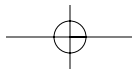
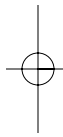
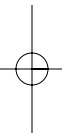
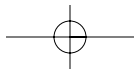
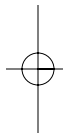
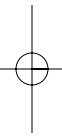




THE CHEMICAL PROMISE





THE CHEMICAL PROMISE

*Experiment and Mysticism
in the Chemical Philosophy
1550–1800*

SELECTED ESSAYS
OF ALLEN G. DEBUS

Morris Fishbein Professor Emeritus
of the History of Science and Medicine
The University of Chicago

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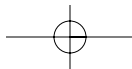
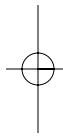
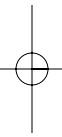
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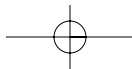
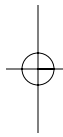
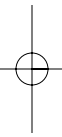
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*In memory of Walter Pagel, a friend who gave generously of his time,
To Bruni who made it possible for me to pursue my research, and
To my graduate students with whom I discussed these topics
in classes and seminars over a period of 35 years.*





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Preface

 here are some who would question the need to republish papers that have already appeared elsewhere. Walter Pagel once said that scholars should think in terms of books rather than research papers since the latter become lost in the literature. When he told me this years ago I was not entirely convinced. Surely the young scholar must publish papers to secure his academic position. In addition, throughout his career he attends conferences—many of which will require the publication of his papers in the resultant conference volumes. By their very nature such papers often discuss topics in greater detail than that scholar's subsequent books. In this case also the papers tend to become “lost” even when there exist extensive guides to the literature such as the Critical Bibliography published annually in *Isis* for historians of science. Many of my own papers over the past forty-five years have indeed appeared in such conference volumes as well as in journals.

The aim of the present volume is to present a collection of my papers relating to chemistry and medicine in the early modern period. A shorter collection of fourteen papers on similar topics appeared earlier as *Chemistry, Alchemy and the New Philosophy 1500–1700* (London: Variorum, 1987). Over the years the object of my research has been primarily to establish the importance of chemistry in the period of the Scientific Revolution and all of the papers included here relate to this problem. It has been decided to publish the papers as they first appeared rather than to write a new book based on them. No attempt has been made to exhaustively cover the current literature although at the end of this preface references will be made to some studies that I have found particularly useful.

While the papers in this collection could have been arranged chronologically, it has been thought better to present them topically. The first paper may serve as an introduction to the others. “Chemists, Physicians, and Changing Perspectives on the Scientific Revolution” [*Isis*, 89 (1998), pp. 66–81] was presented as the Distinguished Lecture at the 1996 meeting of the

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History of Science Society in Atlanta. The purpose of this lecture was to summarize the main features of the early modern Chemical Philosophy and to indicate that the more traditional emphasis on astronomy and the physics of motion is unsatisfactory if we are to understand the Scientific Revolution. Rather, we must take into account other factors—in particular the work and the debates relating to chemistry at that time.

Essential for an understanding of the chemistry of the sixteenth and seventeenth centuries is alchemy. Today alchemy generally refers to the transmutation of base metals to gold. However, in earlier times it had a much broader meaning that included mystical as well as practical procedures. With this in mind I prepared an essay on this subject for the *Dictionary of the History of Ideas*, Philip P. Wiener, Executive Editor (5 vols., New York: Charles Scribner's Sons, 1973), 1, pp. 27–34. Here I summarized the history of alchemy from antiquity through the eighteenth century. Since the appearance of this paper much additional work has appeared. Some of these studies will be referred to at the end of this preface.

In contrast with contemporary science, alchemical texts often employ allegories and myths. I presented examples of this genre in “Myth, Allegory, and Scientific Truth: an Alchemical Tradition in the Period of the Scientific Revolution” [*Nouvelles de la Republique des Lettres*, 1987-I, pp. 13–35], a paper presented at a symposium on “Representation and Value: Literature, Philosophy and Science” at the Georgia Institute of Technology in 1986. Here I discussed the widespread belief that hidden truths were to be found in ancient myths and dreams. Such interpretations were employed not only by alchemical authors, but by more familiar authors associated with the new science of the seventeenth century such as Francis Bacon and Rene Descartes.

