Fields of influence

David Cahan

Robert Mayer and the Conservation of Energy. By Kenneth L. Caneva. *Princeton University Press: 1993. Pp. 439. $49.50, £33.*

DURING the 1840s, several scientists and physicians — among them Robert Mayer, Ludvig Colding, James Prescott Joule and Hermann von Helmholtz — proposed what they, or their successors, called the principle of the conservation of force (or energy). By the 1850s there were already disputes as to who most merited the appellation of discoverer or co-discoverer of the principle. As the title of Kenneth Caneva's scholarly and perceptive work implies, historians of science are still assessing the merits of the pretenders to the crown. Yet they now do so less, if at all, to determine the discoverers than to understand the evolving meaning of such terms as 'force' and 'energy', the early thinking about thermodynamics and physiology, and the more general growth of the modern scientific disciplines.

Caneva greatly advances our understanding of Mayer's work on the conservation of energy — a phrase Mayer never used — by analysing it in the light of its broader scientific, medical, philosophical and theological contexts. The book is therefore not only a study of the slow, complex evolution of Mayer's thinking and how Mayer may have clarified to himself the meaning of what he had discovered. It is also a study of physiology and, to a lesser extent, physics and chemistry in Germany during the 1830s and early 1840s, and of the sources that Mayer may have consulted during his intellectual development.

Without seeking to offer a biography of Mayer (1814–78), Caneva presents a brief, integrated account of Mayer's life and work. We are reminded, for example, of his youthful experience in trying to construct a *perpetuum mobile*, and learn much about his medical training at the University of Tübingen in the 1830s, and his voyage to the Dutch East Indies in 1840, where he studied the physiology of the blood and observed that the blood of Europeans there was lighter in colour than expected. Here too are details of Mayer's religious upbringing and beliefs, in particular his faith in a providential and benevolent God who created a harmonious world and his adamant opposition to materialism. These and other aspects of Mayer's life are recounted with an eye to assessing their possible contribution to the evolution of his scientific work. Above all, Caneva shows that at the heart of Mayer's efforts and claim to be the discoverer of conservation of force lay his attempt to show numerically the equivalence of heat and motion. Although Mayer thought there was a causal (force) relationship between the two, he did not reduce heat to motion. For Mayer, forces were indestructible, mutable and immaterial; they were not properties of matter, but rather the independent, imponderable and analogous counterparts to matter. Force was to physics what matter was to chemistry: the foundation of the entire subject.

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Julius Robert Mayer.

Mary Evans Picture Library

Caneva treats in great, indeed perhaps too great, detail the physiological, medical, physical and chemical contexts of Mayer's work and the general topics of contemporary German views on the nature and scope of science, as well as the religious and spiritual climate in which Mayer worked. We learn about the probable influence on Mayer of studies of blood, respiration and animal heat; the gradual acceptance of the exclusive treatment of physiological phenomena in chemical and physical terms; the slow acceptance of energetic transformations; the relationship of an organism's vital processes to external physical and chemical processes; the alleged role of so-called vital forces in an organism's activity; various analogies and metaphors (force and matter, machines as organisms, the Solar System and living organisms); Mayer's thoroughgoing opposition to materialism; and even homeopathy.

Although his understanding of contemporary physical thought was weak, Mayer nevertheless brought about a central innovation in physics by breaking with the contemporary understanding of force: he made the concept independent of matter and gave it a numerical measure, ultimately calculating the numerical equivalence between heat and work. Scientists and physicians such as J. H. F. Autenrieth, Jacob Friedrich Fries, Antoine Lavoisier, Justus Liebig, Johannes Müller, Theodor Schwann and Friedrich Tiedemann constituted the intellectual milieu in which Mayer worked and probably influenced him. Caneva also argues that contemporary philosophical and theological issues shaped both Mayer's notion of the character and scope of science and his central concept of force: for example, the ideas that causes are linked to effects, which in turn are to be represented as natural forces, and that the scope of science is limited to explaining physical phenomena, so that entities such as souls, minds and vital forces were none of Mayer's strictly scientific business.

Caneva concludes by seeking to reconstruct Mayer's work in context, both by uniting the earlier parts of the book and by assessing the supposed influence of *Naturphilosophie*. He analyses in detail Mayer's publications in their contemporary setting, tracing the probable evolution of Mayer's thought from his surprising observation in the Dutch East Indies, to his new concept of force, and on to the mechanical equivalence of heat. By 1845 Mayer had achieved what he called "the mechanical theory of heat". Certain motifs and scholarly claims notwithstanding, there is little if any evidence that *Naturphilosophie* played any part in Mayer's thinking.

Caneva's meticulous, critical and impressive examination of Mayer's probable route to energy conservation should be of interest to all students of nineteenth-century science. □

David Cahan is in the Department of History, University of Nebraska, 612 Oldfather, PO Box 880327, Lincoln, Nebraska 68588-0327, USA.