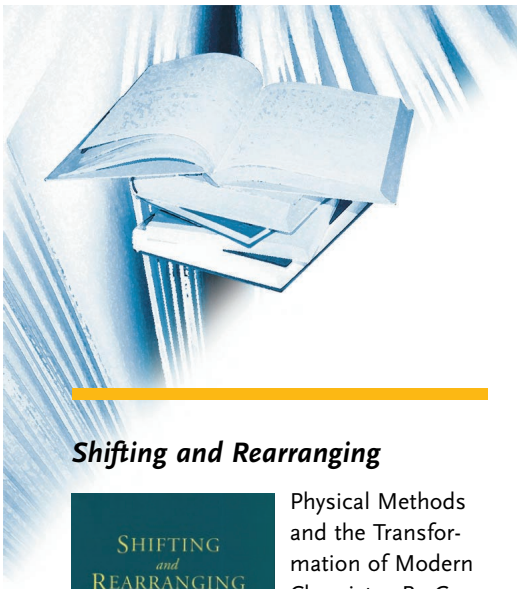
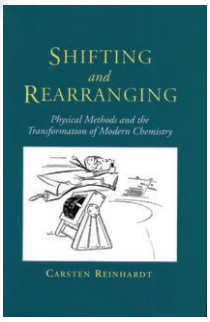


Shifting and Rearranging



Physical Methods and the Transformation of Modern Chemistry. By *Carsten Reinhardt*. Science History Publications, Sagamore Beach 2006. 428 pp., hardcover $ 49.95.—ISBN 0-88135-354-X

This book presents Carsten Reinhardt's view of the "profound transformation" of chemistry, especially organic chemistry, that was effected by the incorporation of physical methods into the chemists' working tool-kit. The focus is on events that occurred in the time period from the 1940s to the present day. A treatment of this topic requires attention not only to the contributions of the chemical community itself, but also to those of industrial instrument manufacturers, academic institutions, and government granting agencies.

Reinhardt has chosen to concentrate the coverage on the work of six scientists: Herbert Gutowsky, John Roberts, and Richard Ernst in the field of nuclear magnetic resonance spectroscopy (NMR), and Fred McLafferty, Klaus Biemann, and Carl Djerassi in mass spectrometry (MS). Other fields of chemical instrumentation receive only passing mention or partial coverage. As a result, topics such as X-ray crystallography, high performance liquid chromatography, and gas chromatography, which arguably can be said to have had significance equal to that of Reinhardt's choices, do not receive the in-depth examination afforded to the others. Nevertheless, the treatment narrowly focused on NMR and MS has permitted, within a book of manageable size, a deeply penetrating examination of those techniques and their contributions to the truly groundbreaking instrumental transformation of organic chemistry. For those who want broader coverage, Reinhardt has provided a carefully chosen set of references to the works of other historians on other fields of instrumentation.

Among the strengths of the book, the most apparent one is the author's thorough examination of original sources, which include laboratory notebooks, personal interviews, correspondence, and other documents from private archives. As a result, the book brings to light the contributions of individual co-workers and of early observations that preceded the ideas that led to the subsequent advances. Reinhardt has presented a number of "how it happened" stories in an entertaining and instructive way, and these contribute strongly to the readability of the work.

I was especially impressed by Reinhardt's treatment of the not-always-smooth, but ultimately fruitful, early interactions between academic and industrial collaborators in the application of instrumental techniques to practical problems in chemistry. Even at the beginnings of such partnerships, conflicts of interest were apparent. A case in point was the arrangement between Biemann and the Swiss firm of Firmenich & Cie, a major producer of essential oils and perfumes. Reinhardt's account leaves the unmistakable impression that Biemann was uneasy about the workload of samples that the company's research required. As the collaboration grew, Biemann found himself trying to satisfy Firmenich's needs in the period of his career when he was trying to establish an academic reputation. In my opinion, it is regrettable that in recent years even more serious conflicts have become widespread in contractual arrangements between academic investigators and private industry. As has been documented in writings by Derek Bok and a number of other authors, the restrictions and conditions of present-day collaborative agreements have sometimes placed the values of academia at cross-purposes with the market-driven goals of industry. Reinhardt does not attempt a history of these difficulties, but the subject deserves a full treatment.

