

BOOK REVIEWS

The Diffident Naturalist: Robert Boyle and the Experimental Philosophy. Rose-Mary Sargent, University of Chicago Press, Chicago, IL, 1995. xi + 355 pp. Paper, \$26.

Robert Boyle and the Limits of Reason. Jan W. Wojcik, Cambridge University Press, Cambridge, 1997. xvi + 243 pp. Hardcover, \$59.95.

Recent years have seen a great revival in historical writing on Robert Boyle, the 17th-century Anglo-Irish nobleman's son best known for "Boyle's Law." He has been celebrated not only for his positive contributions to the early development of hydrostatics and chemistry, but for his advocacy of the experimental method. In his own day, learned men and women throughout Europe knew his name as one of the most thoughtful English proponents of the "new and experimental philosophy," making a visit to his laboratory an almost mandatory stop on their tours of England. Poor Boyle frequently had to entertain visitors, keeping him from the work to which he otherwise devoted every day but Sunday. He and his assistants accomplished enough, however, to make his name well known still; his *Sceptical Chymist* has been in print almost constantly since it was first published in 1661. Boyle has recently recaptured the interest of historians as a representative of the kind of science pursued by the so-called virtuosi. A virtual industry has come into being devoted to writing about the scientific world of Boyle's time as seen through the prism of his life and work, while at the same time Michael Hunter and others have been busy scrutinizing, cataloguing, and publishing his voluminous manuscript papers.

The works of Sargent and Wojcik were published before their authors were able to take advantage of the new information emerging from Boyle's papers, although they had glimpses of that new work, so their books rely mainly on his published works for evidence of his views. It is well known, and acknowledged by both authors, that Boyle took great care to present his polished pieces in a form that would give as little offense as possible, so his first thoughts and more risky hypothesizing seldom show up in his books. Moreover, his potentially explosive opinions about the medical establishment of his time remain mostly hidden from his readers, while he is virtually silent on anything closer to the centers of power. Both authors are well aware that Boyle's thoughts and his published words may not be identical. Nevertheless, as accounts of Boyle's public expressions, both books give us very balanced treatments, especially Sargent's.

Sargent attempts an overview of Boyle's intellectual world and the place of his thoughts within it, and as a result gives us the best general account of his ideas we have had in a generation or two. She divides her analysis into three parts. In the first, the background scene in philosophy, law, and experimentalism is painted in broad strokes but with enough color to make it interesting. Boyle's religious outlook—he famously took up his work as a "Christian virtuoso"—is given in more detail in the second part. The third section takes up his experimental endeavors. This last section will interest historians of science especially for Sargent's tempered but well-considered criticisms of other recent accounts of Boyle's scientific practices; such comments are enough so that readers who want simply to get a view of Boyle's outlook will likely not be distracted (although this re-

viewer found her several negative pronouncements about “contextualist” history irritating). All three sections find Sargent interpreting the words of Boyle and his predecessors with confidence and ease. She, like so many others, finds the center of his concerns to be in uncovering God’s creation so as to appreciate Him better through his works. Religiously and temperamentally, he always remained “diffident,” refraining from bold claims or generalizations announced to be certain. He was a humble experimental scientist, seeking the causes of things but remaining always prepared to reconsider hypotheses in the face of new evidence, which had to be gathered through persistent and patient investigation. Sargent’s final and most detailed examples—from Boyle’s investigations into the causes and consequences of cold temperatures—illustrate very well the way in which he struggled by experiment to stabilize and to make sense of the stunning variety of nature’s phenomena. Sargent has produced an impressive synthesis from Boyle’s best known published books and a few of his lesser known treatises, although whether it well represents his more private work and thoughts is yet to be seen.

The theme of Boyle as a person whose experimental science emerged from his theological concerns is developed further in Wojcik’s book. To the author, Boyle is best assessed as a lay theologian, whose early religious education and eclectic reading turned him away from full confidence in reason. Some parties, most notably the Socinians, argued that nothing in scripture contradicted human reason; others, such as Hobbes and Spinoza, developed rational systems that seemed to leave no place for God, at least once the world was created. The development of such doctrines led away from religious conflict, but also away from Christian trinitarianism and other basic tenets of faith. Boyle left a place in his heart and mind for mysteries beyond human comprehension—in this Wojcik agrees entirely with Sargent that he is well described as diffident. But Wojcik

goes farther. A seldom examined treatise of Boyle’s, *Things Above Reason* (1681), is the main text, supplemented with some of his other theological treatises. From such works, Wojcik finds Boyle to be one who had doubts about the ability of reason to appreciate fully the wonders of God and his works. Because of this, Boyle considered evidence about the world gathered through our senses and tested by considered experiments to be the only way that one could come close to truth about creation and its creator. In other words, the best path toward comprehensive religious knowledge lay through the senses rather than reason, coupled with an acknowledgment that what we learn of the material world depends on a spiritual power that can be only inferred. In limiting the powers of reason in this way, Boyle had to depend on probabilistic conclusions rather than ones that had complete certainty. His science was not that of a mathematical proof but of a close and exacting description of phenomena suggesting as many questions as answers.

