Book Reviews

A History of Magic and Experimental Science, vols. VII and VIII, *The Seventeenth Century.* Lynn Thorndike. Columbia University Press, New York, 1958. x + 695 pp.; viii + 808 pp. Illus. $10 each.

With these volumes Thorndike concludes a work begun in 1902, the first volume of which was printed in 1923. The project began, according to the introduction to the first volume, as an attempt "to treat the history of magic and experimental science and their relations to Christian thought" during the 12th and 13th centuries, the time of greatest medieval productivity. The author realized even before the publication of the first volume, however, "that this period could be best understood by viewing it in the setting of the Greek, Latin, and early Christian writers to whom it owed so much." The subsequent appearance of six additional volumes (volumes I and II cover the period described above) continued the project through four additional centuries and testified to the author's apparent conviction that the extension of the study into the 17th century, to connect it with the nascent era of modern science, would make it even better understood.

No one who makes the acquaintance of this prodigious work can fail to be impressed by the magnitude of the undertaking. This rare example of a work successfully carried far beyond the scope of its original prospectus makes a most unusual contrast with the more typical case of the grandly conceived and only partially accomplished work.

Anyone who has given more than cursory attention to the history of science prior to the 19th century will have become aware of the existence of a veritable multitude of writers on science who are now barely known by name, if at all. If he has pursued the matter further he will have discovered that the works of these writers are virtually unobtainable, and he will have resigned himself to the somewhat uneasy conclusion that they couldn't have been very important. Thorndike has, for the first time, taken the trouble to ferret out a large number of these writers and to present the content of their writing, at least in outline.

Volumes VII and VIII deal with the 17th century and with some 1600 authors and 2446 "topics"—numbers considerably in excess of those dealt with in earlier volumes. This will not occasion surprise, for, as A. F. Bertini noticed in 1699, speaking of the medicine of his age, one of the chief faults of the age was "the printing of too many books, which confuse, rather than instruct, men's intellects" (vol. 8, page 622). Since most of the 1600 authors are obscure, Thorndike's work is invaluable for biobibliographical reference.

As an account of the magic and experimental science of the 17th century the work is less satisfactory. Continuity is lacking to such an extent that the work suffers a serious deficiency in readability. One can readily appreciate the problem posed by the necessity of fitting this multitude of writers and topics into a format established for earlier volumes dealing with simpler and less effusive centuries; to this problem is added the tendency of 17th-century writers to range over all of the sciences, natural and occult, within a single treatise. Others have avoided traversing this jungle by devious detours. Thorndike has managed to get through it, but it is not easy to follow his trail.

A second defect appears when the work is considered as a history of experimental science. In the conclusion to the second volume, Thorndike explained that he had begun with the intention of writing a history of magic but that an unexpected by-product, experimental science, had forced itself increasingly on his attention. He predicted that its importance would increase in subsequent volumes on the 14th and 15th centuries, and the conclusion to the fourth volume states that that expectation has been corroborated. His few exemplifications, however, relate as much to theoretical as to experimental science. The question is scarcely touched upon in the last chapter of the volumes relating to the 16th century or in that now under review, relating to the 17th century. In this strange disappearance of one of the principal topics of the work lies its principal limitation.

Thorndike repeatedly emphasizes the fact that experiment played a role in magic, and this appears to be the origin of his decision to deal also with experimental science. But this experimentation not only arose in simple experience but seems, from this account, to have remained there. That is to say, it was very frequently the result of a single experiment and even more often simply the testimony of a group of "eye witnesses."

In failing to draw conclusions in these volumes as to the progress of experimental science in the 17th century, Thorndike compels the reader to fall back on his incidental references to the subject, which are, to say the least, inconclusive. When he does mention science it is often just "science," for the good reason that theoretical and not experimental science is involved. But these brief references to science are further truncated by the elimination of mathematics from consideration. The result is, to take an example, to present a figure such as Kepler principally from the point of view of astrology. Thorndike has shown convincingly that magic and experimental science are not unrelated. The failure of his long work to present a comprehensive statement of the growth of experimental science suggests that experimental and theoretical science are also related, in a way which nullifies an attempt to treat one without the other.

This defect applies principally to the sections dealing with astronomy and physics. Chemistry and biology, while scarcely disentangled from their related metasciences, are presented with a fullness which contrasts startlingly with most histories of these particular sciences. Conventional histories tend to deal with the 17th century in terms of precursors and scarcely demonstrate that chemistry and biology really existed in that century. Yet the voluminous writings unearthed by Thorndike should convince one that something, if not chemistry and biology as we know them, occupied this area of intellectual interest at that time. The root of the problem seems to be that chemistry and biology, while no longer purely "medieval," had not yet been swept up by the scientific revolution in the 17th century and cannot be treated simply in its terms. Thorndike has not discovered the key to their explanation, but his work should help to force the historians of chemistry and biology to reckon with the problem.

If he keeps in mind the title of the work, the scientist reader should not be shocked by the intrusions of the disreputable ancestors of the sciences or by the inclusion of long chapters on such topics as physiognomy and divination. As Thorndike has demonstrated in earlier volumes, science "grew up in the very midst of superstition and mental anarchy" (vol. 2, page 978). Perhaps the possibility of the converse exists. If so, some acquaintance with this earlier milieu of science might be useful. It is pointed out that Galileo's assumption that he had invented two new sciences

was due in part to his erroneous supposition that there had been no progress in mathematical or experimental physics since Aristotle and Archimedes; to this Thorndike remarks that "most modern physicists do not repeat Galileo's mistake of studying only ancient science and neglecting medieval activity in physics, for the simple reason that they do not pay any attention to the history of science. But is this not doubling his error?" (vol. 7, pages 43–44).