A number of the papers in this volume relate to the scope and development of the Chemical Philosophy. “Chemical Medicine in Early Modern Europe” was prepared for a three volume history of western medical thought edited by Mirko D. Grmek and Bernardino Fantini. The original plan was to publish the set in Italian (1996), French (1997), German and English. In fact only the first two translations appeared in toto and the Harvard University Press published the first volume alone before dropping the project. The present printing therefore is the first publication of my own paper in English. In it I survey the scope of the Chemical Philosophy—particularly in its relation to medicine and its challenge to the Galenic medical establishment. The development of chemical medicine is followed through a number of prominent figures down to the late seventeenth century and its conflict with the iatrophysicists.

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“The Chemical Debates of the Seventeenth Century: the Reaction to Robert Fludd and Jean Baptiste van Helmont” [*Reason, Experiment, and Mysticism in the Scientific Revolution*, editors, M.L. Righini Bonelli and William R. Shea (New York: Science History Publications, 1975), pp. 18–47, 291–298] was prepared for a conference at Capri (1975). Here I compared the work of two contemporary figures, both of whom may be classed as chemical philosophers. Fludd’s mystical and alchemical world view initially generated considerable debate with authors as prominent as Kepler, Gassendi, and Mersenne, but interest in his work barely extended beyond his lifetime. Although van Helmont lived only a few years longer than Fludd, his works appeared after his death at a time when the call for a new philosophy was widespread. His works seemed to present the Chemical Philosophy in a more modern form, one which continued to be a source of debate through the last half of the seventeenth century.

“Guintherius, Libavius and Sennert: The Chemical Compromise in Early Modern Medicine” [*Science, Medicine and Society in the Renaissance. Essays to Honor Walter Pagel*, edited by Allen G. Debus (2 vols., New York: Science History Publications/London: Heinemann, 1972), 1, pp. 151–165] discusses the views of these three figures on chemical medicine. Guinter von Andernach held to traditional anatomy and physiology while praising the new chemical medicines (1571). Libavius also sought medicinal cures through chemistry (1606) and Sennert (1619) found value in the Galenic tradition as well as chemistry. However, the interest of these authors in chemical medicine did not extend to the more mystical speculations of the Paracelsians.

“Chemistry, Pharmacy and Cosmology: A Renaissance Union” [*Pharmacy in History*, 20 (1978), pp. 125–137] was given as the Edward Kremers Award Address of the American Institute of the History of Pharmacy. Here the medieval herbal tradition is discussed along with the development of the distillation books of the Renaissance and the subsequent Paracelsian chemical remedies.

“Quantification and Medical Motivation: Factors in the Interpretation of Early Modern Chemistry” [*Pharmacy in History*, 31 (1989), pp. 3–11] was the Dexter Award Address presented at the meeting of the American Chemical Society in 1987. The application of mathematics to the physical sciences is generally considered to be a defining factor of the Scientific Revolution. But what of chemistry, which was then generally considered to be part of medicine? We find that here too mathematics played an important role. For some this meant the use of a mystical form of numerology while for others it meant the use of the balance. In fact, quantification was important for the chemists,

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but in a different way than it was applied in the physics of motion or in astronomy.

“Chemistry and the Universities in the Seventeenth Century” [*Academiae Analecta: Klasse der Wetenschappen*, 48 (1986), pp. 13–33] was presented in Leuven at the 300th anniversary of the establishment of the Chair in Chemistry (1985). Here it is shown that Leuven was not unusual at the time since chemistry became established in many European universities in the course of the seventeenth century. These chairs were generally associated with the medical faculties and by the end of the century nearly all major medical programs included instruction in pharmaceutical chemistry.

Over the years I have written a number of papers on iatrochemistry in England. “From John Dee to the Royal Society” is a previously unpublished manuscript of a public lecture given at a conference on “Scientific Relations Between Britain and the Continent” held in Leiden in 1991. In this paper I gave examples of the flow of scientific thought in the sixteenth and seventeenth centuries. Dee was surely as well known on the Continent as he was in England while Robert Fludd’s volumes on the macrocosm and the microcosm elicited replies from Kepler, Mersenne and Gassendi. A third example is Theodore Turquet de Mayerne whose views so angered the Medical Faculty in Paris that he emigrated to England where he became instrumental in the preparation of the London *Pharmacopoeia* (1618) which included chemically prepared medicines.

