BOOKS

Science/Technology: An Overview For a Thoughtful Audience

To Light Such a Candle: Chapters in the History of Science and Technology

Keith J. Laidler
Oxford U. P., New York, 1998. 384 pp. $50.00 hc
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Reviewed by George Wise

Keith Laidler's *To Light Such a Candle* is a clearly written and generally accurate review of a large slice of modern science and technology. It should find an audience, but perhaps not the intended one. Laidler, a distinguished physical chemist and educator, recognizes the need for better communication between scientists and the general public. With this book, he hopes to cure what he views as public misunderstandings about science and technology and the links between them. However, the book's mixture of straightforward exposition and biographical anecdote will probably appeal more to reflective scientists than to curious nonscientists.

To Light Such a Candle narrates developments in seven major areas, ranging from photography to quantum theory and relativity, sandwiched between an opening chapter that poses questions and a final chapter that answers them. The engaging narrative is presented in plain English with very few equations and many diagrams. It covers a lot of ground and maintains the likable voice of an experienced scientist and teacher with interests ranging far beyond the laboratory. The title, for example, refers not to Faraday's famous lecture on candle chemistry or Edison's light bulb, but to the words of a 16th-century religious martyr.

The historical information is presented almost always with scrupulous accuracy. (Some exceptions: a dubious claim that recent discoveries of fractional charge may invalidate Robert A. Millikan's oil-drop experiment and the confusion of the Dunkirk evacuation with the Normandy invasion in a discussion of World War II.) The author seldom draws on recent historical findings, however, a deficiency particularly evident in his superficial treatment of solid-state electronics, and in his echoing the mythical view of biochemist and Zionist Chaim Weizmann as a "pure" scientist whose work was scoffed at by colleagues, a view that has been seriously revised by recent Weizmann biographers. The important work Weizmann did on World War I munitions production, an achievement that advanced the Zionist cause, was actually closer to that of other scientists and motivated by a more complex mixture of science, ambition, and practicality than Laidler recognizes.

For one already familiar with the book's scientific content, Laidler's approach provides a useful perspective and much new detail. Physical chemistry gets a particularly effective treatment. For a reader less familiar with the science, the even, one-darn-thing-after-another pace of the technical presentation may raise a "Why are you telling me all this?" reaction. One longs for the more focused effect achieved by other books that address the nature of research and invention but tackle less of the total picture and make more provocative assertions—for example, Robert Root-Bernstein's *Discovering* (Harvard U. P., 1991) and George Basalla's *The Evolution of Technology* (Cambridge U. P., 1989). By contrast, it is hard to imagine that Laidler ever had the slightest uncertainty about his main conclusions: "1) Pure research should be judged entirely on the basis of its quality, not in terms of possible practical applications; 2) technology and engineering must be based on pure science; the time for empirical invention is long past; and 3) decisions about science and technology must be based on a careful consideration of all the factors involved."

The first of these is wrong. Pure research should be judged not entirely on the basis of its quality but also on the basis of ethical standards, as recent controversy over research (some of high scientific quality) performed on concentration camp inmates makes clear. Research that results in harm to, or death of, human subjects must be judged totally unacceptable, regardless of the quality of the results or the "purity" of the research question. The second conclusion remains debatable; exaggerated reports of the death of empirical invention have been heard for nearly a century and hardly seem true for today's advances in computer and information technology. The third assertion is well-meaning but of little practical value. How would one possibly identify in advance all the factors, much less carefully consider them, when deciding to fund a new area of science or technology?

So this is not the book for educating the general public about what science and technology are, how they differ and where they are going. It is, instead, an admirable, often delightful aid to scientists beginning the process of putting some historical perspective on their technical knowledge.

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A Modern Course in Statistical Physics

Linda E. Reichl
Wiley, New York, 1998. 2nd edition. 822 pp. $84.95 hc
ISBN 0-471-59520-9

The depth, subtlety and power of the concepts of statistical physics make it a fascinating subject, although one that can be intimidating to students. One sign of the subject's difficulty is the popularity of this quotation—I found it posted at 27 Web sites—from David L. Goodstein's book *States of Matter*, (Dover, 1985):

> Ludwig Boltzmann, who spent much of his life studying statistical mechanics, died in 1906, by his own hand. Paul Ehrenfest, carrying on the same work, died similarly in 1933. Now it is our turn to study statistical mechanics.

Linda E. Reichl has designed the second edition of *A Modern Course in Statistical Physics* to help graduate students get a grip on this imposing subject. The feature that distinguishes this edition from the previous one, as well as from other texts on the subject, is its plenitude of problems, not only end-of-chapter homework exercises but also worked examples in the text. An instructor's solu-

tion manual is available.

The organization of the new book is similar to that of the first edition. Its first part covers thermodynamics. The second part, "Concepts from Probability Theory," discusses elementary probability distributions and limit theorems (such as the central limit theorem), master equations, Fokker–Planck equations, Markov chains, random walks (including Lévy flights) and ergodic theory. The third part covers equilibrium statistical mechanics—the microcanonical, canonical and grand canonical ensembles, critical phenomena and the equilibrium theory of classical fluids. The book's fourth and largest part is on nonequilibrium statistical mechanics, covering hydrodynamic processes near equilibrium, transport theory and nonequilibrium phase transitions. Hydrodynamic equations for normal fluids and superfluids are derived, and important theorems such as the fluctuation–dissipation theorem and the Onsager relations are discussed. The second edition covers topics not included in the first; two examples are Lévy flights and the thermodynamics underlying biological processes.

