"To Multiply Corn Two-Hundred-Fold": The Alchemical Augmentation of Wheat Seeds in Seventeenth-Century English Husbandry

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The Alchemical Augmentation of Wheat Seeds in Seventeenth-Century English Husbandry

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Abstract

Agricultural reform movements proliferated in seventeenth-century Europe. For many who sought to make farming more economically productive, the practices of chymistry offered a way to accomplish these goals. Placed in the context of the development of a “vegetable philosophy,” or a theory of generation and growth across mineralogical and botanical domains, this article examines the application of chymical techniques in the attempt to enhance wheat seeds through seed-steeping and “fructifying” experiments among seventeenth-century agricultural reformers, particularly in England. I focus on three main sources: instructional husbandry manuals describing how to create “fructifying waters” to fertilize these seeds, the writings of Hugh Plat and Francis Bacon detailing their experiments on wheat seed germination, and the manuscript notebooks and correspondences of the Hartlib Circle, a group of natural philosophers, alchemists, and agricultural reformers who attempted to put these ideas into practice in the 1640s and 1650s. Their attempt to develop an artificial fertilizer regime for important cereal crops like wheat played a small but crucial role in the origins of the British Agricultural Revolution in the seventeenth century.

Keywords

chymistry – vegetable philosophy – British Agricultural Revolution

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1 Seed Steeps and Fructifying Waters: Chymistry, Improvement, and Vegetable Philosophy

Seventeenth-century Europe witnessed an upending of traditional agricultural practices. In England, as part of a broader program of improvement, which historian Paul Slack has described as the “gradual, piecemeal, but cumulative betterment” of social and material conditions, agricultural reformers spearheaded many new projects designed to enhance agriculture.[1] Innovations in crop rotation and fallowing, the introduction of new fodder grasses, novel plowing techniques, massive fenland draining, and enclosure all made farming more efficient and more productive.[2] While these techniques have long figured into histories of the British Agricultural Revolution, chymical experimental trials of agricultural improvement have not, even though they often played a significant role.[3]

Experimental knowledge of chymical substances along with the processes of altering and recombining them led to original liquid concoctions designed to produce more potent seeds. Individuals from all social levels and from widely divergent intellectual backgrounds experimented with chymical substances and applied them to seeds and saplings.[4] In doing so, they hoped to hasten

1 Paul Slack, *The Invention of Improvement: Information and Material Progress in Seventeenth-Century England* (Oxford: Oxford University Press, 2015), 1. On improvement, see also Richard Drayton, *Nature’s Government: Science, Imperial Britain, and the ‘Improvement’ of the World* (New Haven, CT: Yale University Press, 2000), esp. 50–81; Paul Warde, “The Idea of Improvement, c. 1520–1700,” in *Custom, Improvement, and the Landscape in Early Modern Britain*, ed. Richard W. Hoyle (Farnham, UK: Ashgate, 2011), 127–48. On projects and projecting, see e.g., Vera Keller and Ted McCormick, “Towards a History of Projects,” *Early Science and Medicine* 21, no. 5 (2016): 423–44; Koji Yamamoto, *Taming Capitalism before its Triumph: Public Service, Distrust, and ‘Projecting’ in Early Modern England* (Oxford: Oxford University Press, 2018).

2 On these, see, e.g., Mark Overton, *Agricultural Revolution in England: The Transformation of the Agrarian Economy, 1500–1850* (Cambridge: Cambridge University Press, 1996); Joan Thirsk, *Agrarian History of England and Wales*, Vol. 5, *1640–1750*, Pt. 1, *Rural Farming Systems* and Pt. 2, *Agrarian Change* (Cambridge: Cambridge University Press, 1984 and 1985); and Eric Kerridge, *The Agricultural Revolution* (London: Allen Unwin, 1967), though these works come to very different conclusions about the chronology and relative importance of each innovation.

3 For recent work on this topic more broadly, see Antonio Clericuzio, “Plant and Soil Chemistry in Seventeenth-Century England: Worsley, Boyle, and Coxe,” *Early Science and Medicine* 23, nos. 5–6 (2018): 550–83. On the use of “chymistry,” as opposed to “chemistry” or “alchemy,” see William Newman and Lawrence Principe, “Alchemy versus Chemistry: The Etymological Origins of a Historiographical Mistake,” *Early Science and Medicine* 3, no. 1 (1998): 32–65.

4 On the socially and intellectually diverse backgrounds of early modern experimenters, see e.g., Elaine Leong, *Recipes and Everyday Knowledge: Medicine, Science, and the Household in Early Modern England* (Chicago: University of Chicago Press, 2018); Deborah Harkness,

germination, increase the quality and quantity of crop yields, guard against fungal diseases and other maladies, and repel insects, rodents, and other pests. Some, like projectors Benjamin Worsley and Robert Child, had some experience with chymistry in the laboratory while others, like Henry Jenney and John Beale, conducted their experiments entirely in rural agricultural settings.[5] These figures sought input from works on husbandry reform, chymical experimentation, and early modern matter theory and contributed to the growing body of knowledge about seed germination, the lifecycle of plants, and the relationships between plants and soil, water, air, and fertilizers. They also suggested ways that these substances could be manipulated and exploited for agricultural and economic benefit. This was both a practical, makers' knowledge based on experiment and experience as well as the use of cutting-edge theoretical knowledge to inform these practices. The work of these diverse figures reveals the centrality of experiment to test and verify theories, the procedures for which owed as much to the recipe books and how-to manuals of everyday people as they did to chymical laboratory texts.[6]

Farmers engaged in these efforts to fortify seeds and plants used what were known as seed steeps or "fructifying waters"—large containers filled with a water, urine, manure, decaying organic matter or chymical solutions—to achieve their desired ends. While these did not necessarily entail detailed

The Jewel House: Elizabethan London and the Scientific Revolution (New Haven: Yale University Press, 2007); Matteo Valleriani, ed., *The Structures of Practical Knowledge* (Heidelberg: Springer, 2017).

5 On Worsley, see Thomas Leng, *Benjamin Worsley (1618–1677): Trade, Interest, and the Spirit in Revolutionary England* (Woodbridge, UK: Boydell Press, 2008). On Child, see Gary Patterson, *Chemistry in Seventeenth-Century New England* (New York: Springer, 2020), 41 and 73–5, and Walter W. Woodward, *Prospero's America: John Winthrop, Jr., Alchemy, and the Creation of New England Culture, 1606–1676* (Chapel Hill: University of North Carolina Press, 2010), esp. 75–92 and 138–59. On Beale, see Mayling Stubbs, "John Beale, Philosophical Gardener of Herefordshire, Part I: Prelude to the Royal Society (1608–1663)," *Annals of Science* 39 (1982): 463–89; Mayling Stubbs, "John Beale, Philosophical Gardener of Herefordshire, Part II: The Improvement of Agriculture and Trade in the Royal Society (1663–1683)," *Annals of Science* 46 (1989): 323–63. Very little has been written on Jenney. For some insight, see Stephen Clucas, "The Correspondence of a Seventeenth-Century 'Chymicall Gentleman': Sir Cheney Culpeper and the Chemical Interests of the Hartlib Circle," *Ambix* 40 (1993): 147–70, and John T. Young, *Faith, Medical Alchemy, and Natural Philosophy: Johann Moriaen, Reformed Intelligencer, and the Hartlib Circle* (Aldershot, UK: Ashgate Press, 1998), 199–202.

6 On material culture and making as a way of knowing, see e.g., Pamela Smith, Amy R.W. Meyers, and Harold J. Cook, eds., *Ways of Making and Knowing: The Material Culture of Empirical Knowledge* (Ann Arbor: University of Michigan Press, 2014), esp. 1–16; Sven Dupré, ed., *Laboratories of Art: Alchemy and Art Technology from Antiquity to the Eighteenth Century* (New York: Springer, 2014). On recipes, see Leong, *Recipes and Everyday Knowledge*.

knowledge of contemporary chymistry, recipes for many of these steeps contained a plethora of chymical ingredients designed to transform or augment seeds in various ways. Agrarian reformers and projectors, authors of husbandry manuals, and chymical experimenters regularly incorporated substances such as alum, quicklime, natron, blue vitriol, potash, vitriolic acid, verdigris, copperas, and all manner of salts into these liquids for the purposes of boosting fertility or disease resistance.[7] Beyond the economic benefit, they also sought the answers to some of the most vexing questions in botany and plant husbandry: what caused germination, and could this process be controlled?

