Travelogues from Lilliput

George M. Whitesides

THE DANCE OF MOLECULES: How Nanotechnology Is Changing Our Lives. Ted Sargent. xx + 234 pp. Thunder's Mouth Press, 2006. $25.

NANO-HYPE: The Truth Behind the Nanotechnology Buzz. David Berube. Foreword by Mihail C. Roco. 521 pp. Prometheus Books, 2006. $28.

Nanotech! What is it? The term *nano* (as used in such compounds as *nanoscience* and *nanotechnology*), once an obscure adjective found primarily in discussions of electronics, has come in recent years to be identified with exciting discoveries in the physical sciences. The proponents of nanoresearch have ranged from thoughtful, conservative scientists to the most ardent of enthusiasts, and the claims for it have ranged accordingly.

Most new areas of study start life swaddled in optimism; but at a certain point in their adolescence, it is important to have some sense of whether their promise to change the way we think and live will ever become reality. It is still not clear what nanoscience will grow up to be. Two recent books—*The Dance of Molecules*, by Ted Sargent, and *Nano-Hype*, by David Berube—are, in different ways, efforts to explain the field to outsiders.

The Dance of Molecules is the ideal book for your favorite science-infatuated high-school–age niece—someone in love with the potential of science, someone who wants to be amazed and excited, someone who is not too concerned with such picky adjectives as "accurate" or "realistic." In contrast, *Nano-Hype* is for those who would really like to know the history of nanoscience and nanotechnology, to understand the social structure of the discipline and to think about how it is communicated. Author David Berube asks, not "What is nano?," but "How did *this* field so flourish and attract so much attention, whereas others that started with equal promise, and in equal obscurity, have remained safely cloaked in that obscurity? Who pays for this research, and why? What kinds of people and businesses are promoting it, and for what ends? How does public policy deal with it?" Neither book is intended to be a hard-nosed, technically detailed assessment of current nanoscience and nanotechnology or of the economic opportunity and social cost and benefit of the activities that fall under "nano" headings.

The Dance of Molecules is a kind of tone poem, a paean to the idea of the limitless wonders of technology. It is organized into chapters with titles intended to catch the attention of the general-science reader: "Diagnose," "Heal," "Grow," "Energize," "Protect," "Compute," "Humanize." Although its subtitle is "How Nanotechnology Is Changing Our Lives," it mixes what nanoscientists would agree falls in the domain of "nano" with subjects—chemistry and materials science and biotechnology—in which the application of a conventional definition of *nano* is sometimes a stretch. The book is a collection of vignettes describing areas of science that have still-unrealized ambitions to become technologies. It focuses on potential applications, some real and some far-fetched: an electronic "dog's nose" to sniff explosives, "quantum corrals" showing ripples in an underlying electron sea, molecular beacons and quantum dots illuminating the machinery of the cell, liposomes for delivery of anticancer drugs, stem cells for what ails you, solar cells and conducting polymers to generate and transport energy and information. All these wonders are there, and much more.

A smorgasbord of subjects is a fine strategy for this kind of book: What counts are a sense of excitement and examples of what *might* be opportunities for a new field of science and technology. The academic questions of what departments in universities should house the researchers and of how their funding and oversight should be arranged, and the small technical details of probability of success and what size really qualifies for the label *nano* are not very relevant if the objective is to convey a sense of why science is so engaged with small things. I personally do not think that many of the ideas that are so enthusiastically sketched in the book will ever become significant technologies, but that is opinion.

Sargent is associated with MIT, and *The Dance of Molecules* has something of the quality of a photo album from a research-group picnic: "These are my friends, and let me tell you what they are doing and how cool they are." That's fine: There *is* cool stuff done at MIT. That parochialism notwithstanding, this book is very well written for a general-science audience—much of it is

lovely, transparent prose, employing engaging and quirky analogies and displaying a real grace in choice of words. "The year Greta Garbo died of kidney failure in New York was the year I made up my mind to become a nanotechnologist," it begins, and then sweeps the reader along on a roller coaster constructed of mixtures of fact and fantasy. The book is entertaining and very easy to read. It conveys a real sense of the range of the subject and of the enthusiasm of its practitioners. The author's evident love for the research he is writing about illuminates the book.

The nanohyperbole meter runs from nanopanic to nanopanacea: If –10 is one end of the scale ("Nanobots and the 'assembler' are the end of humankind as a species and, indeed, of life on Earth") and +10 the other ("'Nano' is the next turn of the great wheel of technology that powers civilization—akin to the discovery of fire, the integrated circuit or carbonated soft drinks"), I would rank this book at about +7. Still, its tone is not so much hyperbolic as optimistic: Something important *might* come from these activities, if one waits long enough and is not too fussy about tracing where the ultimate good ideas originated.