Exactly what turned the young Boyle from moral philosophy and theology toward experimental science in the mid 1640s is something we may never fully understand from the extant record. Whether some line of thought or inner experience might have been enough to alter the focus of his work is open to question, as must be the issue of how much his science depended on his religious outlook. That he saw no contradiction between his experimentalism and his faith is quite clear, unless one wants to take the position that he protested too much. Both Sargent and Wojcik take him at his word, and that is probably best, at least until we know more from the manuscript sources. As clear and learned interpretations of Boyle’s public professions in favor of a virtuous experimental science, both books can be highly recommended. *Harold J. Cook, Departments of the History of Medicine and History of Science, University of Wisconsin, Madison, WI 53706-1510*

Natural Dyestuffs and Industrial Culture in Europe, 1750-1880. R. Fox and A. Niete-Galan, Ed., Science History Publications/USA, Canton, MA, 1999. xxix + 358 pp. \$49.95

It is a common misconception that there is little of interest to chemist historians concerning natural dyestuffs. To rectify this false perception, a workshop on natural dyestuffs history was held at Oriel College, Oxford, January 4-6, 1996, organized by Robert Fox, Professor of History of Science at Oxford University. Under the sponsorship of the European Science Foundation, a distinguished group gathered to discuss various aspects of natural dyestuffs. This volume contains eleven papers from the workshop and presents to the reader a comprehensive discussion of natural dyestuffs and the industry that developed around them.

These papers deal with the subjects from the perspectives of the history of science, the history of technology, economic history, and the history of art to produce an integrated study at many levels. These eleven papers are divided into four main subject areas. The first deals with the question of whether there is really any chemistry than can be associated with the natural dyestuffs. The second and third discuss questions concerning the role of geography, the markets and the skills of the workers in Europe exploiting natural dyes, and the role natural dyestuffs played in the development of the factory system. The final section deals with the decline of natural dyestuffs and the transition to the science-based synthetic dyestuff industry. From the perspective of the chemist historian, the most satisfying parts of this volume are the first and last sections. The papers in these sections will form the basis of this review.

Bernadette Bensaude-Vincent and Augusti Niete-Galan open the volume with a paper, "Theories of dyeing: a view on a long-standing controversy through the works of Jean-Francois Persoz." Persoz (1805-1868) was involved in many theoretical controversies concerning the dyeing action of natural colorants. A particularly vitriolic controversy occurred with Walter Crum (1796-1867), a Scottish calico printer. Beginning in the eighteenth century French chemists such as Charles-Francois Dufery, Pierre-Joseph Macquer, and Claude Louis Berthollet contributed several treatises on dyeing. Whether the mechanism of dyeing was mechanical or chemical in nature was at the heart of the various controversies. Macquer and Berthollet were the first to

discuss dyeing in terms of the 'new chemistry' with oxygen as the agent of the changes in color and chlorine as a new bleaching agent. Chemical affinity between the fabric, the dye, and the solvent was implied to be the reason for varying degrees of fixation of the dyes.

In 1846 Jean-Baptise Dumas published his views on the theory of dyeing, in which he proposed that there could not be an exclusively physical or chemical explanation. In this same year Jean-Francois Persoz presented his own ideas in a four-volume work, *Traite theoretique et pratique d'impression des tissus*. Persoz, a recognized expert on dyes, served in several official positions associated with the dye industry. As a chemist he was very much concerned with theoretical problems, especially molecular explanations. He viewed chemical reactions as the result of the rearrangement of atoms in a molecule. This put him on a collision course with Walter Crum, who had studied chemistry with Thomas Thomson at Glasgow. Crum succeeded Thomson in the chair of chemistry at Glasgow in 1852. Crum advocated a purely mechanical view that the dye penetrated the fiber, while Persoz took the view that it was deposited on the surface and a reaction then occurred. Crum argued that, since cotton could be dyed without destruction of the fiber, the process had to be more mechanical than chemical. Persoz insisted it was a chemical attraction between metal oxides in the fiber and the organic dye that was responsible for the coloring. Neither Persoz nor Crum was able to convince the other, but the controversy is important in that it allowed the dyeing problem to be reformulated on a new physico-chemical basis. Some of the details of the investigations that followed are discussed in this paper.