Many attempts to unravel these questions—particularly among yeoman farmers and educated gentlemen planters—hinged on interpreting physical change and growth observed in nature in broadly chymical terms. Although the Western tradition of chymistry was largely devoid of vitalistic interpretations of matter, beginning in the late fifteenth century, some chymists influenced by Renaissance natural magic and Neoplatonic philosophy began suggesting that a vital force might permeate the cosmos and indicated that chymists might be able to isolate this.[8] Marsilio Ficino associated the Platonic "spirit of the world" (*spiritus mundi*) with the alchemical quintessence, a physical substance believed to be discoverable through calcination, distillation, or some other chymical processes.[9] Later chymists and natural philosophers, such as Giovanni Augurelli and Heinrich Cornelius Agrippa von Nettesheim, took up Ficino's call and wrote texts integrating these notions.[10] Although the so-called

7 For a fairly comprehensive list of various chymical substances used in pre-Industrial agriculture in Europe, see Allen E. Smith and Diane M. Secoy, "A Compendium of Inorganic Substances Used in European Pest Control before 1850," *Agricultural and Food Chemistry* 24, no. 6 (1976): 1180–91; Allen E. Smith and Diane M. Secoy, "Early Chemical Control of Weeds in Europe," *Weed Science* 24, no. 6 (1976): 594–7; and Allen E. Smith and Diane M. Secoy, "Salt as a Pesticide, Manure, and Seed Steep," *Agricultural History* 50, no. 3 (1976): 506–16.

8 Ku-Ming Chang, "Alchemy as a Study of Life and Matter: Reconsidering the Place of Vitalism in Early Modern Chymistry," *Isis* 102, no. 2 (2011): 322–9; William Newman, "From Alchemy to 'Chymistry,'" in *The Cambridge History of Science*, Vol. 3, *Early Modern Science*, ed. Lorraine Daston and Katherine Park (Cambridge: University of Cambridge, 2006), 497–517, esp. 500–2.

9 Marsilio Ficino, *Three Books on Life*, trans. Carol V. Kaske and John R. Clark (Binghamton, N.Y.: Medieval and Renaissance Texts and Studies, 1989), 255–7. On these developments, see Newman, "From Alchemy to 'Chymistry,'" 500.

10 Giovanni Augurelli, *Ioannis Aurelii Augurelli P. Ariminensis chrysopoeiae libri III* (Basel: Johann Froben, 1518); Cornelius Agrippa, *De occulta philosophia libri tres* [1531–3], ed. V. Perrone Compagni (Leiden: E. J. Brill, 1992), esp. 256–7. See Newman, "From Alchemy to 'Chymistry,'" 501–2, and Chang, "Alchemy as a Study of Life and Matter," 324.

"mercurial" school—in which all metals were composed of variable proportions of philosophical mercury and sulfur—dominated *chrysopoeia* or transmutational chymistry, by the sixteenth century, rival theories began to develop.[11] Paracelsus added salt to the duo of mercury and sulfur to explain the composition of metals and minerals, in part spawning a new school of thought called the *sal nitrum* theory, in which chymists identified salts, and particularly saltpeter, with the principles of life.[12] Within a generation, *sal nitrum* theorists began to develop novel interpretations about how the chymistry of salts affected the generation and growth of plants.

Many seventeenth-century agricultural reformers indebted to chymical interpretations of the material world often shared this worldview, which presumed that an animating force pervaded the cosmos and contributed to the inception, growth, and development of mineral, plant, and animal matter. In this view, all matter was endowed with "seeds," "sperm," or an "agentive force"—such as Johan Baptista Van Helmont's *semina*, Michael Sendivogius's *sperma*, or Paracelsus's *archeus*—which nature animated in various ways.[13] As Allen G. Debus, Antonio Clericuzio, and Hiro Hirai have demonstrated, chymists influenced by vitalist matter theory adopted a strikingly wide range of nuanced positions to explain precisely what forces or processes animated matter, any of

11 Lawrence Principe, *The Secrets of Alchemy* (Chicago: University of Chicago Press, 2013), 35–7; William R. Newman, *The "Summa perfectionis" of Pseudo-Geber* (Leiden: Brill, 1991), esp. 143–92.

12 [Pseudo-?] Paracelsus, *De natura rerum*, in *Sämtliche Werke*, Vol. 11, ed. Karl Sudhoff and Wilhelm Mattießen (Hildesheim: Georg Olms Verlag, 1996), 349; Paracelsus, *Philosophia ad Atheniensis*, in *Sämtliche Werke*, Vol. 13, 393. On the *sal nitrum* school of chymistry, see e.g., William Newman and Lawrence Principe, *Alchemy Tried in the Fire: Starkey, Boyle, and the Fate of Helmontian Chymistry* (Chicago: University of Chicago Press, 2005), 244–56; Leng, *Benjamin Worsley*, 95–117.

13 Each figure defined these terms in various places. See e.g., Paracelsus, *Volumen Medicinae Paramirum*, trans. Kurt Leidecker (Baltimore: Johns Hopkins Press, 1949), 25; Michael Sendivogius, *Novem lumen chemicum* (Frankfurt and Prague, 1604), 43–4 and *passim*; and Joan Baptista Van Helmont, *Eisagoge in artem medicam a Paracelso restitutam* [1607], in *Les premiers ouvrages de J.-B. Van Helmont, Seigneur de Hérode, Royenborch, Oirschot, Pellines, etc. Eisagoge in Artem Medicam a Paracelso Restitutam*, ed. C. Broeckx (Antwerp: J.-E. Buschmann, 1854), 57 and *passim*. On these vital forces or activators, see e.g., Walter Pagel, *Paracelsus: An Introduction to Philosophical Medicine in the Era of the Renaissance*, 2nd ed. (Basel/New York: Karger, 1982), 105–17; Antonio Clericuzio, "From Van Helmont to Boyle: A Study of the Transmission of Helmontian Chemical and Medical Theories in Seventeenth-Century England," *British Journal for the History of Science* 26, no. 3 (1993): 303–34; Zbigniew Szydło, "The Influence of the Central Nitre Theory of Michael Sendivogius on the Chemical Philosophy of the Seventeenth Century," *Ambix* 43, no. 2 (1996): 80–97.

which could be incorporated into, subsumed under, or absorbed by other natural philosophies or empirical practices.[14] Not all identified the vital force with salts, but agrarian and botanical experimenters engaged much more deeply in investigating the physical constituents of life through these theories. For many English agricultural reformers, they provided a natural philosophical framework for the everyday experiences of farmers concerning seed care, the tending of saplings, and the operative principles of fertilizers to explain the observational realities of the life cycles of plants. Adherents of these ideas understood the generative power in nature more broadly as the unfolding of some seminal principle in matter, just as the growth of a plant was the unfolding of some virtue, quality, or design housed in its seed.[15]

In seventeenth-century England, agrarian reformers who had some experience with chymistry attempted to synthesize and reconcile these varied ideas to create a comprehensive explanation for generation and growth across mineralogical and biological domains. Experimental seed steeps and fructifying waters were part of the development of what Oana Matei has described as a "vegetable philosophy."[16] In her words, vegetable philosophy was "technologi-

14 For this diversity of thought, see Allen G. Debus, "Chemistry and the Quest for a Material Spirit of Life in the Seventeenth Century," in *Spiritus: IV Colloquio Internazionale del Lessico Intellettuale Europeo, Roma, 7–9 gennaio 1983*, ed. M. Fattori and M. Bianchi (Rome: Ateneo, 1984), 245–63; Antonio Clericuzio, "The Internal Laboratory: The Chemical Reinterpretation of Medical Spirits in England (1650–80)," in *Alchemy and Chemistry in the Sixteenth and Seventeenth Centuries*, ed. Piyo Rattansi and Antonio Clericuzio (Dordrecht: Kluwer, 1994), 51–83; Hiro Hirai, *Le concept de semence dans les théories de la matière à la Renaissance: De Marsile Ficin à Pierre Gassendi* (Turnhout: Brepols, 2005).

