Molecular Spectroscopy

The Structure of Molecules. Gordon M. Barrow. Benjamin, New York, 1963. xii + 156 pp. Illus. Paper, $1.95; cloth, $3.95.

This introduction to the concepts of molecular structure which are derived from spectroscopy was written for readers who have had at least one year of college chemistry. Students who have progressed to the study of physical chemistry are prepared for a more quantitative presentation. This paperback is one of a series of approximately 15 monographs proposed by the publisher; each volume will deal broadly with one subdivision of general chemistry and will constitute a complete unit within the limitations of the preparation of the students for which it was intended. In theory the textbook used for the course would thus be liberated from having to present a fragmentary treatment of many exciting topics. The editor hopes that "teachers of elementary science will find these volumes invaluable aids to bringing them up to date in the various branches of chemistry."

In this volume the selection of chapter headings is the conventional one, based on the sequence of characteristic energy gaps between levels for rotation, vibration, and electronic excitation. The author should be complimented for concentrating on essential principles and for not attempting to introduce too much material. He did include a few selected topics in electronic spectroscopy, specifically those dealing with simple gas molecules and with metal ions in crystals. The problems and exercises are at the second year level; they are not particularly imaginative, but they will give students a feeling for orders of magnitude. To this end the author has also prepared a number of tables. Most of the illustrations are standard; a few are misleading, and the artist was not sufficiently ingenious in his attempt to give a correct impression of a molecule vibrating in a normal mode. The text was written with evident enthusiasm for the subject, but it appears that this enthusiasm has led to a major difficulty, in my opinion.

The proliferation of misconceptions is a teacher's worst sin. Because there are too many careless statements that can be easily misinterpreted, particularly by students who do not know the implied meanings of the terms used, because there are misleading diagrams and serious errors, I cannot recommend this book to anyone. In his attempt to impress the reader with the fact that "molecules are real, intricate, structural arrangement of atoms in space," the author was needlessly imprecise. It is incorrect to imply that the *models* for molecules, which he describes, are more than just models. His treatment of the term *bond length* is one example: compare the statements on pages 1, 45, and 104. The discussion of Planck's relation (pages 8 and 9) is historically and conceptually in error. The so-called Boltzmann distribution (page 25) is not quite right; and there are many other inaccuracies.

It is regrettable that a serious and worthwhile attempt to present the exciting facts and theories of molecular spectroscopy to undergraduates has come to nought, possibly due to hurried writing and failure to appreciate the difficulties that a beginner may have with the accepted jargon.

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Statistics

Statistical Treatment of Experimental Data. Hugh D. Young. McGraw-Hill, New York, 1962. x + 172 pp. Illus. Paper, $2.95.

Starting from the premise that "every scientist and engineer needs some elementary knowledge of statistical methods for treating experimental errors and analyzing experimental observations," and a "firm belief that some of these techniques should be introduced early in the undergraduate curriculum in science and engineering, so that they may be used in later courses which incorporate laboratory work," the author has written this little book "in an attempt to present these techniques in a form which is understandable, palatable, and even enjoyable for sophomore science or engineering students with little mathematical sophistication and no previous exposure to the subject." The author's premise is unquestionable. I endorse his "firm belief" and commend his objectives. His prose is very readable. His selection of problems for class and homework exercise is good. But I cannot recommend this book to undergraduates in the physical sciences, nor to anyone else, because much of what the author says by way of explanation is confused, inaccurate, misleading, or completely erroneous. This is merely one more of those little books (or chapters) on probability and statistical methods written for physicists, by physicists, with a shocking and inexcusable disregard for the many notable advances which have been made in the mathematical theory of probability and the theory of statistical inference during the past half century and which have led not only to fundamental changes in, but also to considerable clarification of, statistical theory and practice.

Many of the faults and deficiencies of this book stem from one major defect: the author fails to make conceptual and notational distinctions between a *random variable*, X, and a specific number, x, say, that is the realized value of X in some particular instance; and he similarly fails to distinguish between *parameters* of the probability distributions of random variables, *estimators* of these parameters (that is, functions of the random variables used to obtain estimates of parameters from observed values of the random variables), and the *estimates* yielded by these estimators in particular instances.

Any discussion of the statistical interpretation of experimental data that does not carefully and consistently make and preserve such distinctions cannot avoid becoming hopelessly confused. For example, the author uses "σ" not only to denote the standard deviation σ of the probability distribution of X's, but also to denote the sample function

$$S = \sqrt{\sum_{i=1}^{n} (X_i - \bar{X})^2/n}$$

and the value of S in some particular instance,

$$s = \sqrt{\sum_{i=1}^{n} (x_i - \bar{x})^2/n},$$

with the result that the reader may gain the impression that the standard deviation of the sampling distribution of the sample function $\bar{X}$ (or, worse, of $\bar{x}$) is

$$s/\sqrt{n},$$

whereas it is

$$\sigma/\sqrt{n}.$$

Not only are σ, S, and s very different conceptually, but s may differ considerably from σ numerically. ($\bar{x}$, of

course, has no standard deviation because it is a fixed number.)

