ently illustrated by *Life beyond Earth*, the culmination of a collaboration between a Columbia physicist, Gerald Feinberg, and a NYU biochemist, Robert Shapiro. Possessed of unusual skills for serious popularization, lively imaginations, and a passion for proposing exotic forms of life, Feinberg and Shapiro have produced a volume that, one suspects, will be read and relished, but not believed, at least by many experts. Their cosmic elevator COSMEL that transports readers from 10^{-15} to 10^{25} times normal size is but one of their ingenious techniques for bringing greater clarity to a topic already rich with interest.

Among the hundreds of books that have proposed extraterrestrial life, that by Feinberg and Shapiro adopts one of the most extreme positions. In fact, their introductory promise to present a "fertile Universe [wherein life] exists not only on the solid surfaces of planets but also in dense planetary atmospheres, in rarified interstellar clouds, and even inside some stars" is more than made good. In their summarizing "tourist guide" table, which rates the possibilities for life elsewhere in the solar system, Jupiter and the surface of Titan (along with the Earth!) receive four stars, whereas three stars ("still a good bet") go to Saturn and to the interiors of Ganymede, Callisto and Titan. Venus gets two stars—"some possibilities exist"—as does Mars, concerning which the authors provide a detailed analysis of the results of the Viking life-detection package, which they sum up by stating: "In many respects [it] is a good illustration of how not to search for extraterrestrial life."

Concerning life beyond the solar system, four-star ratings go to the "high interiors of ordinary stars" ("plasma life") and the "interiors of white-dwarf stars." To interstellar gas clouds, they assign "radiant life" and three stars, two stars going to neutron star surfaces ("magnetic-atom polymer life") and to very cold planet surfaces ("solid-hydrogen life"). Perhaps the most extraordinary speculation in a book that abounds in suggestions that many scientists will find fantastic occurs when, after describing the strange forms of many galaxies, they write: "These descriptions may make a galaxy sound disturbingly like some of the [lowest] living forms . . . and indeed the structural parallels are eerie. Very probably these resemblances are coincidental, but—?"

Their book would be a gold mine for science fiction writers, except for the fact that they are chiefly concerned, not with the possiblities of *intelligent* life capable of communicating with us, but with life in general, defined in the broadest terms. To give them their due, however, they write with a full knowledge of the claims of those scientists who have adopted much more restrictive views, and they provide readers with comments that enable them to assess the radicalness of their proposals.

Fifteen technical papers presented at the 1979 Montreal meeting of the International Astronomical Union have been collected by Michael D. Papagiannis, a Boston University astronomer, to form a volume entitled *Strategies for the Search for Life in the Universe*. A simple listing of the titles and authors of three of these papers shows how far the astronomical community remains from a consensus concerning the number (N) of technologically advanced civilizations in our galaxy:

Michael Hart: "N Is Very Small"

Frank Drake: "N Is neither Very Small nor Very Large"

Michael Papagiannis: "The Number N . . . Must Be either Very Large or Very Small"

A reading of these papers reveals that the range of N assigned by different authors runs from 10^{0} to 10^{11}, an incredible variation. Some of the promising new techniques for restricting this range are discussed in other papers in this volume. These include new methods of determining whether nearby stars possess planetary systems and also new ways to search for interstellar ships or signals.

The debate over the existence of extraterrestrials is extraordinarily exciting, but its resolution remains elusive. It is difficult to conceive of an instance in the history of science in which many scientists, possessing essentially the same background information and searching for a single number, have differed in their estimates by a factor as great as 10^{11}. One cannot but suspect that nonscientific influences—as lofty as metaphysical considerations, as mundane as funding possiblities—are playing a major if obscure role. In this situation one is impressed by the readiness of the IAU to include papers differing so fundamentally in their approaches and conclusions.

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Theory of the Nuclear Shell Model

R. D. Lawson
546 pp. Oxford U. P., New York, 1981.
$129.00

The nucleus has been a subject of intense study for over 30 years. The number of recent conferences on nuclear physics suggests that the field continues to maintain much excitement. Since the 1950s, physicists have used two broadly applicable models to describe the nucleus: the shell model and the collective model. The manifestations of the former, focusing on the motion of individual particles in the nucleus, are most apparent in the neighborhood of the magic numbers—or closed nucleon shells. The latter applies in the region in between, in particular, when there are large nuclear deformations and where a single-particle description is inadequate. This model was conceived by Aage Bohr and Ben Mottelson, who devoted the first of their two-volume book, *Nuclear Structure*, to single-particle motion and the second to nuclear deformations. The shell model was proposed by Maria Goeppert Mayer and by J. Hans Daniel Jensen, Otto Haxel and Hans Edward Suess. Mayer and Jensen, in their 1955 book *Elementary Theory of Nuclear Shell Structure*, gave the experimental evidence for the shell model and some of the basic theory. In 1963, Amos de-Shalit and Igal Talmi presented the development of the new spectroscopic techniques required to analyze the nucleus in the light of the shell model. Much of the formalism in their book *Nuclear Shell Theory* is based on the tensor algebra of Giulio Racah. Though Racah's methods were meant for atomic spectroscopy, they were neglected by his contemporaries in atomic physics, brought up on their bible, *The Theory of Atomic Spectra* of E. U. Condon and G. H. Shortley. It was the new generation of nuclear physicists who recognized the power and potential of Racah's work.

