The Enlightenment

GIULIANO PANCALDI, *Volta: Science and Culture in the Age of Enlightenment*. Princeton, NJ and Oxford: Princeton University Press, 2003. xvii +381 pp. $35.00; £24.95.

Alessandro Volta has attracted considerable attention from historians of science in recent years, partly but not only in response to the bicentenary in 2000 of Volta's announcement of his great invention, the electric battery. Giuliano Pancaldi's book is a splendid addition to the Voltaic literature that adds dramatic new depth to our understanding both of the man and of what he achieved.

Though framed biographically, Pancaldi's book is by no means an orthodox biography, as demonstrated most strikingly by its extremely cursory treatment of a subject that has dominated most previous accounts of Volta's life and work, his dispute with Luigi Galvani over the latter's famous experiments with frogs' legs twitching in response to electrical discharges. Similarly, Pancaldi tells us virtually nothing about Volta's important contributions to chemistry, or about the period of no less than a quarter of a century that remained to Volta following the heady days of his international triumph when he first brought his battery before the world. Ultimately, in fact, Pancaldi's concern is not with biography at all, but with what he calls "the economy of invention of late eighteenth–century science". The details of Volta's life, richly documented as they are, are important to him only in so far as they help us to understand Volta's career as an innovator in science.

Within this framework, the early stages of Volta's life, during which he was developing his own characteristic approach to science, are naturally given more detailed attention. Pancaldi sets out very clearly young Volta's social and intellectual roots as a member of the lesser nobility in Como, at a period when the traditional domination of intellectual life by the

Church was being challenged by the secularized culture of the Enlightenment. He detects in both Volta's private life and his science an on-going tension between tradition and innovation. He points to Volta's willingness to conform to the traditional social and religious norms of his group and age, notwithstanding his inclination to embrace Enlightenment values and habits in his general approach to life. Paralleling this is Volta's life-long desire to be seen as a natural philosopher of the traditional kind rather than a mere inventor, alongside his preparedness on crucial occasions to abandon the natural philosopher's traditional search for causal understanding and to espouse, instead, an instrumentalist approach to scientific theory.

A central theme in the story Pancaldi tells is the way in which Volta used his science to build a career as a member of the public administration of his native Lombardy, even as the exigencies of that career helped shape the science that he did. A related strand of the analysis—one already pursued to some extent by others in recent publications on Volta—concerns the means by which Volta, living as he did on the periphery of the scientific world of his day, brought his work to the attention of the leading authorities in electrical science and gained recognition, with varying degrees of success in different times and places, as an expert in the field. But Pancaldi also pays close attention to the actual science involved, drawing out the relationships between what Volta did and the work of his contemporaries. He does so with admirable sensitivity to the complexities of thinking about electricity at the time.

Pancaldi focuses in particular on Volta's invention of the electrophorus, his development of the *condensatore* for detecting otherwise undetectably small electrical charges, and his invention of the battery. He finds a common pattern, which he calls "competitive imitation", with Volta in each case imitating but then improving on someone else's experiment:

> The inventions thus contained much that had been known for some time, and something else that was unquestionably new and the result of Volta's own endeavor. The latter, however, was itself the outcome of intense interaction with other experts, and thus part of a pursuit that Volta's competitors had themselves contributed to shape.

Competition, whether for positions or for recognition, is thus presented as a principal driving force in Volta's career, an inevitable result of his ambition both to establish a place for himself in the republic of letters and to secure a decent paid job that would allow him to pursue his science. And, as Pancaldi shows, Volta learned from his mistakes. In particular, in the mid-1770s he learned from Joseph Priestley, the first established scientific figure to take his work seriously, that international recognition would flow much more easily if he focused on presenting novel instruments and experiments, rather than addressing deeper theoretical questions as he had been doing until then. His taking this lesson to heart shaped all his subsequent work, leading him to his brilliant instrumental innovations and, in characterizing the behaviour of these, to emphasising instrumentally based "mid-range" theoretical notions such as capacity and tension, rather than the forces of attraction between particles of matter and electric fluid that he continued to believe were ultimately responsible for the phenomena displayed.

