the brief chapter 11 describing Chandra's later years is not felt as an anticlimax, because the conversations in chapter 12 bring us back to Chandra in the full vigor of his personal style.

I mention three episodes in the book that I found particularly moving: first, the story of Subbalakshmi—the aunt of Chandra's wife, Lalitha—who rose from the tragedy of child-widowhood to become a leader of women's liberation in India and played a major role in Lalitha's life; second, the extraordinary friendship between Chandra and Sir Arthur Eddington, which flowered after Eddington had almost succeeded in wrecking Chandra's career with vicious and intemperate attacks on his work; and third, the love and understanding that Chandra and Lalitha developed for America after they decided to settle in the remote little community at Williams Bay, Wisconsin. In each of the three cultures in which he lived, Chandra formed deep attachments and met bitter opposition. His way was never smooth. In the end he has made his permanent home and found his peace in, of all places, Chicago. This biography explains why.

I remember vividly the first time I met Chandra. He came to Ann Arbor in the summer of 1950 and gave a talk about the polarization of the scattered light in the daytime sky. This was for him a five-finger exercise, an exact analytic solution of a physics problem of no particular importance. But he held the audience spellbound with the elegance of his mathematics, the clarity of his language and the joy he made us feel when at the end the observed polarizations agreed precisely with his predictions. Chandra's joy in the beauty of science also shines through the pages of Wali's book. This joy is the central core of Chandra's life, and Wali has made it accessible to all who can read.

The Physics of Vibration

A. B. Pippard
Cambridge U. P., New York, 1989. Omnibus edition. 639 pp. $65.00 hc
ISBN 0-521-37200-3

In *The Physics of Vibration* (omnibus edition), A. B. Pippard brings together his thorough classical and quantum treatments—previously published separately—of "almost anything that fluctuates in time more or less periodically." This field takes in topics that range from mechanical oscillators to electrical circuits to electromagnetic waves in cavities to nmr to masers.

It is the author's stated intention to make this book valuable to readers who range in sophistication from a student who has completed the elementary sequence in physics to a researcher in a relevant field. To this end the depth of the treatment and the amount of physics background assumed varies widely from topic to topic. However, a consistent level of mathematical sophistication is maintained throughout, and any student with a respectable grasp of calculus and differential equations will be able to work through all the arguments (and will learn some valuable techniques along the way). Extensive use of graphical techniques helps to give insight into the differential equations. This approach is particularly valuable in the treatment of stability, which is extensive enough to please any physicist (though perhaps not an applied mathematician). The text is lucid throughout and has an engaging style that avoids both the grating "folksiness" of many elementary textbooks and the excessively dull, formal tone of most monographs.

It is the author's thesis that many intrinsically quantum problems can be addressed with a classical treatment that gives an equivalent result as well as more physical insight. This leads him to include in part 2 of this book extensive discussions of the classical features of the quantum vibrator, applications of the impulse–response approach to quantum systems and the ammonia maser as both a classical and a quantum system. He does not, however, neglect to point out the circumstances under which this approach will fail. Other authors will upon occasion make reference to classical approaches when presenting quantum analyses, but few develop the point to the degree found in this volume. This complements part 1 of the book, in which Pippard demonstrates with numerous examples the unity of a wide variety of mechanical and electrical phenomena when considered as classical vibrators—another point often mentioned but rarely developed fully by other authors. Careful attention to consistent notation and vocabulary makes the unity more apparent than would be expected in a comparison of separate treatments.

Different parts of this book will prove valuable to different readers. The simpler treatments, particularly those in part 1, would enlighten an upper-level undergraduate in physics or engineering through either self-study or inclusion as examples in classroom lectures. In many cases the author describes simple experiments that he has performed to better understand the phenomena. These could prove useful as lecture demonstrations, but they have the advantage of also being amenable to truly quantitative analysis in an instructional laboratory setting. Some of the examples, though they effectively demonstrate the physical principle in question, may seem somewhat quaint to a student (or even a younger professional): Moving-coil galvanometers and thyratrons are now found primarily in (slightly dusty) lecture demonstrations rather than in research laboratories.