Robert D. Lawson has contributed to furthering our understanding of nuclear spectroscopy for nearly three decades. His *Theory of the Nuclear Shell Model* is a welcome addition to the earlier books on the subject. Although Lawson writes at the outset that his book is written at a level intermediate between the texts of Mayer and Jensen and of de-Shalit and Talmi, "an intermediate mix between theory and experiments" would have been a more appropriate description. In fact, the level is not more elementary than that of de- Shalit and Talmi. As I mentioned, Jensen is largely phenomenological, while de-Shalit and Talmi develop the shell theory with only a handful of physical examples. The new book, on the other hand, intersperses applications to examples of nuclear data among the developed formalism, in line with Lawson's intention to have it serve as a "how-to" text. It is a matter of taste whether this is an appealing format for study or whether the division of individual chapters into text, illustration and appendix, as done by Bohr and Mottelson, makes for easier reading. I am perhaps a particular guinea pig because I read the book as an experimentalist very much interested, but not strictly expert, in nuclear physics. I thus found this book more difficult than de-Shalit and Talmi, where the formalism is developed unashamedly step by step, which makes reading and self-study easier.

Lawson has seven appendices—which constitute about one sixth of the book—devoted to formal background: Five of these cover spectroscopy (generally according to Racah) and angular momentum theory, as succinctly as, for example, A. R. Edmonds does in *Angular Momentum in Quantum Mechanics.* The other two are "Quasi-Spin and Number Dependence of Matrix Elements" and "Relative Center-of-Mass Transformation Coefficients." The text makes frequent reference to these appendices.

The seven chapters—"Single Closed-Shell Nuclei," "Neutron–Proton Problems," "Particles and Holes," "Harmonic Oscillator Wave Functions," "Electromagnetic Properties," "Quasi-Particles" and "Poor Man's Hartree-Fock"—are illustrated with well-chosen experimental examples. There are nice brief treatments of second quantization, which is used extensively, and of seniority. Lawson points out that even with the sophisticated theoretical apparatus developed, the shell model calculations still give nuclear energies good only to a few hundred keV. There are several spectacular exceptions to this, such as in the well-known case of $^{38}_{17}Cl_{21}$ and $^{40}_{19}K_{21}$, ^{208}Pb, where the agreements are within a few or some tens of keV. Lawson demonstrates the use of angular momentum analysis of reactions involving single nucleon transfer to serve as an l meter and as a tool for determining occupied levels. He does the same for spectroscopic factors. He stresses the importance of studying other than energies, for example, multipole moments and transition probabilities, to determine the purity of nucleon configurations. That he doesn't derive the multipole expansion of the electromagnetic interaction suggests again a reader would benefit from prior study of de-Shalit and Talmi or *Theoretical Nuclear Physics* by J. M. Blatt and V. F. Weisskopf.

As might be expected in a book of this size, a few misprints appear—some trivial and obvious (for example, the missing equal sign on page 87 and the misspelling Gordon), others requiring some more attention (as in the diagram of Eq. 1.85. The problem of correct phases is a plague on angular momentum calculations!).

I may well be asked would you pay this price (among the highest I have seen so far) to buy it? Lawson's book contains a wealth of material of bread-and-butter value to the practitioner of nuclear physics. Students would be well-advised to use it after they have studied some of the other books.

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The hospitality of the Alexander von Humboldt Foundation and H. Walter, in Garching, Germany, during the writing of this review are acknowledged.

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Rheometry, Industrial Applications

K. Walters, ed.
418 pp. Wiley, New York, 1980. $75.00

This first volume of the new series "Material Science Research Studies" discusses the uses of rheometry as an industrial tool. Restricting itself to fluid materials, many with yield values, the book is mainly directed to the materials-oriented section of the rheological community, but also provides information useful in the industrial testing laboratory and to the production manager.

There are chapters on fundamental concepts, detergents, lubricants, foods, molten polymers, paints and printing inks, industrial aqueous suspensions (including clays, paper, pharmaceuticals). An extensive source of information for anyone engaged in the design, operation and quality control of industrial processes, this volume also elucidates the intricate relation between measured rheological properties and the real flow that occurs during production and performance.

Shortcomings are unavoidable when seven authors write on seven huge and divergent subjects. Not only do style and level of sophistication differ widely from chapter to chapter, not only is there avoidable overlap, but also there are inconsistencies and even contradictions. True capillary viscosimeters, dies, melt flow indexers, consistency cups—even when entrance and exit conditions and length/diameter ratios are introduced—are treated as "capillary" instruments without regard to which steady-state conditions exist. Thixotropy, shear thinning or thickening, storage hardening, Bingham and other plasticities, viscoelasticity and elasticoviscosity are defined or described in ways that conflict with each other and with standard texts. Efforts to define industrial designations such as structure, hardness, toughness or stringiness, in physical terms are at best tentative, as evident by their absence in the index. No glossaries of terms or of symbols exist.

Some of the authors point out that data that can be reproduced and interpreted can only be gathered under viscosimetric flow conditions, which obtain in well-designed test instruments