Book Reviews

The Development of the Chemical Arts

The Chemists and the Word. The Didactic Origins of Chemistry. OWEN HANNAWAY. Johns Hopkins University Press, Baltimore, 1975. xvi, 166 pp. $10.

Treatments of episodes in the history of chemistry generally are factually oriented and suffer from impoverished conceptions of the dynamics of their subject matter. As a result we often are presented with conceptually fossilized and rather whiggish interpretations of developments in the understanding of chemical phenomena, pale surrogates for comprehensive and historically coherent analyses. Hannaway need not answer such charges. He has written an interesting, well-researched, and judicious book.

The central theme of the book is the emergence of chemistry as a discipline with its own didactic tradition. Hannaway is concerned to modify the consensus according to which chemistry came to have identity as a discipline only during the later part of the 18th century. In the publication in 1597 of Andreas Libavius's *Alchemia* he perceives a turning point in its advancement toward independence as a branch of learning. This important and influential textbook not only, according to Hannaway, founded chemistry as a distinctive subject of scientific instruction, it is motivated by ideological and intellectual commitments that oppose at every turn the Paracelsian chemical and pansophic philosophies of nature.

The Paracelsian Oswald Croll and the more orthodox Protestant Libavius are juxtaposed in accordance with Hannaway's scheme of contrast and conflict in the development of the chemical arts in the late 16th century. Hannaway's explanatory quest goes beyond an analysis of the ingredients in and procedures for the manufacture of new medicaments. Such matters are dealt with effectively, but they are quite properly considered as integral parts of the larger intellectual commitment of each thinker.

Following the leads of such scholars as Walker, Pagel, Yates, and Goldammer concerning Renaissance views of mysticism, gnosticism, magic, and nature philosophy, Hannaway finely delineates the structure of Croll's thought. In 1609 Croll published his *Basilica chemica*. While that work is Paracelsian in orientation, according to Hannaway, the enthusiastic excesses of Paracelsianism are tempered by a Calvinistic sensibility toward nature as a manifestation of the word. In keeping with the Renaissance outlook, Croll viewed humankind as a microcosm within which is reflected, via myriad levels of correspondence, the total structure of the macrocosm. Knowledge is not a process whereby outer reality becomes an object of mental comprehension, but is a gnostic awareness or direct illumination of the hidden features and powers of things along with their cosmic ramifications. Unlike Paracelsus, Hannaway argues, Croll did not believe that human knowledge and praxis have intrinsic redemptive powers over nature. Rather, on Croll's view, they are manifestations of divine grace. Ultimately, for Croll, the powers of nature are nonverbal signs of the divine word that have become potentially sacramental for the elect and are the real signatures of created species, indelibly inscribed in the natures of all species and kinds. The word is thus incarnate in each created thing, and the similitudes and analogies among these signatures converge in man, the microcosm.

It is within this context of belief and commitment that Croll's conception of the relation between chemical theory and practice has significance. Hannaway convincingly shows that for Croll the manipulator of the chemical arts controls the hidden and vivifying principles of things by grasping their deepest meanings. Part of the processes of nature, he is attuned to its fundamental rhythms, and being a "little world" reverberating with a heightened inner experience, he is able to recanalize these processes, as chemically understood, into beneficial and life-giving directions. Of such experience he can only say, with Wittgenstein, "Whereof we cannot speak, we must remain silent."

Libavius would have none of this. The human being is not a magus, endowed with godlike and miracle-making powers. Man's well-being is consistent with the goals of nature, and to further it we must work with nature. There can be no direct dominion over nature, however. Nor can we transcend the processes of the natural world by means of enthusiasm and magic. Human activity is constrained by nature's barriers. The Paracelsians, Croll included, were vain enthusiasts, raging against the alleged evils of carnal reason and projecting their subjective needs upon a world that of necessity is forever neutral. Not only, according to Libavius, did their subjective attitudes despoil the canons of knowledge, they led to self-deception and would eventually undermine the social order.

In order to dramatize the import of Libavius's *Appendix necessaria syntagmatis arcanorum chymicorum* (1615) as a critique of Croll's *Basilica*, Hannaway, in vaguely Foucaultian style, juxtaposes the two works in a cultural setting construed timelessly. The *Appendix* is traditionalist and broadly Aristotelian in its conception of knowledge as a public enterprise founded in a reality independent of sensory experience. Libavius rested his critique of religious enthusiasm and Paracelsian science on a conception of experience as thus subject to legitimation in the light of past and present attempts to comprehend the natural world. With knowledge conceived of as an ongoing dialectic, Libavius deplored the mysticism, subjectivism, and enthusiasm of the philosophers of arcana. Unless the flights of Paracelsian imagination were checked by the discipline of sober experience, self-deluding conceits would everywhere parade as truths. Nature does not speak to the initiate in sacred ciphers indexing the essence of things; rather things are denominated and defined by language, itself a human creation. Nor is experience a matter of direct intuition and hence ineffable, it is shaped and communicated over time by human discourse. Libavius differently serves the word; nature is controlled not by attunement to its meanings, but by verbal dominion over it. To Libavius a textbook on the chemical arts is but an extension of this mission.

Hannaway's closing chapter, "Chemistry invented," is the climax of his book. In it he explores the role of the trivium and the influence of Aristotle, Cicero, and Ramus *et al.* on problems concerning the organization and classification of knowledge during the 16th century. He shows in an interesting way how within this context Libavius struggled with logical and conceptual prob-

lems in treating the chemical arts as an integral and independent branch of effective knowledge. The result is a view of chemistry as an abstract system comprising coherent categories, divisions, and definitions, divorced from its applications and so organized that it provides a foundation for pedagogic techniques.