The level of the book is graduate student and up. Significant background is assumed from the beginning in quantum mechanics (including Dirac bra-ket notation), linear algebra (including eigenvector analysis of non-Hermitian matrices) and partial differential equations. Many of the exercises are rather sophisticated, consistent with the assumption that the reader will have a substantial theoretical background.

As noted in the preface, the sequence of topics is such that subsequent chapters do not necessarily require knowledge of previous chapters for comprehension. The book is, therefore less well suited for independent study—a student could be overwhelmed by the sheer volume of material covered—than as a textbook for a course, during which a professor can cover nonsequential portions of the material and stress the logical connections among topics. Each section includes references to the literature—other textbooks as well as primary references—a feature that students and researchers both will find useful.

The choice of topics reflects the author's research interests. The book is dedicated to Nobel Prize winner Ilya Prigogine, whose influence on Reichl's point of view is particularly apparent in the discussions of ergodic theory and nonequilibrium phase transitions. Despite the breadth of material covered, some important subjects are not treated, such as systems with quenched randomness (for example, random magnets and percolation) and dynamical problems such as interface motion, surface growth and diffusion-limited aggregation. Chaos theory is considered briefly in the discussion of ergodic theory, but there is no mention of universality at transitions to chaos. This omission is particularly regrettable because the close connections to critical phenomena in equilibrium phase transitions can be so illuminating. However, omissions are inevitable, given the extent of modern statistical physics.

Reichl has made a heroic effort to create a textbook that captures the scope of an exciting and important field. Her book should be valuable to students and researchers for years to come.

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Sliding Friction: Physical Principles and Applications

Bo N. J. Persson
Springer-Verlag, New York, 1998.
462 pp. $79.95 hc
ISBN 3-540-63296-4

The past decade has witnessed tremendous advances in our understanding of tribological phenomena in general and friction in particular. This growth has been driven by the new methods available to the experimenter, such as atomic force microscopy and the surface forces apparatus, and by increases in accessible computing power, which has made possible molecular dynamics calculations of tribological systems on ever larger ensembles. Simultaneously, surface analytical approaches have begun to unravel the mysteries of lubricant–surface interactions, driven in part by the need to replace environmentally incorrect additives with more benign alternatives while not sacrificing performance or increasing cost. Paralleling this scientific boom, engineering tribology has continued to prosper, with increasingly refined lubrication models and bearing designs coming on line.

The challenge of the last few years has been to blend our recently enhanced physical understanding with the body of engineering tribological knowledge gathered since the dawn of tool use and codified by the likes of Leonardo da Vinci and Guillaume Amontons. While interdisciplinary conferences and journals have propelled the blending of science and technology at the research level, there has been a need for textbooks to put the last decade's progress in tribological physics into its proper context in a way that can be digested by the entire tribology community. Bo Persson's book goes a long way toward filling this need.

Although several useful textbooks that deal with tribology from a materials science or engineering perspective have appeared in recent years (I. M. Hutchings's *Tribology—Friction and Wear of Engineering Materials*, CRC Press, 1992; J. A. Williams's *Engineering Tribology,* Oxford U. P., 1994; and G. W. Stachowiak and A. W. Batchelor's *Engineering Tribology*, Elsevier, 1993), *Sliding Friction* treats the topic comprehensively from the standpoint of physics. In this sense, it can be thought of as an update of Frank P. Bowden and David Tabor's classic, *The Friction and Lubrication of Solids* (Clarendon, 1985).

Sliding Friction is both readable and comprehensive, and it will serve excellently as a treatise on the subject for advanced undergraduates, graduate students and others carrying out research in tribology. Not only does it cover such fundamentals as real contact, hydrodynamic, elastohydrodynamic and boundary lubrication from an interesting and partially historical standpoint, but it also presents the very latest developments in the field, such as the results of quartz-crystal microbalance and surface forces apparatus measurements on the fundamentals of friction and the author's own theoretical work on time-dependent plastic deformations.

Particularly apparent in this book is Persson's ability to illustrate and discuss phenomena that have been known for many years in light of results obtained by the newer experimental and computational techniques. One example is his coverage of boundary lubrication, where results from both molecular dynamics and the surface forces apparatus are pressed into pedagogical service to illuminate such issues as static/dynamic friction coefficients and stick–slip phenomena. Another example is Persson's illustration of shear thinning (particularly important in animal joint lubrication) by means of projected molecular orientational distributions.

The book closes with a chapter on novel sliding systems, many of which (earthquakes, biotribology and sliding on ice and snow) I found useful and interesting, although some (sliding of flux-line systems and charge-density waves) I found to stretch even the most permissive interpretation of tribology a little far.

Persson is renowned for his contributions to the tribology physics literature. He has now produced a reference