




Historians of science who have argued for the vital agency of artisans in the production of knowledge will find many resonances and much to learn from this work.

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## Catherine Jackson, *Molecular World: Making Modern Chemistry*

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Synthetic chemistry has always been about making molecules, but not in the way we might expect. In *Molecular World: Making Modern Chemistry*, Catherine M. Jackson provides a compelling alternative history of the origins of synthesis in the nineteenth century. Existing histories of synthetic chemistry have largely focused on structure theory, arguing that it enabled chemists to modify molecular structures in order to produce desired targets. As Jackson points out, these histories have resulted in a contradictory and unsatisfactory image of chemistry in this period. Instead, Jackson shifts the emphasis from *molecules* to *making*. The central claim is that synthesis was never about making target molecules, but originated as an investigative tool, thus challenging us to reconceive the foundations of synthetic chemistry as built ‘on practice not theory’ (p. 10). Drawing from two decades of historical research and training as a synthetic organic chemist, Jackson makes a persuasive case for reorienting the narrative of organic synthesis around experiment and practice and forms an important contribution to studies in the history of chemistry, scientific practice and material culture.

In contrast to today’s definition, synthesis in the 1840s, Jackson contends, was a method that enabled chemists to identify molecular formulae as well as to develop theories about what molecules are made of. Only by the end of the nineteenth century did synthesis mean something more recognizable to us today – the purposeful production of naturally occurring substances in the laboratory. This transformation was facilitated by ‘laboratory reasoning’ (pp. 8–9), the concept that Jackson uses to describe how chemists mediated experiment and theory in this period. Though it resists easy definition, a shorthand might be to define it as how new empirical knowledge was gained from a shared methodological, technical, theoretical and instrumental base, or, conversely, that it was not cutting-edge theories driving forward the scientific process. For those who have spent time in a laboratory, this might be more intuitive, but for others, the essence of the phrase can be grasped from the detailed analysis of numerous archival sources across the book’s nine chapters.

Jackson argues that the distinctively modern chemistry in the book’s subtitle was achieved through this laboratory reasoning. ‘Experimental order’ (p. 309), and all its reactions, reagents and glass tubes, rather than structure theory, is what enabled the development of abstract three-dimensional molecules and the molecular world that we associate with chemistry today. Within this framing, the otherwise curious lack of molecular diagrams

in a book about nineteenth-century chemistry makes sense. In lieu of these diagrams, Jackson draws the reader – with all their senses – into the laboratory using a wide variety of archival sources and images that both complement and enrich her argument.

The laboratory is also more than the setting for synthesis. By viewing it as a key ingredient of the material culture of synthetic chemistry, along with Jackson's conscious bias towards practice, new landmarks in the history of chemistry arise. New lampworked glassware enabled chemists to produce and modify new and cheaper instruments from the 1830s, decentring Paris as the hub of chemical research, and the subsequent professionalization of glassblowing led to standardized tools and results. Finally, changes to the laboratory landscape itself proliferated, as dangerous glass-encased experiments led to new hazards for chemists in the second half of the nineteenth century.

To anchor this new practice-oriented history of chemistry, Jackson uses episodes in the history of natural alkaloids: organic alkaline substances that are physiologically active, such as quinine, morphine and strychnine. The book comprises three parts, each of three chapters, which chronologically follow the careers of the German organic chemists and their work on alkaloids: Justus Liebig, August Wilhelm Hofmann, and Albert Ladenburg. Though narrow in its molecular focus, this exposition provides a broad, constellation-style analysis of Liebig's organic analyses of morphine in the 1830s, Hofmann's ammonia type and his turn to synthesis in the decades that followed, and Ladenburg's first total synthesis of coniine in the 1880s. By utilizing a broad array of sources, Jackson makes the new practical capabilities, standards and infrastructures of experimentation in organic chemistry apparent.

*Molecular World's* accessibility is a testament to Jackson's adept management of a diverse academic audience. Historians of chemistry who are already well acquainted with Liebig and Hoffman will enjoy Jackson's new analysis of Liebig's research school and each chemist's personal ambitions, and the chapters on the relatively unexplored Ladenburg will also be of particular interest. And though a high level of technical knowledge is required to fully engage with Chapters 1, 5, 6, and 9, Jackson provides balance with the well-rounded non-technical chapters that any non-chemists can fully enjoy. Philosophers of scientific practice will also find Jackson's work an exemplary case study due to the level of detail in which she reconstructs daily laboratory practice. Whilst readers will gain the most from this richly researched book in its entirety, it is possible to enjoy sections of the book on their own, with many chapters forming stand-alone novel contributions to the history of chemistry.

Jackson's *Molecular World* forms a significant contribution to both the history and historiography of chemistry. Jackson offers a nuanced understanding of how practice fundamentally shaped modern chemistry, and historians, philosophers and chemists have much to gain from reading it. By exploring how nineteenth-century chemists approached their chemistry, Jackson demonstrates the benefits of going back to the (historical) bench and challenging our everyday scientific definitions, and the surprising consequences of doing so.

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