tion in quantum electrodynamics.

The book is aimed at the early graduate level and could be used in the classroom or in a reading course to introduce the student both to the general structure of non-Abelian gauge theories and to the perturbative techniques of QCD. The breadth of the successful applications of these perturbative QCD techniques in current research in both particle and nuclear physics is quite striking. On the negative side, the serious instructor and student are apt to be disappointed by the small number of exercises supplied in the book. The instructor will probably also want to expand on the reference list, which I found incomplete in places. I would also have been happy to see more discussion of factorization, of the various "all-orders" techniques for dealing with mass singularities and of comparisons with data. Still, I must admit that Muta has made a laudable effort to keep the book's length under control while offering a fairly complete discussion. I would mention two other minor problems: The first is Muta's choice of definition for the Feynman rules, which differs by factors of *i* from more common choices. While Muta does supply a plausible explanation for his choice, the reader will have to do some translating to compare Muta's treatment with other discussions of QCD and will probably have to forsake tricks learned elsewhere for checking intermediate steps by counting factors of *i*. The second problem is that Muta refers recurrently to the rapid convergence of the perturbative expansions without pointing out that these series are generally only asymptotic expansions.

Overall I consider this book a very useful compromise among phenomenological and theoretical breadth, rigor and finite length. I recommend it to physicists, both particle and nuclear, who work with strong interactions, and to students entering the field. With a little added effort to put together more problems and outside readings, an instructor could easily make Muta's book the basis of a graduate course.

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The Lightning Discharge

Martin A. Uman
Academic, San Diego, Calif., 1987. 377 pp. $49.00 hc
ISBN 0-12-708350-2

A bolt of lightning commands instant attention. Lightning starts fires, strikes aircraft and manned rockets, shuts down computers and knocks out television reception. Lightning and thunder have provoked awe, myths and finally science.

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steps; subsequent ("dart") leaders propagate smoothly down the channel left by the previous return stroke. Large currents sometimes continue even after a return stroke has ended, and the charge distribution in a cloud changes fitfully between strokes. Later chapters discuss the variations on this pattern that occur for upward lightning initiated from mountaintops and tall structures, lightning deliberately initiated by means of rockets trailing conducting wires, and cloud–cloud discharges.

Several topics were treated more fully in the earlier book—spectroscopy, instrumentation and ball lightning. Spectroscopy has provided unique knowledge of temperatures and of the time-dependent populations of excitation states in the return stroke. Uman contributed notably to the analysis, so the overly brief treatment of spectroscopy here is surprising.

Several other topics in atmospheric electricity are slighted; they do not pertain directly to the lightning discharge but are nonetheless essential for understanding the context in which the lightning discharge takes place. Thunderstorm meteorology is not discussed except incidentally. The fair-weather electric field and current are discussed too briefly. Charge separation is neglected; it has long been one of the most important and controversial topics in atmospheric electricity. Whistler emissions from lightning are mentioned only in connection with planetary lightning, and propagation effects on the power spectra of other radio emissions are discussed sketchily.

Uman's book must therefore be supplemented by others. The National Academy of Sciences has recently published a readable overview of atmospheric electricity, *The Earth's Electrical Environment* (Natl. Acad. P., Washington, D.C., 1986). Hans Volland's *Atmospheric Electrodynamics* (Springer-Verlag, New York, 1984), provides a good survey for physicists of the global electric circuit and its connections to geomagnetism, together with the relevant plasma physics. These books and Richard Feynman's chapter on lightning in the *The Feynman Lectures on Physics* will convince you that you live on the cathode of a giant, leaky spherical capacitor whose anode is the ionosphere and the conducting layers just beneath it. Lightning seems to help keep this capacitor charged, compensating for leakage by the fair-weather current.

Despite its omissions, Uman's book is extremely useful. It can be understood by anyone trained in the physical sciences. I heartily recommend *The Lightning Discharge* to anyone who is curious about lightning.

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Encyclopedia of Medical Devices and Instrumentation, Volumes 1–4

Edited by John G. Webster
Wiley, New York, 1988.
3022 pp. $450.00 hc
ISBN 0-471-82936-6

The technology of medicine has expanded incredibly in the last two decades as advances in physics and engineering have led to new devices and procedures that can replace or complement traditional approaches to patient care. These innovations are yielding more accurate diagnostic data and more predictable therapeutic results thereby reducing morbidity and mortality from disease and injury. They are also raising several challenges: What level of technological sophistication in medicine can we afford—and for what are we willing to pay? How can those of us involved in health care best evaluate a new technology for safety, medical usefulness and cost-effectiveness before it becomes widely adopted in clinical medicine? How can we keep up with all the technological innovations in medicine? And how can we be sure that abnormal data from a diagnostic test or suboptimal results from a therapeutic procedure reflect a problem with the patient, and not with the technology?

The number of physicists and engineers working in medicine has grown slowly over the past century. Recently the need for such people has increased substantially as computers and sophisticated technologies have become widespread in clinical medicine. However, this need has not yet been translated into positions and salaries; consequently medical technologies are used today in many clinical settings without appropriate physics, computer science or engineering support. "User friendly" medical technologies facilitate applications to patient care; they do not, however, ensure that the applications are proper or that the results are optimal, or even correct.

Recognition of these challenges is not universal, even among those of us who are physicists and engineers working in medicine. Usually our attention is focused on a rather narrow area such as diagnostic imaging, respiratory therapy, radiation oncology or cardiovascular dynamics. With such a narrow focus it is difficult to gain a perspective on how pervasive the presence of technology is in medicine. The four-volume *Encyclopedia of Medical Devices and Instrumentation* helps provide that perspective.

The editor of this encyclopedia assumed the not inconsiderable task of assembling the "core knowledge from all the fields encompassed by the application of engineering, physics and computers to problems in medicine." The result is a series of more than 250 articles describing medical devices and instrumentation. The articles are arranged alphabetically by topic, with cross-references and an extensive index. Abbreviations and units are defined in tables right at the outset of the encyclopedia, and SI units are employed throughout. As an example of topics covered, listings under "C" include capacitive sensors, carbon dioxide analyzers, carbon dioxide electrodes, cardiac accelerometers, cardiac output measurements, cardiopulmonary resuscitation, cartilage and menisci, cell counters, cell cultures, ceramics, chemotherapy, chromatography, cine and photospot cameras, clinical chemistry, cobalt-60 units, cochlear prostheses, codes and regulations, colorimetry, colostomy, coloscopy, communicative disorders, composite resins, computed tomography (including single-photon emission CT), computers, contact lenses, contraceptive devices, coronary angioplasty, cryosurgery, cutaneous blood flow, cystic fibrosis and cytology.

As might be expected, the articles vary somewhat in length, style, format and comprehensiveness. Each is written by a recognized expert and presented at a level intelligible to readers with a scientific background, even if they are not intimately familiar with medicine. As the editor notes, the intent is to provide answers to the question, What are the branches of medicine and how does technology assist them? rather than, What are the branches of technology and how could each be used in medicine? The result is a compilation of articles that are both enjoyable and informative to read, whether as references or simply while browsing.

I hope physicists and engineers both inside and outside medicine will read in these books; it probably is too much to expect many to read all of the more than 3000 pages. A lot has been happening in the technology of medicine in the past few years, and there is plenty of room for additional clever ideas. If more physicists and engineers are willing to take the time to