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HYLE Book Review

Luigi Cerruti: *Bella e potente: La chimica del novecento fra scienza e società*, Editori Riuniti, Roma, 2003, 507 pp. [ISBN 88-359-5396-09]

*by Giovanni Villani**

Published only three years after the end of the last century, Cerruti's book is the first wide-ranging work by a single author on the history of chemistry in the 20^{th} century. In fact, the time span covers the period since the final decade of the 19^{th} century until our days. As many other historians, Cerruti prefers to divide the long period into shorter and more intelligible parts. The first part (1894-1918) is entitled "The completion of classical chemistry"; the second one (1918-1945) is named "New achievements, unknown horizons"; the third one (1945-1975) is identified as an age of "Mutation and disguise"; finally, the last part (1975-2000) is described as a process, "Towards the chemistry of complexity". It is evident that the temporal partition follows the most dramatic crises of the century, the two world wars and the oil crisis in the mid-1970s; on the other hand, the book's subtitle puts 20^{th} century chemistry "between science and society". It is also interesting that such a subdivision – in a sense artificial – allows the author providing a particular historical 'sense' to every short period.

In the period before the end of the World War I, the author sees the completion of classical chemistry accomplished in the birth of modern biochemistry, the great success of the *Erzatz* policy of the German chemical industry, and, on very emotional pages, in the tragedy of the 'Great War'. The novelty of the period is the new interest of physics in the atomic and molecular world. The period from 1918 to 1945 is extremely rich of knowledge advancements in several chemical fields, with the establishment of new disciplines, such as macromolecular chemistry and physical organic chemistry. The 'big bang' of quantum mechanics is discussed in some details as well as the parallel progress in instrumental research of the microscopic world (X-ray crystal structure determination; ultraviolet, Raman, and infrared spectroscopies, mass spectrometry). For this period, the industrial side of chemistry is exemplified by the story of new products, as synthetic rubber, liquid combustibles, and pharmaceuticals.

Cerruti uses two evocative terms, 'mutation' and 'disguise', for characterizing the first decades after the World War II. The principal mutations happened both in the chemical industry and the chemical laboratories. All over the world, the national chemical industries followed the example of the American chemical industry, which during and after World War II shifted from coal to oil as the principal raw material. In the chemical laboratory new physico-chemical instrumentation replaced the traditional ways of chemical analysis and structure determination. The range of the new instrumentation varied from big apparatus, such as the first nuclear magnetic resonance machines, to 'minimalist' and extremely efficacious devices, such as paper chromatography tanks. However, it is the term ‘disguise’ that is provocative. Cerruti maintains that for decades ‘molecular biology’ was simply a new name for an old, well-established discipline. The new brand name – ‘molecular biology’ – was adopted by a group of scientists whose common interest was the methodical and methodological use of advanced physical instrumentation, such as powerful X-ray diffractometers and electronic microscopes. The name was immediately successful and many biochemists rallied under the new banner. However, Cerruti argues that great and fundamental results were actually obtained along the lines of the contemporary biochemistry, including the deciphering of the genetic code and the photosynthetic reaction center (PRC) studies. He supports his thesis by a sociological analysis of curricula and academic affiliation of ‘molecular biologists’ as well as by an epistemological analysis of their ‘knowledge procedures’ (on these last terms see later). Anyway, the thesis is not new, and Cerruti underlines that it was put forward by the great biochemist Erwin Chargaff in the 1960s.

The last part of the book outlines the research frontiers of contemporary chemistry. The list of topics of greater interest includes the birth of new disciplines (supramolecular, mathematical, and computational chemistries) as well as old and new themes like the origin of life, oscillating reactions, artificial chemistries, and Gaia. In addition, Cerruti develops two overall epistemological theses about this period. Towards the end of this part – and of the book – the reader is convinced that chemistry is particularly apt to cope with complex problems, and that chemical thought and practices are an essential component of the newborn science of complexity. The second epistemological thesis is more debatable. In fact, Cerruti claims that the profound transformation of the chemical experimental and theoretical procedures depicts a disciplinary situation where chemistry has incorporated a part of physics, and not the other way round. Here Cerruti’s anti-reductionist stance is explicit, which deserves particular attention.