“The Paracelsian Compromise in Elizabethan England” [*Ambix*, 8 (1960), pp. 71–97] is an early paper of mine on Paracelsian thought. Here I discussed the sixteenth century English references to medical chemistry and concluded that for the most part English physicians accepted many of these preparations, but rejected the mystical world view of Paracelsian authors. There were, of course, exceptions to this rule, but in general I have not changed my view today.

Robert (Richard) Bostock had complained in 1585 that the Galenists were so entrenched in the medical schools that there was no opportunity for chemical physicians to present their views. The problem of medical reform in England continued as a subject of debate into the next century and reached a climax in the 1650s. At that time a number of authors wrote works calling for reform, among them the otherwise unknown Noah Biggs (1651). In “Noah Biggs and the Problem of Medical Reform in England” [*Medicine in Seventeenth Century England. The C.D. O'Malley International Symposium*, edited by Allen G. Debus (Berkeley, Los Angeles and London: The University of Cal-

Preface

ifornia Press, 1974), pp. 33–48] I discussed his rejection of traditional medical education. But his work is notable as well for his detailed warning of the dangers of lead poisoning. He cautioned against using lead distillation equipment in the preparation of pharmaceuticals and the use of lead dinnerware.

The bitterness of the educational debate is even more evident three years later with John Webster's *Academiarum Examen, or the Examination of Academies* which was answered by the Oxford dons, John Wilkins and Seth Ward in their *Vindiciae Academiarum*. Webster called for a new experimental study of man and nature based on chemistry and natural magic while Wilkins and Ward felt that the universities must avoid the excesses of Paracelsianism and emphasize instead the new mathematical studies. I examined these tracts in "The Webster-Ward Debate of 1654: The New Philosophy and the Problem of Educational Reform" [*L'Univers à la Renaissance: Microcosme et Macrocosme, Travaux de l'Institut pour l'étude de la Renaissance et de l'Humanisme* (Brussels: P.U.P./P.U.F., 1970), pp. 33–51] for a conference in Brussels and then had the works reprinted in their entirety along with Thomas Hall's Aristotelian reply to Webster.

I also turned occasionally to otherwise relatively unknown authors. John Woodall had been praised for his work on surgery which had been prepared for the East Indian Company (1617). Paracelsian authors generally rejected surgical procedures preferring to cure through chemical preparations. However, Woodall had an interest in alchemy which he discussed in detail. It is this aspect of his writing that I examined in "John Woodall, Paracelsian Surgeon" [*Ambix*, 10 (1962), pp. 108–118].

Thomas Sherley is no less interesting as a seventeenth century chemist. Deeply influenced by the works of van Helmont and Robert Boyle, he sought to define a new philosophy based on the former's doctrine of water and seed and the latter's corpuscular philosophy. In "Thomas Sherley's *Philosophical Essay (1672)*" [*Ambix*, 27 (1980), pp. 125–135] I attempted to show that a union of these views of van Helmont and Boyle could seem plausible to many at the time.

An important example of the application of chemical theory to explain geocosmic events may be found in Edward Jorden's *A Discourse of Naturall Bathes, and Minerall Waters* (1631). Jorden rejected the widespread belief in a central fire and turned to the process of fermentation to explain the internal heat of the earth and the creation of metals. In a second edition (1632) he expanded the section on the analysis of natural spring waters and included a description of the use of a color indicator (scarlet cloth) to differentiate

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between the oil of vitriol (acid) and oil of tartar (base). I discuss Jordan's work in "Edward Jordan and the Fermentation of Metals: An Iatrochemical Study of Terrestrial Phenomena" [*Toward a History of Geology: Proceedings of the New Hampshire Inter-Disciplinary Conference on the History of Geology, September 7-12, 1967*, edited by Cecil J. Schneer (Cambridge, Mass.: M.I.T. Press, 1969), pp. 100-121].

"Van Helmont and Newton's Third Law" [*Paracelsus, Werk und Wirkung. Festgabe für Kurt Goldammer zum 60. Geburtstag*, edited by Sepp Domandl, Salzburger Beiträge zur Paracelsusforschung, 13 (Vienna: Verband der wissenschaftlichen Gesellschaftlichen Österreichs Verlag, 1975), pp. 45-52] was written for a Festschrift for the noted Paracelsus scholar, Kurt Goldammer. Here I examined van Helmont's views on action and reaction. The Galenic theory of cure was explained as a case of equal action and reaction. This was rejected by van Helmont who sought to eliminate contraries in nature in his *Ignota Actio Regiminis*. Although there are no notes by Newton on this tract, he did comment on other work by van Helmont and may well have been familiar with this discussion.

