if any, detrimental health effects have occurred.

A second point of concern arose when the author stated, "The effect of a chemical on human health implies an influence at a higher level than mere chemistry (in our contemporary sense) suggests. Defined in our strict sense, in other words, a chemical has no business affecting human health. Yet it does. How so?" (p. 329). Clearly the problem lies in a faulty definition of 'chemical'. Most readers would agree that a mutated protein qualifies as a 'chemical' and yet to imply that such a species "has no business affecting human health" is absurd. This brings to mind sugar packets that are labeled 'Chemical Free'.

A notable contribution in this section is BOGAARD's discussion of the distinction between quantum chemistry and quantum physics arising from the work of G.N. Lewis. The idea that quantum chemistry must account for both the stability of a molecule and its structure while quantum physics is concerned only with energy (stability) issues is a salient one.

In conclusion, *Chemical Explanation: Characteristics, Development, Autonomy* is a worthy addition to your institution's library. My only major complaint is the lack of a comprehensive subject index. This is inexcusable given current electronic publishing capabilities. The utility of this volume as a resource will be severely limited by this omission – an unfortunate consequence given the high quality of many of the papers. With the ever-growing interest in the philosophy of chemistry, these proceedings will act as a mile marker to gauge how far we have progressed from the summer of 2002.

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WILLIAM R. NEWMAN & LAWRENCE M. PRINCIPE: *Alchemy Tried in the Fire: Starkey, Boyle, and the Fate of Helmontian Chymistry*, The University of Chicago Press, Chicago, 2002, xiv + 344 pp. [ISBN: 0-226-57711-2]

"In this study, we have also tried to provide a view of chymistry in terms of an independent, long-term, and continuous development." This sentence from the final chapter encompasses much of what is analyzed in detail in this book, particularly the "continuous development". The volume is actually a kind of *syntaxis megale*: although readers learn much from it alone, those who seek a deeper study of the topics should first acquaint themselves with the previous books of both authors – Newman's *Gehennical Fire* (Harvard University Press, 1994; reprinted by University of Chicago Press, 2003), and Principe's *The Aspiring Adept* (Princeton University Press, 1998), dealing with Starkey and Boyle, respectively. Those who are even more demanding should consult Newman's critical edition of the *Summa Perfectionis* (Leiden, 1991) because the continuous development mentioned above has its roots in the High Middle Ages. The progress during the 17th century can be further studied in Debus' *The Chemical Philosophy* (Science History Publications, 1977; reprinted by Dover Publications, 2002). This enumeration of Newman's and Principe's books also illustrates the continuous development of both authors.

Apart from a broader historical perspective, the reviewed book is composed in such a way that it forms a closed entity in which several key personalities of the 16th and 17th centuries appear as living beings with specific ideas and personal interactions that are fleshed-out and emphasized. Sometimes the protagonists' personal features appear within the discussion of seemingly different topics, such as with the style of their works. Although the text involves numerous figures of the 16th- and 17th-

century chymical scene, the book focuses on Robert Boyle, George Starkey, and Jan Baptista van Helmont.

In the first chapter, the reader becomes acquainted with Boyle's transformation from a moralist to a scientist, while in the next chapter the role of weight and measure in chemical experimentation is discussed at length. Starkey's approach to laboratory methodology is then revealed through a detailed analysis of his notebooks. The impact of the Hartlib circle on the collaboration and friendship between Boyle and Starkey is likewise shrewdly examined. The book closes by ordering the 'triumvirate' of van Helmont, Starkey, and Boyle, as demonstrative of chymistry's continuous development (in which Homberg was also involved).

This brief recapitulation of the content cannot provide the vivid picture of chymistry that readers find in the book. In this respect, the discussion of intellectual property and Boyle's attitude to that problem (p. 27ff) is particularly interesting. Although he was forced to fight against the plagiarism of his own works, he declined to cite Sennert and Starkey when using their works. Similarly, the origin of Newton's *Clavis* can be traced back to Starkey, though Newton did not cite the original source. This discussion is interesting as it reveals personal characteristics of the figures of this story; but it is also of value to modern science, as the roots of the 'fair' approach to other scholars can be taken as a sign of the emergence of modern scientific attitudes, even though priority problems still occur. It was common in alchemical literature to cite earlier, respected authorities such as Geber (often without distinguishing between the Arabic author Jabir and the later Pseudo-Geber), Raymond Lully, and Basil Valentine, to name a few prominent personalities. However, the citation of contemporary authors was rare in 17th-century chymistry, and it was only modern chemistry that essentially changed this picture.

