have been an intellectually challenging project, but if it had been successful, it would have demonstrated the value of iconographic studies for our field beyond any doubt. As it stands, this book can only reinforce the view that the concept of a detailed iconography is essentially antiquated. I feel that it has been a sadly missed opportunity. Images doubtlessly have a story to tell us, even more than instruments, as they are usually constructed with the aim of conveying a message, but that story has to be presented in imaginative and striking ways that demonstrate that they deserve to be taken seriously. This demands an original approach which is linked to broad issues in our field, such as the deconstruction of the classical view of the chemical revolution or the promotion of 'founder myths'.

Despite my misgivings, I have found much of value here and it is an important contribution to Lavoisier studies, presenting "a cultural biography" (to quote from Roald Hoffmann's foreword) of the Lavoisiers and an overview of the various French attempts to honor his memory. It is worth the price for the reproduction of the many Lavoisier images alone.

Peter Morris:
The Science Museum London, Exhibition Road, London SW7 2DD, UK;
P.Morris@nmsi.ac.uk

Instruments and Experimentation in the History of Chemistry, ed. by FREDERIC L. HOLMES and TREVOR H. LEVERE, MIT Press, Cambridge MA, 2000, xxi + 415 pp. [ISBN 0-262-08282-9]

Instruments and Experimentation in the History of Chemistry is a compilation of 14 articles presented at a Dibner Institute workshop of the same name held in Cambridge, MA on April 12-13, 1996. The papers are divided into three sections, "The Practice of Alchemy" (3 papers), "From Hales to the Chemical Revolution" (6 papers), and "The Nineteenth and Early Twentieth Centuries" (5 papers). The editors state in their introduction that, "The aim of this volume is simply to move the instruments and experiments into the foreground of our concern." This collection of essays certainly succeeds in showing that a global approach to the study of the history of chemistry is desirable, and necessary, for a thorough understanding of the subject to develop.

Contributions to the first section include "The Archaeology of Chemistry" by ROBERT ANDERSON, "Alchemy, Assaying, and Experiment" by WILLIAM NEWMAN, and "Apparatus and Reproducibility in Alchemy" by LAWRENCE PRINCIPE. A highlight of this section is Anderson's work on chemistry prior to 1750 and difficulties regarding the availability, and accuracy, of historical/archaeological records. The practitioners of early chemistry often treated their knowledge as proprietary and, thus, were less than forthcoming in their written descriptions. Likewise, scenes presented in woodcuts were often idealistic and poor reflections of actual laboratory practice. The poor quality of data is exacerbated by the very small sample size available for study. While the fragile nature of chemical ware certainly contributes to this issue, Anderson contends that advances will only be possible when field archaeologists become familiar with early chemical ware and, thus, able to recognize it when encountered.

The second, and main, section of the book contains "'Slippery Substances': Some Practical and Conceptual Problems in the Understanding of Gases in the Pre-Lavoisier Era" by MAURICE CROSLAND, "Measuring Gases and Measuring Goodness" by TREVOR LEVERE, "The Evolution of Lavoisier's Chemical Apparatus" by FREDERIC HOLMES, "'The Chemist's Balance for Fluids': Hydrometers and Their Multiple Identities, 1770-1810" by BERNADETTE BENSAUDE-VINCENT, "'Fit Instruments': Thermometers in Eighteenth-Century Chemistry" by JAN GOLINSKI, and "Platinum and Ground Glass: Some Innovations in Chemical Apparatus by Guyton de Morveau and Others" by WILLIAM SMEATON. While the six titles may appear to be unrelated, a number of common threads tie them together.

