need experimental petrology to interpret field and seismic observations and to unravel the history of the earth's outer layers. Petrology is also relevant to the origin of the solar system. This book demonstrates the importance of a specialized field to a broad spectrum of earth and planetary sciences. The author takes us from detailed geological studies of the surface to speculations on the composition of the deep interior of the earth, the origin of the moon, and the early evolution of the solar system.

Such speculations require input from almost every branch of science: astrophysics, cosmology, geology, physics, chemistry, geochronology, petrology, thermodynamics, crystal field theory, and Newtonian mechanics. Anyone attempting a synthesis of knowledge of the origin of the solar system, the earth, or the earth-moon system must understand constraints imposed by fields other than his own. It is virtually impossible for any individual to be conversant with all the physical and chemical constraints. It is difficult to design a completely consistent scenario for the origin and evolution of even such a well-studied body as the earth. Any attempt to synthesize available data and theories inevitably reflects the biases and specialty of the synthesizer. This book is one of the more Herculean attempts to bring a large amount of the available information to bear on the subject of the composition of the earth's interior and the implications of that composition for a theory of its origin.

The author's original purpose in writing the book was to review recent petrological research and its bearing on knowledge of the composition and constitution of the mantle. Ringwood and his colleagues have developed many techniques of high pressure petrology and have discovered many high pressure phases. They have also made substantial contributions to the subject of magma genesis and the synthesis of petrological and other data bearing on the evolution of the earth. Experimental petrology is becoming more specialized, and it is often difficult for workers in other fields to make full use of the results of this powerful tool. Ringwood attempts to provide a synthesis that will be intelligible to a wide spectrum of earth scientists. A large part of the book is based on Ringwood's own research. Work from other laboratories is also reviewed, but, as Ringwood admits, he found it hard to be objective. Petrologists will consider this a decidedly one-sided view, but few of them have attempted such a broad synthesis of their field. Even a one-sided view is useful from a mind as fertile as Ringwood's.

Part 1 covers the composition of the crust and upper mantle, the gabbro-eclogite transformation, the Mohorovicic discontinuity, the origin of magmas, and the role of water in petrogenesis. Part 2 covers the geophysical and petrological evidence on the composition of and phase assemblages in the deeper mantle, including high pressure transitions in olivines, pyroxenes, and garnets.

The concluding chapter, "Mantle composition and the earth's origin" is a heroic attempt to reconcile the author's earlier work with later developments and information from other fields. Although Ringwood was forced to drop the idea that silicon was the light alloying element in the core, he still believes that the volatiles were initially near the center of the earth, that the core was originally at the surface, and that the moon condensed from material vaporized at the surface of the earth. The inconsistencies with earlier chapters and the biases of the author are painfully obvious.

This is more a monograph than a textbook. It is mainly a collection and distillation of the author's monumental contributions to the petrology of the earth and the moon and his evaluation of the contributions of his competitors. Advanced graduate students in geological and planetary science will profit greatly from reading it. They need not be forewarned of the biases of the author, since they come through clearly. On the whole, the strong imprint of the author's personality is more a plus than a minus. The book is certainly more enjoyable to read than most petrology texts, even though it may infuriate the many earth scientists Ringwood has controversies with.

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Seventeenth-Century Studies

Newton as Chymist

The Foundations of Newton's Alchemy. Or "The Hunting of the Greene Lyon." BETTY JO TEETER DOBBS. Cambridge University Press, New York, 1976. xvi, 300 pp., illus. $22.50.

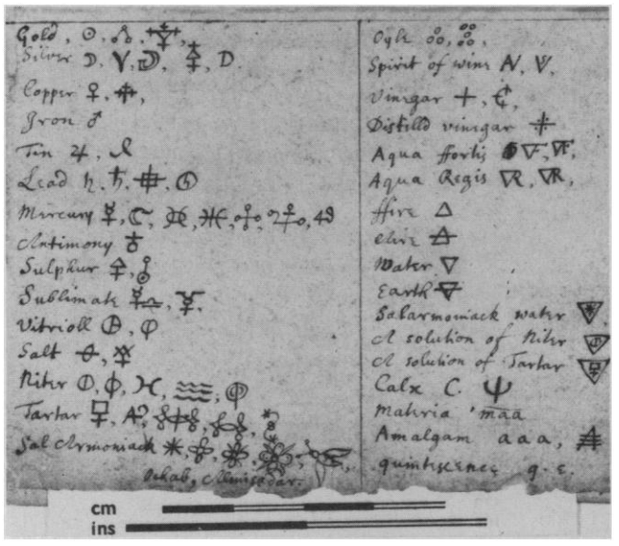
. . . at spring and fall of the leaf . . . he used to employ about six weeks in his elaboratory, the fire scarcely going out either night or day. . . . What his aim might be I was not able to penetrate into, but his pains, his diligence at these set times made me think he aimed at something beyond the reach of human art and industry.

Thus Humphrey Newton, who assisted Isaac Newton in experiments from 1685 to 1690. His suggestion that metallic transmutation was Newton's "chief design" has often infuriated historians who have studied Newton's chemical work. But why then did Newton scribble at least 650,000 words on alchemical topics, mostly as notes from alchemical authors?

Dobbs has attempted to provide an answer by a careful and intensive study of manuscripts she assigns by painstaking handwriting analysis to the period 1668–1675 (constituting about 10 percent of the total). She has chosen to examine Newton's chemical notebook in close conjunction with the alchemical manuscripts for the light each can throw on the other.