15 For a general overview of the relationships among chymistry, botanical sciences, and agronomy, see e.g., Charles Webster, *The Great Instauration: Science, Medicine, and Reform, 1626–1660* (London: Duckworth, 1975), 384–402; Allen G. Debus, *The Chemical Philosophy: Paracelsian Science and Medicine in the Sixteenth and Seventeenth Centuries*, Vol. 2 (New York: Science History Publications, 1977), 420–46; and more recently, essays in "Manipulating Flora: Seventeenth-Century Botanical Practices and Natural Philosophy," ed. Fabrizio Baldassarri and Oana Matei, special issue, *Early Science and Medicine* 23, nos. 5–6 (2018), especially Doina-Christina Rusu, "Same Spirit, Different Structure: Francis Bacon on Inanimate and Animate Matter," 444–58; Dana Jalobeanu, "Spirits Coming Alive: The Subtle Alchemy of Francis Bacon," 459–86; Oana Matei, "Appetitive Matter and Perception in Ralph Austen's Projects of Natural History of Plants," 530–49; and Clericuzio, "Plant and Soil Chemistry in Seventeenth-Century England," 550–83.

16 Oana Matei, "Husbandry Tradition and the Emergence of Vegetable Philosophy in the Hartlib Circle," *Philosophia* 16, no. 1 (2015): 35–52. This is an emerging topic about which much remains to be written. For some early attempts, see Peter R. Antsey, "Experimental versus Speculative Philosophy," in *The Science of Nature in the Seventeenth Century: Patterns of Change in Early Modern Natural Philosophy*, ed. Peter R. Antsey and John A. Schuster (Dordrecht: Springer, 2005), 215–42; Ayesha Mukherjee, "The Secrets of Hugh Plat," in

cal and antispeculative, experimental and operational," was oriented "toward the production of specific results," and used "technologies transferable from one domain to another."[17] It was not only botanical because its objects of study were diverse and included metals, salts, soils, stones, and mineral ores. It was not only agricultural because it employed chymical theory and botanical experimentation. And it could not be reduced to natural philosophy because it was pragmatic, economically motivated, and deeply concerned with the promotion of technological advancement and social welfare.[18] Referencing Renaissance polymath Giambattista della Porta's opaque language in the preface to his 1608 work *Floraes Paradise*, Hugh Plat wrote of the need for an unadorned, straightforward "vegetable philosophy" to explain generation and growth.[19] In his *Observations* of 1658, agrarian reformer Ralph Austen credited Francis Bacon for bequeathing his generation with a "vegetable philosophy" that was his "darling delight, having left unto us much upon Record in his Naturall History," which Austen endeavored to use "to improve unto publique profit."[20]

This article places the use of experimental seed steeps and fructifying waters in the context of this emergent vegetable philosophy, the theoretical and practical chymistry that underpinned it, and the improvement of agriculture, broadly construed. Although agricultural reformers subjected many different crops—from grains and pulses to fruits and vegetables—to these seed steeps and fructifying waters, I focus on wheat seeds for remainder this article, both because of its ubiquity as a staple grain crop in England and because agricultural reformers experimented with it as a prototypical seed type. In the following sections, I examine the practice of seed steeping as described in husbandry manuals beginning in the latter part of the sixteenth century and exploding in

Secrets and Knowledge in Science and Medicine, 1500–1800, ed. Elaine Leong and Alisha Rankin (Burlington, VT: Ashgate Publishing, 2011), 69–86; Fabrizio Baldassarri, "Manipulating Flora. Gardens as Laboratories in Renaissance and Early Modern Europe," *Rivisita di storia della filosofia* 72, no. 1 (2017): 175–8; Dana Jalobeanu and Oana Matei, "Treating Plants as Laboratories: A Chemical History of Vegetation in 17th-Century England," *Centaurus* 62, no. 3 (2020): 542–61.

17 Matei, "Husbandry Tradition and the Emergence of Vegetable Philosophy in the Hartlib Circle," 36. See also the contributions of Oana Matei and Dana Jalobeanu to this special issue.

18 Ibid., 35.

19 Hugh Plat, *Floraes Paradise* (London, 1608), [sig.] A5*r*. This also appears in his "Epistle to the Reader," in the posthumously published, re-edited version of this work, Hugh Plat, *The Garden of Eden* (London, 1653), 15.

20 Ralph Austen, *Observations upon some part of Sr F. Bacon's Naturall history, as it concernes fruit-trees, fruits, and flowers* (Oxford: Henry Hall for Thomoas Robinson, 1658), Dedicatory Epistle [unpaginated].

popularity in the first half of the seventeenth. Chymically informed agrarian reformers adapted these techniques by experimenting with the composition of the steeping liquid, often adding substances believed to enhance fertility or ward off pests. Two prominent experimenters—Plat and Bacon—are used as examples here. Finally, I survey the most intensive efforts to put these practices into action among the Hartlib Circle. The Hartlib Circle—named after its central hub, the Prussian émigré to England and pancontinental intelligencer Samuel Hartlib—was an informal correspondence network of natural philosophers who shared results of experiments and debated issues ranging from chymistry and mathematics to educational reform and finance.[21] Although members had eclectic interests and should not be painted with too broad a brush, most believed that solving the social ills that plagued seventeenth-century European society would be accomplished through an active, scientific engagement with the natural and social worlds. Their application of chymistry to agricultural problems is a testament to this belief.

2 Sources of Agricultural Experiments with Chymical Substances: Husbandry Manuals

Husbandry manuals were one of the prime methods of disseminating agricultural information, techniques, and advice in the early modern period. Though instructional tracts for farming in Western Europe dated back to the Greco-Roman era, the English genre began to develop in earnest in the mid sixteenth century.[22] A heady mixture of custom, folklore, oral history, and centuries of inherited guidance developed into lengthy books describing intricate methods for making agriculture as productive as possible. Major topics generally included proper plowing techniques, instructions for planting and fallowing,

21 Charles Webster, *Samuel Hartlib and the Advancement of Learning* (London: Cambridge University Press, 1970); G.H. Turnbull, *Samuel Hartlib: A Sketch of His Life and His Relation to J.A. Comenius* (London: Oxford University Press, 1920); and Mark Greengrass, Michael Leslie, and Timothy Raylor, eds., *Samuel Hartlib and Universal Reformation: Studies in Intellectual Communication* (London: Cambridge University Press, 1994).

22 See, e.g., Joan Thirsk, "Making a Fresh Start: Sixteenth-Century Agriculture and the Classical Inspiration," in *Culture and Cultivation in Early Modern England: Writing and the Land*, ed. Michael Leslie and Timothy Raylor (Leicester: Leicester University Press, 1992), 15–34; G.E. Fussell, *The Classical Tradition in West European Farming* (Teaneck, NJ: Farleigh Dickinson University Press, 1972); id., "The Classical Tradition in West European Farming: The Sixteenth Century," *Economic History Review* 22, no. 3 (1969): 538–51.

descriptions of soil types and what grew best in them, and so on.[23] How to steep seeds and with what substances became an increasingly important and common topic in these instructional texts throughout the seventeenth century.[24]

The production of these texts accelerated after about 1600 and concern amongst agricultural reformers with deficiencies in contemporary farming practices led to a burgeoning of husbandry manuals and agricultural improvement tracts, especially between the late 1630s and early 1660s, peaking around the year 1650. Members of the Hartlib Circle were responsible for many of these texts. Among these were several notable works by Gabriel Plattes including his *Discovery of Infinite Treasure* (1639) and *Discovery of Subterraneall Treasure* (1639), Walter Blith's *English Improver Improved*, which underwent three editions between 1649 and 1653, Richard Weston's *Discourse on Husbandrie* (1650), Samuel Hartlib's own compilation of many short agricultural writings in his *Legacy of Husbandry* (1655), and four short pamphlets by Cressy Dymock, including his wildly popular "Reformed Husbandman" (1651). All shared common themes concerning the paucity of knowledge about the causes of botanical growth, the necessity of reliable, productive agriculture for a strong nation, and the importance of systematically restructuring husbandry to accompany broader social and political reform.[25] Many emphasized empirical and experimental methodologies and the importance of a chymical understanding of the natural substances involved in agriculture, particularly soil, fertilizers, and plant matter.