One such thread is that scientific advances occur within a framework of existing knowledge and concepts. This is nicely illustrated by Crosland's article involving gases prior to Lavoisier's arrival on the chemical scene. 'Air', the term used for all gases, was thought of in terms of 'spirits' and 'invisible and subtle fluids' such as phlogiston, gravity, ether, and electricity. In addition to the bias that 'air' was unworthy of investigation, the difficulties involved in handling and analyzing gases were immense. Early explorers in this realm of chemistry had little foundation, either from an experimental apparatus / technique or theoretical/conceptual, to build upon. Once the concept of air being comprised of different entities, *i.e.*, type of gases, was realized, work in the area progressed extremely rapidly. For example, the 1766 edition of Macquer's *Dictionary of Chemistry* included a mere two paragraphs on gases while the 1778 edition dedicated 100 pages to the subject!

Levere continues the discussion on the developments involving gases, however, his emphasis is on techniques for measuring amounts of gases. Specifically, he does an excellent job by comparing the relative precision of volumetric *versus* gravimetric methods. A nice argument for resulting improvements in available balances is also put forth which brings us to a second thread in this section: developments in chemistry involve a constant feedback between theory, experiment and instrument design. Advances and improvement in these areas open up new opportunities in each of the others.

This dependence of theory and experimental methods on available apparatus leads nicely into Holmes' discussion of instrumentation developed by Lavoisier. It is well known that Lavoisier's laboratory was extremely well equipped and charges have been leveled that his experiments involved unduly complex, and expensive, apparatus. Holmes refutes this assertion and states, "Lavoisier did not resort to complicated and unique apparatus fortuitously or to make chemical experimentation inaccessible to those less wealthy than he. He did so when confronted with problems that required new solutions." (p. 148)

The essays by Bensaude-Vincent and Golinski are more specific, dealing with the development of hydrometers and thermometers, respectively. These contributions pair nicely as each instrument faced similar difficulties in both the standardization of calibration methods and competition between competing models. I was particularly struck by the difficulty involved in measuring thermal expansion coefficients, and their temperature dependence, when you need this information *a priori* to construct an accurate thermometer. This circular relationship underscores how much 'fundamental science' is currently taken for granted.

The sixth, and final, contribution to the second section of the book involves early uses of platinum for the production of inert laboratory vessels. Although platinum was incorporated into chemical ware as early as the 1770s, very few early specimens still exist. This concurs with Robert Anderson's discussion on the dearth of archeological artifacts dating prior to 1750. However, unlike the proprietary interests and fragility of glassware discussed in the earlier chapter, the lack of platinum specimens can be directly attributed to its high cost and ease of which it can be recycled.

The third, and final, section of *Instruments and Experimentation in the History of Chemistry*, contains five works covering "The Nineteenth and Early Twentieth Century". Contributions include "Multiple Combining Proportions: The Experimental Evidence" by MELVYN USSELMAN, "Organic Analysis in Comparative Perspective: Liebig, Dumas, and Berzelius, 1811-1837" by ALAN ROCKE, "Chemical Techniques in a Preelectronic Age: The Remarkable Apparatus of Edward Frankland" by COLIN RUSSELL, "Bridging Chemistry and Physics in the Experimental Study of Gunpowder" by SEYMOUR MAUSKOPF, and "Laboratory Practice and the Physical Chemistry of Michael Polanyi" by MARY JO NYE.

Usselman's chapter on the development of the law of multiple proportions provides wonderful insight on both the development of a pillar of modern chemistry and its chief protagonists. I found the statement, "Likely, Dalton was able to achieve his nitrous gas – oxygen results only under the impress of his preconceived theory [...]" (p. 266) fascinating at it flies in the face of what many consider 'good' science. Even more troublesome are the implications that Thomas Thompson's experimental 'verification' of Dalton's theory of multiple proportions was fraudulent. Investigation into this potential early example of data falsification justifies further study.

The chapters by Rocke and Russell once again highlight how important the laboratory skills of the experimenter are with respect to obtaining new results. *Exceptional lab skills are found at the center of advancement.* A bonus of Rocke's contribution is his discussion of the personalities, and egos, involved in the birth of organic chemistry, perfectly summarized in a letter from Berzelius to Liebig, "My dear Liebig, I say this without the slightest trace of resentment: you must stop being a chemical executioner..." (p. 294).