Pancaldi throws important new light on the background to Volta's invention of the battery. He insists, in particular, that "no new, decisive conceptual turn had taken place in his investigation in the three years preceding the building of the battery", and that "Volta did not (in any reasonable sense of the word) deduce the battery from his theory of contact electricity". Rather, the building of the battery was inspired, Pancaldi argues, by Volta's reading, some time in the autumn of 1799, an article by William Nicholson discussing a way of imitating both the anatomy of the electric fish, the torpedo, and the shocks it could deliver. Volta, he says, greatly admired Nicholson's model but differed profoundly from him on certain key issues. Whereas Nicholson's proposed model used electrophoruses as the "perpetual" source of electricity required, Volta substituted metallic couples that he knew, as a result of his long-running dispute with Galvani, had an intrinsic electromotive force. And while Nicholson had suggested that the pairs of plates making up the model torpedo should be connected in parallel, Volta's earlier experiences gave him reason to doubt this. This led him to an intense period of research—research that at the time few besides him, with his mastery of experimental techniques for detecting the weak electricity involved, could have successfully undertaken—culminating in his recognition that they needed to be connected in

series, but separated by a moist conducting layer. Thus the battery was born! It is a convincing picture that helps us understand more clearly Volta's references to the torpedo in the paper announcing his great invention. It also reminds us of the essential unity of eighteenth-century science, and of the dangers to historical understanding inherent in imposing later distinctions, such as that between physics and the life sciences, on Enlightenment thinkers.

Pancaldi also has interesting things to say about the reception of Volta's battery. Volta himself somehow knew all along, he suggests, that "he had only a limited grasp of what was going on inside his instrument", an awareness that must have been strongly reinforced by William Nicholson's discovery of the chemical changes associated with its operation that Volta, strangely, had overlooked. As Volta's contemporaries pursued these chemical effects, he gradually lost control of his instrument, though not before honours had been lavished on him, most notably by Napoleon, for his discovery. Pancaldi does not spend much time on later attempts to understand the battery and is apparently unaware of some important work on the subject such as that of L.P. Williams. Instead, he focuses on the different ways the battery was received in different parts of Europe, concluding that "the early history of the voltaic battery does not fit easily either into a traditional, realist interpretation of scientific instruments, or into a constructivist view of science conceived as the product of strictly local cultures. A combination of both seems to be needed if we want to understand the geography of the new continent opened up by the invention of the battery." A final, short chapter that is more or less independent of the rest surveys various ways in which Volta came to be portrayed during the course of the nineteenth century as a hero of Italian science, leading up to the huge celebrations in Como in 1927 to mark the centenary of his death.

Throughout the book, Pancaldi stresses the contingency of Volta's discoveries, and also the importance of diversity in the process of discovery. The Enlightenment, he argues, was by no means the monolithic school of thought that either its upholders or its modern critics have supposed. On the contrary, "it was precisely the diverse, competitive, occasionally conflicting interests of the different constituencies of the republic of natural philosophers that offered an outsider like Volta his best opportunities to innovate and to solicit reward". The claim is a crucial one, with important implications for our view of science. As historians, we are bound to generalize; but in doing so we need always to remember that beneath our grand generalizations are the messy crowds of individuals who populated the past, each with his or her own peculiarities and personal ambitions. In Volta's case, Pancaldi demonstrates that the diversity among them, and the unintended consequences that flowed from this, themselves played a constructive role in the process of scientific discovery. The conclusion, he thinks, applies more generally: "Whether we like it or not, the success of the enterprise we call science and technology seems to depend no less on the diversity of the interests and goals of the people involved, and on the contingency attached to diversity, than on the discipline adopted in its pursuit". If he is right—and his case study is persuasive—the story he tells has important implications for both the philosophy of science and the formulation of science policy.

R. W. HOME, *Department of History and Philosophy of Science, University of Melbourne, Parkville, Victoria 3010, Australia*