Liebig, Adolf von Baeyer, and Emil Fischer and the physiologist Franz Hofmeister.

In *Fermentation: Vital or Chemical Process?* Fruton succinctly summarizes some of the various historical approaches to understanding fermentation from antiquity to the mid-twentieth century. He has divided the subject into four broad periods: vitalistic interpretations of fermentation from antiquity to Paracelsus, the transition to corpuscular theories in the seventeenth and eighteenth centuries, the movement to a chemical explanation in the nineteenth century, and the elucidation of the specific biochemical enzymatic pathway during the twentieth century. Not surprisingly, the last two chapters, where Fruton draws on his knowledge and previous historical work, are the strongest and most detailed.

There are, however, two significant problems with Fruton's approach. First, the chapters unfortunately read like a brief literature review, presenting a list of subjects of one important book or paper after another that offers little analysis of their content or interconnecting themes but includes what would seem to be irrelevant material. A brief introduction and a conclusion do offer some analysis. Fruton's primary conclusion is the importance of analogical thinking for understanding fermentation, from the alchemists' idea of "ferments" in producing metals to the use of specific analogical arguments between biochemical pathways and known chemical reactions.

It is Fruton's use of "analogy" in this regard that leads to the second major problem with this book, which is its imprecise use of the term "fermentation" itself, particularly for the premodern era. Fruton initially defines "fermentation" as the production of beer and wine by yeasts, and it would seem that his goal is to look at explanations for this process, culminating in the twentieth-century chemical understanding of it. Yeast fermentation as such, however, is too restrictive a definition, because until the nineteenth century fermentation was an extremely broad concept, used to explain everything from digestion to metal formation to all vital processes. Fermentation in this broad sense can be seen in the many examples that Fruton cites, yet he does not recognize that many of these phenomena are not brewing or wine making. Surprisingly, Fruton does not even suggest that the fundamental change in understanding fermentation would entail a movement away from this extremely broad understanding to recognition of a specific chemical process.

This is not to say that the book is without merits. It does identify and provide a good overview of the relevant texts and has an excellent set of references to lead the reader to relevant primary and secondary literature (especially for the twentieth century). Yet, overall, readers looking for insight on the level of that offered in Fruton's earlier works will, unfortunately, be disappointed in what is likely the last published work of his otherwise outstanding career.

PETER J. RAMBERG

Stephen Gaukroger. *The Emergence of a Scientific Culture: Science and the Shaping of Modernity, 1210–1685*. ix + 563 pp., figs., bibl., index. Oxford: Oxford University Press, 2006. £35 (cloth).

With the book under review, Stephen Gaukroger presents the first in a planned series of five volumes on the phenomenon of a scientific culture as a distinctive feature of the modern West. By "scientific culture," Gaukroger means a culture in which scientific practice "was able to establish cognitive priority for itself, so that it was able to shape other cognitive values around its own" (p. 19), and, moreover, a culture in which scientific values of both a methodological and a moral nature—commitment only to reason and experience, personal impartiality in the pursuit of the truth, and so forth—became morally and even politically exemplary. Gaukroger uses the term "Scientific Revolution" to refer not to fundamental changes in astronomy, mechanics, or chemistry between Copernicus and Lavoisier but, rather, to the transition from the "cultural idiom" characteristic of the Middle Ages to this scientific culture. And he further asks what the preconditions, factors, and circumstances had been that enabled scientific practice to accomplish this revolution in the West and why it was so successful—that is, why this scientific culture was able to consolidate itself (Pt. 1). The emergence, development, and consolidation of the scientific culture of the West certainly deserve a thorough investigation and elaboration, regardless of whether, or to what extent, one considers scientific culture a matter of the West's self-fashioning. Gaukroger's enterprise is a new attempt at spelling out the significance of the Scientific Revolution for the self-image of our culture today—an attempt in the history of ideas, as this first volume suggests.