Ebenezer Sibly offers us a late eighteenth-century example of an author who reflected recent science and medicine as well as a world view based on the macrocosm and the microcosm ["Scientific Truth and Occult Tradition: The Medical World of Ebenezer Sibly (1751-1799)," *Medical History*, 26 (1982), pp. 259-278]. In the sciences he referred to recent authors such as Benjamin Franklin, Pieter van Musschenbroek and Joseph Priestley while in medicine he wrote of the work of Edward Jenner, William Heberden and Matthew Dobson. Still, Sibly was convinced of the value of natural magic, astrology, and alchemy. He believed in the importance of laboratory investigations and he was at the same time an important English advocate of Franz Anton Mesmer's animal magnetism.

Turning to France, I discussed "Alchemy in an Age of Reason: The Chemical Philosophers in Early Eighteenth Century France" [*Hermeticism and the Renaissance: Intellectual History and the Occult in Early Modern Europe*, edited by Ingrid Merkel and Allen G. Debus (Washington: The Folger Shakespeare Library/London and Toronto: Associated University Presses, 1988), pp. 231-250] at a meeting at the Folger Library. In addition to French texts on alchemy in the period to the mid-eighteenth century, I discussed the works of eighteenth century French Paracelsians. Even the Royal Academy of Sciences included a chemical philosopher, Martino Poli, who attacked the mechanists and defended the Paracelsians. Similarly we find frequent

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reviews of alchemical and Paracelsian treatises in the widely read *Journal des sçavans*.

“French Alchemy in the Early Enlightenment” [*Ésotérisme, Gnosés & Imaginaire Symbolique: Mélanges offerts à Antoine Faivre*, edited by Richard Caron, Joscelyn Godwin, Wouter J. Hanegraaf & Jean-Louis Viellard-Baron (Leuven: Peeters, 2001), pp. 47–59] continued the investigation of mid-eighteenth century French alchemy. Here special attention is given to Nicholas Lenglet du Fresnoy’s three volume *Histoire de la Philosophie Hermetique* (1742) and the work of Antoine-Joseph Pernety. The latter’s *Dictionnaire Mytho-Hermetique* and *Les Fables Égyptiennes et Grecques* were published in 1758 and again at the end of the century when chemists were discussing the recently published work of Lavoisier. In contrast, Pernety presented an alchemical interpretation of ancient myths down to the Trojan War.

An interest in Iberian iatrochemistry led me to write “Chemistry and Iatrochemistry in Early Eighteenth Century Portugal: A Spanish Connection” [*Historia e Desenvolvimento da Ciência em Portugal: I Colóquio—até ao Século XX. Lisboa, 15 a 19 Abril de 1985*, Prof. Doutor António Vasconcellos Marques, Secretary-General of the Colloquium (2 vols., Lisboa: Academia das Ciências de Lisboa, 1986, 2, pp. 1245–1262) which was read at the Academy of Sciences in Lisbon in 1985. Although chemistry is normally considered to have developed in Portugal after the educational reforms of the Marquis of Pombal in the third quarter of the eighteenth century, there was an earlier tradition stemming from pharmacy. Here the work of Joam Vigier (1714), Manuel Rodrigues Coelho (1735) and João Curvo Semmedo (1697) reflected the French chemical texts of the period and presented chemical as well as Galenic preparations to the reader. A connection between Spanish and Portuguese chemistry may be found in the work of Francisco Suarez de Rivera who praised the books of Paracelsus and his disciples. His most important book on chemistry, the *Cirurgia Methodus e Chymico Reformada* (1721) was available in Portuguese translation and Rivera proudly referred to his membership in the Royal Portuguese Medico-Porto-Politana Academy.

