Book Reviews

Newton as Author

Isaac Newton's Philosophiae Naturalis Principia Mathematica. The Third Edition (1726) with Variant Readings. Assembled and edited by ALEXANDRE KOYRÉ and I. BERNARD COHEN with the assistance of Anne Whitman. Harvard University Press, Cambridge, Mass., 1972. In two volumes. xlviii, 916 pp., illus. $60.

Introduction to Newton's 'Principia.' I. BERNARD COHEN. Harvard University Press, Cambridge, Mass., 1971. xxx, 380 pp. + plates. $30.

Once when Isaac Newton was asked how he had come upon his discoveries, he replied simply, "Why, by always thinking unto them." It has become a historical commonplace that Newton accomplished most of his thinking unto the mechanical structure of the universe during two 18-month periods of intense, indeed frenetic, research. The first period stretched from the beginning of 1665 to the middle of 1666, when Newton retreated from plague-struck Cambridge to his isolated home in Woolsthorpe, Lincolnshire. During this enforced interruption of his studies, he invented his methods of series and of fluxions, carried out the experiments with a prism that were to issue in his new theory of colors, and made his first deductions concerning an inverse-square force of gravity that would hold the moon in its orbit (*1*). For a 23-year old student, these 18 months indeed constituted an *annus mirabilis*, a "marvelous year" (*2*). Some 20 years later, in August 1684, Newton, by then Lucasian Professor of Mathematics and Fellow of Trinity College at Cambridge, was approached by Edmond Halley on the question of the orbit a planet would follow if constrained by a centrally directed, inverse-square force. Newton had not only the answer to Halley's immediate inquiry but a good deal more besides. Urged by Halley to publish his results, Newton devoted the next 18 months to the writing of his magnum opus, the *Philosophiae naturalis principia mathematica*, which appeared under the auspices of the Royal Society in the summer of 1687.

The work almost immediately catapulted its author to fame and leadership of English science. It underwent two revised editions during Newton's lifetime, one in 1713 and another in 1726 just prior to his death. Although editorial responsibility for the second and third editions lay largely in the hands of Roger Cotes and Henry Pemberton, respectively, it was known from the outset that Newton himself actively participated in their preparation. Just how active a role he played, however, becomes clear only now with the appearance of I. Bernard Cohen and Alexandre Koyré's "variorum" edition of the *Principia*. Their painstaking collation and comparison of the first three editions of this scientific masterpiece afford tangible evidence that, whatever the changing intensity of Newton's efforts, he was indeed *always* thinking unto his discoveries.

As Cohen himself points out in his *Introduction to Newton's 'Principia'*, a companion volume to the two-volume edition of the *Principia* itself, it is difficult to know just what to call the fruit of his and Koyré's efforts. Although subtitled "The Third Edition (1726) with Variant Readings" [whence the short form "variorum edition" (*3*)], the work does not present "variant readings" in the strict sense of the term, for example, as it is used to characterize editions of medieval treatises. Rather, reproducing the third edition as Newton's final, authoritative text, Cohen and Koyré record in a critical apparatus running at the foot of the page the precise manner in which that edition differs from each of the two earlier ones. The differences are not, however, variant readings; that is, they are not alternative ways of reading the text, among which the scholar may or must choose. They are conscious alterations made by Newton as he continually revised and refined his original work; Newton himself chose the proper reading with each revision.

In short, scholars now have available in one work the three editions of the *Principia* that stem directly from Newton, brought together in a form that facilitates comparison among them. Through the critical apparatus one can pursue the development of Newton's published thought in the years following 1687. One can, in fact, do more than that, for the critical apparatus is not limited to the three printed editions. Newton made most of his changes in the margins or on the interleaves of several of his personal copies of the *Principia*. In addition, the original manuscript printer's copy of the first edition, written by Newton's amanuensis, Humphrey Newton (no relation), is extant. The critical apparatus of the present variorum edition includes the readings of all these intermediate versions, a total of seven (*4*), with the result that one can not only determine the manner in which many revisions came about but also see revisions Newton contemplated but did not ultimately undertake.

