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Expedient obedience: water management and natural order in early eighteenth-century northern Italy

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ABSTRACT

During the seventeenth and early eighteenth centuries, the combination of experimentalism and medical knowledge became a shared trait among a considerable number of Italian authors who belonged to the Galilean tradition and contributed to the study of water management. This common background was frequently associated with an emphasis in the hydrogeological debate on three intertwined and recurring themes: (1) the idea that human intervention should 'support natural inclinations' in order to accomplish its purposes; (2) the usefulness of medical analogies to describe natural phenomena, both in terms of anatomy and therapeutics; (3) the uniformity and immutability of natural laws across space and time. In focusing on some significant case studies, this paper analyzes how such conceptual triad contributed to shape the evolution of the debate on water management and the understanding of the hydrologic cycle in early modern Italy.

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1. Introduction

In many Italian treatises from the seventeenth and early eighteenth centuries that focus, in part or entirely, on water management, there is an interesting recurrence of themes. The idea that human art can only succeed by *agreeing* with natural laws is frequently associated with the notion of the usefulness of anatomical and physiological analogies to describe natural phenomena, and with an emphasis on the uniformity of natural laws across space and time. Are these three topics in any way related? Or do they simply happen to be parallel trends in a context – that of early modern natural philosophy – where eclecticism was less an exception than a common attitude?

It is undeniable that disciplinary boundaries were more blurred in the early days of the *new science* than they are today. Still, there are good reasons to believe that the way these concepts (human art supportive of nature; 'medical understanding' of hydrogeological processes and water management; immutability of natural laws) intertwined in the Italian debate was not just a statistical occurrence. As I will attempt to show, it was

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also the result of two common traits in the educational and professional background of some of the protagonists in this debate: namely, Galilean experimentalism and medical training.

The immense impact of Galileo on Italian science is, as we know, an extensively studied fact. By the last decade of the seventeenth century, the legacy of this author had branched out and expanded its influence from physics and astronomy into medicine and even into the vast field of natural philosophy. During the phase of consolidation of what historians have described as the 'Galilean experimental tradition' (or 'Galilean school'),[1] the Italian scientific front was permeated by notions like the mathematization of nature, the usefulness of metaphor and analogy in scientific discourse (as exemplified in Chapter 6 of *Il Saggiatore* (1623), where the universe is described as a book understandable only through mathematics),[2] and the substantial stability of natural laws.

The evolution of Galileo's thought on this last point intersected with the path that led him to convert from the Ptolemaic system to Copernicanism and had its first resounding expression in the pages of *Sidereus Nuncius* (1610), a pamphlet that marked a methodological turning point in astronomy and in cosmology.[3] Thanks to his improved telescope, in fact, the author was able to describe – together with other celestial bodies – the irregularity of the surface of the Moon. This observation provided him with strong evidence to support the refutation of the traditional, and still predominant, Aristotelian belief in a perfect superlunar world as opposed to the imperfect, mutable and corrupted Earth, which in turn paved the way for the assertion of the uniformity of the laws of nature.[4]

The belief of Galileo in a uniformly driven universe grew in close connection with his understanding of the role of technical knowledge and mechanics, which he advocated as an essential tool to support and validate scientific enterprise. In his view (a view eloquently described in the manuscript *Le mecaniche*), even technology – no matter how advanced or powerful – had to comply with natural laws. Still, it was precisely by learning and by operating in accordance with these laws that human art could exploit them, and

[1]On the Galilean experimental tradition in Italy, see (among the many): *Antonio Vallisneri. La figura, il contesto, le immagini storiografiche,* ed. by Dario Generali (Florence: Olschki, 2008); *La scuola galileiana. Prospettive di ricerca,* ed. by Giovanni Arrighi, Paolo Galluzzi, Maurizio Torrini, Sergio De Angeli, Ugo Baldini, and Lanfranco Belloni (Florence: La Nuova Italia, 1978); *La tradizione galileiana e lo sperimentalismo naturalistico d'età moderna,* ed. by Maria Teresa Monti (Florence: Olschki, 2011); *Scienziati del Seicento,* ed. by Maria Luisa Altieri Biagi and Bruno Basile (Milan-Naples: Ricciardi, 1980); *Scienziati del Settecento,* ed. by Maria Luisa Altieri Biagi and Bruno Basile (Milan-Naples: Ricciardi, 1983); Ugo Baldini, 'La scuola galileiana', in *Scienza e tecnica nella cultura e nella società dal Rinascimento a oggi*, ed. by Gianni Micheli (Turin: Einaudi, 1980), pp. 383–463; Marta Cavazza, *Settecento inquieto: alle origini dell'Istituto delle Scienze di Bologna* (Bologna: Il Mulino, 1990); Cesare S. Maffioli, *Out of Galileo: The Science of Waters, 1628–1718* (Rotterdam: Erasmus Publishing, 1994); Maurizio Torrini, *Galileo nel tempo* (Florence: Olschki, 2021).

[2]Galileo Galilei, *Il Saggiatore* (Roma: Appresso Giacomo Mascardi, 1623), p. 25. On the role of metaphor in Galileo's work, see Stephanie Jed, 'Renaissance Dialogue: Humanities and Science', *Nemla Italian Studies,* 38 (2016), 179–202.

[3]Galileo Galilei, *Sidereus Nuncius* (Venetiis: Apud Thomam Baglionum, 1610). For a recent analysis of this topic, see Fabio Minazzi, *Le ragioni di Galileo. Scienza, tecnica ed epistemologia* (Milan: Franco Angeli, 2023), pp. 327–408. On Galileo's relationship with Copernicanism in the years before the publication of *Sidereus Nuncius,* see Matteo Cosci, 'Il Copernico del "primo" Galileo', in *"Totus Mundus Commutatur": Copernico e l'Università di Padova,* ed. by Vincenzo Milanesi (Padua: Il Poligrafo, 2025), pp. 247–74.

[4]See I. Bernard Cohen, *The Newtonian Revolution* (Cambridge: Cambridge University Press, 1980), pp. 211–15; Id., *Revolution in Science* (Cambridge, MA: The Belknap Press of Harvard University Press, 1985), pp. 9, 136; Dario Generali, '*Le ragioni di Galileo* di Fabio Minazzi', in *Bíos theôrêtikós e bíos praktikós,* ed. by Stefania Barile, Florinda Cambria, and Elisabetta Scolozzi (Milan: Mimesis, 2025), pp. 257–82. For more general considerations on the development of a concept of natural laws in the seventeenth century, see Peter Harrison, 'The Development of the Concept of Laws of Nature', in *Creation: Law and Probability,* ed. by Fraser Watts (London: Routledge, 2008), pp. 13–36.

therefore fulfil its purpose.[5] In this specific regard, the Galilean thought was in line with the staple Baconian advice that 'we cannot command Nature except by obeying her'. And in fact, a few years after Bacon's philosophy reached the Continent, the same view was adopted and promoted with enthusiasm by Galileo himself – and subsequently, by the whole forefront of Italian experimentalism.[6]

The 'empirical harmony' between the Galilean and Baconian understanding of nature proved useful to many Italian scientists also in the aftermath of the Galileo affair – when, following Galileo's trial and condemnation by Catholic authorities in 1633, it became increasingly dangerous to uphold the Copernican system and to address interpretive aspects of science that could have metaphysical and theological, hence potentially heterodox, implications. The risk to incur censorship, or worse, induced Galileo's followers to adopt a prudent strategy of self-censorship. In many cases, this strategy meant a restriction of experimental activity to the observational and technical aspects at the expense of cosmological and natural-philosophical interpretation. Accordingly, the empirical significance of Galileo's work (which was a substantial, but not exclusive, significance) was emphasized at the cost of its cultural and theoretical meaning.[7]

Inevitably, such narrative stretch distorted the historical understanding of Galileo's legacy.[8] On the other hand, it fostered its very success, as it allowed many early modern scientists and natural philosophers in Italy to continue professing themselves as Galilean while keeping a safe distance from metaphysical quarrels. It should not surprise us, therefore, that one of the academic institutions where this tendency was most pronounced was the Papal States-based University of Bologna. Here, carefully selected elements of Galilean experimentalism were blended with ideals and methods of the *new science* modelled after the Accademia del Cimento in Florence, and, later on, the Royal Society of London: this conceptual and methodological combination was realized mainly through the work of Geminiano Montanari (1633–1687), Giovanni Domenico

[5]Galileo wrote the two versions (a shorter and a longer one) of *Le mecaniche* in 1593 and in 1598–1599, during his teaching service at the University of Padua. Although the treatise circulated widely for centuries, it remained unpublished until 1891. I refer here to the most recent critical edition: Galileo Galilei, *Le mecaniche,* ed. by Romano Gatto (Florence: Olschki, 2002). On the role of technology in Galileo's scientific thought, see Paolo Galluzzi, *Momento. Studi galileiani* (Rome: Edizioni dell'Ateneo e Bizzarri, 1979); Id., 'Dalle tecniche alla tecnologia', in *Storia delle scienze: Vol. V, Conoscenze scientifiche e trasferimento tecnologico,* ed. by Vittorio Marchis (Milan: Banca Popolare di Milano, 1994), pp. 32–75 (especially pp. 68–73); Romano Gatto, 'It is Impossible to deceive Nature. Galileo's *Le mecaniche,* a Bridge between the Science of Weights and the Modern Statics', *Philosophia Scientiae,* 21.1 (2017), 71–91; Minazzi, *Le ragioni di Galileo,* pp. 104–16, 425–34.