At the Sixteenth Century Studies Conference in St. Louis in 1996 I discussed the Spanish scene in more detail [“Paracelsus and the Delayed Scientific Revolution in Spain: A Legacy of Philip II,” *Reading the Book of Nature: The Other Side of the Scientific Revolution*, edited by Allen G. Debus and Michael T. Walton, Vol. 41 of Sixteenth Century Studies and Essays, Raymond A. Mentzer, General Editor (Kirksville, MO: Thomas Jefferson Press, 1998), pp. 147–161]. Philip sought to close the borders to foreign ideas that

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might threaten his orthodox Roman Catholicism. The work of Paracelsus was particularly suspect and in successive editions of the Spanish *Index* ever more of his works were listed. As a result, when more liberal views prevailed in the late seventeenth century not only were authors such as Descartes and Galileo introduced to Spanish readers, but also Paracelsus and his followers for the first time. Thus in Spain Paracelsus was viewed by many as one of the new philosophers at a time when Paracelsian views were in decline elsewhere.

In “The Rise and Fall of Chemical Physiology in the Seventeenth Century” [*Memórias das Ciências de Lisboa—Classe de Ciências*, 36 (1996/97, published 1998, pp. 35–60)] I began with the Paracelsian effort to explain the bodily processes chemically. The work of Thomas Willis and Franciscus de la Boë Sylvius built on and modified his work and that of van Helmont. Early in the next century the emphasis of these authors on the chemical concept of fermentation was described in detail by Raymond Vieussens who was attacked by the mechanist Philippe Hecquet. By this time the decline of the chemical physiologists was evident and the widespread influence of Hermann Boerhaave solidified the ascendancy of those who sought to explain the human body in terms of hydraulic and mechanical examples.

“Hermann Boerhaave and the Problem of Medical Chemistry in the Early Eighteenth Century” is a previously unpublished manuscript delivered at the Dexter Award session honoring W.A. Smeaton in Chicago at the American Chemical Society meeting in 2001. Here he is seen as a mechanist who held both the chairs of medicine and chemistry at Leiden. For him the two fields were largely separate and in contrast to earlier Paracelsians and iatrochemists he believed that chemistry played a very small role in medicine. He attacked the “religious alchemy” of earlier authors, but it is of interest that he thought highly of some alchemists whom he considered to be real chemists. Boerhaave himself devoted years to transmutational experiments.

The final two papers in this collection deal with an assessment of the importance of the Paracelsian and alchemical traditions. In “Iatrochemistry and the Chemical Revolution” [*Alchemy Revisited: Proceedings of the International Conference on the History of Alchemy at the University of Groningen 17–19 April 1989*, edited by Z.R.W.M. van Martels (Leiden/New York/Copenhagen/Cologne: E.J. Brill, 1990), pp. 51–66], I suggested that instead of looking at the Chemical Revolution in terms of the overthrow of the Phlogiston Theory by Lavoisier and his colleagues that historians of chemistry should think of a long term revolution in the way that historians of physics look at the progression from Copernicus to Galileo to Newton—roughly a century and a half.

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In the case of chemistry one might begin with the medico-chemical break with Aristotelian philosophy and Galenic medicine by Paracelsus. This phase of such a revolution would center on the rise of Paracelsian and Helmontian chemical medicine. The second phase would center on the attack on the medical chemists by the iatrophysicists—an attack which resulted in the separation of chemistry from medicine. It is this chemistry, largely divorced from medicine, that was the object of Lavoisier and his followers.

“History of Chemistry: Key to Modern Science” [*Atti del IV Convegno Nazionale di Storia e Fondamenti della Chimica: Venezia, 7–9 Novembre 1991, Memorie di Scienze Fisiche e Naturali*, “Rendiconti della Accademia Nazionale della Scienze detta dei XL,” serie V, vol. XVI, Parte II (1992), pp. 117–131] was presented at a conference on the history of chemistry in Venice in 1991. The object of this paper was to return to my belief that any discussion of the Scientific Revolution is incomplete without taking into account the widespread interest and debate over the role of chemistry as the basis for a new philosophy. This contemporary interest makes it a key subject for an understanding of the fundamental changes of that period—no less so than the work of Copernicus, Galileo and Newton.

BIBLIOGRAPHIC NOTE

The papers in the present volume were written over a period of nearly fifty years and even a cursory comparison of the footnotes of the earlier and later papers will show how the literature has changed in the second half of the twentieth century. In the 1950s scholarship on the Scientific Revolution concentrated on the acceptance of the Copernican system of the world from the *De revolutionibus orbium* of 1543 to Newton’s *Principia mathematica* of 1687. This interpretation of the Scientific Revolution paid little attention to other sciences or to the interplay of science and society. This has changed considerably over the years. While no one would reject the importance of technical internalist studies of the physics of motion or astronomy, it is more common today to investigate sciences previously neglected and externalist subjects linking the sciences with society.

