

Obituary

Carl Sagan (1934–96)

Astronomer and popularizer of science

The last third of the twentieth century will be remembered as the time when humans first ventured off Earth. A pivotal figure in this exploration of the Solar System, and the eloquent tour guide for our trip, Carl Sagan succumbed to pneumonia on 20 December 1996, after a two-year battle with myelodysplasia, a bone-marrow disease.

Sagan, educated in the humanities, physics, astronomy and genetics, chose to work in the nascent fields of exobiology and planetary science, starting under the pioneer Gerard Kuiper. His publications, more than 600 in number, spanned a remarkable breadth of fields. The possibility of life elsewhere was his scientific passion, and much of his work touched on some aspect of this, often by pointing out the harshness of our own surroundings.

In his mid-twenties, Carl argued that Venus's intense microwave emissions were thermal radiation from a planet heated by the greenhouse effect of its dense carbon-dioxide atmosphere. Limb observations taken by Mariner 2, the earliest successful interplanetary mission, supported his model. Carl and his first graduate student, the late Jim Pollack, suggested that Mars's changing surface features, which had led to speculations a century earlier that the planet might be habitable, could be produced by wind-blown dust. Mariner 9, the inaugural orbiter of another planet, found shifting dune fields.

Carl was among the first to point out the 'faint early Sun' problem in Earth habitability. Following experiments seen as a student at the University of Chicago, Carl, along with Bishun Khare, former students Chris Chyba and the late Reid Thompson, elucidated prebiotic conditions in the Solar System by zapping various mixtures of common gases with different energy sources to synthesize organic molecules of remarkable complexity. The resulting 'tholins' were good spectroscopic matches for organic-rich outer-Solar-System bodies and cometary dust. Perhaps the most poignant aspect of Carl's death is that the major questions concerning life elsewhere are likely to be answered soon. What are the biochemical pathways to life? How far have protobiological processes advanced on Mars, Europa and Titan? How common are extrasolar Earth-sized planets and what is their nature?

Carl's first book, written jointly with the



distinguished Soviet astrophysicist I. S. Shklovskii, laid out the physics and philosophy behind the search for extraterrestrial intelligence. The LAGEOS, Pioneer and Voyager spacecraft carried messages from Carl, Frank Drake and others, intended ostensibly for any

extraterrestrials who might happen upon the craft; the real purpose (well achieved) was to advertise to other humans that our species had begun to visit the stars.

Carl was not an aloof academic, but frequently entered the public-policy arena over issues such as the arms race, asteroid hazards, and environmental concerns such as the greenhouse effect and the ozone layer. The nuclear winter, Carl's most provocative investigation, developed with Pollack, Rich Turco, Tom Ackerman and former student Brian Toon, proposed that a full-scale conflagration would loft dust into the atmosphere (later Paul Crutzen added smoky firestorms); the resulting clouds could cool the Earth for decades, with consequences far more devastating than the original blast. The size of the effect, even its sign, remains controversial, but the failure of national security agencies to imagine this horrendous outcome highlighted the limitations of previous models.

Sagan enormously influenced the direction of the early US planetary programme, not so much in mission details (although he was active in planning the Mariner, Viking, Voyager and Galileo flights and interpreting their results), but through the publicity that he brought these enterprises and through his access to policy-makers. He was an unwavering critic of NASA's manned space programme, including the Space Station, and a staunch advocate of unmanned planetary exploration. With Bruce Murray, Carl founded the 100,000-member Planetary Society to involve average citizens in this great adventure and, when needed, to lobby the US Congress for its continuation.

Planetary studies was born as a scientific discipline three decades ago, and Carl was a midwife. He helped establish the Division for Planetary Sciences (DPS) of the American Astronomical Society, and

was one of its first chairmen. Early on, he took over the journal *Icarus*, editing it for 11 years. Most of all, Carl set the tone for the discipline, through his infectious enthusiasm about space exploration, his scientific generosity and his interdisciplinary interests. He enticed students and faculty, including myself, to join him in the voyages of discovery across the Solar System.

Carl's talent as a popularizer of science set him apart. A remarkably gifted writer, he was aptly called the poet laureate of science. As James Michener wrote when reviewing the book *Cosmos*, "His style is iridescent, with lights flashing upon unexpected juxtapositions of thought". *Dragons of Eden*, Sagan's ruminations on the evolution of the human brain, received a Pulitzer prize. All told, his books stood on bestseller lists for more than three years. At his death, he was co-producing the movie *Contact*, based on his novel, and the Omnimax film *Comet*.

The award-winning *Cosmos* television series, written with his wife-to-be, science author Annie Druyan, and Steven Soter, was seen by half a billion viewers worldwide. It was a visually stunning amalgam of anthropology, history, biology and astronomy, that showed how our changing perception of the Universe led to a new view of ourselves. In frequent appearances on late-night television, Carl's boyish good looks, puckish humour and charm overturned the popular perception of the colourless scientist.

Perhaps Carl's greatest public influence came through his columns in *Parade*, a Sunday newspaper supplement with a circulation exceeding 80 million. Here, often collaborating with Annie, he shared his exhilaration at nature's beauty and explained difficult scientific concepts, while simultaneously chiding the public for tolerating scientific charlatans. Because of his interest in exobiology and his visibility, Carl was often drawn into public debates about all manner of pseudoscience, from UFOs to parapsychology. With sharp wit, he argued vigorously for rationality and the scientific method, maintaining that the known world was fascinating enough — one need not look for extraterrestrials in every unexplained happening.

A first-generation planetary explorer of the first rank, Carl Sagan left a world that understood itself and its place in the Universe much better. What more can a scientist accomplish?

Joseph A. Burns

Joseph A. Burns is in the Departments of Astronomy and of Theoretical and Applied Mechanics, Cornell University, Ithaca, New York 14853, USA.