The Emergence of a Scientific Culture: Science and the Shaping of Modernity, 1210–1685, investigates the preconditions and very first stages of this revolution, treating the period from 1210, the year of the first condemnation of

Aristotle in Paris, to 1685, just before the appearance of Newton's *Principia*. Given Gaukroger's focus on the emergence of the scientific culture of the West, it is no surprise that we do not find here a grand narrative of the historical development of the different sciences in this period, of the sort presented in David C. Lindberg's *The Beginnings of Western Science* (Chicago, 1992) or A. C. Crombie's *From Augustine to Galileo* (Doubleday, 1959). Instead, we are offered a history that centers on *philosophia naturalis*: its relations to the dogma of the Christian faith after the transformation of theology through the adaptation of Aristotle (Pt. 2) and its transformation into natural philosophy in the course of the sixteenth and the seventeenth centuries (Pts. 3–5).

Part 2—in the manner of standard histories of philosophy—portrays the tensions between *philosophia naturalis* (in the tradition of Aristotle since the thirteenth century as well as, in the fifteenth century, that of Plato) and core articles of the Christian faith (such as the immortality of the soul), as well as the unceasing attempts at a reconciliation of these two cognitive realms. This choice of focus is significant for Gaukroger's enterprise for two reasons. First, and generally, it makes clear at the outset that the relation of religion and science was in no way one of mutual exclusion and thus, with respect to the later Scientific Revolution, that science did not simply replace religion as the shaping force of culture. Second, and more specifically, it allows Gaukroger to present *philosophia naturalis* as becoming (in the thirteenth century) "the entry point in philosophy generally, including philosophical theology" (p. 76). Science, in the form of *philosophia naturalis*, was thus no less central to Western culture since the Middle Age than philosophy and theology. This seems to be the main thesis of Part 2, which exploits an ambiguity in Aristotle between issues in metaphysics and in physics in order to attribute to physics what belonged equally to metaphysics—for example, the Aristotelian distinction between form and matter (p. 85). Readers who are not ready to accept such attributions might start to suspect that this part of the work, rather than showing what Gaukroger wants it to show, boils down to the redundant claim that medieval theology is built on metaphysical foundations. Gaukroger's focus on *philosophia naturalis* entails, furthermore, that this part of the book ignores all fields of inquiry into natural phenomena that did not pertain to it, regardless of how significant they may have been for the development of the sciences in the West. There is no serious discussion of—in some cases not even a remark about—impetus physics or the cosmology of the Paris terminists of the fourteenth century (Buridan, Oresme), statics in the Archimedean tradition (Jordanus), medieval matter theories, and so on. Medieval optics, for instance, is discussed to some extent, yet it is treated not as a field of investigation of natural phenomena but, rather, as a reservoir of metaphors for Neoplatonist philosophers (p. 95 ff.). If Gaukroger is right—that is, if these fields of knowledge can be disregarded because they were without any significance for *philosophia naturalis*—what, one may ask, is the significance of *philosophia naturalis* for the development of the sciences and, by implication, for the emergence of a scientific culture in the West?

Part 3 is concerned mainly with the shaping of what one could call the "moral economy" of the emerging scientific culture: debates on methodological ideals (Ch. 5), new images of the persona of the scientist (Ch. 6), and the "move from a concern with truth to a concern with justification" (p. 238) that Gaukroger diagnoses as characteristic of seventeenth-century natural philosophy (Ch. 7). These new "morals" are depicted through a series of individual studies on relevant discourses of Bacon, Descartes, Galileo, Kepler, and various less prominent figures. It is hard to tell whether Gaukroger considers these men simply role models of the "morals" at stake or also their founders. The question of the historical context of these new ideas and ideals is not raised by Gaukroger, who contents himself with elucidating them by tracing the web of arguments through a virtual dialogue between these heroes.

In Part 4 Gaukroger comes to the core topic of the volume: the transformation of *philosophia naturalis* into natural philosophy in the course of the seventeenth century. He investigates in particular that century's "corpuscularianism" (Ch. 8), "mechanism" (mechanical natural philosophy) (Ch. 9), and experimental natural philosophy (Ch. 10) and the development of "mechanics" toward a quantitative science (Ch. 11). Though Gaukroger can draw to a great extent on his earlier writings, in particular his monographs on Bacon and Descartes, he offers a good deal of new and profound discussion and observations. However, in my view, it is above all his overarching conception of how natural philosophy took shape that deserves attention. He identifies three ingredients, or roots, the interplay of which formed the first stage of what was to become natural philosophy: mechanism—essentially corpuscular matter theory—which took on the foundational role of the traditional *philosophia naturalis*; experimental natural philos-

