

GREEN LABORATORIES: PLANT STUDIES IN THE EARLY MODERN PERIOD.
INTRODUCTION

by

FABRIZIO BALDASSARRI^{1,2,*}¹*Department of Philosophy and Cultural Heritage, Ca' Foscari University of Venice,
Dorsoduro 3246, 30123 Venice, Italy*²*Indiana University Bloomington, 107 S. Indiana Avenue, Bloomington,
IN 47405-7000, USA*

By the 1550s, the Dukes Medici had constructed small laboratories or *fonderie* in Florence. These were buildings with furnaces and stills to perform chymical experiments, preparing distillations and fabricating pharmaceutical therapies. The fame and prestige of Duke Cosimo I de' Medici's (1519–1574) pharmaceutical laboratory has been well recognized by scholars.¹ Since the late sixteenth century, Francesco Bocchi (1548–1618) described these spaces in *Le bellezze della città di Firenze* (1591), while Filippo Pigafetta (1533–1604) acknowledged that in *fonderie* distillations and other alchemical activities were performed. Yet, connected to the furnaces and pharmaceutical laboratory, gardens too became an important space for the investigation of nature. For instance, Pigafetta writes that there was 'a garden with leafy trees and flowers, for the delight of the Crown prince (Cosimo II) ...'; and in the Fonderia 'they continuously distil waters of scented flowers and herbs ... drawing quintessence and ointments, and producing electuaries and restorative confections, liquors against malignant fevers, and plague, and poisons, and powders, and powerful medicines'.² As it appears, gardens were both a space of delight and peaceful rest, and a sort of laboratorial space in which the cultivation of plants and herbs favoured the experimentation in laboratories.³

Although these laboratorial practices overlapped with the pharmacological fabrication of therapies—and with more chymical aims—a naturalistic study of plants in their own right

*fabrizio.baldassarri@unive.it

1 Valentina Corticelli, 'Una storia di storie. La fonderia del Granduca. Laboratorio, Wunderkammer e museo farmaceutico', in *L'alchimia e le arti. La Fonderia degli Uffizi da laboratorio a stanza delle meraviglie* (ed. Valentina Corticelli), pp. 13–33 (Sillabe, Livorno, 2012); Cristina Bellorini, *The world of plants in Renaissance Tuscany: medicine and botany* (Ashgate, Farnham, 2016), pp. 28–40; Giovanni Piccardi, *La farmacia granducale di Firenze* (Olschki, Florence, 2018); Georgiana Hedesan, 'Alchemy and Paracelsianism at the Casino di San Marco in Florence: an examination of *La fonderia dell'Ill.mo et Ecc.mo Signor don Antonio de' Medici (1604)*', *Nuncius* 31, 119–143 (2022); Sheila Barker, 'Cosimo I de' Medici and the Renaissance sciences: 'to measure and to see'', in *A companion to Cosimo I de' Medici* (ed. Alessio Assonitis and Henk Th. van Veen), pp. 520–580 (Brill, Leiden and Boston, 2022).

2 Filippo Pigafetta, *Le bellezze di Firenze*, in *Saggio istorico della Real Galleria di Firenze*, 2 vols (ed. Giuseppe Pelli Bencivenni), vol. 1, pp. 198–199 (Cambiasi, Florence, 1779).

3 Andrew Cunningham, 'The culture of gardens', in *Cultures of natural history* (ed. Nicholas Jardine, James A. Secord, and Emma C. Spary), pp. 38–56 (Cambridge University Press, 1996).