This is a question for the conscience of the physicist, but he can hardly be expected to do anything about it without the aid of those trained in the exploration of the dark continent of obsolete science. Thorndike has done far more than his share in mapping this region.

ROBERT P. MULTHAUF
Department of Science and Technology, Smithsonian Institution

Solid State Physics. vol. 6, *Advances in Research and Application.* Frederick Seitz and David Turnbull, Eds. Academic Press, New York, 1958. xiv + 429 pp. $12.

As the successive volumes in this series come out, at a rate of something like two a year, and as one scans the list of articles planned for future volumes, one cannot help but be impressed by the diversity of the subjects which come under the general classification of solid-state physics. And so it is with the volume under review, the sixth of the series, which contains the following articles: "Compression of solids by strong shock waves," by M. H. Rice, R. G. McQueen, and J. M. Walsh; "Changes of state of simple solid and liquid metals," by G. Borelius; "Electroluminescence," by W. W. Piper and F. E. Williams; "Macroscopic symmetry and properties of crystals," by Charles S. Smith; "Secondary electron emission," by A. J. Dekker; "Optical properties of metals," by M. Parker Givens; and "Theory of the optical properties of imperfections in nonmetals," by D. L. Dexter.

During World War II scientists were interested in the propagation of shock waves through various media, primarily from the armaments standpoint, and a general theory of this process was worked out by Bethe for media satisfying a wide range of possible equations of state. The realization that the experimental data could be inverted to yield information about the equation of state of solids has opened up an interesting field for research, and the very welcome article by Rice *et al.* summarizes the progress in this field to date. These authors present the hydrodynamical and thermodynamic equations basic to a discussion of shock-wave propagation in solids, together with a description of experimental methods and a comparison of the results of experiments and theoretical calculations.

The article by Borelius is less a survey article than the others in this volume and is concerned primarily with an exposition of his recent work on changes of state (particularly melting) which occur at zero pressure. The theory is essentially phenomenological, and with a proper choice of parameters in his equations Borelius is able to obtain good agreement with experimental values for the changes in energy, entropy, and volume on melting.

Electroluminescence is the excitation of light emission in phosphors as a result of an applied potential difference across the phosphor. In their article, the longest in this volume, Piper and Williams are concerned primarily with the basic mechanisms of electroluminescence and with the effect of local field conditions in determining the operative mechanism in any particular case. This exhaustive article, with over 200 references to the literature, should become an essential part of the library of any physicist conducting research in this field.

Although there exist several books and review articles dealing with the effect of the symmetry of a crystal on the components of the tensors describing the physical properties of the crystal, Smith's article serves as an excellent introduction to this subject. Since most introductory discussions of crystallography are usually limited to formal explanations of symmetry operations and point groups and to definitions of concepts such as space groups, the present article, which goes beyond this, with its emphasis on the relation between crystalline symmetry and macroscopic crystalline properties, is very welcome.

The stated purpose of the review by Dekker is to present and discuss experimental information that seems pertinent to an understanding of the secondary emission process. This the article does, but in addition it contains a careful discussion of several theories of this process, comparing their predictions with the experimental results.

The last two articles deal with the optical properties of metals and of imperfections in nonmetals, respectively. The article by Givens is divided almost equally between a theoretical discussion of the index of refraction and of the absorption coefficient of metals and a description of experimental techniques for their determination, together with a summary of the experimental data for a large number of metals. The theoretical treatment is essentially classical, except for the discussions of the internal photoelectric effect and the anomalous skin effect. Dexter's article, on the other hand, is concerned exclusively with the theory of those optical properties of nonmetals which are explicitly connected with the presence of imperfections. It is primarily a description of the various techniques which have been developed over the years for investigations of this problem, together with a summary of the results obtained. Some discussion of the relation of experimental results to theoretical predictions is given, but the emphasis is principally on the theoretical aspects of the problem.

All of the articles in this volume are written by people well known for their contributions to their respective fields. They are well written and are certainly up to the high standards set by the preceding volumes in this series, to which the present volume makes a fit addition.

ALEXEI A. MARADUDIN
Institute for Fluid Dynamics, and Applied Mathematics, University of Maryland

Genetics. A survey of the principles of heredity. A. M. Winchester. Houghton Mifflin, Boston, Mass., ed. 2, 1958. xiii + 414 pp. Illus. $6.25.

This is an anthropomorphically oriented elementary textbook of genetics that is evidently written for the college student who has had little previous formal education. A veritable picture book, it presents genetics primarily as a social science in the best merchandizing tradition of the elementary-textbook trade. It is impossible to recommend this text for use as supplementary material for any serious beginner's course in genetics.

S. R. GROSS
Rockefeller Institute

Land, the Yearbook of Agriculture, 1958. U.S. Department of Agriculture, Washington, D.C., 1958 (order from Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C.). xi + 605 pp. Illus. + plates. $2.25.

The first volume in this series was published by the Commissioner of Patents in 1849. Since 1936 each volume has been devoted to a special subject important to American agriculture. The present volume returns to the most fundamental problem of agriculture—the land—and discusses the physical, legal, and economic characteristics of land and the past, present, and probable future utilization of this resource.

In 67 chapters, which include numerous attractive pictures and many instructive charts and maps, 93 eminent authorities from inside and outside the Department of Agriculture tell how our domain has been acquired and put to