At various places, Cerruti provides a detailed analysis of the theoretical and experimental practices of chemists, trying to depict a realistic picture of a chemist at work. It is in this sense that he speaks of ‘knowledge procedures’. As we can read in any standard dictionary, the term ‘procedure’ refers to "a way of doing something, especially the usual or correct way", and to "the official or formal order or way of doing something". At a purely linguistic level, Cerruti’s choice of the term ‘procedure’ seems to point to a necessary consensus inside the scientific community. Anyway, in the first, introductory chapter, he investigates the many components of a scientific knowledge procedure, some of which are interesting from a philosophy of science point of view. For example, Cerruti points out the use of ‘local theories’ and of ‘fragments of theories"; the problem of the knowledge stability of disciplines and specialties; and the ontological and sociological questions posed by the use of instruments, machines, and industrial plants. As to instruments, an important issue is the impressive investment of collective knowledge and social work embodied in NMR or mass spectrometers. In fact, Cerruti links this kind of investment to the long period of ‘digestion’ of physical instruments by organic chemists – the majority of the chemical community.

Much of the historical narrative of the book is about the boundary between chemistry and other experimental sciences, so that the author is required to point out the characteristics and peculiarities of chemical procedures. We reproduce below Cerruti’s Scheme 1 from the introductory chapter. The left column shows three steps of the classical knowledge procedure of chemistry. The specific epistemological trait of chemistry becomes evident at the third step. In fact, the results of the chemical experimental procedure include both knowledge and substances. In addition, the contrast with physics (right column) is evident.

Scheme 1

Chemistry	Physics
Handles macroscopic substances	Uses macroscopic instruments
↓	↓
Carries out events at the microscopic level	Carries out events at the microscopic level

↓ ↓ ↓

Produces macroscopic substances	Produces disciplinary knowledge	Produces disciplinary knowledge

While his analysis of knowledge procedures makes up the epistemological backbone of the historical narrative, Cerruti's overall historiographic and philosophical interpretation draws on the theory of autopoiesis by H. Maturana and F. Varela (*Autopoiesis and Cognition: The Realization of the Living*, Dordrecht, Reidel, 1980). A generation after their principal work was published in English, their concept of autopoiesis has found its way into many cultural fields, from complexity theory to corporate management. Cerruti employs their theory in his interpretation of the development of chemistry in the 20th century. First, he demonstrates that 'chemistry' is a huge and complex system, including, besides disciplinary knowledge, many other components, such as scientists, instruments, industrial plants, books, and academic institutions. Second, he considers this complex system an 'autonomous unit' (in Maturana and Varela's sense), characterized by a specific 'organization' and a particular 'structure'. In simple terms, 'organization' means whatever allows an observer to refer to a particular system as a member of a particular class of systems, while the term 'structure' refers to how a given organization might be realized in a particular case and time. Thus, 'chemistry' is a member of the class 'experimental sciences', with many organizational features similar to those of other sciences, and with at least one internal relation that identifies 'chemistry'. The specific epistemological (and pragmatic) relation of chemistry is that of the left column of Scheme 1.

Following Maturana and Varela's theory, Cerruti describes the historical evolution of chemistry as a co-evolution of this discipline with other sciences and their common social environment. Because of its 'operational closure', any autonomous unit cannot interact with its the environment by means of inputs and outputs, but only through 'structural couplings', which – at the same time – modify the autonomous unit and the environment. Physics, biology, and society interact with chemistry in this way. Cerruti emphasizes that the subtitle of his book ("between science and society") refers to this kind of structural coupling and that the history of chemistry is essentially the story of its internal structural changes and of its most important 'structural coupling' with society and the other sciences. Finally, in the same manner, he describes the structural transformation of the chemical laboratory during the last decades of the century and justifies his claim that chemistry has incorporated a part of physics, i.e. the knowledge procedure in the right column of Scheme 1.

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