somehow arose in this context. Indeed, Cosimo I was praised for his naturalistic knowledge and especially for his passion for plants and his patronage of botanists. He had read and commented upon Dioscorides' *Materia medica*, mostly concentrating on the curative faculties of plants, but he was also aware of the importance of knowing the nature of plants and performing direct observations on specimens to achieve this goal. He certainly shared the view of Luca Ghini (1490–1556), whom he had invited as a professor of materia medica at the University of Pisa, which reopened in 1543. While teaching 'the nascent field of botany ... [Ghini] inaugurated the botanical garden in Pisa in 1543, the first such laboratory for the study of nature in any Italian university, but also the one in Florence in 1544, and eventually inspired the one in Bologna founded in 1568'.⁴ Indeed, Ghini advocated learning from direct observation of actual plants and their cultivation,⁵ and gardens, *horti vivi*, as well as herbaria, *horti sicci*, were crucial instruments to acquire sound botanical knowledge.⁶ Many of his disciples, namely, Andrea Cesalpino (1524–1603), Gherardo Cibo (1512–1600), Michele Merini, and Ulisse Aldrovandi (1522–1606), carried on Ghini's enterprise, working at botanical gardens, fabricating herbaria, and favouring the observation of, and experimentation with, plants.⁷ In sixteenth-century Tuscany, from private gardens to *fonderie* and botanical gardens, plants were accommodated and cultivated for the purposes of identification and natural historical knowledge, aiming at plant classification and at possessing the abundant diversity of nature, but were also the object of experimentation, aiming at a more profound knowledge of the nature and operations of vegetation.⁸

This was not restricted to Tuscany, as botanical experimentation gained momentum throughout Western Europe, and botanical gardens served experimental purposes and were outdoor laboratories, somehow complementing the abilities to accommodate and cultivate plants by gardeners and horticulturalists who worked in private gardens.⁹ For instance, the correspondence of the naturalist Carolus Clusius (1526–1609) testifies to the experimentation in his circle and at the Leiden *hortus botanicus*.¹⁰ Among other cases, Clusius informed German botanist Joachim Camerarius (1534–1598) of his trials with anemones, and Flemish

4 Paula Findlen, 'The death of a naturalist: knowledge and community in late Renaissance Italy', in *Professors, physicians and practices in the history of medicine: essays in honor of Nancy Siraisi* (ed. Gideon Manning and Cynthia Klestinec), pp. 155–196, at p. 160 (Springer, Cham, 2017). Cf. Anatole Tchikine, 'Gardens of mistaken identity: the Giardino delle Stalle in Florence and the Giardino dell'Arsenale in Pisa', *Stud. Hist. Gard. Design. Landsc.* **33**, 39–51 (2013).

5 Carmelo Battiato, 'Luca Ghini (1496–1556), medico e botanico, fondatore di orti botanici e pioniere degli erbari', *Rivista di storia della medicina* **16**, 155–163 (1972); Fabio Garbari, 'Luca Ghini a Pisa, cardine della cultura botanica del XVI secolo', *Museologia scientifica* **8**, 223–236 (1991–1992); Fabio Garbari, Lucia Tongiorgi Tomasi, and Alessandro Tosi (ed.), *Il giardino dei semplici. L'orto botanico di Pisa dal XVI al XX secolo* (Pacini Editore, Pisa, 1991); Dietrich von Engelhardt, 'Luca Ghini (um1490–1556) und die Botanik des 16. Jahrhunderts: Leben, Initiativen, Kontakte, Resonanz', *Medizinhistorisches J.* **30**, 3–49 (1995). For a general reconstruction of the late medieval and early sixteenth century botany, see Karen M. Reeds, *Botany in medieval and Renaissance universities* (Garland, New York and London, 1991).

6 See Guido Moggi, 'La conoscenza del mondo vegetale prima e dopo Andrea Cesalpino', in *Le Monde végétal (XIIe–XVIIIe siècles). Savoirs et usages sociaux* (ed. Allen J. Grieco, Odile Redon, and Lucia Tongiorgi Tomasi), pp. 123–140 (Presses Universitaires de Vincennes, Saint-Denis, 1995).

7 Lucia Tongiorgi Tomasi, 'The visual arts and the science of horticulture in Tuscany from the 16th to the 18th century', *Adv. Horticult. Sci.* **4**, 3–18 (1990).

8 The literature on this topic is vast. See, for instance, Brian W. Ogilvie, *The science of describing: natural history in Renaissance Europe* (University of Chicago Press, 2006).

9 On gardens as laboratories, see Pamela H. Smith, 'Laboratories', in *The Cambridge history of science*, vol. 3, *Early modern science* (ed. Katharine Park and Lorraine Daston), pp. 290–305 (Cambridge University Press, 2006).