The earliest of these that contained information about seed-steeping were often strikingly simple. Some of the oldest and most basic recipes for steeping seeds involved water mixed with salts. Throughout the sixteenth century, saline chymistry evolved rapidly to explain major developments in both matter theory and the technological aspects of industrial salt production. Those influenced by Paracelsus had elevated salt to the same level of importance as the traditional elements of sulfur and mercury, while the *sal nitrum* theorists argued that the starting material for the philosophers' stone was saltpeter. Common salt's preservative and curative properties suggested medical uses.[26]

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23 Andrew McRae, "Husbandry Manuals and the Language of Agrarian Improvement," in *Culture and Cultivation*, 35–62.

24 F.A. Buttress and R.W.G. Dennis, "The Early History of Cereal Seed Treatment in England," *Agricultural History Review* 21, no. 2 (1947): 93–103.

25 Webster, *The Great Instauration*, 384–402.

26 Anna Marie Roos, *The Salt of the Earth: Natural Philosophy, Chemistry, and Medicine in England, 1650–1750* (Boston: Brill, 2007), 10–46; Newman, "From Alchemy to 'Chymistry,'" 504–6.

Saltpeter's effectiveness as a fertilizer had become apparent over the course of the Later Middle Ages and into the sixteenth century, at least in part due to the observation that fertile raw materials like composted vegetable waste, manure, and urine were sourced for its production in the gunpowder industry.[27] Saltpeter could be baked into clods of soil and then crumbled over land or dissolved into water intended to soak seeds or be sprayed over fields. Other salts also saw a great deal of use in seed-steeps and brining liquids, either as germination aids or pest control. These were regularly combined with unslaked lime, in addition to well-known fertile materials such as animal dungs and urine, marl, clay, or pond muck.[28]

For the purposes of steeping, common salt seemed best suited to prevent mildew, smut diseases, fungal infections, and other ailments that threatened to rot seeds, rather than as an agent to boost a seed's fertility. Saltpeter was better suited to that purpose, though it too tended to be mentioned in husbandry manuals for its resistance to disease, vermin, and insects. One of the more vigorous promotions of saltpeter as a fertilizer in seed steeps came from agricultural reformer and chymist Robert Child. In his "Large Letter concerning the Defects and Remedies of English Husbandry," published in Samuel Hartlib's *Legacy of Husbandry*, Child noted the historical uses of salts in seed steeping:

> The *Ancients* used to steep *Beans* in salt-water: and in *Kent* it's usuall to steep *Barley*, when they sow late, that it may grow the faster; and also to take away the soil: for wild *Oats, Cockle*, and all save *Drake* will swim: as also much of the light Corn, which to take away is very good. If you put *Pigeons-dung* into the water, and let it steep all night, it may be as it were half a dunging: take heed of steeping *Pease* too long; for I have seen them sprout in three or four hours.[29]

Importantly for Child, saltpeter replicated the properties of manure because he believed the crucial procreant ingredients in manure were various salts. He called saltpeter "a special cause of fruitfulness," and argued that "the salt of

27 David Cressy, *Saltpeter: The Mother of Gunpowder* (Oxford: Oxford University Press, 2013), 11–25.

28 Joan Thirsk, *Agricultural Change: Policy and Practice, 1500–1750*, vol. 3, *Chapters from the Agrarian History of England and Wales* (Cambridge: Cambridge University Press, 1990), 20–21.

29 Robert Child, "A Large Letter concerning the Defects and Remedies of English Husbandry, written to Samuel Hartlib," in Samuel Hartlib, *His Legacy of Husbandry …* (London, 1655), 37.

ashes, &c. seemeth … to have as much, if not more affinity to common salt as to *Niter*, as appears by its Cubick form; yet they do much fertilize both Corn and Pasture."[30]

Another letter published in Hartlib's *Legacy of Husbandry* from an unnamed sender in "the Low Countries" described a "secret experiment" from Paris—which the author claimed to have learned from a physician named "Hartmannus," but which had also appeared in Gervase Markham's *Farewell to Husbandry*—in which boiling hot water was mixed with quicklime or unslaked lime until "an Egge may swim in it."[31] Quoting Gabriel Plattes, the anonymous author directed farmers to steep seeds in this mixture for twenty-four hours, sometimes mixed with rainwater or cow dung, and afterwards to sow on wet or sandy ground. At this point, one could sprinkle either saltpeter or sheep's dung over the top, either of which, the author opined, would fertilize the mixture in equal measure.[32]

Although saltpeter featured prominently in many of these seed steeping recipes, many other substances typically found in laboratories or apothecaries make appearances. Specifically, for wheat seed steeping, recipes often focused on chemical irritants with the power to drive away pests or protect against molds, smuts, and bunt. Thomas Hill, in his *Gardener's Labyrinth*, and Charles Estienne and Jean Liebault, in their *Maison Rustique*, mentioned that wheat steeped in water and sal ammoniac, or "Salt of Ammon," drove away weasels.[33] Hill also recommended alum as a way of keeping flies away from seeds, and

30 Robert Child, "An Answer to the Animadversor on the Letter to Mr. *Samuel Hartlib* of Husbandry," in Samuel Hartlib, *His Legacy of Husbandry …*, 149. By "Cubick form," Child may have been referring to its appearance under a microscope. Notably, Child did *not* equate saltpeter with the vital salt that *sal nitrum* theorists believed made life possible. See Robert Child to Samuel Hartlib, October 9, 1652, University of Sheffield, Hartlib Papers (hereafter HP), 15/5/18A–19A, https://www.dhi.ac.uk/hartlib/ (accessed September 24, 2021).

31 Samuel Hartlib, *His Legacy of Husbandry …*, 110. On Markham, see *Farewell to Husbandry* (London, 1620), 21, though he described this as the way to test the appropriate amount of bay salt rather than quicklime. By Hartmannus, the author of the letter might have meant the chymical physician and University of Marburg professor Johannes Hartmann, though there are no other references to him in this work against which to check this. On Hartmann, see Bruce T. Moran, *Chemical Pharmacy Enters the University: Johannes Hartmann and the Didactic Care of* Chymiatria *in the Early Seventeenth Century* (Madison, WI: American Institute of the History of Pharmacy, 1991).

32 Hartlib, *His Legacy of Husbandry …*, 110–11.

33 Thomas Hill, *The Gardener's Labyrinth* (London, 1586), 74; Charles Estienne and Jean Liebault, *Maison Rustique or The Rustic Farmer*, trans. R. Surflet (London, 1600), 399. See also Smith and Secoy, "A Compendium of Inorganic Substances Used in European Pest Control before 1850," 1186.

there is evidence that later eighteenth-century farmers used it for this purpose, along with copperas, in seed steeps.[34] Markham, Hartlib, and Adolphus Speed all noted that wheat seeds sprinkled with lime or soaked in limed water poisoned birds and insects and defended against bunt and smut disease.[35] Markham also noted similar results for worms with potash, while Speed recorded that meat treated with corrosive sublimate killed crows, rooks, and magpies and advocated for its use in cereal steeping for similar purposes.[36] Although seed steep recipes in husbandry manuals did not all involve chymical materials, seventeenth-century agricultural reformers seeking a vegetable philosophy suggested that the composition of these steeps held clues for understanding how and why seeds germinated and grew into plants. Experimental trials to investigate the chymistry of seed steeps began in earnest in the early seventeenth century.