[6]'Natura non nisi parendo vincitur' (Francis Bacon, *Instauratio Magna. II: Novum organum* (Londini: Apud Ioannem Billium, 1620), Liber 1, CXXIX). On this topic, see also Fabio Minazzi, *Galileo "filosofo geometra"* (Milan: Rusconi, 1994), p. 235. A collection of studies on the interaction between early modern technical culture and Baconian philosophy is offered in *Philosophies of Technology: Francis Bacon and his Contemporaries,* ed. by Claus Zittel, Romano Nanni, Gisela Engel, and Nicole Karafyllis (Leiden: Brill, 2008). See in particular: Luisa Dolza, 'Technology and Culture during Francis Bacon's Stay in France', pp. 1–19; Jürgen Klein, 'Francis Bacon's *Scientia Operativa,* the Tradition of the Workshops, and the Secrets of Nature', pp. 21–49; Romano Nanni, 'Technical Knowledge and the Advancement of Learning', pp. 51–66; Sophie Weeks, 'The Role of Mechanics in Francis Bacon's *Great Instauration*', pp. 131–95; Dana Jalobeanu, 'Bacon's Brotherhood and its Classical Sources: Producing and Communicating Knowledge in the Project of the Great Instauration', pp. 197–230. On the role of mathematics in Bacon's philosophy, see Giuliano Mori, 'Mathematical subtleties and scientific knowledge: Francis Bacon and mathematics, at the crossing of two traditions', *British Journal for the History of Science,* 50.1 (2017), 1–21.

[7]Cfr. *Scienza, filosofia e religione tra '600 e '700 in Italia,* ed. by Maria Vittoria Predaval Magrini (Milan: Franco Angeli, 1990); Cavazza, *Settecento inquieto;* Paolo Galluzzi, 'L'Accademia del Cimento: «gusti» del principe, filosofia e ideologia dell'esperimento', *Quaderni storici,* 48 (1981), 788–844; Dario Generali, 'Repubblica delle lettere fra censura e libero pensiero. La comunicazione epistolare filosofico-scientifica nell'Italia fra Sei e Settecento', *Intersezioni,* 6.1 (1986), 73–94; Maffioli, *Out of Galileo,* pp. 29–37.

[8]On this issue, see in particular Minazzi, *Le ragioni di Galileo.*

Cassini (1625–1712), and – with particular respect to medicine – Marcello Malpighi (1628–1694).[9]

Malpighi's academic and scientific prominence, in particular, holds the key to understanding how the interaction between the Galilean and medical traditions influenced the Italian debate on water management in the following decades. Together with his friend and mentor, Giovanni Alfonso Borelli (1608–1679), Malpighi became the main Italian proponent of the experimental method in medicine during the second half of the seventeenth century. As he himself declared, he had made Galilean experimentalism the keystone of his medical work: however, he also reinforced this keystone with notions and methods drawn from Cartesian mechanics, Baconian philosophy, Boylean corpuscularism and – last but not least – the writings of William Harvey (1578–1657).[10] In doing so, Malpighi opened the most advanced medical and natural-philosophical centre of that time in Italy to a body of knowledge whose empirical emphasis resonated with, and shielded from inquisitorial eyes, the Galilean core of his research. It was especially thanks to this 'protective stratagem' that, between the seventeenth and eighteenth centuries, the influence of the Galilean school in Italy was extended from physics to medicine and natural philosophy. And since a medical training was a common trait of many scholars who contributed to the comprehension of the hydrologic cycle and to water management, we can understand how the interaction between the Galilean and medical traditions – and, therefore, the association of themes highlighted earlier in this paper: human art supportive of nature, medical analogies, uniformity of natural laws – came to affect the northern Italian hydrogeological debate.

In the following, I will take the reader through a series of case studies, excerpted from the work of Italian authors, displaying in an exemplary way this connection of topics and its fruitful consequences.

But first, some more historical contextualization is in order.

2. A centuries-long debate

Ever since the *new science* took its first steps, the management of rivers and other water bodies became the subject of study and discussion. In grappling with this problem, the new wave of experimentalists who entered the European stage responded to a need that had already challenged many other experts before them. And with good reason: for, just like in the Middle Ages, even the early modern chronicles from all over the Continent are replete with anecdotes of floods, droughts, epidemics, famines and with the

[9]On the relationship between the scientific milieu in Bologna, the Accademia del Cimento, and the Royal Society of London, see Marta Cavazza, 'Bologna and the Royal Society in the Seventeenth Century', *Notes and Records of the Royal Society,* 35.2 (1980), 105–23; Generali, '*Le ragioni di Galileo* di Fabio Minazzi', pp. 264–5; William E. Knowles Middleton, *The Experimenters: A Study of the Accademia del Cimento* (Baltimore: The Johns Hopkins University Press, 1971), pp. 281–95; Cesare S. Maffioli, 'Guglielmini vs. Papin (1691–1697). Science in Bologna at the end of the XVIIth century through a debate on hydraulics', *Janus,* 71 (1984), 63–105 (pp. 63–4).

[10]On the experimental method promoted by Malpighi in Bologna and its intellectual roots and influences, see Domenico Bertoloni Meli, *Marcello Malpighi, Anatomist and Physician* (Florence: Olschki, 1997); Id., *Mechanism, Experiment, Disease: Marcello Malpighi and Seventeenth-Century Anatomy* (Baltimore: The Johns Hopkins University Press, 2011); Cavazza, 'Bologna and the Royal Society in the Seventeenth Century'; Ead., *Settecento inquieto;* Dario Generali, *Antonio Vallisneri. Gli anni della formazione e le prime ricerche* (Florence: Olschki, 2007), pp. 30–47; Gianni Micheli, 'Malpighi e il microscopio della natura', in *From Makers to Users: Microscopes, Markets, and Scientific Practices,* ed. by Dario Generali and Marc J. Ratcliff (Florence: Olschki, 2007), pp. 191–209.

grim socio-political corollaries that make the difference between the demise of a country and its survival (or its prosperity).[11]

The tangle of environmental, technical, social, political and economic issues that typically surrounds water management was, if possible, even more inextricable in the case of the Republic of Venice. For the *Serenissima,* preserving the fragile balance between land and sea had always been the cornerstone not only of its might, but of its very existence. At political and institutional levels, this concern led to the establishment in the early sixteenth century of the *Magistrato alle acque* ('Magistrate for the Waters'): a powerful and long-lasting bureau whose board of experts was responsible for the administration of water resources in both the Lagoon and the *Domini di Terraferma* (that is, Venice's mainland domains).[12] In line with its hydraulic commitment, Venice remained an international hub for technological and scientific inquiry throughout most of its history. It attracted engineers, mathematicians, hydraulic engineers, natural philosophers and many other *theorists* and *practicians* whose interaction with local experts allowed the Republic to succeed in the centuries-long struggle to preserve its precious Lagoon, together with its even more precious independence.[13]

[11]On the social, political, legal, and economic significance of water management in Renaissance and early modern Europe, see (among the many other studies): *Eaux et conflits dans l'Europe médiévale et moderne,* ed. by Patrick Fournier and Sandrine Lavaud (Toulouse: Presses universitaires du Midi, 2012); *La civiltà delle acque tra Medioevo e Rinascimento,* ed. by Arturo Calzona and Daniela Lamberini (Florence: Olschki, 2010); *The History of Water Management in the Iberian Peninsula: Between the 16th and 19th Centuries,* ed. by Ana Duarte Rodrigues and Carmen Toribio Marín (Cham: Birkhäuser, 2020); *Water Management, Communities, and Environment: The Low Countries in Comparative Perspective, c. 1000–c. 1800,* ed. by Hild Greefs and Marjolein 't Hart (Ghent: Academia Press, 2006); *Water Management in Europe (12th-18th Centuries),* ed. by Giampiero Nigro (Florence: Firenze University Press, 2018); Eric H. Ash, *The Draining of the Fens: Projectors, Popular Politics, and State Building in Early Modern England* (Baltimore: Johns Hopkins University Press, 2017); Piet van Cruyningen, 'Dealing with Drainage: State Regulation of Drainage Projects in the Dutch Republic, France, and England During the Sixteenth and Seventeenth Centuries', *Economic History Review,* 68.2 (2015), 420–40; Franco Cazzola, *Uomini e fiumi. Per una storia idraulica della bassa pianura del Po (1450–1620)* (Rome: Viella, 2021); John Emrys Morgan, 'The Micro-Politics of Water Management in Early Modern England: Regulation and Representation in Commissions of Sewers', *Environment and History,* 23.3 (2017), 409–30; Chandra Mukerji, *Impossible Engineering: Technology and Territoriality on the Canal du Midi* (Princeton: Princeton University Press, 2009); Tim Soens, 'Flood Security in the Medieval and Early Modern North Sea Area: A Question of Entitlement?', *Environment and History,* 19.2 (2013), 209–32; Matteo di Tullio, 'Contested Water. The Management of Natural Resources and the Emergence of Sustainability Problems in Northern Italy During the Early Modern Period', *Global Environment,* 18.3 (2025), 515–34; Matteo di Tullio and Martino Lorenzo Fagnani, *Una storia ambientale dell'età moderna. Società, saperi, economie* (Rome: Carocci, 2024), especially pp. 115–32; Matteo di Tullio and Claudio Lorenzini, 'Natural Resources, Conflict and Sustainability in Northern Italy in the Early Modern Period', in *Ecosystem Services in Floodplains,* ed. by Dario Canzian and Elisabetta Novello (Padua: Padova University Press, 2019), pp. 73–96.

[12]For an exhaustive analysis of this subject, see in particular: *Conterminazione lagunare: Storia, ingegneria, politica e diritto nella Laguna di Venezia* (Venice: Istituto Veneto di Scienze, Lettere ed Arti, 1991); *Guida alle Magistrature. Elementi per la conoscenza della Repubblica Veneta,* ed. by Catia Milan, Antonio Politi, and Bruno Vianello (Verona: Cierre, 2008); *«Ingegnosi artificij»: Serenissima Repubblica di Venezia. Trecento anni di storia della scienza, della tecnica e dell'innovazione (1474-1788),* Voll. I-III, ed. by Roberto Berveglieri (Verona: Cierre, 2020–2024); *Laguna, fiumi, lidi. Cinque secoli di gestione delle acque nelle Venezie* (Venice: La Press, 1983); Roberto Berveglieri, *Le vie di Venezia. Canali lagunari e rii a Venezia: inventori, brevetti, tecnologie e legislazione nei secoli xiii-xviii* (Verona: Cierre, 1999); Pietro Daniel Omodeo, 'Marco Cornaro e la Geografia umana delle acque venete nelle carte di Giambattista Venturi', in *Storia e filosofia della scienza. Tradizioni storiografiche e prospettive epistemologiche,* ed. by Silvia Caianiello, Dario Generali, and Fabio Minazzi (Rome: Valore Italiano Editore, 2025), pp. 157–80.

