BOOKS: BIOGRAPHY

Two Views of a Star's Life

Clark R. Chapman

When he died three years ago, Carl Sagan was the best known astronomer ever. The synergy of the mass-market book and television industries with Sagan's talents made him the preeminent scientific superstar. Sagan was also a researcher and teacher who helped create two related, multidisciplinary sciences: planetary science and exobiology (or "astrobiology"). From these fields, he ranged across many facets of science, among them the origins of life, the search for extraterrestrial intelligence (SETI), and the potential climate disasters (especially "nuclear winter") that might snuff out civilization. Sagan's unique celebrity helped him rejuvenate flagging public interest in science while he staved off pseudoscience and irrationalism.

Carl Sagan
A Life in the Cosmos
by William Poundstone
Henry Holt, New York, 1999. 491 pp. $30, C$45. ISBN 0-8050-5766-8.

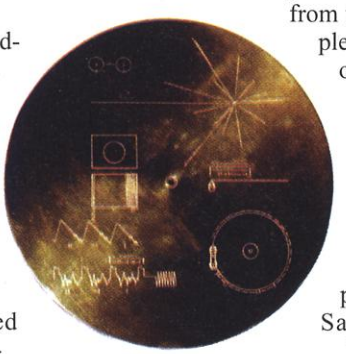
Carl Sagan
A Life
by Keay Davidson
John Wiley, New York, 1999. 560 pp. $30, C$41.95. ISBN 0-471-25286-7.

It is a tribute to Sagan that his life has inspired first-rate, serious biographies by two science writers: the San Francisco *Examiner*'s Keay Davidson and Los Angeles–based William Poundstone. Both lengthy books are highly readable and thoroughly footnoted. The approaches differ, but the portrayals of Sagan are similar and ring true. (I was a student of Sagan's in the late 1960s and an occasional scientific collaborator over the following decades.)

Poundstone's *Carl Sagan: A Life in the Cosmos* is the more traditional biography. Better organized and less repetitive than Davidson's account, it includes some intelligent analysis but aims primarily at an objective view of what is known, both good and bad, about Sagan's life. Poundstone emphasizes Sagan's science more heavily. He devotes 15 pages to a seminal 1971 SETI meeting in Armenia and nearly 30 pages to the Viking project's search for life on Mars. And his bibliography includes an extensive selection of Sagan's scientific papers.

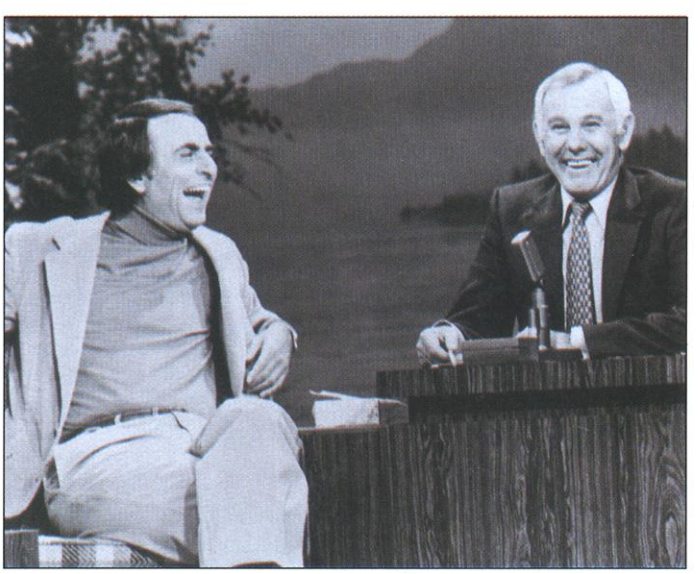
The author is in the Department of Space Studies, Southwest Research Institute, 1050 Walnut Street, Suite 426, Boulder, CO 80302, USA. E-mail: cchapman@boulder.swri.edu

On the other hand, Davidson's *Carl Sagan: A Life* is a richer book. It aims to link Sagan with his historical and cultural times, to trace themes of his adult life from their seeds in his youth, and to develop grand psychophilosophical themes about Sagan's multifaceted personality. Davidson's numerous conjectures and metaphors are often plausible, but they are neither robust nor trustworthy. In places, he gets personally involved, jumping erratically from incisive castigation (sometimes using an interviewee as proxy) to ebullient praise of Sagan. Sociologists of science, intrigued with the often-ignored interplay between scientists' personal and professional lives, should be cautious as they seek insight from Davidson's musings.