One of the areas that has benefited from this expansion of the history of science has been chemistry which has been examined not only for its technical development, but also for its relation to mystical, religious and even political factors. It would be too much to try to list all of the literature of the past

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fifty years of significance, but perhaps it is worthwhile to mention some of the work I have found useful. My emphasis will be on books and monographs although I will mention a few articles.

Although early modern chemistry is based today on many monographic studies of specific topics, there are some general works that remain indispensable. J.R. Partington's massive *A History of Chemistry* (4 vols., London: Macmillan, 1961–1970) will always be a first port of call for historians of chemistry while Lynn Thorndike's *History of Magic and Experimental Science* (8 vols., New York: Columbia University Press, 1923–1958) will lead the reader to authors he might otherwise miss. For Paracelsus the best introduction remains Walter Pagel's *Paracelsus: An Introduction to the Philosophical Medicine in the Era of the Renaissance* (Basle: Karger, 1958; Revised edition, 1982). And for a discussion of Hermeticism and its impact on Renaissance science there is Frances A. Yates' *Giordano Bruno and the Hermetic Tradition* (Chicago: University of Chicago Press, 1964), a work which fostered heated debate when it appeared. A more recent collection of papers on Hermeticism by scholars in the field is *Hermeticism and the Renaissance: Intellectual History and the Occult in Early Modern Europe*, edited by Ingrid Merkel and Allen G. Debus (Washington: The Folger Shakespeare Library/Toronto: Associated University Presses, 1988).

The early development of alchemy is a subject of intense interest to scholars, but there is no thoroughly acceptable survey. Jack Lindsay's *The Origins of Alchemy in Graeco-Roman Egypt* (London: Muller, 1970) will present the reader with some useful material. However, relatively few alchemical texts have been examined in detail. Robert Halleux is editing a new series of Greek texts, *Les alchimistes grecs: Tome I. Papyrus de Leyde: Papyrus de Stockholm: Fragments de recettes* (Paris: Société d'Édition "Les Belles Lettres": 1981) and William R. Newman has authored *The Summa Perfectionis of pseudo-Geber. A Critical Edition. Translation and Study* (Leiden et al.: E.J. Brill, 1991). Elias Ashmole's collection, the *Theatrum Chemicum Britannicum* (1652) with an introduction by Allen G. Debus was reprinted by the Johnson Reprint Corporation (New York, 1967). Current research in the field will be found in the journals *Ambix* and *Chrysopoeia*. A collection of papers from the former will be found in *Alchemy and Early Modern Chemistry: Papers from Ambix*, edited by Allen G. Debus (London: Jeremy Mills for The Society for the History of Alchemy and Chemistry, 2004). Another source for recent research will be found in *Alchemy Revisited: Proceedings of the International Conference on the History of Alchemy at the University of Groningen 17–19 April 1989*, edited by

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Z.R.W.M. van Martels (Leiden: Brill, 1990). Important for an understanding of the related fields of magic and astrology is Wolf-Dieter Müller-Jahncke's *Astrologisch-Magische Theorie und Praxis in der Heilkunde der Frühen Neuzeit, Sudhoffs Archiv*, Beiheft 25 (Stuttgart: Franz Steiner, 1985).

Beyond Pagel's work on Paracelsus mentioned above, one should refer to the collected works edited by Karl Sudhoff and Wilhelm Matthiessen [*Sämtliche Werke*, 15 vols., Munich/Berlin: R. Oldenbourg (Vols. VI–IX, O.W. Barth), 1922–1933]. A number of conferences resulting in books appeared at the time of the five hundredth anniversary of his birth (1493). Among them is *Paracelsus, The Man and His Reputation: His Ideas and Their Transformation*, edited by Ole Peter Grell (Leiden et al.: E.J. Brill, 1998). I summarized the works and debates of the chemical philosophers in *The Chemical Philosophy: Paracelsian Science and Medicine in the Sixteenth and Seventeenth Centuries* (2 vols., New York: Science History Publications, 1977, reprinted Dover, 2002) and later in a series of lectures presented at the Istituto Filosofici in Naples in 1990 [*Paracelso e la Tradizione Paracelsiana* (Naples: Citta del Sole, 1996)].