[13]The political and environmental history of Venice has captured the attention of countless authors. Amid the wealth of studies produced in the past decades, see *A Companion to Venetian History, 1400–1797,* ed. by Eric Dursteler (Leiden-Boston: Brill, 2013), especially pp. 1–318; *Acque e territorio nel Veneto medievale,* ed. by Dario Canzian and Remy Simonetti (Rome: Viella, 2012); *Arte e scienza delle acque nel Rinascimento,* ed. by Alessandra Fiocca, Daniela Lamberini, and Cesare S. Maffioli (Venice: Marsilio, 2003); *Polesine e acque nell'età moderna e contemporanea,* ed. by Filiberto Agostini and Leonardo Raito (Milan: Franco Angeli, 2021); *Venice and the Anthropocene: An Ecocritical Guide,* ed. by Cristina Baldacci, Shaul Bassi, Lucio De Capitani, and Pietro Daniel Omodeo (Venice: Wetlands Books, 2022); Karl Appuhn, *A Forest on the Sea: Environmental Expertise in Renaissance Venice* (Baltimore: The Johns Hopkins University Press, 2009); Piero Bevilacqua, *Venezia e le acque. Una metafora planetaria* (Rome: Donzelli, 1995); Salvatore Ciriacono, *Building on Water:*

Needless to say, the interaction, although undoubtedly fruitful, was not always peaceful. A certain amount of disagreement – when not outright dispute – was, so to speak, a physiological part of a debate that focused on an extremely complex subject (to say the least) and whose impact stretched far beyond the natural-philosophical concern to affect public health and safety, industry, farming, fishing, trade, foreign relations and even warfare. In fact, it is in consideration of this overlapping of themes and interests that we can fully appreciate the 'socialized dimension of the scientific and managerial practices'[14] which became a distinctive feature of the *Magistrato alle acque* and, more generally, of Venice's water management policies: an approach that was an expression of a republic where 'opinions and theses' had to be 'discussed, defended and negotiated' in accordance with 'participatory forms of knowledge exchange and consensus building',[15] and that, ultimately, proved more stable than the environmental challenges it had to tackle.

Unlike today, in the seventeenth and eighteenth centuries the main environmental threat to the Venetian Lagoon was the shoaling caused by the sediments transported by the inflowing waters. A great part of the projects promoted in those years, therefore, concerned the diversion of rivers and torrents in the *Terraferma*, so as to reduce the amount of sediments carried downstream and prevent the occurrence of floods in the fertile and populous areas of the mainland. Here, among the many turbulent streams, one in particular had proved a steady source of trouble: the Adige River. As a historical and geographical connector between the Tyrolean Alps and the Po Plain (hence, between the predominantly German-speaking Habsburg lands and the Italian states), this waterway had been responsible for massive damage to people, crops, cattle and for a lot of diplomatic quarrels.[16]

Venice was all too aware of the problem. Year after year, countless resources and efforts had been invested in the attempt to prevent or, at least, minimize the havoc caused by the Adige. According to a chronicle from 1751, among the largest cities located on its course, Verona alone spent up to '14,000 ducats per year' to build dams, dykes and to fund periodical works of hydraulic engineering in order to keep the river at bay.[17] As necessary as these circumscribed interventions were, however, they never

Venice, Holland and the Construction of the European Landscape in Early Modern Times (New York-Oxford: Berghahn Books, 2006); Élisabeth Crouzet-Pavan, 'Toward an Ecological Understanding of the Myth of Venice', in *Venice Reconsidered: The History and Civilization of an Italian City-State (1297–1797),* ed. by John Jeffries Martin and Dennis Romano (Baltimore: The Johns Hopkins University Press, 2000), pp. 39–64; Robert C. Davis, *Shipbuilders of the Venetian Arsenal: Workers and Workplace in the Preindustrial City* (Baltimore: The Johns Hopkins University Press, 1991); Piero Del Negro, 'Venetian Policy Toward the University of Padua and Scientific Progress During the 18th Century', in *Universities and Science in the Early Modern Period,* ed. by Mordechai Feingold and Victor Navarro-Brotons (Dordrecht: Springer, 2006), pp. 169–81; Francesco Gaglianò, *L'Arsenale di Venezia. Una storia produttiva* (Catanzaro: Rubbettino, 2022); Antonio Lazzarini, *Boschi, legnami, costruzioni navali: L'Arsenale di Venezia fra XVI e XVIII secolo* (Rome: Viella, 2021); Luca Molà, 'La Repubblica di Venezia tra acque dolci e acque salse: investimenti tecnologici a Lizzafusina nel Rinascimento', in *La civiltà delle acque tra Medioevo e Rinascimento,* pp. 447–72; Walter Panciera, *«L'acqua giusta»: Il sistema portuale veneziano nel XVIII secolo* (Rome: Viella, 2021); Pietro Daniel Omodeo, Sebastiano Trevisani, and Senthil Babu, 'Benedetto Castelli's *Considerations on the Lagoon of Venice:* Mathematical Expertise and Hydrogeomorphological Transformations in Seventeenth-Century Venice', *Earth Sciences History,* 39.2 (2020), 420–46; Raffaello Vergani, 'Problemi d'acque e scavo di canali nell'alta pianura veneta dei secoli XIV-XVI', in *La civiltà delle acque tra Medioevo e Rinascimento,* pp. 507–26.

[14]Omodeo, Trevisan, and Babu, 'Benedetto Castelli's *Considerations on the Lagoon of Venice*', 435.

[15]Ibid., p. 442.

[16]On this topic, cfr. the volume *Il fiume, le terre, l'immaginario. L'Adige come fenomeno storiografico complesso,* ed. by Vito Rovigo (Rovereto: Osiride, 2016).

[17]Gianfrancesco Pivati, *Nuovo Dizionario Scientifico e Curioso Sacro-Profano, Tomo decimo ed ultimo, contenente V-X-Y-Z* (Venezia: Benedetto Milocco, 1751), p. 256.

completely prevented floods from occurring with mournful regularity. For this reason, the Venetian authorities occasionally considered also large-scale projects that promised to provide a permanent or, at least, more stable, solution to the problem. But in most cases, so ambitious and pioneering were these projects, and so many were the technological and financial risks that they posed, that the water officers – in an understandable act of prudence – did not approve them.[18]

As official cartographer and cosmographer of the Republic of Venice, the Franciscan friar Vincenzo Maria Coronelli (1650–1718) was likely well aware of the risk of failure when, in 1712, he submitted a plan to build a diversion canal connecting the Adige River with Lake Garda (in order, he claimed, to prevent the river from flooding the plains of Verona and Polesine). It is therefore possible that he did not flinch too much when, following a debate between experts and authorities, his project was rejected. Not only was it technically challenging and too expensive, the surveyors had decided, but it was also diplomatically risky: for the excess water discharged into the lake would have led to more water in the outflowing Mincio River – and, consequently, to potential flooding in the neighbouring and Habsburg-ruled territory of Mantua (Figure 1)

It goes as a posthumous tribute to Coronelli's foresight and talent that his proposal became reality not earlier than two centuries after his death. In 1959 to be exact, when the young Republic of Italy (which, in turn, had resumed a project promoted in 1939 by the Fascist government) managed to complete what today is known as the Mori-Torbole diversion tunnel.[19] On the other hand, it is a tribute to Venice's prudence that this new project, too, has been (and still is) met with harsh criticism from many experts and the public alike, because of the many environmental concerns associated with its use. But such is the price of change after all: and even more so when change affects environments like rivers, where fixing a problem in one place often means causing other problems elsewhere.

3. *Aemula naturae ars*

Among the hydraulic experts whom Venice asked to assess Coronelli's proposal was Count Jacopo Riccati (1676–1754), who was regarded as one of the best mathematicians of his time. In *Parere sopra la proposta di moderare l'Adige del P.M. Vincenzo Coronelli* (1712) Riccati approved the project, although with some important caveats.[20] On the

[18]See Francesco Luzzini, 'L'Itale Terre a vagheggiare inteso. La regolazione dell'Adige nel XVIII secolo: tra storia e scienza', in *Il fiume, le terre, l'immaginario,* pp. 287–312 (291).

[19]On this topic, see *Galleria Adige-Garda. Da Mori a Torbole per lo scolmo nel Lago di Garda delle piene dell'Adige* (Trento: Ufficio del Genio civile – Magistrato alle acque, 1959); Francesco Luzzini, 'Un dibattito lungo secoli: La galleria Adige-Garda', *Acque Sotterranee, Italian Journal of Groundwater,* 3.1 (2014), 65–6. On Coronelli's life and work, see *Un intellettuale europeo e il suo universo: Vincenzo Coronelli (1650–1718),* ed. by Maria Gioia Tavoni (Bologna: Costa, 1999); *Vincenzo Coronelli e l'*Imago mundi, ed. by Donatino Domini and Marica Milanesi (Ravenna: Longo, 1998); Ermanno Armao, *Vincenzo Coronelli. Cenni sull'uomo e la sua vita. Catalogo ragionato delle sue opere. Lettere, fonti bibliografiche, indici* (Florence: Olschki, 1944); Id., *Il "Catalogo degli Autori" di Vincenzo Coronelli. Una biobibliografia geografica del '600* (Florence: Olschki, 1957); Fabrizio Bonoli and Flavia Marcacci, 'Vincenzo Coronelli: descrittore o studioso del cosmo?', *Il Santo. Rivista francescana di storia dottrina arte,* 54.1-2 (2019), 45–62; Francesco Bonasera, *Vincenzo Coronelli cosmografo della Serenissima, 1650–1718: vita ed opera* (Ancona: Tipografia Anconitana, 1950); Augusto De Ferrari, 'Coronelli, Vincenzo', *Dizionario Biografico degli Italiani,* Vol. 29 (Rome: Istituto dell'Enciclopedia Italiana, 1983); Marica Milanesi, *Vincenzo Coronelli Cosmographer (1650–1718)* (Turnhout: Brepols, 2016).

