father, Ronald Reagan. Moreover, as Broad emphasizes, Teller has had a major, perhaps inordinate, impact on national security decision-making at least since the days of Dwight Eisenhower. But to say that Teller is "more icon than flesh and blood" (p. 247), that he is "the most influential scientist of the nuclear era—and perhaps the century" (p. 20), overstates the case, in some instances (such as the beginnings of SDI) directly contradicting Broad's own evidence. In a sense Broad seems to have been captured by Teller, seduced by the man he so strongly criticizes.

On the plus side, *Teller's War* does a good job of recounting the very complex set of circumstances surrounding the origins of SDI. It sets the idea introduced in Reagan's 23 March 1983 speech in excellent context. The "selling" of Star Wars, as Broad colorfully puts it, involved numerous individuals with widely different motivations and perspectives, ranging from Admiral James D. Watkins's moral and ethical concerns about nuclear weapons to national security adviser Robert McFarlane's use of antimissile rhetoric as an arms control "bargaining chip" strategy. Broad details particularly well Reagan's own thinking on the issue, with SDI being the culmination of a search for a technological solution to the dual problems of nuclear weapons and the evil empire. Feeding into this picture was the "intellectual turmoil" and public debate of the early 1980s over the "proper role" of nuclear arms in national strategy, manifesting itself most visibly in the now nearly forgotten nuclear freeze movement.

Another positive contribution of the book, especially for the general readership it is likely to attract, is the dispelling of whatever might be left of the myth of monolithic thinking at the national nuclear weapons design laboratories. Although the final word is yet to be written on the subject, Broad's elaboration on the rift between Teller and Roy Woodruff shows that SDI generated as much controversy and criticism within the Lawrence Livermore Laboratory as it did from external public sources. The long tradition of friendly competition and outright rivalry between Livermore and Los Alamos scientists also jumps from these pages.

Still, after all of this, Broad again inexorably, inevitably comes back to Teller. Without Teller and his active promotion of the x-ray laser, Broad maintains, the Star Wars program would not have "materialized" (p. 136). Teller perhaps was the most zealous advocate, but, as Broad himself shows, a large cast of characters and forces were involved. Moreover, because everything begins and ends with Teller in Broad's account, we lose a sense of what was going on in antimissile research *before* March 1983. In actuality, Washington consistently spent a great deal on missile defense prior to Reagan's public pronouncement by way of allocations to the individual military services. Broad thus misses the initial, largely consolidating role of SDI and the SDI organization. Comparative budget figures for the x-ray laser and other aspects of the program as it subsequently developed would have been helpful as well.

Edward Teller. [From *Teller's War*; Los Alamos National Laboratory]

Broad's overemphasis on Teller's influence extends to such secondary subjects of the book as arms control and the creation of the Livermore Laboratory. According to the author, Teller "begat" the laboratory and defeated single-handed the drive for a comprehensive nuclear test ban in the late 1950s: "He felt the nation needed another lab for the design of nuclear weapons—and it materialized. He opposed the ending of nuclear tests—and the blasts continued" (pp. 19, 270). This characterization seriously underestimates the role of other scientists and policy-makers in these episodes, most directly the role of Berkeley scientists E. O. Lawrence and Herbert York in the founding of Livermore and that of the Atomic Energy Commission, the Joint Chiefs of Staff, and the President's Science Advisory Committee in the test ban debate.

Certainly, this is a good book to learn more about the secret and largely closed world of the national laboratories and their relation to Washington, D.C. But Broad's ultimate fascination with Teller—a key figure to be sure—really prevents us from getting a clear picture about the true dynamics of the arms race, arms development, and arms control.

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Lives of a Chemist

Steroids Made It Possible. CARL DJERASSI. American Chemical Society, Washington, DC, 1990. xxiv, 205 pp., illus. $24.95. Profiles, Pathways, and Dreams: Autobiographies of Eminent Chemists.

The Pill, Pygmy Chimps, and Degas' Horse. The Autobiography of CARL DJERASSI. Basic Books, New York, 1992. viii, 319 pp. + plates. $25.