ophy, which Gaukroger considers a transformation of the traditional *historia naturalis*; and mechanics, practical mathematics in the tradition of Archimedes that was extended to encompass motion and forces. Gaukroger's view of experimental philosophy (Boyle, Hooke, etc.) as a transformation or new branch of *historia naturalis* is particularly intriguing but may stir up objections. It is regrettable that Gaukroger did not go into Bacon's project of an experimental history to make this important case. Perhaps more irritating is the fact that two of the three roots of the emerging natural philosophy—namely, the *historia naturalis* tradition and the tradition of practical mathematics (mechanics, mostly statics)—enter Gaukroger's picture "out of the blue." They were not dealt with in the earlier parts of the volume (the short digression on *historia naturalis* in Chapter 4 focuses on features of this tradition that have no bearing on Gaukroger's claim). In my view, the fact that Gaukroger did not allot the same historical attention to these two branches of knowledge as he did to the tradition of *philosophia naturalis* weakens the persuasiveness of the overall narrative.

Summing up: Gaukroger's book is a historical reconstruction that brackets historical context (social, practical, political, etc.) and offers a plethora of studies in intellectual history on a variety of subjects that deserve attention in any investigation of the emergence of the scientific culture of the West. It also presents highly interesting general conceptions of the interplay of learned or expert knowledge traditions that shaped the first stage of the Scientific Revolution. It might, however, seem imbalanced: many of the issues one would expect to be prominent in a book on this general topic receive only marginal treatment or are even totally neglected, whereas others are discussed at considerable length. But this assessment might turn out to be premature. What appears to be an uneven distribution of attention and effort, when regarding this first volume in isolation, may prove a deliberate and canny deployment of arguments for making Gaukroger's case about scientific culture in the volumes to come.

WOLFGANG LEFÈVRE

I. S. Glass. *Revolutionaries of the Cosmos: The Astro-Physicists*. xiii + 317 pp., figs., bibls., index. Oxford: Oxford University Press, 2006. £35 (cloth).

Helge S. Kragh. *Conceptions of Cosmos: From Myths to the Accelerating Universe: A History of Cosmology*. 276 pp., bibl., index. Oxford: Oxford University Press, 2006. £35 (cloth).

Helge Kragh's *Conceptions of Cosmos* is an effort to tell the whole history of cosmology from the Presocratic philosophers to the hot big bang and beyond. While there are short sections in the early portions of the book on ancient Egypt and Babylonia, as well as on the Old Testament, the book is unabashedly a history of Western cosmology, from the ancient Greeks, through the Christian Middle Ages and the scientific revolution, down to our own day. While European cosmology from antiquity through the nineteenth century is a well-worked field, historians have done relatively little with recent cosmology. So it is noteworthy that more than half of Kragh's short volume is devoted to the twentieth century.

The book is traditional internalist history of science, with emphasis on the technical details of theories. In his chosen genre, Kragh is sure-handed, clear, and interesting and has done a fine job of telling a complex story in short compass. The later chapters especially repay close reading. For example, Kragh traces the history of "Hubble's law" (that the distances of the galaxies are proportional to their redshifts) in the two decades before Edwin Hubble's 1929 paper, thus nicely illustrating the roles of chance and influence in the apportionment of historical credit. The chapter on the hot big bang, based in part on Kragh's own *Cosmology and Controversy* (Princeton, 1996), deftly traces the construction of the standard cosmology of our day, including its brief period of confrontation with the rival steady-state theory. As Kragh shows, although the steady-state theory turned out to be wrong, it contributed a good deal by forcing cosmologists to devise better observational strategies for eliminating possibilities. The closing chapter, on cosmological developments after 1970, including the discovery of the acceleration in the expansion of the universe, will be welcomed by many readers, for Kragh has the knack for explaining difficult scientific concepts clearly and concisely.

The earlier portion of the book is less original and, being more dependent on secondary sources, is somewhat less reliable. Kragh says, for example, that "Aristotle reports" that Thales fell down a well while looking at the heavens and was made fun of by a "clever and delightful Thracian serving-girl" (p. 13). Actually, the story comes from Plato's *Theatetus* (174A), but Kragh does not cite an ancient source and refers only to a recently published history of Presocratic philosophy. And he confuses (p. 22) the Sosigenes who in the first century B.C.E. advised