[20]This text was republished in Jacopo Riccati, 'Parere sopra la proposta di moderare l'Adige del P.M. Vincenzo Coronelli', in Id., *Opere,* Vol. IV (Lucca: Giuseppe Rocchi, 1765), pp. 97–109. On Riccati's works and studies, cfr. *I Riccati e la cultura della Marca nel Settecento europeo,* ed. by Gregorio Piaia and Maria Laura Soppelsa (Florence: Olschki, 1992); Roberta



Figure 1. The lower Adige valley, Lake Garda, and the city of Verona. Detail from a map by Frederik de Wit, *Accuratissima Dominii Veneti in Italia, Ducatus Parmae, Placentiae, Modenae Regii Et Mantuae, Episcopatus Tridentini Tabula, quae est Lombardia Inferior* (Amsterdam, ca. 1680). Source: Norman B. Leventhal Map & Education Center at the Boston Public Library, Boston (MA), USA (https://collections.leventhalmap.org/search/commonwealth:cj82ks99x). Public domain.

contrary, sharp criticism was expressed against the plan by the patrician Scipione Maffei (1675–1755) in his *Ragionamento sopra la regolazione dell'Adige.*[21] Maffei was especially fearful that the new canal, instead of improving the situation, would cause further floodings in his native city of Verona, along with its fields and crops. Thus, at a political level he did all in his power to influence the Venetian authorities in order to prevent the project from being implemented.[22]

The divergence of views is understandable, given the audacity and complexity of Coronelli's project and the many different interests at stake. Still, the disagreement between Riccati and Maffei did not prevent their arguments from resting on a common principle:

Bortolozzo, *L'universo ben temperato dei Riccati. Cosmologia e musica in una famiglia di illuministi trevigiani* (Venice: Il Cardo, 1995); Maffioli, *Out of Galileo,* pp. 384–415.

[21]Scipione Maffei, 'Ragionamento sopra la regolazione dell'Adige. A S.E. il Signor Girolamo Giustiniani Procurator di S. Marco', in Id., *Rime e prose del Sig. Marchese Maffei* (Venezia: Sebastiano Coleti, 1719), pp. 340–74. On Maffei, see *Scipione Maffei nell'Europa del Settecento,* ed. by Gian Paolo Romagnani (Verona: Consorzio Editori Veneti, 1998); Giuseppe Silvestri, *Un europeo del Settecento: Scipione Maffei* (Treviso: Canova 1954); Paolo Ulvioni, *«Riformar il mondo». Il pensiero civile di Scipione Maffei* (Alessandria: Edizioni dell'Orso, 2008); Franco Venturi, *Settecento riformatore. Da Muratori a Beccaria*, Vol. I (Turin: Einaudi, 1972), pp. 355–77.

[22]Silvestri, *Un europeo del Settecento,* p. 139. See also Luzzini, 'L'Itale Terre a vagheggiare inteso', pp. 303–4.

whether the course of the river was to be promoted without diversions (Maffei) or a new canal was to be excavated (Riccati), it would be imperative to *support natural inclinations* in order to succeed. In other words, it would be essential to *agree* with nature to fix the problems.

Of course, the idea of a technology imitating the operation of nature – of 'aemula naturae ars',[23] the word *ars* being understood in the broad sense of technology and craftwork – was not exclusive to the discussion on Coronelli's project. It had deep roots in the medical and philosophical debates of classical antiquity, and from there it had been influencing the evolution of technical and scientific knowledge throughout the Middle Ages, Renaissance and early modern period. In Italy, in particular, this 'ancient precept that art should imitate nature'[24] provided common ground for engineers, technicians and mathematicians to set aside their conceptual and methodological disagreements. In working as a facilitating concept, it helped to foster the 'mathematical and philosophical appropriation of the mechanical arts'[25] (and, more generally, the circulation of practical and theoretical knowledge) which would shape the new science of waters and, at the turn of the eighteenth century, would define it as an autonomous discipline.[26] And, in narrowing the focus to the hydrogeological debate in early eighteenth-century northern Italy, we find that the idea of *aemula naturae ars* was not only recurrent but also frequently linked to two other intertwined themes that help to explain the reasons and choices behind the water management policies of those decades: the usefulness of medical analogies to describe natural phenomena, and the uniformity and immutability of natural laws across space and time.

A clear example of this conceptual interconnection can be found in the work of the physician, mathematician and hydraulic expert Domenico Guglielmini (1655–1710), regarded as the 'leading Italian scholar on river hydraulics toward the close of the seventeenth century'.[27] Several studies have analysed in detail the educational, intellectual and professional path of this author and the contribution he gave to hydrology and hydrogeology.[28] A pupil of two advocates of experimentalism like Montanari and Malpighi,

[23]The quote is from Giovanni Poleni, *De castellis per quae derivantur fluviorum aquae* (Patavii: Typis Iosephi Comini, 1718), p. 5. The original, and slightly different, version – 'ars aemula naturae' – is from Apuleius's *Metamorphoses,* in a passage where the protagonist describes a marble sculpture with parts made so skilfully that they seem real: 'Sub extrema saxi margine poma et uvae faberrime politae dependent, quas ars aemula naturae veritati similes explicuit' ('Up under the very edge of the rock hung apples and the most skilfully polished grapes, which art, rivalling nature, displayed to resemble reality'). Apuleius, *Metamorphoses,* ed. and transl. by John Arthur Hanson (Cambridge, MA: Harvard University Press, 1989), pp. 54–5.

[24]Cesare S. Maffioli, 'A Fruitful Exchange/Conflict: Engineers and Mathematicians in Early Modern Italy', *Annals of Science,* 70.2 (2013), 197–228 (217).

[25]Ibid., 204.

[26]On this topic, see ibid.; Id., *Out of Galileo;* Id., *La via delle acque (1500–1700). Appropriazione delle arti e trasformazione delle matematiche* (Florence: Olschki, 2010). On the concept of human art obeying/imitating nature, cfr. also Anthony J. Close, 'Philosophical Theories of Art and Nature in Classical Antiquity', *Journal of the History of Ideas,* 32 (1971), 163–84; Lenka Karfíková, 'Ars Naturae Imitatio: Stoa, Plotinus, Augustine', *Freiburger Zeitschrift für Philosophie und Theologie,* 69 (2022), 197–212; Heinrich von Staden, 'Aulus Cornelius Celsus on ars and natura', in *Tradición griega y textos médicos latinos en el período presalernitano,* ed. by Arsenio Ferraces Rodríguez (Coruña: Universidade da Coruña, Servizo de Publicacións, 2007), pp. 347–71; Csilla Szekeres, 'Omnis ars naturae imitatio est. Seneca and the fine arts', *Acta classica Universitatis Scientiarum Debreceniensis,* 48 (2012), 59–68.

[27]Domenico Bertoloni Meli, *Thinking with Objects: The Transformation of Mechanics in the Seventeenth Century* (Baltimore: The Johns Hopkins University Press, 2006), p. 181.

[28]See ibid., pp. 166–72; Julián Simón Calero, *The Genesis of Fluid Mechanics, 1640–1780* (Dordrecht: Springer, 2008), pp. 8–11, 268–85; Mario Di Fidio and Claudio Gandolfi, *Idraulici italiani* (Milan: Fondazione Biblioteca Europea di Informazione e Cultura, 2014), pp. 109–21; Maffioli, 'Guglielmini vs. Papin (1691–1697)'; Id., 'Domenico Guglielmini, Geminiano Rondelli e la nuova cattedra d'idrometria nello Studio di Bologna (1694)', *Studi e Memorie per la Storia dell'Università di*

Guglielmini's eclectic synthesis of mathematical, technical, medical and natural-philosophical knowledge shines through in his *Aquarum fluentium mensura* (1691) and in the subsequent *Della natura de' fiumi* (1697).[29] In these works, Guglielmini acknowledged the need and usefulness of water management. Still, he also highlighted how human intervention must proceed in concert with natural laws to succeed: for 'whenever men, deceived by appearance, have thought of relieving the river beds of the water that they believed to be in excess, and whenever they have done so by diverting some stream that flowed into [these rivers], they have not been long in feeling the bad effects'[30] (Figure 2)

At the same time, Guglielmini used powerful medical analogies in describing the structure and operation of rivers:

> There is a great analogy between the movement of blood through the vessels and that of water in a river, and the rupture of a blood vessel is the same as the breaking of a river bank […]; which I meant to explain, so that the hydrostatic and the medical disciplines (including the medical-practical), are shown to be not so different from each other, unlike some people think; the former being, in fact, most necessary to those who aim to understand the latter, as I hope to show in due time, by applying much of the information deduced from this treatise to medical physiology and to the doctrine of particular ailments.[31]

Both concepts – the requirement for human art to conform to nature in order to be effective, and a 'medical understanding' of water streams, natural and artificial alike – were hallmarks of Guglielmini's approach to hydraulics, an approach that did not result solely from the immense influence of Bacon and Galileo on the Italian experimental front. A very important role, in fact, was also played by the theoretical frameworks of Cartesian mechanism and Boylean corpuscularism. Having studied under Marcello Malpighi in Bologna, where he graduated in medicine in 1678, Guglielmini had become well acquainted with – and a warm supporter of – the combination of Galilean experimentalism, Baconian philosophy, and Cartesian and Boylean principles upheld by his teacher. It is also in light of this influence that we can contextualize the author's stress on the importance of anatomical study as a necessary step to handle the complexity of both

Bologna, 6 (1987), 81–124; Id., *Out of Galileo,* pp. 29–272; Id., 'Domenico Guglielmini', in *Professori e scienziati a Padova nel Settecento,* ed. by Sandra Casellato and Luciana Sitran Rea (Treviso: Antilia, 2002), pp. 505–29; Id., *La via delle acque,* pp. 151–319; Id., 'A Fruitful Exchange/Conflict', 217–23; Id., 'Saper condurre le acque', in *Enciclopedia Italiana. Ottava Appendice: Il contributo italiano alla storia del pensiero – Tecnica,* ed. by Vittorio Marchis and Francesco Profumo (Rome: Istituto dell'Enciclopedia Italiana, 2013), pp. 79–90 (see especially the first chapter, 'Domenico Guglielmini e l'imitazione della natura', https://www.treccani.it/enciclopedia/saper-condurre-le-acque_(Il-Contributo-italiano-alla-storia-del-Pensiero:-Tecnica)/); Maurizio Mamiani, 'Il metodo della filosofia naturale nelle *Riflessioni filosofiche dedotte dalle figure de'sali* di Domenico Guglielmini', in *Science and imagination in XVIIIth-century British culture,* ed. by Sergio Rossi (Milan: Unicopli, 1987), pp. 247–52.