Within less than two years, Carl Djerassi, "father" of the birth control pill, has given us two autobiographies. The earlier of the two, *Steroids Made It Possible*, is part of a 22-volume series of autobiographies whose stated goal is "to document the development of modern organic chemistry by having individual chemists discuss their roles in this development." With four and a half decades of scientific accomplishment described in more than 1100 research publications, Djerassi's was no mean task. Fortunately, there are a few *leitmotivs* that unify large groups of these papers, and Djerassi is successful in showing how his research on subjects as disparate as magnetic circular dichroism, artificial intelligence, and marine phospholipids all grew out of his early and abiding passion for steroids. Readers will appreciate the author's overview, along with his selection of his own "greatest hits," since it is unlikely that many will ever read a significant fraction of this massive output. Organic chemists will be pleased to acquire some incidental trivia, such as the fact that the "dienone-phenol" rearrangement and the "Birch reduction" were christened by Djerassi.

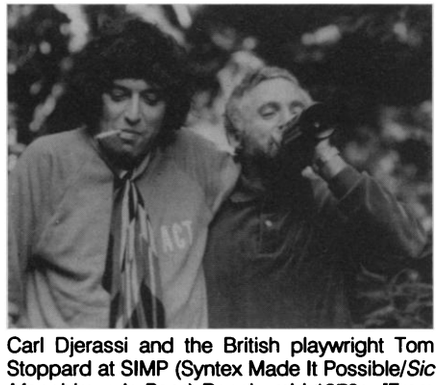
Though the chief purpose of the 1990 volume is to summarize scientific accomplishments, the opening and closing chapters that frame the science provide tantalizing glimpses into some non-scientific aspects of a remarkable life. Djerassi's boyhood as the son of two physicians in Vienna and Sofia prepared him for a career in medicine. However, his whirlwind undergraduate education at Newark Junior College, Tarkio College (Wallace H.

Carothers's alma mater), and Kenyon College, subsequent to his and his mother's flight from Europe in 1939, inspired him to pursue chemistry. A year of research in medicinal chemistry at CIBA, followed by a University of Wisconsin doctorate (earned in two years), launched Djerassi on a breathtaking career. His subsequent research productivity at CIBA and then at the Syntex laboratories in Mexico City quickly established him as one of the most aggressive and successful players in the field of "natural products" chemistry. Early insights led to the synthesis of cortisone from a readily available precursor, diosgenin, and to the discovery of the first steroidal, orally active contraceptive agent. These achievements, before the age of 30, gave him *Wunderkind* status. His subsequent academic career at Wayne (now Wayne State) University and at Stanford, pursued simultaneously with his leadership roles at Syntex and Zoecon, more than realized this early promise.

"King Carl XVI Gustaf of Sweden eyeing two immobilized cockroaches held by Zoecon's director of biological research, Gerardus Staal, 1984. Between the king and [Carl Djerassi, foreground] is Karl-Erik Sahlberg (president of Perstorp AB); at the extreme right is Bengt Modeer of the Royal Swedish Academy of Engineering Sciences." [From *The Pill, Pygmy Chimps, and Degas' Horse*]

In these pages there are cameo appearances (and often candid photos) of much of *le beau monde* of 20th-century organic chemistry (Lord Todd, Robert Robinson, D. H. R. Barton, Arthur Birch, Vlado Prelog, Duilio Arigoni, André Dreiding, Gilbert Stork, R. B. Woodward, W. S. Johnson, E. J. Corey, Koji Nakanishi, Franz Sondheimer, J. D. Roberts, Hans Muxfeldt, Kurt Mislow, Ronald Breslow, Louis and Mary Fieser, Lew Sarett, Jean-Marie Lehn), although neither Djerassi's scientific nor his social relationships are explored in depth. Robert Maxwell puts in a brief appearance as the father of Djerassi's son's bride. There are two gems of chemical humor: a mock report by a group of Gordon Conference stalwarts on the partial synthesis of cortisone from a precursor ("neohamptogenin") found in maple syrup, and a communication by Ben Tursch describing the discovery of a remarkable contraceptive agent isolated from an invisible marine invertebrate.

