Carbon capers

Philip Ball

The Most Beautiful Molecule: An Adventure in Chemistry. By Hugh Aldersey-Williams. *Aurum: 1994. Pp. 340. £18.95.*
Perfect Symmetry: The Accidental Discovery of a New Form of Carbon. By Jim Baggott. *Oxford University Press: 1994. Pp. 320. £18.99, $29.99.*

WHAT should we look for in books about scientific discoveries? James Watson's *The Double Helix* had colourful characters (the author being not the least of them) and the excitement of a race. George Smoot and Keay Davidson's *Wrinkles in Time* had a big question, perhaps the biggest there is. Frank Close's *Too Hot to Handle* had a moral about the scientific enterprise. What is there in an account of the discovery of C_{60} that might illuminate, captivate, entertain?

In detailing the revolution in carbon physics and chemistry that has taken place in the past nine years, both Baggott and Aldersey-Williams hope to capture a certain amount of interest by the sheer beauty of the C_{60} molecule. It is questionable, however, whether this would have had much resonance beyond the chemistry community had the structure not been so easily translated into that of a soccer ball. An icosahedral cluster (as opposed to the truncated form) would be a tougher individual to sell to the world at large.

Then there is the name. Something as extravagantly titled as buckminsterfullerene must surely have an interesting story attached, whereas soccerene or spherene, as it might have been called, would probably now seem trite or prosaic. Buckyballs and buckytubes, for all that *Nature* has avoided the terms, are catchy.

But in terms of illuminating the process by which science is done — a reasonable objective of any book of this sort — the fullerene story has in its favour an abundance of interdisciplinarity. Both books begin in interstellar space and end by roaming the borders of nanotechnology, taking in on the way combustion science, architecture, biological growth and form and solid-state physics.

Those who have publicly or privately deplored fullerene hype should find little to fault here — the authors show why the breadth of fullerene science warrants the excitement, but their assessments are commendably restrained. And it was a matter of some relief to me that both books are relatively free from the swaggering, sound-bite-spewing scientific caricatures that bedevil so much popular science writing.

Perhaps the major attraction of the C_{60} story, however, is that it required a leap of imagination and a generous helping of intuitive faith. This is what takes it beyond the mundane business of science as cautious, incremental steps forward, of Kuhn's 'normal' science. Would the tale be half so gripping, for example, if a total synthesis of C_{60} had been the means for its mass production? A genuine organic synthesis would have been a far greater intellectual *tour de force* than its formation in an arc reactor (it still would be); but that would also have been a matter of steady, careful and wholly rational steps converging on the final goal, not the consequence of a physicist's "crazy idea". Sadly, perhaps, but for good reason, I cannot see a popular book being written on the total synthesis of taxol.

What in fact happened was an appealing reversal of the usual progression of research. The story began on the high-tech cluster-beam apparatus in Rick Smalley's laboratory at Rice, an instrument worth hundred of thousands of dollars, and progressed to ever simpler, cheaper and more *ad hoc* arrangements, through Wolfgang Krätschmer's arc-discharge system inside a bell jar at Heidelberg to the absurd extreme of Don Bethune's burning-peanut can in a fume cupboard at IBM Almaden. What made mass production of C_{60} so difficult was disbelief that it could be so easy. Thus fullerene chasing became science on an ever more modest scale, to which postgraduate and undergraduate students could make valuable contributions, and in which the financial margin between success and failure could be as little as £80, the cost of replacing a burnt-out transformer.

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This was an essential part of the fullerene explosion. Not only was it possible, in late 1990, to produce C_{60} in large quantities; it was also possible to do so very cheaply. Anyone could play. My own first glimpse of the red powder of semi-refined fullerenes came in a laboratory in northeast China in 1992, which had its own makeshift arc reactor. But by the end of 1990 you didn't even need that: C_{60} was available by mail order.

There is also the spice, in these accounts, of watching top-rate scientists adrift in a foreign place. How does soot form? The musings of physical chemists Smalley and Harry Kroto were covered in opprobrium by the combustion community. How does one dissolve C_{60} from soot? Benzene is the screamingly obvious solvent, but not to the Heidelberg physicists. How do you make a closed sphere from hexagons? The impossibility of doing so is evident from the theorem due to Euler that is taught in high schools, but the discoverers of C_{60} spent frustrating days at the task. None of this is to the shame of the scientists concerned, but is simply an indication that great discoveries need not, and usually do not, require omniscience.

Aldersey-Williams is thorough as far as he goes, but he does not go everywhere. Remarkably, for example, as prominent a part of the fullerene myth as David Jones's prescient article in 1966 on "graphite balloons" gets no mention, nor does the theoretical work on C_{60} by Eiji Osawa or the Soviets D. A. Bochvar and E. G. Gal'pern in the 1970s. And the reader is left to ponder why Orville Chapman at the University of California, Los Angeles, was to be found trying to synthesize the molecule in 1980, five years before its 'discovery'.

Sometimes too the author's grip wavers, particularly in the account of fullerene superconductivity. In characterizing superconductors as poorly understood, he fails to make a distinction between conventional materials and the high-T_c copper oxides. And the fullerene development will no doubt seem all the more technologically significant when the reader is not told that the 77-K barrier was broken long before doped C_{60} started creeping towards it.

On the other hand, Aldersey-Williams takes us on some illuminating detours through the symmetry properties of polyhedra and the strange and recondite world of Buckminster Fuller the architect, many of whose meanderings he dismisses rightly, if irreverently, as exemplary pseudoscience.

Baggott is more comprehensive, but less reflective. He tells the story straight, in more or less chronological fashion with few diversions. A minor drawback of this is that his book will occasionally be tough going for nonscientists, and that it sometimes sags under the weight of extraneous detail. But it provides an overview of the state of the field that is as well informed and as up to date as one could wish.

For production values, Baggott wins hands down: his book is lavishly illustrated, largely with figures from the original sources. But whereas Baggott is closer to his topic, Aldersey-Williams maintains a distance that allows him to tread on more toes, no bad thing in a field laden with dispute and rivalry. So the two books serve slightly different ends, but both are very well written and rewarding. You will get an excellent account of the story from either, and the fact that they have appeared now rather than closer to the 1990 breakthrough means that either can provide a perspective that should persuade the reader that this one will run and run. □

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