[29] Domenico Guglielmini, *Aquarum fluentium mensura nova methodo inquisita* (Bononiae: Ex Typographia Pisariana, 1690); Id., *Della natura de' fiumi trattato fisico-matematico* (Bologna: Per gl'eredi d'Antonio Pisarri, 1697).

[30] 'E qual volta gl'uomini, ingannati dall'apparenza, hanno pensato di sgravare gli alvei de' fiumi maggiori dall'acque, che si credevano soverchie, e lo hanno fatto col divertire qualche fiume, o torrente solito a sboccare in esso; non hanno tardato molto a sentirne i cattivi effetti' (Guglielmini, *Della natura de' fiumi,* p. 245).

[31] '[..] avendo una grande analogia il corso del sangue per li propri vasi, a quello dell'acque per gli alvei de' fiumi, et equivalendo l'apertura della vena alla rottura di un argine; sì come con questo simbolizano le tuniche de' vasi predetti; il che ho voluto in questo luogo motivare, acciò appaia, non essere così disparate, le dottrine idrostatiche dalle mediche, anco pratiche, com'altri per avventura si crede; anzi essere affatto necessarie le prime, a chi vuol ben intendere in molte parti le seconde, come spero di far vedere a suo tempo, applicando molte notizie desunte da questo trattato, alla fisiologia medica, et alla dottrina de' mali particolari' (ibid., p. 266).

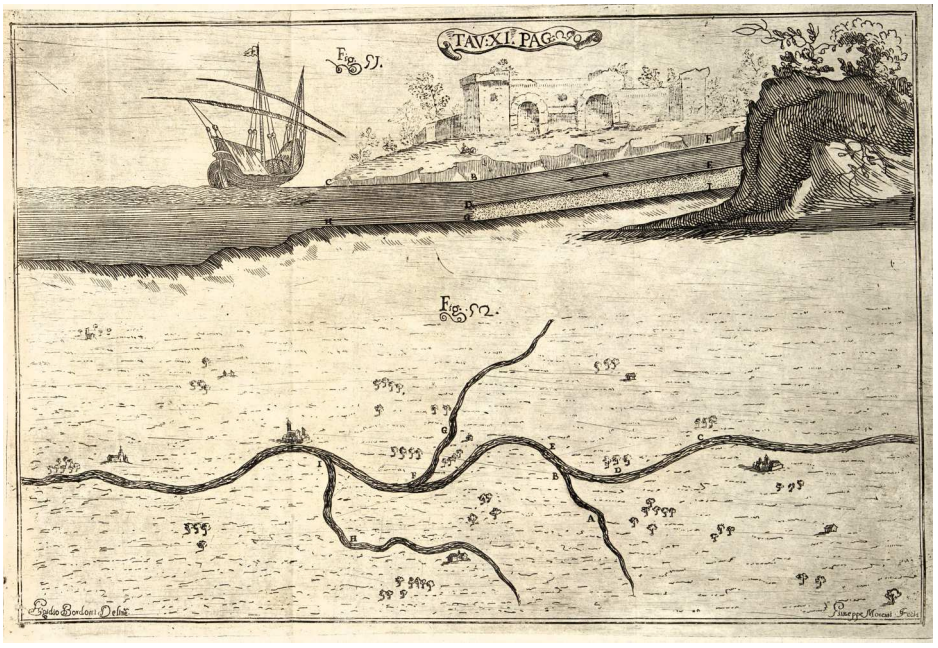


Figure 2. Study of rivers. Table XI from Guglielmini's *Della natura de' fiumi* (1697). Source: Wellcome Collection, London, UK (https://wellcomecollection.org/works/t26cjtsd/items?canvas=293). Public domain.

human and water *bodies*. For this step, in turn, held the key to the understanding and treatment of the *diseases* of humans and rivers alike.[32]

As said, both the Galilean and Baconian views advocated the idea of a supportive role of human intervention towards nature. The same notion, however, was also deeply rooted in the engineering and technical knowledge that had developed and consolidated in early modern Italy well before the advent of experimentalism, which also helps to better understand Galileo's appreciation for these traditions.[33] Not by chance, a similar caveat against a 'denaturation' of the environmental setting by human activity can also be found in the writings of the already mentioned Jacopo Riccati: an author who did not have a medical background, but who had been deeply influenced by Galilean experimentalism.

In his *Parere* on Coronelli's project, Riccati repeatedly warned against this risk. Indeed, he approved Coronelli's plan precisely because (in his opinion) it would not affect the natural course of the Adige River excessively:

> My system, from which Father Coronelli's does not differ, consists in letting the River keep all the water of which it is capable, neither more nor less. And if the flow rate is proportionate to the capacity of its vessel, how can it be thought that the bed is not sufficiently excavated by a moderate impetus, but operating with a force neither too weak nor excessive?

[32]Maffioli, 'A Fruitful Exchange/Conflict', 222–3. See also Id., 'Saper condurre le acque'. On Malpighi's theories and research method, cfr. note 10.
[33]As expressed in *Le mecaniche* (cfr. the introduction to this article and note 5). On this topic, see also Maffioli, 'Saper condurre le acque'.

> How many rivers are there lesser than the Adige, which remain sufficiently deep, and serve for navigation?[34]

And in Riccati, too, we find a suitable use of the medical analogy, as attested by his remarks in addressing the complex hydrostatic issues related to the excavation of the canal:

> Thus, since the threshold of [the river] must be high, so that it denies the exit of the useful waters, and allows it to the superfluous, it follows that the force, and the velocity, with which the turbid waters will be pushed into the outfall, will have to be calculated from the elevation of the river […] above the spillway. Hence, there being no pressure of the whole height of the water, but only of a part, there will be a low velocity, and consequently a discharge not proportionate to the need; in the manner of those physicians, who barely open the vein, when a copious emission of blood is necessary.[35]

Another pupil of Malpighi and a protagonist of the Italian experimental front, Antonio Vallisneri (1661–1730), resumed and praised Guglielmini's view of the usefulness of medical analogies to the comprehension of the natural world – and, vice versa, the usefulness of hydrological/hydrogeological knowledge to medicine. As he declared in his treatise on the origin of springs, *Lezione accademica intorno all'origine delle fontane* (1715), 'I intend to prove how all these notions are very useful for theoretical and practical medicine, […] despite some *smarties,* either out of ignorance or out of malice, deem these useless to a physician'.[36] And right before quoting Guglielmini: 'That these data on the origin of springs, of the course of the waters, and of their nature, are useful to medicine, it cannot be denied except by those who are completely unlearned of the medical and physical history'.[37]

In this and in many other works of his, Vallisneri made no mystery of how his unifying conception of natural phenomena was functional to a view of the world that was strongly influenced by Cartesian, Malebranchian and Leibnizian motifs, a world where God's omnipotence was to be recognized in the immutable harmony of natural laws.[38]

[34]'Il mio sistema, da cui non discorda quello del P. Coronelli, consiste principalmente nel lasciare all'Adige tutta la quantità dell'acqua, della qual è capace né più, né meno. E se la portata del fiume è proporzionata alla continenza del suo vaso, come mai può sospettarsi, che il letto non resti sufficientemente escavato da un impeto moderato bensì, ma che opera continuamente con una forza né troppo fiacca, né troppo gagliarda? Quanti fiumi vi sono minori dell'Adige, che pure si mantengono in una competente profondità, e servono all'uso della navigazione?' (Riccati, *Opere,* Vol. IV, p. 105).

[35]'Dovendo per tanto la soglia del nostro livello essere elevata, in maniera che nieghi l'esito delle acque giovevoli, e lo permetta alle superflue, ne segue che la forza, e la celerità, con cui le torbide verranno spinte nell'emissario, dovrà calcolarsi dall'elevazione del fiume nelle sue escrescenze sopra il piano dello stramazzo. Onde non essendovi la pressione di tutta l'altezza viva dell'acqua, ma solo di una parte, si avrà una mediocre velocità, ed in conseguenza uno scarico non proporzionato al bisogno; a guisa di que' medici, che aprono appena la vena, quando è necessaria una copiosa emissione di sangue' (ibid., p. 100).

[36]'Dimostrerei finalmente come tutte queste notizie sono utilissime alla medicina teorica, e pratica, seguendo le pedate infino del nostro Ippocrate; benché certi ingegni [..], o per ignoranza, o per malizia, le giudichino a un medico infruttuose' (Antonio Vallisneri, *Lezione accademica intorno all'origine delle fontane* (Venezia: Appresso Gio. Gabbriello Ertz, 1715), p. 13). On Vallisneri's research work (especially, but not exclusively, with respect to the Earth sciences), see *Antonio Vallisneri. La figura, il contesto, le immagini storiografiche;* Generali, *Antonio Vallisneri. Gli anni della formazione e le prime ricerche;* Id., 'Dall'uniformità della natura alla Teoria del contagio vivo in Antonio Vallisneri', *Laboratorio dell'ISPF,* 17 (2020), 1–18; Francesco Luzzini, *Il miracolo inutile. Antonio Vallisneri e le scienze della Terra in Europa tra XVII e XVIII secolo* (Florence: Olschki, 2013); Id., *Theory, Practice, and Nature In-between: Antonio Vallisneri's* Primi Itineris Specimen (Berlin: Edition Open Access/MPIWG Berlin, 2018).

[37]'Che finalmente queste notizie della generazione delle sorgenti, del corso delle acque, e della natura loro, sieno utili alla medicina, non lo si può negare, se non chi è affatto ignaro della medica, e fisica storia' (Vallisneri, *Lezione accademica intorno all'origine delle fontane,* p. 71).

[38]On the influence exerted on Vallisneri by Descartes, Malebranche, and the Leibnizian doctrines of *scala naturae* and of the recognition of divine providence in creation, see Dario Generali, 'Antonio Vallisneri corrispondente leibniziano', in

Hence the need for an *ars* – in medicine as well as in natural philosophy – that would comply with rather than contrast these laws. Just like in medicine, therefore, any drastic intervention on the course of rivers would only make things worse: whereas, in order to be truly useful, human intervention should support what the healing power of nature (*vis medicatrix naturae*) is already doing.