Other portions of the book may serve the researcher seeking to learn about a new field in preparation for study of the literature. This is particularly true of the section on nmr and the chapters on two-level systems and line broadening. Extensive cross-references to other relevant portions of the text appear in the margins making it easier to use for this purpose. The bibliography is not large and concentrates primarily on more extensive pedagogical treatments of the topics, with a sprinkling of references to the research literature for examples. These references mostly appeared before 1977 (parts 1 and 2 of this edition having been originally published in 1979 and 1983) and include a modestly small but select group of references to the author's own well-known work in electronic states in solids.

In sum, this is a well-written book that would prove of use to an instructor of intermediate and advanced physics or engineering, as well as to a researcher seeking basic physical insights about an oscillatory system before turning to the primary literature.

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Quark–Gluon Plasma

Edited by Rudolph C. Hwa
World Scientific, Teaneck, N. J., 1990. 712 pp. hc
ISBN 9971-50-900-8

An exciting prospect in subatomic physics is the possibility of producing a new state of matter at extremely high temperature and density. This new state, the quark–gluon plasma, would be created in collisions of extremely energetic nuclei. The conditions of high density and temperature would allow the ordinary particles of subatomic physics to dissolve into

their quark and gluon constituents.

Experiments have been underway at CERN to produce and detect the plasma, and the search is the focus of a new accelerator project at Brookhaven National Laboratory. These experimental activities are prompted by theoretical predictions of the new phase, suggested since the 1970s by the modern quantum chromodynamics theory of strong interactions. In recent years theoretical activity has burgeoned, with speculations on the properties of the plasma, numerical calculations of QCD and many models of the nuclear collisions that may produce the plasma.

The book reviewed here is a collection of 14 theoretical articles ranging over topics related to the quest for the quark–gluon plasma. A major theme of the book is the behavior of nuclear collisions at high energy, and the chapters on this subject provide an excellent introduction and survey. In a chapter on hydrodynamic modeling, Jean-Paul Blaizot and Jean-Yves Ollitrault introduce the basic equations and develop some important tools for analytic studies, including shock relationships and scaling solutions. They cover the useful idealized models of Lev Landau and of J. D. Bjorken. Of course, hydrodynamics is only valid when the system is in local thermal equilibrium. To describe the initial stages of the collision, the equations must come out of the fundamental QCD theory. The search for useful transport equations from QCD is a theme of several other chapters. Unfortunately, little progress has been made to date, and even such simple processes as the damping of collective plasma waves are not well understood.

More phenomenological approaches to the pre-equilibrium physics, on the other hand, have been very helpful; these are reviewed in the chapter by Miklos Gyulassy. Computer codes based on string and quark parton pictures describe collisions between individual hadrons very well. Gyulassy discusses the essential ingredients in these models and their implications for the more complex nucleus–nucleus collisions.

A major problem in the quest for the quark–gluon plasma is finding a measurable signature for the new phase; it is too short-lived for experimenters to see anything but the decay products. The duration and overall size of the interaction region are important quantities, measurable by pion interferometry. If there were a substantial phase transition, the decay of the hot matter would be delayed. The pion interferometry and

the time required to form the hot matter are discussed in Gyulassy's chapter. Another important observable is the production rate of flavored particles. In fact, the measured rate of J/Ψ production at CERN was interpreted as "smoking gun" evidence for the phase transition. The case no longer seems so clear cut; details are given in the chapters by Helmut Satz and Blaizot. Fluctuations in the distribution of the final products might also give significant information about the plasma phase, as discussed in Rudolph Hwa's chapter.

On a more fundamental level, the implications of QCD for hot matter are discussed in chapters by Fritjof Karsch and by Janos Polonyi. Karsch's chapter provides an excellent introduction to QCD thermodynamics and its modeling on a lattice. He includes the analytic results valid at high temperature and compares them to the numerical findings from lattice studies. However, the central question—the nature of the phase transition—has not yet been answered, and the exposition here is more like a progress report. The relevant lattice calculations are very difficult, since the result depends on the number of colors, the number of quarks and their masses. It is not yet known whether the phase transition is first or second order or if indeed there is a sharp transition at all. A more analytic approach to the phase transition question is taken by Polonyi in his chapter. Unfortunately, important concepts such as the Polyakov loop and the $z - 3$ symmetry are better expounded in the original literature.