3 Sources of Chymical Experiments with Agriculture: Hugh Plat and Francis Bacon

One major source for agricultural reformers interested in augmenting wheat seeds in the early seventeenth century was the polymath writer on gardening, agriculture, botany, and chymistry, Hugh Plat.[37] His experimental and obser-

34 Hill, *Gardener's Labyrinth*, 68. In modern chemical terms, alum is defined as hydrated potassium aluminum sulfate ($KAl(SO_4)_2 \cdot 12\ H_2O$), though in the seventeenth-century, it referred to many double sulfates containing aluminum. It is mentioned in seed steep recipes in John Mortimer, *The Whole Art of Husbandry* (Dublin, 1721), 84; Thomas Hale, *A Compleat Body of Husbandry* (London, 1756), 364; and Henri-Louis Duhemel du Monceau, *A Practical Treatise of Husbandry* (London, 1762), 94. In modern chemical terms, copperas refers to ferrous sulfate ($FeSO_4$). On eighteenth-century chemical seed steeps, especially as poisons, see Matthew Holmes, "Melancholy Consequences: Britain's Long Relationship with Agricultural Chemicals since the Mid-Eighteenth Century," *Environment and History* 25 (2019): 117–34.

35 Markham, *Farewell to Husbandry*, 88; Hartlib, *Legacy of Husbandry …*, 16; Adolphus Speed, *Adam out of Eden* (London, 1659), 98. See also Smith and Secoy, "A Compendium of Inorganic Substances Used in European Pest Control before 1850," 1183. In modern chemical terms, sal ammoniac is ammonium chloride (NH_4Cl).

36 Gervase Markham, *A Way to Get Wealth* (London, 1631), 95; Speed, *Adam out of Eden*, 176. In modern chemical terms, corrosive sublimate is mercuric chloride ($HgCl_2$).

37 On Plat in general, see Harkness, *The Jewel House*, 211–53; and Malcolm Thick, *Sir Hugh Plat: The Search for Useful Knowledge in Early Modern London* (Totnes, UK: Prospect Books, 2010). On his work on plants and soil, see Clericuzio, "Plant and Soil Chemistry in Seventeenth-Century England," 555–7. On his chymistry, see Ayesha Mukherjee, "*In Vulcano Veritas*: Sir Hugh Platt's Alchemical Exchanges," in *Economies of Literature and Knowl-*

vational work with seed steeps provided a chymical context for much of what hitherto had been written in husbandry manuals. In his *Jewel House of Art and Nature*, for instance, Plat wrote that he had witnessed a poor rural farmer drop a bag of seed corn into a shallow bay, which became fully submerged under saltwater such that he was not able to recover it until low tide. As this was his only bag, he had no choice but to sow the seed. Much to the farmer's surprise, his crop provided yields superior to his neighbors, even though he had sown it on inferior land.[38] Plat went on to describe inland salt pits at Nantwich visited by farmers in Cheshire who gathered salt for steeping and fertilizing. Eventually, he provided proper proportions of salt, water, and grain, recommending one part salt to two parts grain for fertilizing upon the ground and a ratio in steeping liquids of one part salt to eighteen or twenty parts water, which "in diverse ground procure a good increase."[39] In this, he simply relayed the best contemporary estimate of the ratio of salt to water as found naturally in seawater.[40] The eyewitness observations of multiple agricultural reformers helped solidify the connections between this particular husbandry practice and chymical theory.

Plat's notions of the chymistry of seed and soil fertility were very much of his time.[41] He was an avid collector of domestic and exotic plants and seeds, and both his house and garden, which he referred to as his "laboratory," were typically brimming with new specimens.[42] As in his previous works and many other horticultural and gardening texts of his era, Plat moved seamlessly back and forth between practical, operational advice for gardeners and esoteric explanations of botanical knowledge. In a short span of text from *Floraes Paradise*,

edge in Early Modern Europe: Change and Exchange, ed. Subha Mukerji, Dunstan Roberts, Rebecca Tomlin and George Oppitz-Trotman (London: Palgrave Macmillan, 2020), 207–37.

38 Hugh Plat, "Diverse New Sorts of Soyle not yet brought into any publique use," in *The Jewel House of Art and Nature* (London, 1594), 41 [separate pagination].

39 Plat, "Diverse New Sorts of Soyle," 41; and Hugh Plat, *A New and Admirable Arte of Setting of Corne* (London, 1600), [sig.] D*r-v*. See also, Smith and Secoy, "Salt as a Pesticide, Manure, and Seed Steep," 511–12.

40 The actual ratio of salt to water for most seawater is between 1:27 and 1:28.5 (or 3.5%—3.7% salinity), most of which is sodium chloride, though there are other salts as well.

41 On the social dimension of soil fertility in early modern England, see Simon Schaffer, "The Earth's Fertility as a Social Fact in Early Modern Britain," in *Nature and Society in Historical Context*, ed. Mikuláš Teich, Roy Porter, and Bo Gustafsson (Cambridge: Cambridge University Press, 1997), 124–47. On the Enlightenment approach to the materiality of the earth more generally, see Simon Schaffer, "Enlightenment Brought Down to Earth," *History of Science* 41, no. 3 (2003): 257–68.

42 Elizabeth Scott, "The Secret Nature of Seeds: Science and Seed Improvement, c. 1520–1700" (PhD diss., University of East Anglia, 2016), 76.

in which he recounted a recipe for an artificial fertilizer, Plat cited, among others, Renaissance writers on natural magic Heinrich Cornelius Agrippa and Giambattista della Porta, as well as the physician Francisco Vallés and the craftsman Bernard Palissy.[43] After combining vegetable matter with various herbs and allowing the mixture to sit undisturbed for several days, Plat commented that the "Heauenly Earth so manured with the Starres" would bring forth the most robust plants, making them "prosper in the highest degree."[44] According to Plat, this composted vegetable matter contained "elemental" Saturn and Mercury, which he equated to philosophical lead and quicksilver, respectively. These philosophical elements, which absorbed the stellar seminal virtue that Plat called *aqua coelestis*, combined in the proper ratio to produce fermentation in seeds. This fermentation released a *quintessence*, which caused transmutation in the seed producing a plant.[45] He called the seminal virtue "a vegetable salt," which nature transmuted from common salts and contributed a crucial source of fertility to support plant life as part of a never-ending circulation of vital spirits throughout the cosmos.[46] For Plat, the chymical process of fermentation and transmutation explained the physical process of fertilization and germination in seeds.[47]

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43 On these, see Peter R. Antsey, "Boyle on 'Seminal Principles,'" *Studies in the History of Biology and Biomedical Science* 33, no. 4 (2002): 597–630; Kevin Killeen, "Duckweed and the Word of God: Seminal Principles and Creation in Thomas Browne," in *The Word and the World: Biblical Exegesis and Early Modern Science*, ed. Kevin Killeen and Peter Forshaw (Basingstoke, UK: Palgrave, 2007), 215–33; and Hiro Hirai, "Les Logoi Spermatikoi et le Concept de Semence dans la Mineralogie et la Cosmogonie de Paracelse," *Revue d'histoire des sciences* 61, no. 2 (2008): 245–64.

44 Plat, *Floraes Paradise*, 6–7.

45 Plat, *Garden of Eden*, 168.

46 Ayesha Mukherjee, "'Manured with the Starres': Recovering an Early Modern Discourse of Sustainability," *Literature Compass* 11, no. 9 (2014): 602–14, at 607 and 611 n. 12. In this, Plat disagreed with Palissy, who argued that common salts could not transform into vegetable salts. See Plat, "Diverse New Sorts of Soyle," 40–3.