Voyager's message. Cover art for the record that is carrying music and photographs beyond the solar system.

As a person, Carl Sagan was no wallflower. Throughout his life, he powerfully affected friends, family, and colleagues in complex, contradictory ways. Both Davidson and Poundstone interviewed two of Sagan's three wives, his adult sons, his closest friends, and many of his colleagues. These cooperative sources provide intimate and consonant perspectives about Sagan's human inconsistencies.



Cosmic conversationalists. Through his role as the house astronomer on Johnny Carson's *The Tonight Show*, Sagan reached millions and millions of viewers.

Yet I wonder whether it facilitates the understanding of a prominent scientist to learn that—like many men who grew up in or before the 1950s—the young, married Sagan, despite his later feminist stance, hardly ever washed the dishes? Details from the lives of most active people could sustain a banal soap opera, but we care about Sagan because he was an enormously creative and public scientist.

More relevant is the drama of Sagan's interactions with other scientists. Many anecdotes reveal the profound ambiguities that Sagan's professional colleagues, chiefly astronomers, had in coming to grips with one of their own as a superstar and with his uncommon personality traits and unconventional approaches to science. Both books contain faithful quotations from colleagues who fault Sagan for not being the scientist they wished him to be. How could an intelligent, mathematically oriented space physicist speak so glibly about (or appear to take credit for) topics that he—unlike the complainant—had never personally researched? How could a man who once treated you so charmingly later ignore you when you needed his help or advice? How could such a rational and dispassionate researcher, who systematically undercut his own hopes for habitable climates on Venus and Mars, become so cocky as to predict (in a mass-marketed paperback) that the Viking cameras might image polar bears on Mars? Or to claim, against his own collaborators' advice (and on "Nightline" no less), that Saddam's burning of the Kuwaiti oil fields could starve millions in India? (Which it did not.)

The answers lie not so much in Sagan, I feel, but in his colleagues' parochialism and lack of empathy, which are all too common in scientific culture. As we learn to criticize others (an essential activity in science), we gain hubris and come to believe that others should do science our way.

CREDITS: (TOP) JET PROPULSION LABORATORY; (BOTTOM) COURTESY CARSON PRODUCTIONS/NBC

Sagan had an unconventional ability to fathom the panorama of unanticipated, low-probability results or outcomes that nevertheless may occur and might even have huge consequences. Such views often justify unpopular caution (about the danger of extraterrestrial contamination of Earth, for example), and they endorse sheer exploration as a valid alternative scientific strategy to traditional goal-directed hypothesis testing.

In Hollywood and professional sports, celebrities suffer the crush of fans with their friends, and their agents shield them from impossible pressures or threats. Sagan was equally famous, yet had no comparably famous scientific peers with whom to commiserate. Despite the loyal efforts of his wives and of his long-time secretary Shirley Arden, Sagan's personal and academic support structure was unfamiliar with handling celebrity. Sagan's colleagues, however, often scorned his self-protective measures and rarely imagined how they might cope in his shoes. Some felt snubbed when his priorities turned toward averting nuclear war. History will decide whether Sagan was only a bit-player or was more influential, but should we complain about having one of our own at that table?

Should Sagan really have chosen, in the late 1970s, to continue editing *Icarus* and researching aeolian processes on Mars, rather than to embark on *Cosmos*? Do Sagan's critics really want no books like the Pulitzer Prize–winning *Dragons of Eden*? If Sagan had not been available to journalists for comments on someone else's spacecraft results, would there have been any coverage at all? Scientists became so jealous that Sagan was famously barred from membership in the National Academy of Sciences and his nomination for a posthumous award from his narrowest circle of professional colleagues even met obstacles. Is that a reflection on Sagan or on his colleagues?

We need dedicated specialty researchers, but we also need broader multidisciplinary synthesizers. Carl Sagan gave us even more than that: He was, for all his failures to meet the ideals of others, a renaissance man during an age when that was—and still is—virtually impossible (and is sometimes even held in disrepute). We should be grateful for the treasured moments so many of us shared with Carl. I occasionally had my own one-on-one hours with him, but I also joined countless millions who watched him on Johnny Carson and *Cosmos* or read his well-crafted writings. An enormous fraction of my younger colleagues credit Sagan with turning them to science at a time when science was in cultural retreat. Both these biographies offer informative perspectives on how and why he was able to do that.