An additional topic I would like to have seen discussed is the role of the QCD phase transition in the evolution of the early universe. Aside from this omission, the volume is quite comprehensive.

As might be expected from a book with 20 authors, the level of presentation and quality of the chapters is uneven. Nevertheless, the book should be very useful both as an expository treatise and as a handy reference to the important primary literature.

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Biological Radiation Effects

Jürgen Kiefer
Springer-Verlag, New York, 1990. 444 pp. $69.50 pb
ISBN 0-387-51089

Jürgen Kiefer's book *Biological Radiation Effects* is yet another addition to a numerous collection of books on radiation biology already available. Perhaps one of the distinguishing features of this work is not the content of the book itself, but rather the fact that the author is a physicist by training and not a biologist or radiation biologist. That fact is readily apparent in the first several chapters of the book, which are devoted to the fundamentals of the radiological sciences.

The requisite and customary review of radiologic physics included within the book contains far more formulas than are normally contained in similar works and clearly bears the mark of a physicist rather than a biologist. Unfortunately, the inclusion of derivations and formulas, as in the somewhat tedious description of the relativistic collision of two point masses, appears to provide no *additional* insight into the nature of the response of a biological system to radiation, the stated intent of the book. My suspicion is that the biologist would quickly skim over the first several chapters because he or she would find them unintelligible, while the physicist would omit reading them because he or she would be familiar with the material.

The book improves when it begins to discuss photochemistry and radiation chemistry. A more logical approach to the presentation of these subjects, however, might be to separate the discussion of photochemistry from ionizing-radiation chemistry. The organization selected by the author is cumbersome and detracts from the coherent presentation of these important topics. In fact, as a general observation, one senses a lack of continuity between chapters throughout the book. The number of chapters might easily be reduced by presenting the subject material in a progressive and logical sequence. For example, both the discussion of repair inhibitors presented in chapter 14 and the material contained in chapter 13 ("Repair and Recovery") could easily be combined and presented before discussing radioprotectors and radiosensitizers (chapter 9).

Perhaps another disappointment with the book is the five-page chapter on cell survival in relation to whole-body effects. The title of this chapter describes a significant topic about which much could have been discussed. Very little was covered, and much of the material that was presented was peripheral to the stated chapter subject.

The practicing health physicist would be dismayed by the chapter titled "Principles of Radiation Protection Regulations." This chapter is superficial, containing less-than-adequate definitions of important health physics terms. Of greater significance is the failure to discuss in detail the scientific basis of regulatory protective guides in a clear and understandable fashion.

Many of the references cited are somewhat dated. Although reference to classic papers is obviously important in a basic text on radiation biology, the inclusion of a greater number of more current references would be welcomed.

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Origins: The Lives and Worlds of Modern Cosmologists

Alan Lightman and Roberta Brawer
Harvard U. P., Cambridge, Mass., 1990. 561 pp. $29.95
hc ISBN 0-674-64470-0

Astronomers today generally agree that cosmology has undergone major changes in outlook and technique in the last decade or two. One movement has come largely from within the discipline, in the form of new powerful mapping programs that are today testing the assumptions of cosmological homogeneity, and the other has come from outside the discipline, chiefly from particle physics, whose practitioners have been flowing into astronomy to explore the first femtomoment of physical existence.

Many within the disciplines responsible for these changes have attempted to convey the excitement of contemporary cosmology through popular writing, editing, lecturing and documentary filming. In the book reviewed here a science writer–astronomer, Alan Lightman, has teamed with a graduate student of cosmology and of the history of science, Roberta Brawer, to present a series of interviews with cosmologists that address a set of specific questions they hope will illuminate current attitudes held about the universe and the state of its study on Earth.

These questions are set out in an introduction that reviews issues such as the flatness problem (that the universe seems to be very close to being either open or closed), the horizon problem (that the universe until recently has appeared to possess large-scale homogeneity), and how various models, such as the inflationary universe, or the anthropic uni-