Cohen and Koyré first embarked on this Herculean task in 1956. Since Koyré's death in 1964, Cohen has carried on with the assistance of Anne Whitman. The final product is worth the long wait. In its main purpose of recording all variations among the seven texts, it appears both complete and accurate (*5*). In addition, by judicious use of symbols and conventions, the editors have largely overcome the difficulties inherent in presenting the many different readings without confusion. With the help of a "Guide to the Apparatus Criticus" at the beginning of volume 1, the reader soon learns to follow the most intricate sequences of additions, alterations, deletions, and changes of mind contained in the seven texts. Furthermore, a host of supplements and appendices, both in the variorum edition and in Cohen's *Introduction*, supply additional information not adaptable to the critical apparatus.

All this information is accessible, of course, only to those who read Latin and understand the scientific and mathematical terminology of Newton's day. With the scholarly accuracy of Cohen and Koyré's edition comes also the limitation on its use outside the professional community of historians of science (and to some extent even within it). This variorum edition is a primary document that provides neither translation nor commentary, but rather Newton's own words as he wrote them. A

boon to scholars, it will in its present form bring Newton's *Principia* no closer to the public at large.

Cohen's *Introduction* does take some steps in that direction, however, both in what it offers and in what it promises. It promises that it and the variorum edition are but the first of a series of works devoted to the *Principia*; still to follow are, *inter alia*, a complete modern translation and an extended commentary. For the moment it offers a complete and detailed study of the publication history of the first three editions. Cohen has made extensive use of primary and secondary sources in piecing together the often intricate train of events leading to each of the editions and the various stages through which the text went in reaching final form. Of special interest here is Cohen's unraveling of the often conflicting accounts of Edmond Halley's visit to Newton in the late summer of 1684. It was then that the outside world gained its first glimpse into the research on which Newton had been engaged since entering self-imposed exile after his acrid debate with Hooke, Huygens, and Pardies over the theory of colors. Cohen carefully traces Halley's role in urging Newton to undertake publication of his results and in guiding the *Principia* through the press.

What emerges is the story of one man's selfless dedication to the work of another, a story repeated several times over the next 40 years. Halley was only the first of a series of actual and would-be editors of the *Principia*. Nicolas Fatio de Duillier sought hard in the early 1700's to gain that role and, with it, recognition and support of his theory of gravity. It was, however, Roger Cotes who finally cajoled, even bullied, Newton into concentrating on the revisions for the second edition in 1713 and who himself wrote the long "Editor's Preface" to it (*6*). For his extensive efforts, Cotes received not even Newton's thanks; indeed, Newton could only complain about the trifling errors that remained. All financial return from the second edition went to Richard Bentley, who acted as patron and stylistic gadfly of the project. The editorship of the third edition fell to Henry Pemberton, who received only slightly more gratitude from Newton than had Cotes.

In each instance, Cohen carefully analyzes the editor's contribution to the substantial revisions undertaken. With some exceptions, his analysis only underlines the extent to which the *Principia* was Newton's own work. And a mere glance at the variorum edition suffices to show the extensive changes Newton did make after 1687. Almost no part of the *Principia* was left untouched. Even where the substance remained the same, Newton continually polished the style of presentation (here, in particular, Cohen notes the important role of the various editors in calling matters to Newton's attention). Books II and III received special care as Newton, in response partly to his own dissatisfaction and partly to outside criticism, substantially revised his fluid dynamics and his planetary theory. With respect to the latter, the second and third editions included more recent and more accurate observational data than were available to Newton in the 1670's and 1680's and reveal their influence on his calculations. Some of these observations stemmed from the Astronomer Royal, John Flamsteed, to whom Newton turned in the early 1700's for help in refining his lunar theory. Apparently unimpressed by Newton's scientific stature, Flamsteed was loath to turn his painstaking results over to another who would then garner the glory of solving the problem of the moon's motion. The second and third editions of the *Principia* reflect in subtle ways the ill feeling generated by Flamsteed's attitude, as they do the changing course of Newton's famous dispute with Leibniz over the invention of the calculus.