BOOKS: LANGUAGE

Why Do Kids Say Goed and Brang?

James L. McClelland and Mark S. Seidenberg

As Steven Pinker notes in his new book *Words and Rules*, kids say the darnedest things. In the late 1950s, language researchers noticed that kids occasionally say odd things like "Daddy goed to work" and "I taked the last cookie." These past-tense forms were intriguing because children seemed to be generating them without having heard them before. And indeed, when children were tested with nonce verbs such as "glick" and "mott" they often generated novel past-tense forms like "glicked" and "motted." These forms suggested that the children had discovered a simple rule for forming the past tense: add a variant of "-ed" to the base form of the verb. Such actions fit Noam Chomsky's argument that syntactic rules are the basis of our grammatical ability. Thus the formation of novel past-tense forms came to be taken as the quintessential demonstration that language is produced through the use of a system of rules.

Words and Rules
The Ingredients of Language
by Steven Pinker
Basic Books, New York, 1999. 362 pp. $26, C$39.50. ISBN 0-465-07269-0.

But if language involves the application of rules, why are there so many exceptions? Why is the past tense of take "took" instead of "taked"? Why do we use "stood," not "standed"? "sang," not "singed"? and "went," not "goed"? Within the rule-based framework, explanations of such apparent exceptions follow two approaches: One tries to construct a more complex set of rules (to cover all the cases). The other introduces a second mechanism, a mental lexicon, to handle cases where the usual rules do not apply.

Perhaps, however, the brain stores language in a way that systems of rules and lists of words can only approximate. The rules of language, such as the past tense, need not be explicitly represented. They could instead stem from the operation of more fundamental underlying processes. In the mid-1980s, a group of psychologists, neuroscientists, and computer scientists began to explore the possibility that lawful performance might reflect the operation of a mechanism that never constructed or consulted a rule per se. For example, in the production of past-tense forms of verbs, the mechanism might simply adjust the connections among the neurons involved in forming past tenses when the network encounters the past-tense form of a word.

David Rumelhart and one of us (McClelland) developed this idea using a computer simulation of a simple neural network (*1*). The model had two sets of neuron-like units, one for representing the base form of a verb, and one for representing its past tense. The model was trained using repeated presentations of present and past-tense pairs. After each presentation, the connections from the units representing the features of the present tense to the units representing the features of the past tense were adjusted by a small amount to allow the active input units to excite the appropriate output units. The model captured the correct use of both regular and exceptional forms, and it exhibited the capacity to generalize. Thus, within a single network, it accounted for many essential aspects of the past-tense phenomena without a rule or a lexicon.

At this point, Steven Pinker entered the debate. Now well known through his popular science writing, Pinker emerged as a prominent psycholinguist on Chomsky's home ground at the Massachusetts Institute of Technology. In an influential article (*2*), Pinker and Alan Prince drew on their broad knowledge of language to develop a blistering critique of the neural network model. After correctly noting several shortcomings of the specific model used by Rumelhart and McClelland, they went on to claim that no neural network could ever adequately capture the generality and absoluteness of the English past-tense system.

In a later paper (*3*), however, Pinker acknowledged that the neural network model did have some positive properties. Unlike a standard lexical lookup mechanism, it captured another type of generalization based on patterns found among the exceptions. Using the pattern found in pairs like "sing-sang" and "ring-rang," children sometimes say "brang" for the past tense of "bring." Writing rules to capture the fact that some verbs form their past tense by changing "i" to "a" won't do, said Pinker, because such rules are not fully generative. The pattern only applies to some words with the short vowel "i," and the ones it does apply to share a "family resemblance" structure of the kind that was well captured by the neu-

James L. McClelland is at the Center for the Neural Basis of Cognition, and the Department of Psychology, Carnegie Mellon University, 115 Mellon Institute, Pittsburgh, PA 15213, USA. E-mail: jlm@cnbc.cmu.edu. Mark S. Seidenberg is in the Neuroscience Program, and the Department of Psychology, University of Southern California, 3614 Watt Way, Los Angeles, CA 90089–2520, USA. E-mail: marks@gizmo.usc.edu