Cesare S. Maffioli, *La via delle acque (1500-1700): Appropriazione delle arti e trasformazione delle matematiche* (Florence: Leo S. Olschki, 2010), pp. 394, ills., €43.00, ISBN 978 88 222 6008 6.

This erudite and important book develops two interrelated topics. The first comprises a thematically organized study of the hydraulic arts and sciences that ranges from Leonardo da Vinci through Girolamo Cardano, Francesco Patrizi, Galileo, Benedetto Castelli, and finally, in the late seventeenth century, Domenico Guglielmini. The second uses the rich empirical data of the first to discuss the relationships of the practical arts, the developing new science of hydraulics, and the social and disciplinary transformation of mathematics in the sixteenth and seventeenth centuries. Maffioli suggests that the appropriation of the arts must be studied in tandem with the transformation of mathematics. He points out that the mathematical science of waters and rivers was a novelty of the baroque age. It was a science that lasted as a unified topic for only two centuries. In 1697, after the publication of Guglielmini's *Della natura de' fiumi*, the unitary physics of that work disappeared as the field separated into two strands—the study of currents and the study of river beds. Then, during the eighteenth and early nineteenth centuries, the topic divided again; some parts were subsumed under geomorphology, others under fluvial hydraulics, and some disappeared.

In an overview, Maffioli discusses the ways in which the mechanical arts came to be transformed into objects of investigation and discovery; and the ways in which mathematics came to be integrated into these new studies. He emphasizes that these developing activities aligned themselves against the methods of the scholasticism of the universities, but also against a mathematics that was too theoretical and too far from reality. Mechanics and pneumatics were not just understood as a kind of violence against nature. From antiquity they also opened the door to consideration of the naturalness of both motion and the structure of materials. The examples in this chapter range widely and beyond hydraulics, including the ballistics of Nicolò Tartaglia and the anatomy of Vesalius. Maffioli also ties the new mathematical science of water to hydraulic developments in Lombardi, emphasizing that Leonardo first learned from the canals and hydraulic works of the Sforza before developing his own ideas.

The growing interrelationships of the art and philosophy of water occurred within specific local contexts that shaped them in a variety of ways. Giovan Battista Benedetti used an "Archimedian" approach to problems of motion and of water, seeing the issues primarily through the lens of a debate in Parma after the Farnese prince asked why rivers always flow to the sea. Benedetti explicated his mathematical approach in detail, sometimes against Aristotle, but often integrating specific Aristotelian points into his own divergent outlook. From a different point of view, Patrizi developed highly original ideas about water in the service of the duke of Ferrara and in the context of the dispute between Ferrara and Bologna concerning the systemization of the Reno River. Concerned with problems of running water, Patrizi analyzed the volume and velocity of the water in a river as the riverbed narrowed. He conceded that at times water may run more quickly in narrow sections of the river. It was also possible, he thought that

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the volume of water could change as its particles combined with space, light, and heat in turbulent stretches, and thereby the velocity could remain the same.

At the heart of the book is a chapter on Galileo, his student Castelli, and the invention of the Galilean science of waters. Maffioli astutely analyses Galileo's mechanics, focusing on the 1638 *Discourse on the Two New Sciences*, and then turns to the much earlier 1612 work on floating bodies and the ensuing debate. Both Castelli and Galileo invoked a corpuscular concept of matter and the principle of the incompressibility of water. Castelli, in his 1628 treatise on the measurement of running water, concluded that diverse parts of the river pass the same amount of water at the same time, and that the velocity of the current thus varies with changes in the riverbed. Arguing for the incompressibility of water, he provided a dramatically simplified physical model of rivers which allowed for the quantification of their water flow (at a time before the development of infinitesimal calculus, which would have been needed for a more complex mathematical analysis).

Castelli developed his ideas as part of a critique of a pamphlet written by the architect and engineer Giovanni Fontana on the flooding of the Tiber River in Rome. Fontana, writing after the terrible flood of 1598, had calculated the quantity of water that had entered the Tiber during the catastrophe. Maffioli underscores the close interrelationships of such practical engineering problems and hydrological theory. Another river that drew the attention of engineers and theorists was the Bisenzio, which flowed into the Arno and contributed to its flooding. The engineer overseeing the river, Alessandro Bartolotti, had proposed to solve the problem by constructing a straight canal, channeling the river out of its winding natural riverbed. Castelli argued that such a canal would be costly and would make no difference. Galileo contributed his own analysis to the issue, thereby hoping to show that his new science of motion had practical value as well as theoretical interest. A major critique of Castelli's work is found in the work of the Jesuit Nicolò Cabeo. He attempted to keep physics separate from mathematics in his commentary on Aristotle's *Meteorology*. The merging of the two as in Castelli's work, Cabeo argued, involved a process of oversimplification. Ten years later in 1656, the Lombard engineer Giovan Battista Barattieri, published the *Architettura d'acque*. This work shows, Maffioli suggests, how extensively practical engineering knowledge was now integrated with philosophical and mathematical considerations.

The mathematician and physician, Domenico Guglielmini, in his *Della natura de' fiumi* of 1697 incorporated Barattieri's work but took it further, creating a concept of hydrostatic pressure conceived dynamically. Like Castelli in the 1620s, Guglielmini (as mathematician and superintendent for water for the city of Bologna) was motivated by the problems of the Reno River and the ongoing conflict that it occasioned between Ferrara and Bologna. Ferrara's defense against the Reno's flooding was to construct dams, whereas the Bolognese wanted the Ferrarese to let the river flow where (they suggested) nature directed it, that is, along the line of greatest slope (toward Ferrara); thereby the Bolognese painted the issue as a conflict between art and nature, themselves being on the side of nature. Maffioli follows Guglielmini as he moved from Bologna to the University of Padua to take up a career in mathematics and medicine.

Guglielmini's medical thought, Maffioli suggests, was part of his wide ranging study of a unified nature in which the naturalness of mathematics and the mathematization of complexity become central.

This book is an original contribution to the history of the hydraulic sciences that has the range and depth available to a scholar who has spent years investigating that topic. The study places hydrology alongside astronomy, mechanics, and other disciplines as centrally important in the development of the new sciences—and notable for its comparative complexity. Beyond hydraulics, this book comprises a brilliant synthesis of the history of the mathematization of the new sciences in the sixteenth and seventeenth centuries. Indeed, the subtitle of the book is a more accurate indication of its contents than the title. It should be read by every historian of science and deserves the wider readership that an English translation would provide.

Pamela O. Long
Washington, D.C.