10 See Florike Egmond, *The world of Carolus Clusius: natural history in the making, 1550–1610* (Pickering & Chatto, London, 2010); Florike Egmond, 'Experimenting with living nature: documented practices of sixteenth-century naturalists and naturalia collectors', *J. Early Mod. Stud.* **6**, 21–45 (2017). Cf. Harm Beukers, 'Clinical teaching in Leiden from its beginning until the end of the eighteenth century', *Clio Medica* **21**, 139–152 (1987–1988).

philosopher Justus Lipsius (1547–1606) of his observations with plant transformations when placing seeds and buds in different soils—both activities were widespread in sixteenth- and early seventeenth-century botanical experimentation.

A crucial epistemological systematization of botanical experimentation is to be found in Cesalpino's *De plantis libri XVI* (1583), a theoretical–philosophical work on plants, in which Cesalpino reveals how important plant observation, manipulation, and experimentation have been in understanding vegetal structure and physiology, ultimately paving the way to his classification of plants and to pharmacological activities.¹¹ In the first book of *De plantis*, he outlines plant dissections and observations as a way to inspect the structure of seeds and herbs through spectacles and magnifying lenses—practices that were gaining momentum in Renaissance Europe—and the role of experimentation to deal with plant studies at large.¹²

Despite the complex reception of Cesalpino's *De plantis*, the sixteenth-century experiential approach to plants persisted and expanded throughout the seventeenth century—also through other sources, such as Giovanni Battista Della Porta's (1535–1615) works, for instance—when anatomical observation and experimentation with plants became paramount. This specifies the ways 'the new science ... looked toward a direct engagement with nature as a source of 'scientific', or certain, knowledge'.¹³ At the Accademia de' Lincei, Prince Federico Cesi (1585–1630) and his fellows performed several observations of plants, as the case of fern pores described by Johannes Faber (1574–1629) highlights—Faber was a former collaborator of Cesalpino, and the director of the Papal botanical garden in Rome.¹⁴ And later, through the investigation of Francesco Stelluti (1577–1652) and Giovanni Battista Ferrari (1584–1655), similar projects developed at the Accademia del Cimento.¹⁵

The English philosopher and naturalist Francis Bacon (1561–1626) included gardens as laboratorial spaces in his *New Atlantis* (1627), and even collected a wide set of experiments with vegetal bodies in the *Sylva Sylvarum* (1626).¹⁶ Later in the seventeenth century, these texts famously gave impetus to studies at the Hartlib Circle and at the Royal Society.¹⁷ Similarly, French alchemist and physician Guy de La Brosse (1586–1641), the

11 On the various layers of Cesalpino's botany, see Fabrizio Baldassarri, 'Cesalpino's (Aristotelian) philosophy of plants: a science of botany in the Renaissance', in *Andrea Cesalpino and Renaissance Aristotelianism: natural philosophy in the 16th century* (ed. Fabrizio Baldassarri and Craig Martin), pp. 107–130, esp. p. 120 (Bloomsbury, London, 2023).

12 See Vincent Iardi, *Renaissance vision from spectacles to telescopes* (American Philosophical Society, Philadelphia, 2007), p. 45: 'the first documented use of a concave metal mirror as a simple microscope was recorded by ... Giovanni Rucellai [who] was able to describe the anatomy of bees ... anticipating by almost a century similar observations with the compound microscope'.

13 Smith, 'Laboratories', *op. cit.* (note 9), p. 305.

14 See Luigi Guerrini, *I trattati naturalistici di Federico Cesi* (Accademia dei Lincei, Roma, 2006). Paolo Galluzzi, *The lynx and the telescope: the parallel worlds of Cesi and Galileo* (Brill, Leiden and Boston, 2017).

15 See Lorenzo Malagotti (ed.), *Saggi di naturali esperienze fatte nell'Accademia del Cimento* (Giuseppe Cocchini, Florence, 1667); Francesco Redi, *Esperienze intorno ai sali fattizi*, in *Opere di Francesco Redi*, vol. 4, pp. 275–290 (Accademia della Crusca, Milan, 1811).