47 This sequence of events is very close, at least in the terminology used, to alchemical instructions for "the vegetable work for fructification only, or for physick, wrought without any plant at all only by aqua coelestis and mercury," written by Plat and found in the British Library, MS Sloane 2246, fols. 11*b*-20. On the relationship between these processes, see Bruce T. Moran, *Distilling Knowledge: Alchemy, Chemistry, and the Scientific Revolution* (Cambridge: Harvard University Press, 2005), 67–98. On early modern chymical definitions of fermentation, see Walter Pagel, *Joan Baptista Van Helmont: Reformer of Science and Medicine* (Cambridge: Cambridge University Press, 1982), 79–87; Joseph S. Fruton, *Fermentation: Vital or Chemical Process?* (Leiden: Brill, 2006), 8–39; Antonio Clericuzio, "Mechanism and Chemical Medicine in Seventeenth-Century England: Boyle's Investigation of Ferments and Fermentation," in *Early Modern Medicine and*

According to Plat, discovering this vegetative salt required careful study of soil, putrefied plant matter, animal manures, and the thick, silt- and lime-rich sedimentary marl that could be found throughout the British Isles, all of which contained salts.[48] Using language similar to Palissy (and ultimately derived from Paracelsus), Plat argued that the vegetative salt caused heat, which activated an inner virtue within a seed that instigated its germination.[49] "There is not any kind of vegetable whatsoever, that coulde grow or flourishe," Plat wrote, "without the action of salt, which lieth hidde in everie seed."[50] Found in animal manures, the amount and quality depended a great deal on salts found in the grasses and other fodder plants they consumed. Plat concluded that it was the salts held within animal dung that explained its fertility in the first place. "All excrements as well of man and beast, serve to fatten and enrich the earth," he wrote, "but if any man will plow and sow his ground yearly without dunging the same, the hungry seed in time will drink up all the salt of the earth, whereby the Earth being robbed of her salt, can bring forth no more fruit, until it be dunged again, or suffer to lie fallow a certain time, to the end that it may gather a new saltnesse from the clouds, and rain that falleth up on it."[51] Here, Plat had discerned the problem of soil exhaustion and intuited that possibilities other than fallowing existed. With keen insight into the movement of nutrition through the food chain, Plat endeavored to record salt content through each step in the process: he took note of salt in putrefied plant matter, salt in the dung of ani-

Natural Philosophy, ed. Peter Distelzweig, Benjamin Goldberg, and Evan Ragland (Dordrecht: Springer, 2016), 271–94.

48 Malcolm Thick, "Sir Hugh Plat and the Chemistry of Marling," *Agricultural History Review* 42, no. 2 (1994): 156–7; Allen G. Debus, "Palissy, Plat, and English Agricultural Chemistry in the Sixteenth and Seventeenth Centuries," *Archives Internationales d'Histoire des Sciences* 21, no. 1 (1968): 67–88.

49 Plat, "Diverse New Sorts of Soyle," 23. Plat paraphrased and cited passages from the chapter "Des sels divers" in Bernard Palissy, *Discours Admirables, de la nature des eaux et fontaines, tant naturelles qu'artificielles, des metaux, des sels et salines, des pierres, des terres, du feu et des maux* (Paris, 1580), 164–78. On Paracelsus as Palissy's source for salt as "the balsam of life" that prevented decay and contributed to the fertility of soil, see Paracelsus, *Von natürlichen Dingen*, in *Sämtliche Werke*, Vol. 2, 98–110, and Paracelsus, *Herbarium*, in *Sämtliche Werke*, Vol. 2, 3–58. For more on Paracelsus as a source for Plat and Palissy, see Allen G. Debus, *The Chemical Philosophy: Paracelsian Science and Medicine in the Sixteenth and Seventeenth Centuries*, Vol. 1 (New York: Science History Publications, 1977), 414–16, and Clericuzio, "Plant and Soil Chemistry in Seventeenth-Century England," 555–6.

50 Ibid., 10.

51 Plat, *Jewel House of Art and Nature*, 103. For more context of these passages, particularly in relation to Plat's debt to Palissy, see Debus, *Chemical Philosophy*, 411–9. "Saltnesse from the clouds" may refer to the "aerial niter theory," a relative of the *sal nitrum* theory. See Allen G. Debus, "Paracelsian Aerial Nitre," *Isis* 55, no. 1 (1964): 43–61.

mals that had fed on similar plants, salt levels in the soil, and salt levels in seeds to be planted on farms.[52] Should a seed contain too little natural salt, then brining, liming, or steeping might be necessary (Fig. 1).

These types of investigation into seed steep recipes became quite common in the early seventeenth century. Francis Bacon further explained the scientific justification for the use of on-field fertilizers and seed steeps and attempted to provide both a natural history and an experimental foundation for their chymical attributes and practical uses.[53] Bacon's work proved highly influential to the next generation of experimental agricultural reformers among the Hartlib Circle who adopted chymical techniques for these purposes. Bacon did not explicitly adhere to any specific theory of generation and growth and argued that it was a mistake to seek any "vital principles" of matter in any one specific chymical substance. Nevertheless, like Plat, he too recommended the use of salts as manures and in seed steeps, asserting that land "obtained a special vertue by the salt: for salt is the first rudiment of life."[54] He further remarked that sea-sand was the second-best nutrient for rich soil, on account of its saltiness. It was surpassed only by marl, a dense clay-like soil found throughout the British Isles, which possessed "the most fatnesse," meaning fertility.[55] Again, saltpeter exhibited the qualities of an exemplary salt for these purposes. Bacon wrote that if one were to mix saltpeter with water until it reached the viscosity of honey and brush this on the buds of flowering plants, they would open faster, due to the "Spirit of the *Nitre;* For *Nitre*" was "the Life of *Vegetables*."[56] Like Plat, Bacon believed that fertilizing through steeping was a chymical process that manipulated the matter within the seed.[57] He designed an experimental regime to demonstrate this.

In one series of experiments recorded in his posthumously published *Sylva sylvarum* (1627), Bacon steeped numerous seeds from different grain, pulse, and vegetable species in all manner of steeping liquids (Fig. 2). In the first mention,

52 For Plat's understanding of the nutrient transfer of salt to seed, see Scott, "Secret Nature of Seeds," 199–200.

53 Clericuzio, "Plant and Soil Chemistry in Seventeenth-Century England," 557–60. On Bacon's interest in chymistry, see Graham Rees, "Francis Bacon's Semi-Paracelsian Cosmology," *Ambix* 22, no. 2 (1975): 81–101; Graham Rees, "Francis Bacon's Semi-Paracelsian Cosmology and the *Great Instauration*," *Ambix* 22, no. 3 (1975): 161–73; and more recently, Jalobeanu, "Spirits Coming Alive: The Subtle Alchemy of Francis Bacon," 459–86.

