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.

CHURCHILL EISENHART
National Bureau of Standards, Washington, D.C.

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."

H. L. NIEBURG
Department of Political Science, University of Wisconsin, Milwaukee

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

evolution, novae, and galactic formations and distances, all presented within a lively context of some original explanation or illuminating conception; the reader is also treated to many historical anecdotes of genuine interest and relevance. Essays such as these constitute a worthy and vitalizing element of the current literature of science, a kind of Third Program that serves as a supplement to original scientific papers, on the one hand, and to textbooks or monographs, on the other. At present, men of Asimov's scientific erudition and literary skill are far too rare. One can only hope that the growing literature of science will bring forth more like him.

MARK GRAUBARD
Natural Science Program,
University of Minnesota

Instruments and Techniques

Analysis Instrumentation, 1963. Proceedings of a symposium. L. Fowler, R. D. Eanes, and T. J. Kehoe, Eds. Plenum Press, New York, 1963. x + 261 pp. Illus. $12.50.

According to the introduction, this book contains only the significant papers that were presented at the symposium held by the Analysis Instrumentation Division of the Instrument Society of America, at Houston, Texas, 29 April–1 May 1963. The 30 contributions are divided, somewhat arbitrarily, into six sections: Keynote Session, Dynamics of Analysis, Instrument Problems of Analyzer Applications, Laboratory Instrumentation, Electrochemical and Chemical Methods, and Radiation Methods of Analysis.

Those who are interested in the broad aspects of instrumentation will find that the keynote session is primarily of general, though passing, interest. The remaining 26 papers, with few exceptions, are often lengthy presentations of applications and design considerations for specific instruments. That most of the instruments are manufactured by the firms which the authors represent is not surprising. However, the information given does go well beyond that available in the literature supplied by the manufacturer, and it will be of value to users with similar problems.

While the average technical level of the book is good, there are wide variations in the levels of the individual papers, as the audience at this symposium are probably well aware. It is very likely that these papers were published as they were written for oral presentation. In this instance, elimination of the excess and elementary verbiage that seems to creep into lecture manuscripts would have saved a considerable amount of space and also the readers' time. Such editing was specifically avoided in the interest of rapid publication. Several papers, a number of cartoons, and many passport-type photographs of instruments may well owe their inclusion to the editors' haste.

Modified or new methodology and techniques in gas chromatography and a few other methods of instrumental analysis are presented in several papers. These will interest analysts and some engineers who like to mentally catalog new wrinkles.

The use of instrumental analysis in direct process control via feedback is covered from several viewpoints. This subject would seem to warrant more emphasis by the Analysis Instrument Division.

DAVID K. ROE
Department of Chemistry,
Massachusetts Institute of Technology

Organic Chemistry

Organic Syntheses: Collective Volume IV (a revised edition of annual volumes 30–39). Norman Rabjohn, Ed. Wiley, New York, 1963. xiv + 1036 pp. Illus. $16.50.

Synthetic Methods of Organic Chemistry. William Theilheimer. Karger, Basel, Switzerland, 1963. xvi + 507 pp. Illus. $38.50.

These newest members of two long-established and highly regarded series that deal with experimental methods of organic chemistry are sure to receive as warm a welcome as their predecessors. For over 40 years the volumes entitled *Organic Syntheses* have been supplying detailed directions for the preparation of organic compounds; *Collective Volume IV* comprises 368 tried and true "recipes" selected from volumes 30 to 39, which covered the years 1950 to 1959. Careful determination of optimum conditions for each preparation by its submitters and testing by independent checkers have given the series a trusted reputation for dependability which hardly requires elaboration. *Synthetic Methods* represents, on the other hand, William Theilheimer's heroic efforts to cull, from the wilderness of chemical literature, laboratory procedures that exemplify new synthetic methods or improvements in older methods. Most of the nearly 1000 procedures cited in volume 17 are taken from journals published in the period 1960 to 1962.

Both series have maintained such a high level of excellence that it is difficult to find anything to criticize. Both are well-organized, cross-referenced, and thoroughly indexed, all of which makes them easy to use. At one point Theilheimer describes the same preparation on consecutive pages, but on the whole his work is carefully and admirably done. One might carp that this collective volume of *Organic Syntheses* includes a relatively large number of either pedestrian or overly specialized preparations, but a recent change in policy, which requires a statement indicating demonstrable merit to accompany each compound or procedure submitted, has answered this objection in subsequent volumes.

Nevertheless, the genuinely new and general methods in *Collective Volume IV* make a delectable assortment: a benzene reaction, an amine oxide pyrolysis, tetracyanoethylene and its relatives, cyclodecane derivatives, formylation with dimethylformamide, and improved syntheses of aliphatic iodo and nitro compounds, to mention only a few. Theilheimer's selections, particularly, serve as a yardstick with which we can measure progress in synthetic methods, and one notes the almost incredible specificity and variety in reagents and procedures, which are available today. Especially noteworthy in this volume are the continued development of specific reducing agents, the new syntheses of heterocycles and organometallics, and the surprising effectiveness of photochemical methods of synthesis.

Both of these collections make enjoyable and rewarding browsing. Organic chemists who depend on the success of laboratory work will want both volumes on their shelves, so that they can turn to them again and again.

RICHARD K. HILL
Frick Chemical Laboratory,
Princeton University