Starkey's criticism of contemporary university curricula is no less interesting to modern audiences (p. 163). He was not alone though, as there were numerous critics of the educational establishment at that time (see chapter 6 of Debus' *The Chemical Philosophy*). Although not directly linked to the development of chymistry or modern chemistry, the topic remains alive in today's continual debates on the subject matter of university curricula. For readers unfamiliar with this history, it is only further evidence that 'nothing is new under the sun' in the field of university education. Though this remark may appear beyond the scope of the review, it illustrates the broad scope of the book.

All the scholars whose activities are described in the book were to some extent inclined toward the alchemical world – Starkey and Boyle were particularly arduous adherents. Even von Suchten, who is said to have denunciated *alchemia transmutatoria* (p. 52) regarding the failure of the artificial preparation of metals from antimony, had a second attitude. His own work focused on the *tinctura philosophorum* (*Alexandri von Suchten Chymische Schrifften*, Hamburg 1680, p. 34ff.), and he emphasized that only a madman would ever reveal the secrets of alchemy (p. 163, "es müste doch einer / der solche herzliche Kunst hätte / ein Thor seyn / daß sie [...] ohn alle vertunkelte Wort an Tag geben wolt."). The book mentions Boyle's secrecy on his alchemical pursuits, but Principe's *Aspiring Adept* has much more details.

The ideas introduced in the second chapter, "Number, Weight, Measure, and Experiment in Chymistry", continue through the rest of the book like Ariadne's thread. The authors reveal how two lines of development gradually converged toward modern chemistry. One of these was the use of increasingly precise weights in laboratory techniques, which peaks in Lavoisier's experiments (and Cavendish's, but his work is beyond the scope of this book). The second was a gradual increase in the purity

of substances used in chemical experimentation. Both lines are still approaching the ideal state that modern science would like to reach, but every additional 'nine' at the end of the purity grade of manufactured compounds illustrates the difficulty of attaining this state even in the era of nanotechnology. In the past, however, the distance between precise weighing and the purity of substances was much greater, such that for instance apparently identical processes could yield quite different products. There was a gray zone of alchemical recipes in the space between these converging curves. Such recipes, though nebulous at first sight, nevertheless describe reasonable chemical operations. As one of the authors (L.M.P.) has noted elsewhere ('Chemical Translation and the Role of Impurities in Alchemy', *Ambix*, **34** [1987] 21-30), the role of impurities in past chemical experiments was of considerable significance. The reviewed book contains numerous descriptions of experiments, but some readers might miss explanations in terms of modern chemistry, which the authors only occasionally provide (as in the footnote 46, p. 287). Keeping in mind the problems of interpreting old recipes, it would seem that more modern explanations better illuminate what the experimenters described in this book actually prepared and how they understood their results.

Both authors are well-known for their attempts to outline the scope of alchemy. Their attitude toward the esoteric branch of alchemy is rather skeptical, and they touch this point especially in relation to Jung and Eliade (p. 36). Although the present reviewer shares this skepticism to some extent, further analysis of this problem would be useful. The first difficulty is to clearly define what alchemy actually was, or what can be all included into this concept. History shows this to be a difficult problem, because alchemy underwent deep changes in space and time, such that, for example, Indian alchemy should be looked upon differently than that of the Hellenistic world or the European Renaissance. Continuous communication between alchemists and 'craftworkers' altered the face of alchemy over the centuries. Mystical approaches to alchemy did exist, but their roots are multiple and complicated. What might be considered as a distant echo of shamanism in some of Ko Hung's statements, could, in some other culture, be interpreted as reflecting a different influence. In the European sphere, religion should be considered important, as many of those who pursued alchemical activities were deeply religious. Boyle, as Principe has shown in *The Aspiring Adept*, was intensely religious, though he followed a rationalist line of scientific thinking. That does not mean, however, that all the European alchemists and chymists agreed on the role of religion and mysticism in their work. Others, like Starkey, considered divine intervention as natural and beneficial to their laboratory operations, while to other workers of that era it was a requisite condition of success that would also throw a divine light on themselves. Although Newman and Principe are correct in pointing out that the older historiography of alchemy overestimated esotericism, that does not mean that it did not exist at all. Yet, as mentioned above, it is a very difficult task to analyze this problem as long as alchemy has rather nebulous boundaries. Further studies will hopefully reveal a fuller picture of this issue

In summary, this book provides an excellent picture of a period of transition, an epoch when the development of chymistry accelerated, against the background of deeply rooted scientific traditions that resulted in the vacillation between elements, principles, and corpuscles, and between alchemy and chymistry. It was a time in which earlier ideas were gradually shattered. This process did not come as a bolt from the blue, but had its roots in the past, from at least as far back as the time of Pseudo-Geber. Though the field of chymistry in the 17th century was ripe for change, it

occurred, as the introductory sentence of this review indicates, as a continuous process that accelerated over time. This book is useful and enjoyable not only for historians of chemistry, but also for anyone interested in the history of science in general.

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