Nano-Hype is a more sober and scholarly work. For the most part, it is a useful, evenhanded, detailed history of the development of nanoscience, as viewed through the eyes of a social scientist. Berube clearly has followed the field from its beginning and has paid close attention to its details as they have appeared. The book is extensively documented; it offers the most encyclopedic account of the development of nanoscience and technology that I know. I am certain that it will be mined for references by generations of future graduate students in the sociology and history of science. Its prose is clear, if prolix, and better at conveying information than excitement.

Exhaustively documented history can sometimes be a little tedious, and, perhaps to avoid this quality and to add color, the book seems to have had one (or several) human-interest stories grafted onto its scholarly trunk. These grafts have not quite taken. The sections that focus on "hype" tend (at least from the vantage of someone working in the vineyards of nanotechnology) to overstate issues, and the squabbles between Eric Drexler and reactionary establishment science (the late Rick Smalley and I are taken as representatives of this group) are given a weight that they did not have from inside the squabble. Issues in ethics and risk in nanotechnology simply are not as serious and immediate as those, for example, in biotechnology or nuclear weapons or global climate change.

As a scientist, I was particularly interested in the light shed on "nano" by the social sciences. It is a *very* different spectrum of frequencies! "My goal is to provide the reader with a better understanding of how nanotechnology has been communicated to the many audiences willing . . . to listen," Berube explains. Later he notes that "Nanotechnology is another in a long list of media- and government-

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sanctioned fears." The chapters are primarily oriented toward processes: "Speculation and Criticism about Nanotechnology," "Government Actors in Nanotechnology," "Government Initiatives in Nanotechnology," "Promotional Reports on Nanotechnology," "Nano-Industry and Nano-Entrepreneurs," "Nongovernmental Organizations and Nano." There *are* chapters on technical and ethical issues—"Nanohazards and Nanotoxicology," "Applications of Nanoscience," "Societal and Ethical Implications of Nanotechnology Research"—but these also tend to focus more on the processes used to explore these subjects than on the outcomes of those processes. So, the focus of the book is less on "nano" *per se*, and more on how "nano" is perceived, discussed, paid for, regulated and promoted. These issues are interesting and important ones, and reading *Nano-Hype* will give anyone who wishes to understand the societal machinery that supports scientific research a most useful education.

In defining "hyperbole," Berube quotes Boston University linguist Bruce Fraser: "Hyperbole involves the conveying of a proposition that so distorts the obvious truth that the hearer recognizes the non-literal intention on the speaker's part." Berube continues by pointing out that hyperbole can be hard to recognize, and he notes that "Misunderstanding predicated on the improper decoding of hyperbole is not all bad." Probably true, but in science, "hype" has come to mean (my definition) "uncritical claims for unrealizable potential, sometimes for reasons that are self-serving, sometimes through an excess of enthusiasm, and sometimes simply through error or misunderstanding of the science or the problem." Berube's book serves, among other valuable purposes, as a kind of Rosetta stone: Read it, and perhaps—as a scientist—you might begin to understand how someone interested in communication thinks about science. It's a useful and important thing to learn.

Nanoscience and nanotechnology are in a phase of high activity, high growth and more than a little exaggeration. Sargent gives a romantic, pointillist introduction to the subject; stand back far enough from the details of his vignettes, and an impressionist painting of current research emerges. Berube describes the paint, the paint brushes, the canvas, the frame and the easel. Both perspectives are important. Neither book really focuses on the subjects that, to me, are the most interesting, large-scale issues associated with "nano": the ability of evolutionary nanotechnology that is already rapidly developing in the electronics industry to make the storage of information effectively free, and the uses and abuses (for example, the erosion of privacy) of that capability; the opportunity for nanoengineered catalysts and materials in global-scale production of energy; the importance of nanoscale particles and colloids in areas of science ranging from modeling global climate to studies of the origin of life. But then, Sargent and Berube may be right and I may be wrong; it's too early to tell.

Much of the history of science, as recounted by scientists, is revisionist. A random walk across ideas and experiments—false starts and stops, flimsy justifications that are abandoned and replaced by better ideas, extraordinary technologies grown from ordinary science almost by accident—is usually tidied up into a well-planned straight line. These two books are both witnesses to the real, chaotic, messy process of developing new technologies. Both are well worth reading, although by different audiences and for different reasons.

George M. Whitesides, a chemist by background, is Woodford L. and Ann A. Flowers University Professor at Harvard University. "I am bipedal," he adds, "and hope, soon, to grow large diaphanous wings that are reflective to space-based radar. I tag along with a group of graduate students and postdocs who study materials science, condensed-matter physics and chemistry, and biochemistry. In my spare time, I think about subjects such as the performance of musical instruments in extreme environments (for example, under water, in ultrahigh vacuum, at cryogenic temperatures and so on)."