The papers by Gerard Empotz and Girolamo Ramunni in French, and hence less accessible to the general reader, round out this first section. Ramunni presents a discussion of the controversy among French chemists associated with the true coloring matter of the red natural dyestuff madder or Turkey red. In 1868, Carl Graebe and Carl Liebermann synthesized alizarin, thus establishing it as the key component of natural madder. Rumanni chronicles disputes over the mechanism of the natural dyeing process through a discussion of papers that appeared in *Annales de chimie et de physique*. The end result of this research did not produce a comprehensive answer, but it stimulated significant work that would later be useful.

In his paper, "Chimie des colorants et qualité des couleurs face au changement technique dans les années

1860," Gerald Empotz discusses the contributions of Persoz, Michael-Eugene Chevrene, and Paul Schutzberger in the era that preceded the change to synthetic dyestuffs. These investigators were more interested in the use of chemistry to establish quality control than in the potential of chemistry to create new dyes. They were fearful for the most part that synthetic dyestuffs would decimate an industry that was associated with so much artisan skill. A general conclusion is that there may have been an attempt to use chemistry to explain the dyeing process but that there was no systematic science of natural dyestuffs.

The last three papers of the collection are of special interest to the chemist historian. Richard L. Hills presents a fascinating study, "James Watt and Bleaching." Hills has studied Watt's papers, which have only recently become available, to highlight this little known facet of Watt's career. This is concerned with the development of a process to make chlorine in sufficient quantities and at a suitable price so that it could be used commercially for bleaching. Watt maintained a lifelong interest in chemistry and especially in its application to commercial ventures. In a visit to Paris in 1786, Watt learned of the bleaching power of chlorine from its discoverer Berthollet. Watt immediately recognized the possibility of chlorine as a replacement for other methods then being used to bleach cotton. Watt's father-in-law James McGregor, who was in the textile business in Glasgow, became his partner in the venture. Hill's paper describes Watt's improvement of the Berthollet process for preparing chlorine and the development of the equipment to produce chlorine on a commercial scale. Our lack of awareness of this aspect of Watt's career, according to Hills, stems from the secrecy in which Watt shrouded his operations to prevent their being copied and stolen. Others soon developed competing processes to make chlorine; this venture never afforded the rewards that the steam engine did for Watt, to whom must be given the long overdue credit for developing a chemical apparatus which could produce chlorine safely and easily.

Anthony Travis presents a case study of the transition from natural to synthetic dyes through a discussion

of the career of Heinrich Caro (1834-1910). Caro was unique in that he was a chemically trained textile colorist, whose early career in Germany was centered on natural dyestuffs and the calico printing industry and who made the transition to the new synthetic dyestuffs. In 1859, Caro left Germany to work at Rober, Dale & Co. in Manchester, the center of the textile industry in England. Initially Caro worked in natural dyestuffs, but by 1862 he was completely involved in the new coal tar-based aniline dyes discovered by Perkin in 1856. Over the next five years Caro participated in the discovery of novel dyestuffs and finding more efficient processes for products already on the market. He also did technical service work for his employer. Returning to Germany in 1866, he worked with Bunsen at Heidelberg for two years until he joined BASF. There Caro was instrumental in the development of azo dyes and synthetic indigo. The many contributions made by chemists such as Caro in producing new synthetic dyes and understanding their chemistry led to the gradual collapse of the natural dyestuffs industry in many parts of Europe by the 1880s.

Christian Simon, in "The transition from natural dyestuffs to synthetic dyestuffs: the case of Basel 1850-1940," shows that natural dyestuffs were not as quickly replaced by synthetic materials as is generally assumed. His paper is a case study of the firm J. R. Geigy, which, from 1860-1940, operated two adjoining plants, one for natural and the other for synthetic dyes. According to Simon, there is an abundance of archival material to assess how these two coexisting ventures fared. The author presents a comprehensive history of the development of the Geigy Company and shows that there was a linkage between the natural and synthetic dyes at times and that they complemented each other for almost eighty years. By the 1940s natural dyes had essentially disappeared because their cost rendered them noncompetitive.

All the papers in this volume include extensive notes which offer the reader further opportunities to explore the subjects in greater detail. *Martin D. Saltzman, Providence College, Providence, RI 02918.*