54 Francis Bacon, *Sylva sylvarum, or a Natural History in Ten Centuries …* (London: W. Lee, 1627), 149–50.

55 Ibid.

56 Ibid., 117.

57 On this comparison, see Scott, "Secret Nature of Seeds," 185–7.

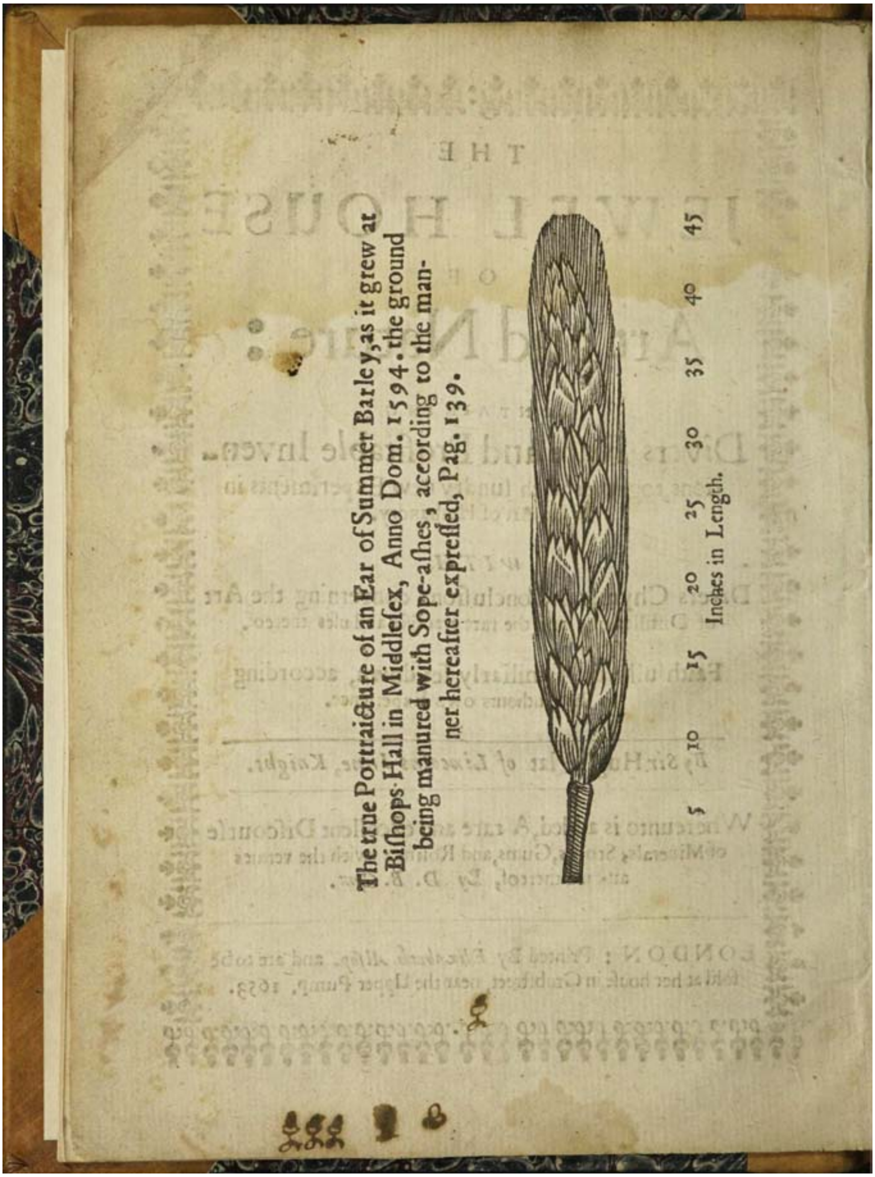
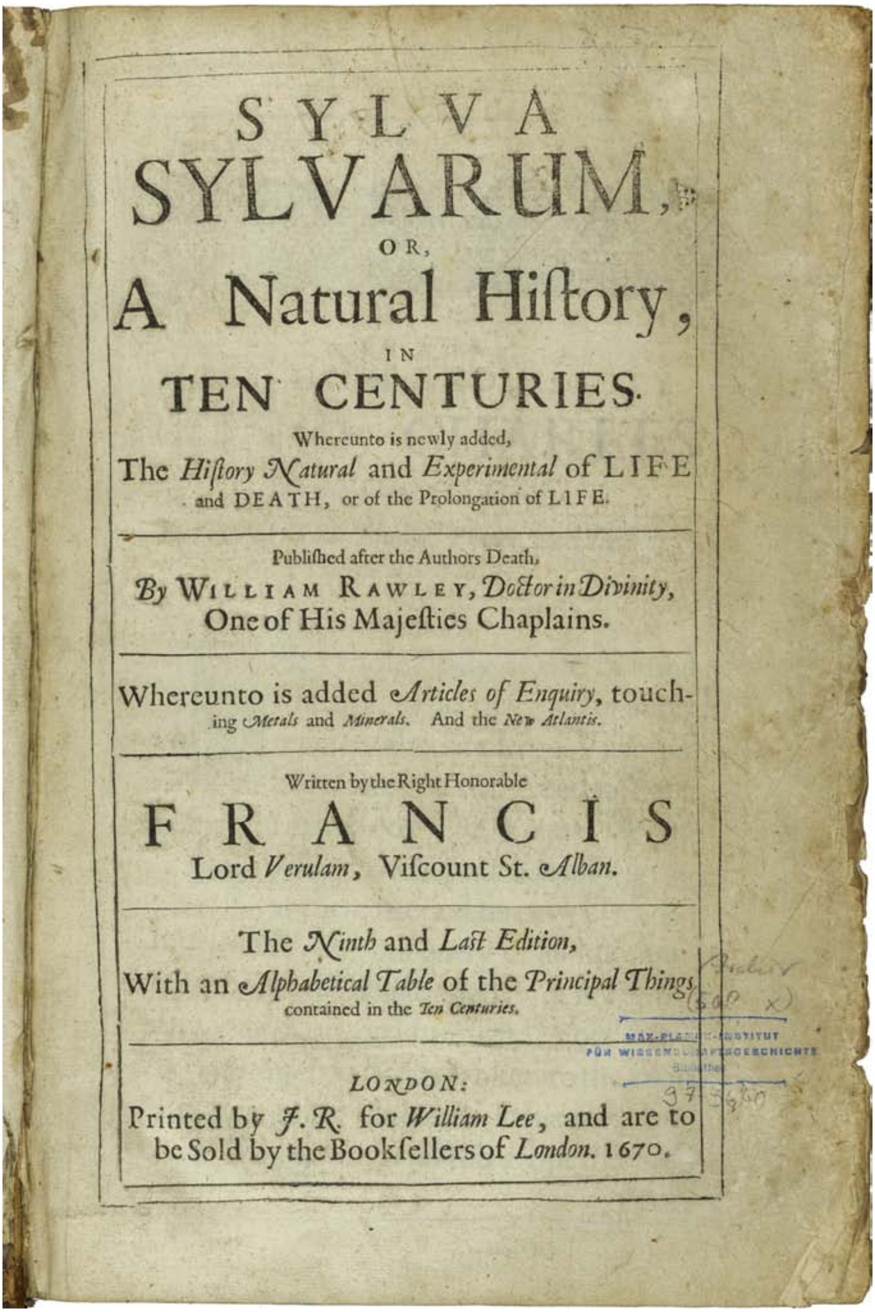


FIGURE 1 Hugh Plat, *The Jewel House of Art and Nature* (London, 1594), [sig.] A1*v*
PUBLIC DOMAIN



SYLVA
SYLVARUM,
OR,
A Natural Hiſtory,
IN
TEN CENTURIES.
Whereunto is newly added,
The *Hiſtory Natural* and *Experimental* of LIFE
and DEATH, or of the Prolongation of LIFE.

Publiſhed after the Authors Death,
By WILLIAM RAWLEY, *Doctor in Divinity*,
One of His Majeſties Chaplains.

Whereunto is added *Articles of Enquiry*, touching *Metals* and *Minerals*. And the *New Atlantis*.

Written by the Right Honorable
FRANCIS
Lord *Verulam*, Viſcount St. *Alban*.

The *Ninth* and *Last Edition*,
With an *Alphabetical Table* of the *Principal Things* contained in the *Ten Centuries*.

LONDON:
Printed by *J. R.* for *William Lee*, and are to be Sold by the Bookſellers of *London*. 1670.