Perhaps the most explicit advocacy of the supportive role of the *ars* of men towards nature can be found in the work of the natural philosopher and mathematician Bernardo Trevisan (1652–1720), *Della Laguna di Venezia* (1715). Given his research interests, and being a well-connected senator of the Republic and a member of the *Quarantia* ('Council of Forty', the supreme court of the *Serenissima*), Trevisan could reasonably claim to have a say in the knowledge of the lagoon. In discussing the main actions taken by Venice in the centuries-long effort to preserve the balance between land and sea, he criticized the choice of managing water bodies through drastic interventions. On the contrary, he recommended promoting the course of streams in order to ease their 'natural inclination' ('The general rule is not impeding in any way, but promoting […] the course of the waters, while operating in this way, the lesser the labor, the lighter the expense, and the lagoon can perpetually maintain itself').[39]

There were good reasons for this 'general rule'. As Trevisan wrote, he was

> […] more and more convinced of the following: that the world, [without human intervention], maintains itself in that disposition, and with those forms, that its Creator assigned to it; that the intervention of *art* has never been able to take away that aspect, which by natural disposition it must maintain; [and] Nature does not change its ordinary dispositions, if God does not promote, or at least does not permit such accidents, which change it almost violently […] See, for example, […] the vain labors done by […] monarchs in cutting isthmuses, in diverting rivers; and […] in transforming ponds, and marshes.[40]

Let then

> […] some preach the expensive digging of beds, and long canals; the erection of embankments, and elevated places; the scraping of sandbanks; the removal of mud from the bottom of the lagoon, and other works more suited to their own interest, than to the public good; and let us seek only to help the inclinations of the waters; for nature,

Rapporti di scienziati europei con lo Studio bolognese fra '600 e '700, ed. by Marta Cavazza (Bologna: Istituto per la Storia dell'Universita, 1987), pp. 125–40; Id., *Antonio Vallisneri. Gli anni della formazione e le prime ricerche,* pp. 36–7, 42, 60, 83, 85, 128, 226, 229, 354, 437, 379, 428–9; Luzzini, *Theory, Practice, and Nature In-between,* pp. 14, 23–4, 27, 51, 94, 172, 97, 175.

[39] 'La massima, che deve tenersi per le cose sin ad ora trattate, si è adunque il non impedire in alcun modo, ma promuovere, e fomentare il corso dell'acque, mentre operando in tal guisa, minore è assai la fatica, lieve il dispendio, e la laguna può mantenersi perpetuamente' (Bernardo Trevisan, *Della laguna di Venezia* (Venezia: Per Domenico Lovisa, 1715), p. 102). On Trevisan, cfr. Stefania De Toma, 'Aspetti retorici del confronto tra Giambattista Vico e Bernardo Trevisan', in *Il «Giornale de' Letterati d'Italia» trecento anni dopo: Scienza, storia, arte, identità (1710–2010),* ed. by Enza del Tedesco (Pisa: Fabrizio Serra, 2012), pp. 235–45; Vernon Hyde Minor, *The Death of the Baroque and the Rhetoric of Good Taste* (Cambridge: Cambridge University Press, 2006), pp. 48–54; Paolo Ulvioni, *Atene sulle lagune. Bernardo Trevisan e la cultura veneziana tra Sei e Settecento* (Venice: Ateneo Veneto, 2000).

[40] 'Io dunque sempre più mi stabilisco nel sentimento suddetto, che il mondo dalle sole vicende condotto, si mantenga in quella positura, e con quelle apparenze, che il suo Creatore ha voluto ad esso assegnare; che l'applicazioni dell'arte non abbiano mai potuto levare (almen totalmente) ad alcune delle sue situazioni quell'aspetto, che per naturale disposizione de[ve] mantenere; né che la natura cangi le proprie sue disposizioni ordinarie, se l'autore della medesima non promove, o almeno non permette tali accidenti, che le vengano quasi con violenza a mutare. Ed a stabilire ciò non ci mancano gli esempli, quando si voglia co' medesimi confermarlo. Possono servire d'esempio [..] le vane fatiche praticate dal potere di più monarchi nel tagliar istmi, nel divertire la corrente de' fiumi; e per non partirmi dal punto, di cui si tratta, nel trasformare stagni, e paludi' (Trevisan, *Della laguna di Venezia,* p. 107).

> without our labor, will not only do what art fails to do; but [will also] do everything with utility, whereas art often labors to produce the useless, and sometimes the harmful.[41]

Nor is Trevisan's book lacking in medical analogies. For, both in the human and in the natural body, the *vis medicatrix naturae* proceeds without the help of men: indeed, sometimes human intervention is more harmful than helpful, as the author warns in commenting a notorious case of poor water management in the Venetian Lagoon ('after the [artificial] interventions ceased, [the lagoon] with the benefit of its natural dispositions was preserved, and recovered: just like a sick person who, having left the too intrusive medicines, is recovering with the help of its natural vigor alone').[42]

Trevisan's admonishment not to interfere, but rather to 'help the inclinations of the waters', emanates from the belief that these inclinations cannot be altered in any way. In other words, for the author – as for Riccati, Vallisneri, Guglielmini – the inescapability of natural laws sets insurmountable limits on technology. Still, these laws and limits are as inescapable as they are immutable, which makes them a reliable key to comprehend nature in its complexity. Another great mathematician and physicist of the time, the Venetian Giovanni Poleni (1683–1761), explained this concept with unparalleled clarity in his treatise *De motu aquae mixto* (1717):

> And in fact, I am convinced that the same laws are preserved by nature in acting everywhere, and the laws of nature are to be displayed everywhere by the same explanations; so I have it as most certain, that one single explanation may be applied in various ways to the various features of places.[43]

Like Vallisneri, Poleni was another champion of the Italian experimental front.[44] And he, too, was unwavering on one point: natural laws – he affirmed – apply uniformly through time and space. Hence his frequent warnings on the futility of trying to contrast these laws, rather than abiding by them: warnings that might sound even more consequential if we consider that they came from one of the most acknowledged experts in

[41] 'Si lascino dunque predicare a certuni le dispendiosissime escavazioni di grand'alvei, e lunghi canali; l'erezione d'argini, e luoghi eminenti; lo scrostar barene; il rimover velme, ed altre opere più confacevoli al loro interesse, che giovevoli al pubblico bene; e si applichi solo ad aiutar le inclinazioni delle acque; che la natura senza nostra fatica e dispendio farà non solo ciò, che l'arte non mai giugne a fare; ma tutto con giovamento, mentre l'arte spesso s'affanna a produrre l'inutile, e talvolta ciò, ch'è dannoso' (ibid., pp. 113–4).

[42] '[…] così dopo che le manipulazioni sopradette cessarono, quasi infermo, che lasciando i farmaci troppo infesti, si va rimettendo col solo suffragio del natural suo vigore, appunto [la laguna] col benefizio delle sue naturali disposizioni tuttavia si conserva, e rimette' (ibid., pp. 99–100).

[43] 'Ut enim persuasum habeo, easdem a natura in agendo leges ubique conservari, et iisdem ubique explicationibus exponendas esse naturae leges; ita etiam tam certum, quam quod certissimum, habeo, unam eandemque explicationem varie variis locorum proprietatibus esse applicandam' (Giovanni Poleni, *De motu aquae mixto libri duo* (Patavii: Typis Iosephi Comini, 1717), p. 104).

[44] On this author, see *Giovanni Poleni (1683–1761) nel bicentenario della morte* (Padua: Accademia Patavina di Scienze, Lettere ed Arti, 1963); *Giovanni Poleni: idraulico, matematico, architetto, filologo (1683–1761),* ed. by Maria Laura Soppelsa (Padua: Accademia Patavina di Scienze, Lettere ed Arti, 1988); *Giovanni Poleni tra Venezia e Padova,* ed. by Piero Del Negro (Venice: Istituto Veneto di Scienze, Lettere ed Arti, 2013); Di Fidio and Gandolfi, *Idraulici italiani,* pp. 181–90; Brendan Dooley, 'Science teaching as a career at Padua in the early 18th century: The case of Giovanni Poleni', *History of Universities,* 4 (1984), 115–51; Céline Le Gall, *Giovanni Poleni (1683-1761) et l'essor de la technologie maritime au siècle des Lumières* (Turnhout: Brepols, 2019); Cesare S. Maffioli, 'Italian Hydraulics and Experimental Physics in Eighteenth-Century Holland. From Poleni to Volta', in *Italian Scientists in the Low Countries in the XVIIth and XVIIIth Centuries,* ed. by Cesare S. Maffioli and Lodewijk C. Palm (Leiden: Brill, 1989), pp. 243–75; Id., *Out of Galileo,* pp. 326–84; Id., 'La sperimentazione in campo idraulico: Giovanni Poleni e Francesco Domenico Michelotti', in *Il sapere scientifico in Italia nel secolo dei Lumi,* ed. by Giampiero Sironi, Alberto Conte, and Gian Antonio Danieli (Venice: Istituto Veneto di Scienze, Lettere ed Arti, 2015), pp. 89–106; Gian Antonio Salandin and Maria Pancino, *Il Teatro di filosofia sperimentale di Giovanni Poleni* (Trieste: Lint, 1987).

service to the Venetian *Magistrato alle acque* during the first half of eighteenth century, who had a very clear understanding of the limits to which human art was bound. One year later, Poleni would reaffirm his 'synergic interpretation' of technology in the first pages of another treatise of his, *De castellis per quae derivantur fluviorum aquae* (1718): since 'attempting to make an art work against the laws of motion would be pointless […] as it would be equally pointless attempting to break the natural ratio between the amount of water and its velocity',[45] it follows that the work of art 'should not force nature to those things that art itself strives for. Rather, it should combine its energy with the laws and principles of nature in such a way that nature, being engaged in collaboration (so to speak), may accomplish spontaneuously what is to be accomplished'.[46]

The best and most useful thing that humans can do, then, is to interpret and facilitate the work of nature. Far from diminishing the dignity of technology, this task actually reveals technology in its full importance, as the slowness of natural processes might conflict with human needs. We can see, therefore, why an *aemula naturae ars* (an art that – in accordance with the double meaning of the Latin word *aemulus* – not only *imitates,* but also *rivals* the operation of nature) is useful to compensate for the temporal gap between human urgency and natural pace. A concept, this one, which would be illustrated some years later by Guglielmini's favourite pupil, Bernardino Zendrini (1679–1747).