16 See Paula Findlen, 'Anatomy theaters, botanical gardens, and natural history collections', in *The Cambridge history of science*, vol. 3, *Early modern science* (ed. Katharine Park and Lorraine Daston), pp. 272–289 (Cambridge University Press, 2006); Doina-Cristina Rusu, 'Rethinking *Sylva Sylvarum*: Francis Bacon's use of Giambattista Della Porta's *Magia naturalis*', *Perspect. Sci.* **25**, 1–35 (2017); Doina-Cristina Rusu, 'Same spirit, different structure: Francis Bacon on inanimate and animate matter', *Early Sci. Med.* **23**, 444–458 (2018); Dana Jalobeanu, 'Spirits coming alive: the subtle alchemy of Francis Bacon's *Sylva Sylvarum*', *Early Sci. Med.* **23**, 459–486 (2018); Doina-Cristina Rusu, 'Using instruments in the study of animate beings: Della Porta's and Bacon's experiments with plants', *Centaurus* **62**, 393–405 (2020); Guido Giglioni, 'Large as life: Francis Bacon on the animate matter of plants', *Notes Rec. R. Soc. Lond.* **77**, 677–696 (2023).

17 See Rebecca Bushnell, *Green desire: imagining early modern English gardens* (Cornell University Press, Ithaca, 2003); Juliet Odgers, 'Resemblance and figure in garden and laboratory. Gaffarel's influence on John Evelyn', in *Jacques Gaffarel between magic and science* (ed. Hiro Hirai), pp. 85–108 (Serra, Roma, 2014).

founder of the Parisian Jardin des plantes, observed the structure and physiology of plants, while performing several alchemical experiments.¹⁸ Daniel Sennert's (1572–1637) *Epitome naturalis scientiae* (1618) and *Physica Hypomnemata* (1636) provide a set of vegetal observations, especially concerning spontaneous generation, a subject that attracted Fortunio Liceti's (1577–1657) attention as well. In Adrianus Spigelius' (Adriaan van der Spiegel, 1578–1625) first book, *Isagoges in rem herbariam libri duo* (1606), the author describes the experimental investigation underlying the study of the forms, structure, and nature of plants he probably performed at the Paduan *hortus botanicus*. Rooted in sixteenth-century experimentation, seventeenth-century studies of plants developed as a combination of cultivation, gardening passion, and experiential investigations that resulted in the major botanical texts of the second half of the seventeenth century. Among these were Nehemiah Grew's (1641–1712) *Anatomy of Plants* (1682), Marcello Malpighi's (1628–1694) *Anatome plantarum* (1675–1679), Edme Mariotte's (162–1684) *Essais de physique: De la vegetation des plantes* (1679–1681), John Ray's (1627–1705) *Historia plantarum* (1686), Claude Perrault's (1613–1688) *Essais de Physique* (1680–1688), and Joseph Pitton de Tournefort's (1656–1708) *Insitutiones rei herbariae* (1710), to name a few. Botanical observations, generally performed at botanical gardens, became a central feature of early modern science.

The aim of this special issue is to reinstate the centrality of vegetal laboratorial spaces as an environment for early modern plant studies—thus including botany in the studies of early modern laboratories.¹⁹ As I have rapidly sketched, botanical gardens and laboratories were not only places of cultivation of, and fascination for, the outward varieties of plants, aiming at their classification and systematization, but were also spaces to anatomize and observe the internal structures of vegetal bodies. The ultimate goal of these experiments consisted of knowing the nature of plants in their own right, thus shaping a science of plants in its complexity and entirety.

Indeed, plants became parts of the laboratory and the subject–object of experimental investigation, that is, green laboratories themselves.²⁰ For instance, plants were seen as natural alembics to observe natural activities in detail—thus paralleling the claim that the earth was a chymical laboratory.²¹ In this special issue, we aim to explore this claim, discussing the cases in which early modern scholars conceived plants as objects of laboratory studies to investigate nature at large, leaving partly aside the investigation of botanical gardens and canonical botany—if this existed separately. Here we demonstrate

18 See Alice Stroup, *A company of scientists: botany, patronage, and community at the seventeenth century Parisian Royal Academy of Science* (University of California Press, Berkeley, 1990); Antonio Clericuzio, 'Medicina, chimica e botanica al Jardin Royal des plantes di Parigi (1635–1700)', *Medicina nei secoli* 12, 565–585 (2000); Dominique Brancher, *Quand l'esprit vient aux plantes. Botanique sensibles et subversion libertine (XVIe–XVIIe siècles)* (Droz, Geneva, 2015).