Although Cohen mentions these and other issues of historical importance raised by the many revisions of the *Principia* in the course of its first three editions, he probes the details of very few of them. His discussion frequently reveals the depth of investigations he has carried out elsewhere (all cited in an extensive and up-to-date bibliography at the end of the *Introduction*), but for the most part he has left for future research those matters that do not bear directly on the history of the publication of the *Principia*. Hence, Cohen constantly whets the reader's appetite; for example, in chapter 6 where he describes the reception of Newton's work on the Continent. Although generally positive in tone, the first reviews in the two major scientific journals of the day, the *Acta eruditorum* and the *Journal des Sçavans*, were far from uncritical, and reviews of the second edition maintained this critical stance. Cohen pursues some of the changes in the second and third editions that may have been occasioned by these reviews, but he leaves open the larger question of the reception of Newton's ideas across the Channel. It is an intriguing question if only because Cohen later notes that the second edition was quickly sold out and that the Continental demand warranted two subsequent reprints in Amsterdam (1714, 1723). Clearly, Newton's most critical audience was also his best market.

If the variorum edition supplies the central primary documentation for the development of Newton's thought after 1687, it unfortunately sheds little light on the more important development prior to the first edition. That this is so is the fault of the sources, not of the editors. In his *Introduction* Cohen analyzes fully the extant preliminary compilations that issue in the *Principia*, most notably a treatise *De motu* sent to the Royal Society in the spring of 1686 (the basis of Book I), a fragment of a treatise entitled *De motu corporum in mediis regulariter cedentibus* (an early version of Book II), and a collection of material supposedly delivered as the Lucasian Lectures in 1684 (Cohen disputes on good grounds Newton's own dating here). But the step from these works, which John Herivel has already published in his *Background to Newton's Principia* (Oxford University Press, 1966), to the manuscript printer's copy of the *Principia* is a giant step, and there is little to fill the gap. This is especially true of Book III, containing the "System of the World." As Cohen notes (pp. 78–79), "The paucity of actual work sheets in Newton's hand is utterly baffling to anyone who wishes to find out how Newton wrote the *Principia*. . . . The absence of the first rough drafts, the pages of trial and error, of all three books of the *Principia* is especially noteworthy because of Newton's oft-repeated statement that they were very different in form from the *Principia* itself" (*7*). The extant papers leave us, then, at the one extreme with the promise of things to come and at the other with their fulfillment, but the intricate process of realization remains, for the moment at least, a mystery.

None of the above should be construed as criticism of the three volumes Cohen has finally offered his fellow historians of science. The variorum edition of the *Principia* is a worthy addition to a growing series of Newtoniana already distinguished by the superb scholarship of H. W. Turnbull's *Correspondence of Isaac Newton* and D. T. Whiteside's *Mathematical Papers of Isaac Newton*. Cohen's *Introduction* reveals the sure hand of an experienced

historian of science who has devoted much of his long career to the work of Newton and who is therefore at home in the maze of contemporary sources. Behind the immense amount of concrete information and often subtle analysis of the material lies Cohen's confident sense of Newton the man and the thinker. He has already told us much about Newton; his *Introduction* carries the promise that he can tell us more. We can only hope he will soon do so.

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References and Notes

1. See Newton's own account in various letters of the work achieved during this period in Supplement I of Cohen's *Introduction*.
2. See "The *Annus Mirabilis* of Sir Isaac Newton: Tricentennial Celebration," *Texas Quarterly* **10**, No. 3 (Autumn 1967), republished in 1970 by M.I.T. Press.
3. See Cohen's explanation of the term, *Introduction*, p. 3.
4. To be precise, they are: M (the manuscript printer's copy), E_1 (the first edition), E_1a (Newton's annotated copy of E_1), E_1i (his interleaved copy of E_1), E_2 (the second edition), E_2a (his annotated copy of E_2), E_2i (his interleaved copy of E_2), and E_3 (the third edition).
5. A random spot check using the first edition revealed no discrepancies.
6. Cohen, *Introduction*, p. 231: "Prodded by Cotes, Newton enriched the *Principia* to a degree that would never have been achieved but for Cotes's intervention. It is clear, I believe, from a reading of the Newton-Cotes correspondence that Newton had originally intended a far less drastic revision of Books II and III than he eventually produced. The credit is Cotes's."
7. In particular, this absence of work sheets leaves unresolved the question of whether Newton employed his algebraic method of fluxions to derive the theorems presented in classical geometric form in the *Principia*.

Lepidoptera

Butterflies of the Australian Region. BERNARD D'ABRERA. Lansdowne, Melbourne, 1971 (U.S. distributor, Entomological Reprint Specialists, Los Angeles). 416 pp., illus. $39.95.