Reinhardt's discussion of the history that he has chosen to explore is of such high quality that complaints may be considered carping. Nevertheless, there are some prominent flaws. Perhaps the most important from the perspective of a reader may be put in the form of a question: why is there a bibliography but no subject index? The book's bibliography is just a list of references in alphabetical order by author's name, but these references are tied to the text in only one direction, namely text to reference. If one is looking for the treatment of a subject, it is necessary to know the name of an author who might have been associated with it, or one needs to leaf through the book with the hope of stumbling across it.

The book also shows noteworthy deficiencies in its understanding of several important conceptual advances in chemistry. Reinhardt states that "physical instruments threatened to destroy the methodological autonomy of chemistry … [now] engineers and physicists appeared on the scene, attempting to displace chemistry by electronics". As one who lived through that exciting period, I recall that chemists were not at all worried by this imagined displacement, and gave little thought to "trying to rescue the methodological autonomy of chemistry". On the contrary, we welcomed with enthusiasm the new powers placed at our disposal by instrumental advances. As Reinhardt himself emphasizes, the chemical community closed ranks to insist that their parent institutions acquire the new tools in order to stay competitive.

A number of misconceptions and errors in the chemical parts of Reinhardt's discussion are apparent. The treatment of the controversy between the resonance and molecular orbital theories makes no mention of a crucial conflict, namely the failure of resonance theory to explain aromaticity. Similarly, on page 99 we find mention of "… the tropylium ion [which] had attracted considerable interest in the chemical community because of its unexpected aromatic behavior". In fact, the aroma-

ticity of tropylium ion had been predicted by Erich Hückel 30 years earlier.

In another misleading passage, Reinhardt leaves the uninformed reader with the impression that Roberts was the pioneer of non-classical ions. Thus, on page 181 Reinhardt writes: "Roberts's contributions to physical organic chemistry were far-reaching. With the term 'non-classical carbocation' he pushed forward a notion that was controversially discussed during three decades". I certainly agree with the first of those two sentences, but—if I understand what Reinhardt is trying to say—not with the second. The concept (or "notion") of non-classical ions goes back at least to work in the 1930s by Winstein and Lucas in the U.S.A., and to Nevell, de Salas, and Wilson in Britain. Whether Roberts did in fact provide a name-tag for the concept I don't know. Reinhardt does not give us a reference, but in any case one is reminded of an admonition by Cram (in Newman's *Steric Effects in Organic Chemistry*, p. 262, fn. 29): "The invention of nomenclature should not be confused with the discovery of the phenomena in question".

On page 13, Reinhardt perpetuates an error by Nye, who listed the "conjugated dienes" benzene and acetoacetic acid as examples of substances whose properties could be explained with MO theory. Neither of those compounds is a conjugated diene.

Finally, Reinhardt (p. 8) expresses the opinion that, although in the 1960s physical organic chemistry was a "lead-discipline in 1960s U.S. chemistry", which supplied the social prestige necessary to achieve success in academia, later it "faded away when scientists moved into bioorganic and organometallic chemistry". If the implication is that physical organic chemistry is no longer practiced, that is incorrect. Physical organic chemistry is embedded in, and is a guiding intellectual and structural element of, both bioorganic and organometallic chemistry, as well as of the recently emerging field of materials science. In fact, the practitioners of those disciplines are the first to acknowledge that connection. Moreover, the intellectual scope of physical organic chemistry itself is in a strong growth phase. Lively conferences reporting new work in the field continue, and its proponents interact fruitfully with scientists in chemical physics, quantum theory, and cosmology. It does seem to be the case that funding for research in physical organic chemistry as such has declined to a smaller fraction of government granting programs. Also, some universities report a decline in the number of students interested in pursuing the field, especially with the reduction of employment opportunities therein. However, which is cause and which is effect? Is the diminished support due to a loss of inherent scientific vitality, as Reinhardt implies, or is the trend a consequence of decisions by the granting agencies and by American industry that are based on other considerations? This is a complex puzzle whose dimensions are vast. Reinhardt does not come to grips with it, but someone should.

Overall, despite these blemishes, this book is an excellent serious work of scholarship. Readers will find it stimulating to read, and Carsten Reinhardt should be congratulated for delving so deeply into some of the key historical developments in chemistry.

Jerome A. Berson
Department of Chemistry
Yale University
New Haven (USA)

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