19 See Sven Dupré (ed.), *Laboratories of art: alchemy and art technology from antiquity to the 18th century* (Springer, Cham, 2014). See also more recent studies on plant sciences and gardens in the early modern period, such as Hubertus Fischer, Volker R. Remmert and Joachim Wolschke-Bulmahn (eds), *Gardens, knowledge and the sciences in the early modern period* (Birkhäuser, Basel, 2016); Juliette Ferdinand (ed.), *From art to science. Experiencing nature in the European garden 1500–1700* (Zed edizioni, Treviso, 2016); Fabrizio Baldassarri and Oana Matei (eds), 'Manipulating flora: seventeenth-century botanical practices and natural philosophy', *Early Sci. Med.* 23, 413–583 (2018).

20 See Dana Jalobeanu and Oana Matei, 'Treating plants as laboratories: a chemical natural history of vegetation in 17th-century England', *Centaurus* 62, 542–561 (2020).

21 See, for instance, John Beale, 'The causes of Mineral Springs further inquired: And the strange and secret Changes of Liquors examined'. *Phil. Trans. R. Soc. Lond.* 4, 1131–1134, at p. 1133 (1669): according to whom, plants and their channels are 'the natural Limbecs, where the common Raine, Water, and Air, are digested into very much differing Leaves, Fruit, Seed, Resins, Gums, etc.'

the complexity of plant studies, as early modern scholars, philosophers, and naturalists conceived plants not only as a subject of botanical studies, but also as a laboratory object that mediates the study of nature at large. The contributions to this special issue discuss three main intersections between plants and disciplines, namely, chymistry, physics, and the sciences of life. (A fourth axis—the animal–plant analogy, or the anatomical study of plants as a simpler form of animal life—is not treated in this fascicle.²²)

The first case is the intersection between plants and minerals, as the investigation of plants was not separated from chymical studies—at different stages, plants were indeed conceived as minerals themselves. In the Renaissance, the analogy between plants (and animals) and metallurgy clearly developed, for instance in Vannoccio Biringuccio (1480–1539), and found new vitality throughout the seventeenth-century chymical approach to vegetation that especially developed in England.²³ These two lines are discussed in this fascicle. In his article, ‘Harvesting underground: (re)generative theories and vegetal analogies in the early modern debate on mineral ores (I)’, Francesco Luzzini draws attention to the rise of botanical models to account for the arrangement, movement, and growth of minerals in ores, following vegetal analogies and ultimately attributing a life cycle to minerals, therefore showing an outstanding intersection between plant studies and mineralogy. In her article, ‘Plant alchemy, Paracelsianism and internal signature theory in the writings of Guy de La Brosse (1586–1641)’, Georgiana D. Hedesan deals with a remarkable and prototypical case of plant alchemy that develops in the writings of Guy de La Brosse. In *De la Nature, vertu et utilité des plantes* (1628), La Brosse’s rejection of Aristotelian interpretations of vegetation develops from his Paracelsian views of the soul, spirit and matter, and the experimental practices on plants performed at the Jardin des plantes.

The second case is the study of plants to understand living nature at large. Since the Aristotelian definition situated plants at the edges of living nature, in the separation between non-living and living beings, scholars and philosophers conceived plants as minimally alive and possessing the basic faculties of life, namely, nutrition, growth, and reproduction. Following Galenic and Platonic interpretations, Renaissance scholars alternatively presented plants as endowed with superior faculties. A champion of this re-interpretation of the scale of living beings was Guy de La Brosse, but challenges to the division of life and artificial attempts to manipulate life emerge in diverse cases. In her article, ‘Creating life in the laboratory: Francis Bacon’s journey from living spirits to animate bodies’, Dana Jalobeanu lays bare Francis Bacon’s attempts to create life in the laboratory, as evidenced in the *Historia et inquisitio de animato et inanimato* (posthumously published). In this text, Bacon used plants as appropriate objects to understand and manipulate life, fully exploiting plant experimentation in *Sylva Sylvarum*.