Such confusion of distinctly different concepts makes impossible clear and accurate exposition of the sampling distribution of X—and a fortiori, of the law of large numbers, of the central limit theorem, and of confidence intervals for the parameter μ. Failure to make and preserve important conceptual and notational distinctions gets the author into many such difficulties.

In addition, the author makes misleading statements of fact. For example, he implies (at the top of page 96) that the validity of the formula

$$\sigma/\sqrt{n}$$

(for the standard deviation of the distribution of $\overline{X}$) is sensitive to the form of the "parent" distribution of the X's, but "is true for the Gauss distribution, as may be proved from a theorem known as the *central limit theorem*." This is putting the cart before the horse! The central limit theorem (and the law of large numbers) are consequences of this formula, not vice versa! Furthermore, the formula is valid whenever the X's are independent and have a common finite standard deviation. Independence of the X's is an essential requirement. The author makes no mention of the critical role of independence, here or elsewhere in the book.

An individual who seeks "some elementary knowledge of statistical methods for treating experimental errors and analyzing experimental observations" will be much better advised if he consults the lucid, up-to-date treatment of these matters in chapters 7, 8, and 9 of E. Bright Wilson, Jr.'s, *An Introduction to Scientific Research*, which is also available in the same McGraw-Hill paperback series.

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Science and the Humanities

The Role of Science in Civilization. Robert Bruce Lindsay. Harper and Row, New York, 1963. x + 318 pp. Illus. $6.50; text ed., $5.50.

This book is an attempt to clarify the nature of science and its relations to other ways of describing and understanding human experience. It makes some unusual and compelling observations in a style whose clarity and balance make it immensely readable and stimulating.

Lindsay, a physicist and the dean of the Graduate School at Brown University, stresses the role of creativity in what he terms the "essentially arbitrary character of scientific theorizing." What is usually considered "the discovery" of truth is here interpreted as the "invention" of some brilliant and imaginative scientist. The scientist indulges in preferences and prejudices not merely in his nonprofessional life, but in the very act of creating new knowledge.

A successful theory represents a selection of materials available in the prevailing culture, and the evolution of scientific theory follows cultural laws as well as necessities implicit in nature. The predictive power and economy of a "scientific truth" is, in Lindsay's view, not the only basis upon which the theory becomes established. More important is the role of the creative scientist, a role not at all alien to the process that gives rise to literature, philosophy, and art. Lack of understanding of this leads to dogmatism, to unwarranted assignment of larger meanings to formal hypotheses, and to "scientism," a pseudoreligious faith which often obstructs scientific progress.

From this point of view, the author undertakes to relate the essential facts of science and technology to all of the various artifacts of civilization, including mathematics, logic, the humanistic disciplines, communication, and ethics. He dwells on similarities as well as differences and finds an essential kinship, despite the historical alienation between Science and the Humanities. He does not hesitate to essay an ethical system based on the laws of thermodynamics (energy and entropy), although this results in nothing more concrete than the golden rule. It is a pleasant, if not idle, conceit whose exploration one is willing to grant in an otherwise hard-headed philosophic work. There are several interesting sorties into symbolic logic, mathematics, and communication theory.

This is a literate and graceful volume, full of much solid science and good sense. It belongs in the category of the philosophy of science, and it should appeal to the scientist who wishes to test his world outlook, the humanistic scholar aware of the challenge of the scientific method to his discipline, and the layman buffaloed by the myths of "Scientism."

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Science for the Layman

View From a Height. Isaac Asimov. Doubleday, Garden City, N.Y., 1963. xii + 252 pp. $4.50.

Speculative essays which touch upon the various horizons that embellish the farflung realms of science, are not wholly new to scientific literature. Yet, Asimov's choice of material and the imaginative uses to which he puts it, are novel, refreshing, and rewarding. He consistently selects items that are of the latest vintage, diverse in origin and content, and, glory be to the laws of nature, his themes are seldom stultified by the often stereotyped mannerisms of many science fictionists with whom he occasionally associates.

The present volume contains 17 essays that deal with problems gleaned from modern biology, chemistry, physics, and astronomy. Each one is well written, informative, and above all, generates a theme or idea that is challenging and original. Some of the biological essays merely organize such known data as animal sizes, egg volumes, molecular or atomic numbers per cell, and the like, but Asimov has arranged his facts in a manner that affords new perspectives and suggestive reorientations. The other essays are also intellectually most enjoyable and they are packed with both interesting data and exciting ideas. Few readers, one may venture to predict, regardless of their status as scientists, will fail to derive some new information from more than one of these essays, and hardly a single person, even though he is familiar with all the data here called upon, will put down the book without feeling that he has gained new insight into many frontiers of science.

Asimov offers the reader a host of fascinating and lucidly described tidbits from recent researches in the spheres of isotopes, radioactivity, nuclear particles, entropy, RNA and organic molecules, chromosomal replication, heat and temperature, stellar