has used that skill to engage us as a society in some of the biggest issues of our time. . . . With the conscience of a humanist and the consummate skill of the scientist, he addresses the needs of the society in which we live, and we are the richer for it" (Terzian and Bilson 1997).

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