The penultimate chapter covers investigations into gunpowder conducted from a truly scientific perspective and a more pragmatic, engineering, perspective. As stated by Mauskopf, "Chemistry has always been the quintessential 'mixed' science, as much devoted to the creation and improvement of material products as to the elucidation of the natural laws that govern material behavior" (p. 335). His analysis and comparison of investigations by Bunsen and Schischkoff with those of Nobel and Abel superbly support this statement.

The final contribution covers Michael Polanyi's contributions to physical chemistry before he turned his efforts to philosophical issues. Having read Nye's account of Polanyi's early work I could not help but notice the number of false starts and missed opportunities he experienced early in his career. A startling example of this is his misinterpretation of x-ray results for cellulose in the mid-1920s. As with much of the work presented in earlier chapters, there is a clear dependence of scientific advances on the development of new, or improvements to existing, experimental methods and instrumentation.

This collection of essays plays an important role in reminding us that chemistry is a laboratory science. Advances in our understanding of the subject are intrinsically tied to advances in instrument design and the development, and deployment, of superb laboratory skills. Although these concepts are constantly lurking below the surface of scholarly endeavors, they have only recently begun to be examined. Another recent example of work in this area include the Workshop of the Commission on the

History of Modern Chemistry entitled, *From the Test-tube to the Autoanalyzer: The Development of Chemical Instrumentation in the Twentieth Century* held in August of 2000 at the Science Museum of London, previously reported in this journal (*Hyle,* 7 [2001], 78-81) and published in a book edited by Peter Morris, *From Classical to Modern Chemistry: The Instrumental Revolution* (Royal Society of Chemistry, 2002) (see Daniel Rothbart's book review in the present *Hyle* issue).

In conclusion, *Instruments and Experimentation in the History of Chemistry* is an important early step in recognizing the experimental nature of our science. Any rigorous investigation into chemistry's experimental roots must include an analysis of the instruments involved. This is superbly summarized by Mauskopf when he states, "Sometimes, indeed, even conceptually separating experimental techniques and instruments from theories is difficult" (p. 354). Although some of the included papers are presented in incomplete form, the book as a whole presents a coherent analysis of its subject matter. It will make a fine addition to the bookshelf of anyone interested in the experimental aspects of chemistry's roots, as well as institutional libraries.

Shawn B. Allin:
Department of Chemistry, Spring Hill College, Mobile, AL 36608, U.S.A.; sallin@shc.edu

The Revolution in Instrumentation

From Classical to Modern Chemistry: The Instrumental Revolution, ed. by PETER J. T. MORRIS, The Royal Society of Chemistry, Cambridge, 2002, xxv + 347 pp., £75.00 [ISBN 0-85404-479-5].

The maxim that technological discoveries are derived from theoretical advances in pure research cannot account for the twentieth-century revolution in instrumentation. The transition in research techniques from 'wet chemistry', for example, to a chemistry driven by the fingerprinting techniques of electronic instrumentation had a profound effect on 'pure research'. More significantly, the alleged privilege given to pure researchers over instrument makers is undermined as the close relationship between instruments and their experimental results emerges. This instrumentation revolution was waged in the offices, conference rooms, and laboratories of the chemical industry, responsive to the needs of manufacturers, government agencies, and military institutions; and these are the themes explored in a recently released work, *From Classical to Modern Chemistry: The Instrumental Revolution*.

All but three of the chapters in this volume are revisions of presentations at a conference held at Imperial College, London, in August 2000. The volume is well organized by the editor, PETER J. T. MORRIS, and the high level of scholarly rigor exhibited in these pages reflects the expertise of the authors. The reader will be richly rewarded by this fine work, finding depth in the case studies of various instruments and breadth in the range of ideas related to the science/technology interaction in chemistry. Many of the instruments examined in this volume are identified as research technologies, to use TERRY SHINN's phrase.