Together with Poleni, Zendrini was the other 'ace of hydraulics' who served the *Magistrato alle acque* during the first decades of the eighteenth century. His appointment as 'Mathematician and General Superintendent of the waters, rivers, lagoons, and bridges' of the Republic of Venice, in 1720, marked the final phase of what has been described as the geographical shift towards northeast of Galilean mathematics applied to hydraulics: a process that, within a century, led the epicentre of this tradition to migrate from Medici Tuscany to Bologna, and, finally, to the *Serenissima* – and which proceeded in parallel with a more general shift of the intellectual debates from princely courts to the civic, and more 'institutionalized', context of universities.[47]

A versed engineer and mathematician, but also a physician and astronomer, with the publication of *Leggi e fenomeni, regolazioni ed usi delle acque correnti* (1741), Zendrini became one of the first Italian scientists to provide a description of hydraulic phenomena

[45] 'Ac illud in primis constituo, frustra conari artem quidpiam efficere contra leges naturales motuum, quorum viribus limosae aquae partes, quantum fert talium partium motuumque natura, veluti suspensae detinentur: frustra etiam laborare, si tentet, naturalem rationem inter aquae copiam, eiusdemque velocitatem infringere' (Poleni, *De castellis per quae derivantur fluviorum aquae,* p. 7).

[46] 'Quare eo spectare artis industria non debet, ut naturam ad res illas, quas ipsa ars molitur, cogat; sed ut suam industriam cum naturae legibus atque rationibus ita coniungat, ut natura in societatem operis adducta id ultro (ut ita dicam) efficiat, quod est efficiendum' (ibid., p. 7). With the publication of *De Castellis,* Poleni joined the controversy opposing Leibnizian to Newtonian followers about the measure of force and the notion of *vis viva:* he provided experimental evidence in support of the Leibnizian faction. See Silvio Bergia and Paolo Fantazzini, 'Dalla regolamentazione delle acque alle leggi del'urto centrale elastico. Una rivalutazione del ruolo di Giovanni Poleni nella disputa delle forze vive', *Giornale di Fisica,* 21 (1980), 46–60; Maffioli, 'Italian Hydraulics and Experimental Physics in Eighteenth-Century Holland', pp. 263–6; Andrea Reichenberger, 'Leibniz's Quantity of Force: A 'Heresy'? Emilie Du Châtelet's *Institutions* in the Context of the *Vis Viva* Controversy', in *Emilie Du Châtelet Between Leibniz and Newton,* ed. by Ruth Hagengruber (Dordrecht: Springer, 2012), pp. 157–72 (159–60); Maria Pancino, 'L'intervento di Giovanni Poleni nella disputa delle forze vive', in *Giovanni Poleni: idraulico, matematico, architetto, filologo (1683–1761),* pp. 39–54; Cornelis de Pater, 'The Textbooks of 's Gravesande and van Musschenbroek in Italy', in *Italian Scientists in the Low Countries in the XVIIth and XVIIIth Centuries,* pp. 231–41.

[47] Maffioli, *Out of Galileo.* On the decline of court/princely patronage in early modern Italy, see in particular pp. 2, 24–5, 34–5, 109–10, 116, 424–5. See also Id., 'Sul filo delle acque. Aspetti delle scienze fisiche in Italia tra Seicento e primo Settecento', *Nuncius,* 8.2 (1993), 41–74 (64–73).

based on calculus.[48] His awareness of the existing gap between human needs and the timescale of many natural processes is especially evident in Chapter XIII, the one dealing with land reclamation. In a telling passage towards the end of the chapter, for example, the author warns that '[…] the owner of the land to be reclaimed will not have to be in any hurry to obtain profit from it. For, with these means we rely on Nature; and it is known that [Nature] works infallibly in producing its effects, but it proceeds slowly in perfecting its works'.[49]

The operation of Nature, Zendrini warns, is as slow as it is relentless; and if human intervention can do something to promote or (at best) accelerate its course, it can do nothing to contrast it. As the author remarked in a posthumous work of his, *Memorie storiche dello stato antico e moderno delle lagune di Venezia,* 'the secret inclinations of Nature can too hardly be counteracted by art, which, in order to operate properly, can only go along with them, in case they are going in the right direction; or correct them with great caution, when they are poorly aimed'.[50]

In other words, *ars* (that is, technology) is essentially an effort to make the best use of natural laws, but without any pretense of changing them.

4. Confluences

'Medical understanding' of hydrogeological processes and water management, immutability of natural laws across space and time, and a conception of technology supportive of nature. In all the sources analyzed here, these three motifs seem to intertwine and validate each other insistently.

This paper has striven to show that the roots of such thematic interconnection can be traced to the interplay of Galilean experimentalism and medical tradition, an interplay that marked the professional background of key figures in the Italian hydrogeological debate of the late seventeenth and early eighteenth centuries. As we have seen, this conceptual and methodological combination owed a lot to Marcello Malpighi: his blend of Galilean experimentalism and (carefully chosen) Baconian, Cartesian, Boylean and Harveyan notions was crucial in safeguarding Galileo's legacy against inquisitorial threats –

[48]On this specific issue, see Silvia Mazzone and Clara Silvia Roero, *Jacob Hermann and the Diffusion of the Leibnizian Calculus in Italy* (Florence: Olschki, 1997), pp. 114–27; Clara Silvia Roero, 'La Rivoluzione scientifica: i domini della conoscenza. Diffusione e primi sviluppi del calcolo infinitesimale', in *Storia della Scienza* (Rome: Istituto dell'Enciclopedia Italiana, 2002, https://www.treccani.it/enciclopedia/la-rivoluzione-scientifica-i-domini-della-conoscenza-diffusione-e-primi-sviluppi-del-calcolo-infinitesimale_(Storia-della-Scienza)/). On Zendrini's life and work more in general, cfr. *Polesine e acque nell'età moderna e contemporanea,* pp. 87–90, 181–2; Giacomo Bonan, 'Hydraulic Engineers and Antiquarians: Political Use of the Past in Nineteenth-Century Venice', *Technology and Culture,* 64.3 (2023), 845–74; Ciriacono, *Building on Water,* pp. 111, 117, 122, 124–30, 134, 138–41, 150–3, 183–4; Di Fidio and Gandolfi, *Idraulici italiani,* pp. 169–79; Alessandra Fiocca, 'Bernardino Zendrini', in *Professori e scienziati a Padova nel Settecento,* pp. 403–12; Wilko Graf von Hardenberg, 'Making a Stable Sea: The Littorals of Eighteenth-Century Europe and the Origins of a Spatial Concept', *Isis,* 112.1 (2021), 130–40; Maffioli, *Out of Galileo,* pp. 21, 156, 311–4; Francesca Venuto, 'Zendrini Bernardino, ingegnere e architetto', in *Nuovo Liruti. Dizionario biografico dei friulani.* Vol. II, *L'Età Veneta,* ed. by Cesare Scalon, Claudio Griggio, and Ugo Rozzo (Udine: Forum, 2009), pp. 2635–9.

[49]'[..] il padrone de' fondi da bonificarsi non avrà ad aver fretta alcuna per ricavarne il frutto, conciosiaché con tali mezzi commettendosi quasi tutto l'affare alla natura, è noto che questa quanto opera sicuramente nel produrre i suoi effetti, altrettanto va tarda nella perfezione de' propri lavorieri' (Bernardino Zendrini, *Leggi e fenomeni, regolazioni ed usi delle acque correnti* (In Venezia: Presso Giambattista Pasquali, 1741), p. 401).

[50]'[..] l'inclinazioni poi occulte della natura possono troppo difficilmente essere contrastate dall'arte, la quale per oprar rettamente non deve che secondarle, se bene sono indrizzate; o con somma cautela correggerle, se male stanno dirette' (Bernardino Zendrini, *Memorie storiche dello stato antico e moderno delle lagune di Venezia,* Vol. I (Padova: Nella Stamperia del Seminario, 1811), p. 50).

and, therefore, in extending the impact of this legacy into medicine and natural philosophy. Malpighi's research approach was then passed on to his students and collaborators, who, in the following decades, would shape nearly all branches of natural philosophy in Italy.[51] With no exception for water management: a discipline at the crossroads between hydraulics and the Earth sciences that was, as it is now, a central topic for communities and governments alike – and which, for this very reason, became a subject of investigation and controversy by many scholars and technicians who had been influenced by the new experimental wave, turning to the study of waters either out of philosophical curiosity or institutional responsibility.

Actually, the growing importance accorded to the study of waters in northern Italy at the turn of the eighteenth century cannot be fully understood without considering the 'institutional factor'. During the century-long process that saw intellectual and scientific patronage shift from princely courts to universities and civic bureaus (like, for example, the *Magistrato alle acque* in the Republic of Venice), more and more university-trained experts came to rely on a broad social support: for, not only the authorities, but also increasingly larger segments of public opinion acknowledged the usefulness of these professionals in serving the public good, and favoured the idea of providing the financial and logistic means for their studies to thrive and diversify.[52]

As said, many of these experts were trained as physicians. And, in the work of those authors belonging to the experimental tradition who engaged in the hydrogeological debate, the integration of notions from other natural-philosophical models taught in universities overlapped with – and further reinforced – the 'Galilean insights' underlying the thematic recurrence discussed in this paper. Let us consider, for example, the case of Cartesian iatrophysics and William Harvey's interpretation of the circulation of blood. It is most probable that these models, which influenced two medical champions of Galilean experimentalism like Borelli and Malpighi, provided a reasonable conceptual gateway for an even deeper penetration of 'hydraulic thinking' into medicine. This, in turn, would pave the way to the extension of the anatomical-physiological interpretation to water *bodies*.[53]

We may suspect that another factor might have played a role in the success of the correlation between the human and the natural body – and, therefore, in the confluence of the medical language with hydraulics: the professional inclination of those influential medical voices in the hydrogeological debate (like Guglielmini, Zendrini, Vallisneri) who sensed clearly the interpretive strain caused by the passage of the experimental method from medicine to natural philosophy.