The Pill, Pygmy Chimps, and Degas' Horse, intended for the general reader, is a welcome sequel to *Steroids*. In it, we find a fuller and often more eloquent account of Djerassi's multi-faceted life. This scientific autobiography is an outstanding example of the genre pioneered (at least among organic chemists) by Richard Willstätter and continued with notable success by Martin Kamen, Francis Crick, and Arthur Kornberg. There are amusing details, such as the author's mastering two different Bar Mitzvah ceremonies because his father's professional commitments required a last-minute change of dates. A chapter devoted to an account of how he convinced his oldest friend, Gilbert Stork, along with Syntex colleagues George Rosenkranz and Alejandro Zaffaroni, to invest in the production of an English-language B movie in Mexico City makes for a welcome humorous interlude. As this project encountered assorted obstacles, Elkan Blout and Jack Dreyfus were drawn into the circle of investors. The first (and apparently last) screening of the completed film before an invited audience of some 400 friends and colleagues in Stanford's Memorial Hall, some nine years after the start of the project, was the kind of disaster whose only redeeming feature is the telling of the story afterwards.



Carl Djerassi and the British playwright Tom Stoppard at SIMP (Syntex Made It Possible/*Sic Manebimus in Pace*) Ranch, mid-1970s. [From *The Pill, Pygmy Chimps, and Degas' Horse*]

Not unexpectedly, both the science and the politics of human contraception are explored in considerable depth in a series of chapters distributed throughout this volume. Forty years have elapsed since Louis Miramontes, George Rosenkranz, and Djerassi synthesized 19-nor-17α-ethynyltestosterone, which went on to become the active progestational ingredient of nearly half of the oral contraceptives used worldwide. The extended analysis of how this discovery influenced human behavior in its broadest sense is certainly one of the most fascinating features of this book.

Though the matter is not explicitly discussed in either volume, it is worth noting that Djerassi's style of chemistry has not been a popular one, at least not within the American academic organic chemistry community. His many accomplishments were not those that most contemporary curricula prepare chemists to appreciate. Since the blossoming of physical organic chemistry in the United States in the 1940s, there has been a growing tendency to present most of organic chemistry as a set of consequences predictable from the electronic structures of molecules. Though this sort of axiomatic approach has been enormously effective in many areas, it has no bearing on that part of chemistry concerned with isolating, characterizing, and understanding new naturally occurring compounds. Consequently, Djerassi's extensive discoveries of many previously undescribed cactus constituents and of the unusual array of steroids and lipids he was able to characterize from marine organisms have not been fully appreciated.

In a similar vein, his systematic experimental studies of optical rotatory dispersion and of mass spectrometric fragmentation patterns failed to captivate the minds of chemical colleagues in the way Stork's or Woodward's brilliant total syntheses or the concept of the aromaticity of tropone did. Consequently, in spite of the unique, worldwide impact of Djerassi's early work on steroid chemistry, recognition for his purely chemical achievements has come only recently. At just about the same time, it is clear that the purely chemical chapters in Djerassi's life have come to a close.

The final image that emerges from reading these volumes is of a man with the liveliest intelligence who defines his objectives with unusual clarity and pursues them with relentless intensity. Quite apart from his success as a researcher, charismatic teacher, and industrial entrepreneur, Djerassi has played an important role in advancing science in South America and Africa (the latter the site of a venture in primatology referred to in the second book's title). He has been both a serious collector and an influential patron of

the arts (the horse in the book title is a sculpture Djerassi owns), and in recent years he has become a published writer of novels, short stories, and poems. Especially in the later autobiography Djerassi provides a poignant account of his unconventional childhood, of his three marriages, and of his sometimes strained interactions with his son and daughter. His decision to reveal so much of a personal nature in this volume in itself represents a new direction in his life and results in our learning much more than we might have expected from a scientist's autobiography. Though the interplay between his private life and his professional one is not really explored, Djerassi may nevertheless have set a new standard for openness in a work of this character. Overall, Carl Djerassi's ability to overcome difficulties of both a physical and a spiritual nature, his startling combination of competitive spirit and altruism, his breadth of interest, and his successful move away from scientific research and into entirely new fields of endeavor at a stage when many would be quietly retiring are all portrayed with clarity and enthusiasm in these complementary accounts of a rich and complex life.