22 On the plant–animal analogy in the early modern period, see Fabrizio Baldassarri, ‘In the beginning was the plant: the plant–animal continuity in the early modern medical reception of Galen’, in *Galen and the early moderns* (ed. Matteo Favaretti Camposampiero and Emanuela Scribano), pp. 55–81 (Springer, Cham, 2022); Fabrizio Baldassarri, ‘From the analogy with animals to the anatomy of plants in medicine: the physiology of living processes from Harvey to Malpighi’, in *Plants in 16th and 17th century: botany between science and medicine* (ed. Fabrizio Baldassarri), pp. 121–144 (De Gruyter, Berlin, 2023). See also Justin Begley, ‘Seeing plants as animals: analogical reasoning in Nehemiah Grew’s *Anatomy of Plants* (1682)’, *Centaurus* 65 (4) (2023).

23 On sixteenth-century mining, see Tina Asmussen and Pamela O. Long, ‘The cultural and material worlds of mining in the early modern world’, *Renaiss. Stud.* 34, 8–30 (2020). On the British intersections between chymistry and botanical studies, see Anna Marie Roos, *The salt of the earth: natural philosophy, medicine and chymistry in England, 1650–1750* (Brill, Leiden/Boston, 2007); Antonio Clericuzio, ‘Plant and soil chemistry in seventeenth-century England: Worsley, Boyle and Coxe’, *Early Sci. Med.* 23, 550–583 (2018).

The third case is the role of plants in the study of physics that especially develops in the investigation of sap motion in plants. In his article, ‘Plants and laboratories: the ascent of sap between physics and vegetal physiology’, Fabrizio Baldassarri outlines the parallel between the physical understanding of the motion of liquors in tubes and the various interpretations of the ascent of liquids in plants. He especially analyses the British and Italian contexts, up to the work of Malpighi and Grew. In this case, plants surface as laboratory objects to test the laws of physics, revealing how much the diverse physical frameworks apply to botany, and making the latter an autonomous discipline. Moving from the late seventeenth century, in her article, ‘Vegetal agency: the sap controversy in early eighteenth-century France gardening treatises’, Sarah Benharrech draws attention to the eighteenth-century French attempts to explain the ascent of sap. In this context, while opposing the physico-theological ontology elaborated by the abbé Pluche (Noël-Antoine, 1688–1761) with the empirical approach of Jean de La Quintinie (1626–1688) and Pierre Le Lorrain de Vallemont (1649–1721), these scholars used botanical investigations to confirm their philosophical interpretation of nature.

The articles collected in this special issue outline the new paradigmatic uses of gardens. Whereas gardens have traditionally had multiple connotations—such as places of leisure, philosophical inspiration and learning, *loci amoeni* to escape daily confusion, symbols of the idyllic return to the Paradise Lost and for ideal wellbeing, or as spaces to recover, preserve, or geometrically recreate the variety of nature—this special issue focuses on gardens as laboratorial settings, in which naturalists and scholars performed observations and treated vegetal bodies as objects of experimental knowledge in order to probe more deeply into the secrets of nature from the Renaissance to the eighteenth century.²⁴ But another feature emerges, consistent with the hybrid nature of botany, which can be explored in future researches. Indeed, botany was not a fully fledged discipline at the time, but trained scholars benefited from the expertise of gardeners, horticulturalists, experts-cum-apothecaries, or unlearned people with a passion for plants—or other experts, trying to give disciplinary status to the science of plants. Importantly, these interconnections arose not only in fieldwork,²⁵ but also in the achievement of botanical sciences in green laboratories.

DATA ACCESSIBILITY

This article has no additional data.

DECLARATION OF AI USE

I have not used AI-assisted technologies in creating this article.

²⁴ Clare Hickman, ‘The garden as a laboratory: the role of domestic gardens as places of scientific exploration in the long 18th century’, *Postmedieval Archaeol.* **48**, 229–247 (2014).

²⁵ Florike Egmond, ‘Into the wild: botanical fieldwork in the sixteenth century’, in *Naturalists in the field: collecting, recording and preserving the natural world from the fifteenth to the twenty-first century* (ed. A. MacGregor), pp. 166–211 (Brill, Leiden and Boston, 2018).

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