This is a good book. It enhances the historian's art, and it deserves readership. Here is another sign that history of science is reaching its majority.

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Marine Chemistry

Analytical Methods in Oceanography. Papers from a symposium, Atlantic City, N.J., Sept. 1974. THOMAS R. P. GIBB, JR., Ed. American Chemical Society, Washington, D.C., 1975. x, 238 pp., illus. $26.50. Advances in Chemistry Series, 147.

The editor of this book gives its purpose as "to acquaint land-locked chemists with the accomplishments and problems of marine chemists so that the accomplishments will be more widely honored and the problem solving shared." The book is not, he further says, "designed to inform sea-going chemists of recent advances by shore-based chemists." Gibb has assembled contributions from an interesting group of researchers that nicely accomplish the stated goals as applied to the study of trace metals and, to a lesser extent, to the study of nonbiological organic material.

Hume briefly describes the chemical nature of the oceans and the variety of unique problems encountered in work at sea. The next eight chapters discuss trace metal work. The three on sampling problems and techniques all point up the low concentrations encountered and the severe problem of contamination associated with sampling and processing in the oceans. Two chapters discuss the techniques for concentrating trace metals, a procedure that is generally necessary because of the low levels encountered in the oceans. Three chapters cover the analytical techniques: two on flameless atomic absorption and one on anodic stripping voltammetry. These eight chapters will be indispensable reading for anyone contemplating doing any trace metal work in seawater.

The other chapters of the book that will be of particular interest to chemists pertain to studies of hydrocarbons in the oceans. A well-rounded status report on the techniques used and the concentrations of the hydrocarbons in the oceans is given in three chapters. The techniques range from simple gas chromatography to computer-coupled gas chromatography and mass spectroscopy. Wangersky gives an enlightening summary of organic carbon analysis in seawater, with attention to the pitfalls.

Two chapters on studies of radioactive material in seawater give the concentrations of the radioactive substances encountered as well as details of techniques used. Livingston, Mann, and Bowen cover the transuranic elements and Silker discusses beryllium, zirconium, ruthenium, cerium, thallium, radium, and thorium.

The book falls short of completeness in that it fails to present methods for determining major constituents, nutrients, and man-made organic and inorganic pollutants. On the whole it can be especially recommended to scientists having an interest in the trace metals and hydrocarbons in the oceans.

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Primate Studies

Phylogeny of the Primates. A Multidisciplinary Approach. Proceedings of a symposium, Burg Wartenstein, Austria, July 1974. W. PATRICK LUCKETT and FREDERICK S. SZALAY, Eds. Plenum, New York, 1975. xiv, 484 pp., illus. $39.50.

The authors of the 17 papers collected in this book review various kinds of evidence used to draw inferences about the phylogeny of primates, ranging from the structure of fossil teeth to the structure of DNA molecules, from anatomy to behavior. The articles I found most stimulating were those by M. Cartmill (for approaches to interpreting morphology), F. Szalay (for new information on fossil prosimians), and M. McKenna (for new ideas on early mammalian evolution).

Cartmill analyzes morphological evidence of the lemuriform-lorisiform dichotomy and the phylogenetic relationships of cheirogaleids. On the basis of differences in cranial anatomy, lemuriform prosimians (Malagasy lemurs, indris, and aye-ayes) have long been considered a distinct group from the lorisiforms (lorises, pottos, and galagos, found in Asia and Africa), and cheirogaleids (mouse and dwarf lemurs) until recently were classified as a subfamily of the Lemuridae. However, recent reassessment of old information has suggested that cheirogaleids are actually more closely related to lorisiforms. How does one weigh the evidence? Cartmill demonstrates that the unusual "anterior carotid" artery found in lorisiforms and cheirogaleids is not a neomorph, but rather an enlarged ascending pharyngeal artery, a vessel found in most placental mammals. Why did it replace the internal carotid stapedial and promontory branches, seen in other prosimians, as a major pathway for blood to the brain? The presence of a rete mirabile on the ascending pharyngeal artery in lorisiforms leads Cartmill to suggest that it serves a thermoregulatory function, allowing short bursts of intense activity to raise body temperature without triggering the hypothalamus to initiate heat-dissipating, but dehydrating, panting reactions. The absence of that rete mirabile in the tiny cheirogaleid *Microcebus* must be explained, and Cartmill invokes allometry, suggesting that in such a small animal mere contact between the ascending pharyngeal artery and nasopharyngeal veins would be enough to cool cerebrum-bound blood. One way of testing that hypothesis, suggested by Cartmill, is to find out if a rete mirabile is present in the larger relatives of *Microcebus*, or lacking in the smallest lorisiforms.

One of the traditional diagnostic characters of lemuriforms is the presence of a tympanic ring suspended "free" within the auditory bulla, rather than forming part of its lateral wall (as in lorisiforms). Cartmill argues that the main difference is not a "free" ring (the ring is attached to the bulla by the sometimes ossified annulus membrane), but rather that the tympanic cavity has expanded laterally beneath the tympanic ring in lemuriforms. That perspective allows new interpretations of early fossil primate ear regions. Cartmill notes that at least some plesiadapiforms (*Plesiadapis*) and tarsiiforms (*Necrolemur*) share with early lemuriforms (*Adapis*, *Notharctus*) the subtympanic expansion of the middle ear cavity seen in modern lemuriforms, which thus appears to be the primitive condition. Ontogenetic studies show that the lorisiform condition occurs as a stage in the development of the lemuriform middle ear (it can be seen in newborn lemurs), and therefore would be easy to retain into adulthood. From allometric considerations of middle ear morphology, Cartmill suggests that the lorisiform ear region would be expected in any lemuriform lineages undergoing reduction in body size. (That hypothesis can be tested by examining allometric relationships