Studies of specific authors have appeared from a number of scholars. Owen Hannaway's *The Chemists and the Word* (Baltimore: The Johns Hopkins Press, 1975) compares the work of Oswald Croll and Andreas Libavius. Walter Pagel's *The Smiling Spleen: Paracelsianism in Storm and Stress* (Basel: S. Karger, 1984) discusses the work of a number of sixteen and seventeenth century chemical physicians. An author well acquainted with the Paracelsian texts was John Dee who has been a subject of interest for a number of historians. Perhaps the most significant contribution on Dee in recent years is Nicholas H. Clulee's *John Dee's Natural Philosophy: Between Science and Religion* (London: Routledge, 1988) while the first biography of Robert Fludd in nearly ninety years was written by William H. Huffman [*Robert Fludd and the End of the Renaissance* (London: Routledge, 1988)]. Zbigniew Szydło has examined the work of the Polish chemist, Sendivogius in *Water Which Does Not Wet Hands: The Alchemy of Michael Sendivogius* (London and Warsaw: Polish Academy of Sciences, 1994) and Zahkan E. Gel'man presented a survey of the work of Angelo Sala in "Angelo Sala, An Iatrochemist of the late Renaissance," *Ambix*, 41 (1994), 42–60. Bernard Joly has had a special interest in the work of the seventeenth century chemist, Pierre-Jean Fabre, which has resulted in his book, *Rationalité de l'alchimie au XVIIe Siècle* (includes a translation of his *Manuscriptum ad Fredericum*, 1653) (Paris: Librairie Philosophique, J. Vrin, 1992). Leonhard Thurneisser has received

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deserved attention in Peter Morys' *Medizin und Pharmazie in der Kosmologie Leonhard Thurneisser zum Thurn (1531–1596)*. Abhandlungen zum Geschichte der Medizin und der Naturwissenschaften, Heft 43 (Husum: Matthiesen Verlag Ingevert Paulsen Jr., 1982). David Harley has finally identified the author of *The difference between the auncient Phisicke . . . and the latter Phisicke* (1585) in "Rychard Bostok of Tandridge, Surrey (c. 1530–1605), M.P., Paracelsian Propagandist and Friend of John Dee" [*Ambix*, 47 (2000), pp. 29–36]. And Jole Shackelford has penned a major work on Peter Severinus and Danish Paracelsians in *A Philosophical Path for Paracelsian Medicine: The Ideas, Intellectual Context, and Influence of Petrus Severinus: 1540–1602* (Copenhagen: Museum Tusculanum Press. University of Copenhagen, 2004). On a related topic, mention should be made of William Eamon's *Science and the Secrets of Nature: Books of Secrets in Medieval and Early Modern Culture* (Princeton: Princeton U.P., 1994).

There remains much to be done in regard to the educational debates of the early modern period. Robert G. Frank has discussed "Early English Universities" in *History of Science*, 11 (1973), pp. 194–216, 239–269. Special note should be made of Bruce T. Moran's studies of Johannes Hartmann to be found in *The Alchemical World of the German Court: Occult Philosophy and Chemical Medicine in the Circle of Moritz of Hessen (1572–1632)*. *Sudhoffs Archiv*, 29 (Stuttgart: Franz Steiner Verlag, 1991); *Chemical Pharmacy Enters the University: Johannes Hartmann and the Didactic Case of Chymiatría in the Early Seventeenth Century* (Madison: American Institute of the History of Pharmacy, 1991). The original texts of John Webster, Seth Ward, John Wilkins and Thomas Hall are reprinted in Allen G. Debus, *Science and Education in the Seventeenth Century: The Webster-Ward Debate* (London: Macdonald/New York: American Elsevier, 1970).

The English scene has been studied by a number of authors. Important background material will be found in Keith Thomas' *Religion and the Decline of Magic* (London: Weidenfeld and Nicolson, 1971). Charles Webster's *The Great Instauration: Science, Medicine and Reform 1626–1660* (London: Duckworth, 1975) discusses the middle decades of the century in detail. P.M. Rattansi's incisive papers have been gathered in *Science, Religion and Society 1500–1700: From Paracelsus to Newton* (Variorum Collected Studies Series, in press). See also my *The English Paracelsians* (London: Oldbourne, 1965).