Dobbs quickly disposes of the view that Newton was searching through alchemical authors for nuggets of useful information. He selected the most mysterious and esoteric passages. He then drew on his knowledge of other alchemical writings, chemical operations, mythology, and anything else that could help unravel the meaning. Finally he tested out the resulting hypotheses in laboratory operations. Underlying the interpretative techniques was the conviction of a secret "wisdom of the ancients" hidden in myth as in alchemical enigmas. As an adherent of the mechanical worldview, he was led to restate alchemical ideas in mechanical and particulate terms.

Newton's first experiments aimed at recovering the "mercury of metals," which was supposed to give metals their specific characteristics. One method was to heat various metals with the volatile sublimate of mercury. Since the mercury released in the substitute reaction was



Alchemical symbols from one of Newton's earliest alchemical manuscripts, Keynes MS 31, Kings College Library, Cambridge. The table part of which is shown here is one "that Newton prepared for himself to explicate the symbols used in the recipes he had copied." [Reproduced in *The Foundations of Newton's Alchemy* with permission from the Provost and Fellows of Kings College, Cambridge]

contaminated with the metal, the "chymist" concluded that it was the mercury of the particular metal used. Newton's experiments were marked by a quantitative precision absent from traditional alchemy, and he used the same weight of sublimate and various metals (not being in possession of a concept of chemically equivalent weights). Though convinced of his success, he soon turned to the more ambitious alchemical end of making a "philosophick mercury" that would attract the powers of the alchemical "universal spirit." Dobbs ingeniously traces the path by which Newton arrived at the conclusion that "magnet," which would draw down that spirit, was made of the star-shaped regulus of antimony. After many trials, he believed he had converted ordinary mercury into "philosophick mercury," the proof being its power to dissolve all metals including gold.

Dobbs agrees with some earlier studies that alchemical notions deeply influenced Newton's early speculations on aether. R. S. Westfall has recently argued that as the philosophical difficulties of aetherial explanations and his accurate pendulum experiments led Newton to reject the existence of an aetherial medium, he reintroduced the attractions and repulsions that had so impressed him in his alchemical experiments. An attractive force analogous to that postulated by the "chymists" appeared in Newton's work on the dynamics of orbital motion in 1679–80. Dobbs points out that the apparent success of his attractive "magnet" in this same period may have been of crucial importance in any such development. That alchemical study and experiments occupied so much of Newton's time even during the period of feverish work on the *Principia* is a surprising fact. But as Dobbs points out, there are numerous indications that Newton had hoped to present in the *Principia* a system quantifying not only the gravitational force but also the short-range forces ruling "the properties and actions of all corporeal things."

By analyzing Newton's mature chemical thought, Dobbs pursues the fate of some of the earlier alchemical ideas. With a more complex hierarchical notion of matter, Newton perhaps could no longer believe in the power of his old "philosophick mercury" to penetrate and dissolve gold to its particles of "first composition." But he never seems to have given up the dream of transmutation. The continuing influence of alchemical ideas is evident in the "spirit" of the General Scholium to the *Principia*, in speculations on colors and particle size, and in much in the chemical Queries to the *Opticks*.

The most valuable results of Dobbs's study are presented in two chapters of the book (pp. 126–232). Other chapters review earlier studies and attempt to provide a historical and conceptual background to 17th-century alchemy. These more general chapters, for example one on chemistry and alchemy in Cambridge, may be vulnerable to the charge of sometimes oversimplifying complex intellectual patterns. But such criticisms do not detract from the solid achievement of Dobbs's general interpretation of Newton's alchemical studies, which all future assessments of Newton's thought must fully take into account.

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The International Scene

The Correspondence of Marcello Malpighi. HOWARD B. ADELMANN, Ed. Cornell University Press, Ithaca, N.Y., 1975. Five volumes, boxed. Vol. 1, 1658–1669; xxii pp. + pp. 1–436. Vol. 2, 1670–1683; xiv pp. + pp. 437–916. Vol. 3, 1684–1688; xvi pp. + pp. 917–1420. Vol. 4, 1689–1692; xvi pp. + pp. 1421–1850. Vol. 5, 1693–1694; xii pp. + pp. 1851–2228. $95. Cornell Publications in the History of Science.

The great tradition of study and research in the Italian universities continued well into the latter half of the 17th century. In anatomy and medicine no one better illustrates this continuity than Marcello Malpighi of Bologna. A master of dissection, he was among the earliest advocates and practitioners of comparative anatomy (from simple animals, he observed, we learn much which in higher forms, notably man, is hidden by complexity); sympathetic to the Galilean outlook, he sought to meld descriptive anatomy and functional interpretation, creating a mechanistic physiology; widely experienced in the demands of medical practice, he ended his days in Rome as personal physician to Innocent XII.

Malpighi's scientific career was pursued in Pisa, Messina, and Bologna. International travel was not his lot; international communication most definitely was. His correspondence was abundant, diverse in concern, and conducted on a European scale. This new *Correspondence* (numerous earlier and quite incomplete collections exist) includes letters written by and to Malpighi. One thousand seventy-nine letters are published (for the most part in the original Italian), brief summaries of the contents of each are given in English, and annotation is abundant. The work concludes with an enormous bibliography and a spendid index.

Through his correspondence (and his many scientific publications) Malpighi entered the nascent international scientific world. Most celebrated in this context is, of course, his contact with the Royal Society of London, beginning in 1667 and continuing until his death. Malpighi's correspondence with Henry Oldenburg of the Royal Society and with various English physicians and anatomists occupies a good portion of this edition. French correspondents are vanishingly few; there are more from the Germanies. Italy, then divided into a host of kingdoms, duchies, a republic, and the Papal States, itself presented an international scene, and it is within this smaller world that the vast bulk of Mal-