[51]To give an clearer idea of the 'experimentalist homogeneity' of the authors discussed in this paper, let us remind that all of them (with the only exception of Guglielmini, who died in 1710) contributed to the first volumes of the *Giornale de' Letterati d'Italia,* the first learned journal in Italy featuring a specific section devoted to science – where, in fact, Vallisneri was editor for medicine and natural philosophy. The journal was supported by the Republic of Venice and was published continuously from 1710 to 1733. Cfr. *Il «Giornale de' Letterati d'Italia» trecento anni dopo;* Brendan Dooley, *Science, Politics, and Society in Eighteenth-Century Italy: The* Giornale de' letterati d'Italia *and its World* (New York: Garland, 1991); Dario Generali, 'Il «Giornale de' letterati d'Italia» e la cultura veneta del primo Settecento', *Rivista di storia della filosofia,* 39.2 (1984), 243–81; Id., *Antonio Vallisneri. Gli anni della formazione e le prime ricerche,* pp. 383–411.

[52]Maffioli, *Out of Galileo,* pp. 2, 24–5, 34–5, 109–10, 116, 424–5; Id., 'Sul filo delle acque'. See also note 49.

[53]On the mechanization of anatomy (and, more generally, of the life sciences) in the seventeenth century, see Nuno Castel-Branco, 'Physico-mathematics and the life sciences: experiencing the mechanism of venous return, 1650s–1680s', *Annals of Science,* 79.4 (2022), 442–67. A seminal discussion of the analogies linking fluid mechanics, physiology, society, and politics in the seventeenth century is featured in I. Bernard Cohen, *Interactions: Some Contacts between the Natural Sciences and the Social Sciences* (Cambridge, MA: The MIT Press, 1994).

This transition posed practical, methodological, and even epistemological, challenges, since not only the different nature of the subject matter, but also its very *size* played a role in the problem. Unlike most living bodies, in fact, hydrogeological features such as rivers, fountains, canals and lakes could not be examined in laboratories and anatomical theatres where to perform controlled tests. In these cases, nature could not enter laboratories, and laboratories had to enter – literally – nature. Therefore, stressing the analogy between human and natural bodies (even by means of terminology) might have helped these authors to compensate for, or at least, mitigate, the theory-practice tension and the interpretive strains caused by such an inverted approach.[54]

All these efforts rested on an assumption that was still far from obvious, not to say unanimously accepted, at the time when the debates discussed here were taking place: the uniformity and immutability of natural laws independent from time and space. Actually, this concept – which would later merge into the concept of *uniformitarianism* – continued to raise ferocious debate within the European Republic of Letters at least until the first half of the nineteenth century. Its acceptance proceeded in concert with, on the one hand, the refinement of a well-defined methodology of field research, and, on the other, the cumulative impact of geographical discoveries on scientific knowledge. As we know, both processes required much effort and time before being fully or reasonably accomplished.

And yet, in the face of the resistance still met by uniformitarianism in the early eighteenth century, it is safe to say that this notion was already accepted (and enthusiastically, too) by all the authors introduced in these pages, mainly because of their shared 'Galilean ancestry'. Another important role, however, was played by the influence exerted on their work by the great natural-philosophical systems of the era like the Cartesian, the Leibnizian, and the Newtonian, all of which – despite the important differences – shared an unshakable faith in the notion of an immutably harmonious universe.[55] It was also thanks to the work of these Italian scholars that the idea of uniformity of natural laws

[54]About this issue, see Francesco Luzzini, '(Re)Shaping a Method: Field Research and Experimental Legacy in Vallisneri's *Primi Itineris Specimen* (1705)', in *Connecting Territories: Exploring People and Nature, 1700–1850,* ed. by Simona Boscani Leoni, Sarah Baumgartner, and Meike Knittel (Leiden: Brill, 2021), pp. 54–74.

[55]On the reception of the Cartesian, Newtonian, and Leibnizian philosophies in the Republic of Venice and, more generally, in the Italian context, see Giulia Belgioioso, 'Images of Descartes in Italy', in *Receptions of Descartes: Cartesianism and Anti-Cartesianism in Early Modern Europe,* ed. by Tad M. Schmaltz (New York: Routledge, 2005), pp. 171–96; Ead., ''Italy did not want to be Cartesian': And for Good Reason', in *The Oxford Handbook of Descartes and Cartesianism,* ed. by Steven Nadler, Tad M. Schmaltz, and Delphine Antoine-Mahut (Oxford: Oxford University Press, 2019), pp. 514–30; Paolo Casini, *Newton e la coscienza europea* (Bologna: Il Mulino, 1983); Francesca Maria Crasta, 'Sulla presenza di Descartes nella 'Galleria di Minerva'', *Giornale critico della filosofia italiana,* 75.3 (1996), 312–29; Vincenzo Ferrone, *Scienza, natura, religione. Mondo newtoniano e cultura italiana nel primo Settecento* (Naples: Jovene, 1982); Id., *The Intellectual Roots of the Italian Enlightenment: Newtonian Science, Religion, and Politics in the Early Eighteenth Century* (Atlantic Highlands (NJ): Humanities Press, 1995); Generali, 'Il «Giornale de' letterati d'Italia» e la cultura veneta del primo Settecento'; Id., 'Antonio Vallisneri corrispondente leibniziano'; Id., *Antonio Vallisneri. Gli anni della formazione e le prime ricerche,* pp. 36–7, 41–3, 60, 85, 122, 125, 128, 224, 226, 229, 239; Jonathan I. Israel, *Radical Enlightnenment: Philosophy and the Making of Modernity, 1650–1750* (Oxford: Oxford University Press, 2001), pp. 664–83; Erika Luciano, 'Peano and His School Between Leibniz and Couturat: The Influence in Mathematics and in International Language', in *New Essays on Leibniz Reception,* ed. by Ralf Krömer and Yannick Chin-Drian (Basel: Springer, 2012), pp. 41–64; Mazzone and Roero, *Jacob Hermann and the Diffusion of the Leibnizian Calculus in Italy;* Massimo Mazzotti, 'Newton in Italy', in *The Reception of Isaac Newton in Europe,* Vol. I, ed. by Helmut Pulte and Scott Mandelbrote (London: Bloomsbury, 2019), pp. 159–78; James G. O'Hara, *Leibniz's Correspondence in Science, Technology and Medicine (1676–1701): Core Themes and Core Texts* (Leiden: Brill, 2024).

was refined and, later on, could establish itself as a cornerstone element of the Earth sciences and of scientific endeavour more in general.[56]

This study has focused expressly on early modern northern Italy, an analysis at a European, or even broader, level being beyond the scope of my paper and beyond my own competence. Actually, it would take much more than just one paper (and more than one author) to explore if – and how – the interplay of medical and natural-philosophical models affected water management across different geographical and cultural contexts, and if – and how – these contexts interacted with and influenced each other. Such a goal would require an interdisciplinary and cross-cultural approach, which would require a joint effort by historians of science and medicine with complementary expertise and research interests: a perspective that might provide inspiration for more ambitious projects in the future.

In any case, as we know, historical research – like science – is a collective and cumulative enterprise; and I hope that this investigation, however limited, has contributed to shed light on a fairly unexplored aspect of the debate on water management in early eighteenth-century northern Italy. A debate where a 'medical understanding' of the natural world (both in terms of anatomy and therapeutics, as we have seen) helped to make sense of a natural order that, although undeniable, often seemed to be beyond the grasp of the human mind. Whereas, in fact, matching the human body with the 'hydrogeological body' would help to provide a unified explanation of the medical and technical arts; of the roles of physicians and technicians; and, finally, of the immutable and eternal laws of nature to which *arts* and *artists* alike were bound in (expedient) obedience.

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[56]For a discussion of the notion of uniformitarianism (including the relationship of the early modern concept of uniformity/immutability of natural laws with 18th- and 19th-century geological uniformitarianism), see Claude C. Albritton Jr., *The Abyss of Time: Changing Conceptions of the Earth's Antiquity after the Sixteenth Century* (San Francisco: Freeman Cooper, 1980), pp. 87–8, 100, 132, 139–47, 186 –9, 215; Henry Faul and Carol Faul, *It Began with a Stone: A History of Geology from Stone Age to the Age of Plate Tectonics* (New York: John Wiley & Sons, 1983), pp. 89, 90–1, 138, 184, 218; Stephen Jay Gould, 'Is Uniformitarianism Necessary?', *American Journal of Science,* 263.3 (1965), pp. 223–8; Reijer Hooykaas, *Natural Law and Divine Miracle: The Principle of Uniformity in Geology, Biology and Theology* (Leiden: Brill, 1963); Francesco Luzzini, 'Through dark and mysterious paths: Early modern science and the search for the origin of springs from the 16th to the 18th centuries', *Earth Sciences History,* 34.2 (2015), 169–89 (184–5); David R. Oldroyd, *Thinking About the Earth: A History of Ideas in Geology* (London: Athlone, 1996), pp. 82, 134, 136–9, 142–3, 177, 202, 301, 330–331; Rhoda Rappaport, *When Geologists were Historians, 1665–1750* (Ithaca (NY): Cornell University Press, 1997), pp. 95, 162, 164, 167, 205–6, 238–42, 246; Marco Romano, 'Reviewing the term uniformitarianism in modern Earth sciences', *Earth-Science Reviews,* 148 (2015), pp. 65–76; Martin J.S. Rudwick, *The Meaning of Fossils: Episodes in the History of Paleontology* (Chicago: The University of Chicago Press, 1972), pp. 110, 130–2, 169–72, 179, 185–8, 231, 235, 259; James H. Shea, 'Twelve Fallacies of Uniformitarianism', *Geology,* 10.9 (1982): 455–60.; Davis A. Young, *The Biblical Flood: A Case Study of the Church's Response to Extrabiblical Evidence* (Grand Rapids: William B. Eerdmans Publishing Company – Carlisle: The Paternoster Press, 1995), pp. 176, 178, 182, 209, 246, 248, 260–3, 270, 285, 290–3, 296.

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