There has been an increasing interest in Spanish chemistry and Paracelsianism. José Maria López Piñero has published extensively on all aspects of Spanish science and medicine. Of particular importance is his reprint of the

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“Dialogus” (1589) of the Paracelsist, Llorenç Coçar (Valencia: Catedra e Instituto de Historia de la Medicina, 1977). His *Ciencia y Técnica en la Sociedad Española de los Siglos XVI y XVII* (Barcelona: Editorial Labor, 1979) is an important survey of the sciences in early modern Spain. More recently Mar Rey Bueno has written *El Hechizado: Medicina, Alquimia y Superstition en la Corte de Carlos II* (Madrid Ediciones Corona Borealis, 1998) and *Las Señores del Fuego: Destiladores y espagíricos en la corte de Asturias 1500–1700* (Madrid: Ediciones Corona Borealis, 2002). Miguel López Pérez has written *Asclepio Renovado: Alquimia y Medicina en la España Moderna* (Madrid: Ediciones Corona Borealis, 2003).

Lawrence Brockliss and Colin Jones have written *The Medical World of Early Modern France* (Oxford: Clarendon Press, 1997), an essential work for anyone interested in French developments. This may be supplemented with my *The French Paracelsians: The Chemical Challenge to Medical and Scientific Tradition in Early Modern France* (Cambridge: Cambridge U.P., 1991). A useful source for chemical medicine in Italy will be found in Giancarlo Zanier’s *Medicina e Filosofia tra ‘500 e ‘600* (Milan: Franco Angeli Editore, 1983).

In recent years there has been an increasing interest in Jean Baptiste van Helmont because of his far reaching influence. Here a key work is Walter Pagel’s *Joan Baptista Van Helmont: Reformer of Science and Medicine* (Cambridge: Cambridge U.P., 1981). Guido Giglioni has written another valuable study, *Immaginazione e Malattia: Saggio su Jan Baptiste van Helmont* (Milan: Franco Angeli, 2000). Among others who have studied van Helmont’s massive works is Antonio Clericuzio in *Elements, Principles and Corpuscles: A Study of Atomism and Chemistry in the Seventeenth Century* (Dordrecht: Kluwer, 2000). I have dealt with the influence of van Helmont in *Chemistry and Medical Debate: van Helmont to Boerhaave* (Canton, MA: Science History Publications, 2001).

Although my own research has not dealt in depth with Robert Boyle or Isaac Newton, mention should be made of a few of the many studies relating to the more esoteric aspects of their work. Until a few years ago only their positivistic contributions seemed to interest historians. However, Betty Jo Teeter Dobbs’ *The Foundations of Newton’s Alchemy or ‘The Hunting of the Greene Lyon’* (Cambridge: Cambridge U.P., 1975) and *The Janus Faces of Genius: The Role of Alchemy in Newton’s Thought* (Cambridge: Cambridge U.P., 1991) presented a different side of his work.

The works of Robert Boyle have attracted increasing attention also since the publication of Marie Boas’ *Robert Boyle and Seventeenth Century Chemistry* (Cambridge: Cambridge U.P., 1958). Steven Shapin and Simon Schaffner’s

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Leviathan and the Air Pump: Hobbes, Boyle and the Experimental Life (Princeton: Princeton University Press, 1985) and Rose-Mary Sargent's *The Diffident Naturalist: Robert Boyle and the Philosophy of Experiment* (Chicago: University of Chicago Press, 1995) helped to place Boyle as an experimental philosopher while Barbara Beguin Kaplan examined his medical views in *Divulging of Useful Truths in Physick. The Medical Agenda of Robert Boyle* (Baltimore: The Johns Hopkins Press, 1993). William R. Newman's *Gehennical Fire: The Lives of George Starkey, an American Alchemist in the Scientific Revolution* (Cambridge, MA: Harvard University Press, 1994) dealt with a key figure linking van Helmont and Boyle. Lawrence M. Principe has discussed Boyle's alchemical interests in *The Aspiring Adept: Robert Boyle and His Alchemical Quest* (Princeton: Princeton U.P., 1998). A collection of essays by a number of scholars interested in Boyle has been edited by Michael Hunter in *Robert Boyle Reconsidered* (Cambridge: Cambridge U.P., 1994). There is little doubt that interest in Boyle will continue to escalate with the publication of the new edition of *The Works of Robert Boyle* (14 vols., London: Pickering and Chatto, 1999–2000) edited by Michael Hunter and Edward B. Davis.

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