Australian Butterflies. CHARLES MCCUBBIN. Nelson, Melbourne, 1971 (U.S. distributor, Entomological Reprint Specialists, Los Angeles). xxxii, 206 pp., illus. $30.

The publication of these two books ends a long period during which there have been no major works on the Australian butterflies, although much new information about them has accumulated. Both books are large and sumptuously illustrated in color and cover their respective fields thoroughly and authoritatively. Diagnostic characters for identification are pointed out, larval food plants are listed, and basic information is given about geographic distribution, life histories, and habitats. The books are, however, quite different from each other in other respects because of the particular interests and abilities of their authors.

Butterflies of the Australian Region covers not only Australia but the whole zoogeographic unit that includes New Zealand, New Guinea, eastern Indonesia, and such island groups as New Britain, New Caledonia, the Solomons, and Fiji. It will, therefore, be especially valuable to zoogeographers, as well as to taxonomists, in its treatment of such characteristic endemic groups as *Ornithoptera* and *Delias*. The author has done a very thorough job taxonomically, studying types when possible and illustrating many of these. The illustrations, which are of the highest quality, consist of more than 3000 color photographs made by the author. Most of these show specimens, but many are of early stages, environments, and habits. Only the true butterflies are covered. Short sections deal with such subjects as the butterflies' place in nature, mimicry and protective resemblance, and classification and nomenclature, and there is a very interesting short history of the collecting and study of the butterflies of the region. (This includes a photograph of the first specimen of the great high-flying *Ornithoptera*, collected in 1884 or 1885 with a shotgun!) A few new subspecies are named. There are also maps, a glossary, a good selected bibliography, and a general index. Unquestionably all taxonomists and other student of Australasian butterflies will find this book particularly valuable.

Australian Butterflies is illustrated by a vast number of paintings by the author, who is a scion of an Australian family distinguished in the arts. The paintings of specimens are excellent and accurate, and entirely adequate for identification. Only Australia is covered. Not only the true butterflies (Papilionoidea) but the very numerous skippers (Hesperioidea) are included. A great many food plants and the early stages of many species are illustrated. Many charming paintings of butterfly habitats and collecting localities and scenes are very attractive. Perhaps one of the most distinctive, and one of the most valuable, features is the large number of descriptions of butterfly habits and behavior, the majority from the personal observations of the author. These include accounts of courtships and mating behavior, flights, oviposition, larval activities, "hilltopping," and the relationships with ants for which so many Australian Lycaenidae are famous. Detailed directions for collecting and caring for specimens will be very useful for the amateur. There are also a large bibliography, a map and key to localities, a glossary, and two indexes, one listing the plants separately. Though not based on such wide taxonomic and zoogeographic studies as D'Abrera's work, this is a very important book that will have special appeal to all naturalists and collectors.

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Various Groups of Viruses

Comparative Virology. A conference, Montreal, Sept. 1969. KARL MARAMOROSCH and EDOUARD KURSTAK, Eds. Academic Press, New York, 1971. xvi, 584 pp., illus. $27.50.

This book arose out of the First International Conference on Comparative Virology. However, it is not a "symposium volume" but a series of long review articles on various groups of viruses written from a comparative point of view. As such it contains a good deal of new material, or at least new ways of looking at known data.

Moves over the last 20 years, initiated by Sir Christopher Andrewes, and brought to fruition by André Lwoff, have resulted in the establishment of an International Committee on Nomenclature of Viruses (ICNV), dedicated to the classification of viruses according to physicochemical criteria, irrespective of the nature of the host. *Comparative Virology*, therefore, comprises much more than just the comparison of viruses of different species of vertebrates or plants; it involves the consideration of physicochemical criteria of the classification of viruses of vertebrates, invertebrates, bacteria, and plants.

The volume opens with an essay on the classification of viruses, in which Lwoff and Tournier acclaim the virtues of their "system" and castigate the mistakes of those who do not yet accept it. Valuable though Lwoff's contributions have been, it is probably a mistake to hasten as rapidly as he would like in classification and nomenclature; however, the "committee" system of the ICNV will probably ensure that changes occur slowly.

In spite of the avowed intentions of the conference and the editors of the book, most of the articles that follow deal with viruses of vertebrates, of