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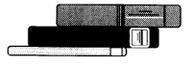

So-Called Quasicrystals

Quasicrystals. The State of the Art. D. P. DiVINCENZO and P. J. STEINHARDT, Eds. World Scientific, Teaneck, NJ, 1991. x, 524 pp., illus. $58; paper, $28. Directions in Condensed Matter Physics, vol. 11.

As many readers will recall, the 1984 announcement by Schechtman, Blech, Gratias, and Cahn of the discovery of AlMg alloys with icosahedral symmetry sent shock waves through the world of solid state science. Since the beginning of the 19th century, it had been almost universally accepted that icosahedral symmetry was incompatible with periodicity, and several hundred years of mineralogy and crystallography had laboriously established the hypothesis that crystal structure is periodic. It was therefore assumed that icosahedral symmetry was impossible for a crystal, so when researchers were confronted with a crystal that exhibited this symmetry their immediate response was to call it something else. Eight years later, we seem to be stuck with the term "quasicrystal," despite the fact that today many crystals with "forbidden" symmetries are known.

That the distinction between "crystals" and "quasicrystals" is highly artificial and should be abolished is in fact the point of view taken by David Mermin, one of the authors in *Quasicrystals*. Mermin argues that the symmetry groups of crystals and quasicrystals can and should be placed together in a single conceptual classification scheme. By focusing on the groups, rather than the structures whose symmetry they describe, he avoids dealing with rather complex models for quasicrystal structures. However, the object of quasicrystal research is to determine the structure of quasicrystals, so the problem of characterizing the structures whose symmetry is described by the groups remains a central one.

Two early models, intricate twinning and icosahedral glasses, no longer seem viable. Tilings, on the other hand, continue to be studied intensively. Tiling models stimulate geometric intuition and imagination, are amenable to calculation, and pose many problems that are at least superficially analogous to those posed by quasicrystals. For example, the debate over the respective roles of energy and entropy in stabilizing quasicrystals can be formulated in tiling language: Are quasicrystals better modeled by "classical" Penrose tilings (whose structure is determined by matching rules) or by "random" tilings, in which the same shapes are used but the matching rules are relaxed? Both points of view are vigorously represented in this book, though Penrose models serve as the starting point for most of the investigations. The range of physical problems explored through such models includes quasicrystal growth, facet and surface roughening, electronic structure, and transport.

Important information about tiling models is obtained by "lifting" the tilings to higher-dimensional spaces, in which they can be seen as sections or projections of periodic patterns (lattices with an "atomic surface" attached to each lattice point). Conversely, large classes of orderly but nonperiodic point sets can be obtained by section or projection, including point sets that cannot be meaningfully associated with tilings. Higher-dimensional methods are extensively used in the analysis of diffraction data. Unfortunately, structure determination is underrepresented in this book.

Although the editors describe *Quasicrystals* as a "progress report" that "takes stock of the current state of affairs in the science of quasicrystals," there are several respects in which the contributions do not fully portray "the state of the art." This most probably results from the fact that the collection reflects the interests of researchers at the two main centers of quasicrystal research in the United States—the University of Pennsylvania and Cornell. Most of the authors are or have been connected with one or the other of them. To be sure, the

"Decagonal prismatic solidification morphology of a single grain Al-Co quasicrystal. In the ternary $Al_{65}Co_{20}Cu_{15}$ or $Al_{70}Co_{15}Ni_{15}$ form the decagonal phase becomes a stable compound and single grains of several millimeters can be grown." [From R. S. Becker and A. R. Kortan's chapter in *Quasicrystals*]