FIGURE 2 Francis Bacon, *Sylva sylvarum, or a Natural History in Ten Centuries* [1627] (London: W. Lee, 1670), frontispiece
MAX PLANCK INSTITUTE FOR THE HISTORY OF SCIENCE, BERLIN

at the opening of his "Naturall Historie" section, Century V, he wrote of sowing a bed of turnip, radish, and cucumber seeds along with wheat and peas. "There was taken Horse-dung, old, and well rotted," he wrote, which was

> laid upon a Banke, halfe a foot high, and supported round about with Planks; And upon the Top was cast Sifted Earth, some two Fingers deepe; And then the *Seed* Sprinkled upon it, having beene steeped all night in *Water* Mixed with *Cow dung*. The *Turnip-Seed*, and the *Wheat* came up halfe an Inch above Ground, within two dayes after, without any Watring. The Rest the third day. The *Experiment* was made in *October;* And (it may be) in the *Spring*, the *Accelerating* would have beene the speedier. This is a Noble *Experiment;* For without this helpe, they would have beene foure times as long in comming up.[58]

While the experimental results appeared to confirm the use of water and dung, as any farmer knew, he cautioned that there was no real economic benefit in having these crops harvested mere days early, with the possible exception of peas, which commanded higher prices earlier in the growing season, along with strawberries, cherries, and other sweet fruits, which he claimed were also improved by this manner of steeping.[59]

More important for Bacon was a comparative analysis of steeped seeds and unsteeped seeds. Unlike the previous experiment in which the steep remained constant while multiple types of seeds were tested, Bacon conducted another experiment with wheat grains as the archetypal seed that he steeped in a number of different liquid solutions to determine which led to the quickest germination, the healthiest plants, and the highest yields. He steeped wheat in water mixed with cow dung, horse dung, pigeon dung, human urine, powdered chalk, soot, ashes, bay-salt, claret wine (a red, Bordeaux wine), malmsey (a sweet, fortified Madeira wine), and spirit of wine, or aqua vitae.[60] The proportion was one part each ingredient to three parts water, except the bay-salt, which was one part salt to seven parts water.[61] He did not dilute the urine, claret, or spirit of wine with water. Bacon steeped the seeds for twelve hours before planting,

58 Bacon, *Sylva sylvarum*, 109–10.
59 Ibid.
60 In modern chemical terms, spirit of wine, also called aqua vitae and *spiritus vini*, typically referred to concentrated, aqueous ethanol (C_2H_6O), called spirit of wine as it was usually distilled from wine. It was typically 50%—70% ethanol by volume. See William Newman, "Alchemical Glossary," http://webapp1.dlib.indiana.edu/newton/reference/glossary.do (accessed July 10, 2018).
61 Notably, this was a much saltier mixture than Plat's steeping brine.

and, as a control, also planted unsteeped wheat that he watered twice a day with warm water and unsteeped wheat that he did not water at all. The result was

> That those that were in the Mixture of *Dung*, and *Urine*, and *Soot, Chalke, Ashes*, and *Salt*, came up within six dayes: And those that afterwards proved the Highest, Thickest, and most Lustie, were; First the *Urine;* And then the *Dungs*, Next the *Chalke;* Next the *Soot;* Next the *Ashes;* Next the *Salt;* Next the *Wheat Simple* of it selfe, unsteeped, and unwatered; Next the *Watered twice a day* with warme water; Next the *Claret Wine*. So that these three last were slower than the ordinary *Wheat* of it selfe; And this Culture did rather retard, than advance. As for those that were steeped in *Malmsey*, and *Spirit* of *Wine*, they came not up at all.[62]

Importantly for Bacon, and for agricultural reformers, the most effective ingredients were cheap and easy to procure.[63]

In the seventeenth century, several entrepreneurs established an interest in developing, standardizing, and profiting from these types of seed steeps and fructifying waters. As Joan Thirsk and G.E. Fussell have noted, there is evidence that industrious merchants performed many similar experiments in steeping seeds around the same time as Bacon and Plat.[64] At least three applied for patents. In June of 1613, a grant was issued to Adam Newton, John South Coke, and John Wood to "use the art of steeping seed to be sown, for the furtherance of tillage in England and Wales, for 11 years."[65] Their process involved steeping wheat seeds in rapeseed oil. Once steeped, the mixture was sprinkled with a powder comprised of crushed, malted beans, pulverized rapeseed, one quart of lime, and urine. According to the recipe, the powder could be sprinkled directly on the land just as one would spread manure, though whether one needed to steep the seeds in liquid beforehand was not mentioned. The three merchants listed alternative substances to use if any of the ingredients could not be

62 Bacon, *Sylva sylvarum*, 109–10.

63 Smith and Secoy, "Salt as a Pesticide, Manure, and Seed Steep," 512–13.

64 Thirsk, *Agricultural Change: Policy and Practice 1500–1750*, 20–1; G.E. Fussell, *Crop Nutrition: Science and Practice before Liebig* (Lawrence, Kan.: Coronado Press, 1971), 60.

65 "James 1—volume 74: June 1613," in *Calendar of State Papers, Domestic: James 1, 1611–18*, ed. Mary Everett Green (London: Her Majesty's Stationery Office, 1858), 186–9, *British History Online*, http://www.british-history.ac.uk/cal-state-papers/domestic/jas1/1611-18/pp186-189 (accessed August 1, 2018). For the details of the patent, see The National Archives, Kew, SP 14/187/22A.

obtained.[66] Although they specified wheat seeds, the proclamation mentioned that it was "a liquor for steeping all kinds of grains for sowing" and the patentees proclaimed their "willingness to give information, Etc upon it."[67] Though there is scant other evidence of attempts to patent these liquids, there is a great deal of evidence of further experimental trials, to replicate earlier methods found in chymical recipes, husbandry manuals, and natural histories of experimenters like Plat and Bacon.[68] A preponderance of these occurred between the 1630s and 1660s among members of the Hartlib Circle interested in adapting chymical experimentation for agricultural reform.

4 The Hartlib Circle and the Chymical Augmentation of Wheat Seeds

By the late 1630s, many members of the Hartlib Circle had become especially keen on pushing these experiments even further, testing various organic and inorganic chymical ingredients, seeking inexpensive solutions to fertilizing land and seeds, and uncovering dormant productive virtues in waters, from seawater to pond water to water carefully distilled in an alembic. One such example comes from the work of Gabriel Plattes and his readers. Plattes wrote several books very quickly in the half decade before his death in 1644, one of which was *The Discovery of Infinite Treasure*. The titular "treasure"—shared in the title to one of his other prominent works, *The Discovery of Subterraneall Treasure*—referred to the renewable and sustainable soil and mineral wealth that, with proper technical knowledge, the nation could maintain in perpetuity. In the former, Plattes purported to explain how to "putrefy" rainwater without the addition of any external organic materials. He claimed that he had

> tried to putrifie water by it selfe, and also with helps, and doe finde that it may be done even as milke by helpe of rennet is curded into cheese; a thing that no man would beleeve, but that experience shewes it to be true; but as yet I have not brought the experiment to full perfection, and there-

66 For the rest of the information not contained in the *Calendar of State Papers, Domestic*, see Anonymous, *A direction to the husbandman in a new cheap and easy way of fertilizing and enriching arable ground* (London, 1634).

67 Green, ed., *Calendar of State Papers, Domestic, James I, 1611–18*, 186.

68 See, e.g., Buttress and Dennis, "The Early History of Cereal Seed Treatment in England," 93–103; G.E. Fussell, "Crop Nutrition in Tudor and Early Stuart England," *The Agricultural History Review* 3, no. 2 (1955): 95–106; Malcolm Thick, "Garden Seeds in England before the Late Eighteenth Century, Part 1: Seed Growing," *The Agricultural History Review* 38, no. 1 (1990): 58–71.

> fore as yet I will respit the publishing thereof: some experience hereof may be seene in the Moats and standing Pooles which yeeld great store of good Manure, and I wish that they were more made use of.[69]

In this context, the use of the term "putrefy" may have had a double meaning, with both botanical and chymical connotations. Outside of chymistry, putrefaction simply referred to the decaying of organic matter; but in this case, Plattes indicated that water itself had some spontaneously generative property. This possibility was in no way problematic and aligned with what he and most other early moderns expected from nonliving matter. Literature dating back to the ancient world had detailed the genesis of small animal life from decaying plants and animals. Dead bulls reputedly birthed bees. Other rotting animal carcasses produced flies, while worms and crawling insects emerged from putrefied mud, pond scum, or decomposing plant matter.[70] Plattes suggested that farmers might be able to synthesize a propagative liquid with similar properties to accelerate the generation of plants. Later in the same chapter of *The Discovery of Infinite Treasure*, Plattes claimed that he had accomplished the feat of creating fructifying water from putrefied rainwater, but "not in such exquisite manner for expedition in great quantitie."[71]

Among members of the Hartlib Circle, seed steeps and fructifying waters consumed a great deal of intellectual energy throughout the 1650s. In Cressy Dymock's pamphlet "A Discoverie For Division or Setting out of Land," he included "an experiment for the multiplying of corn, practiced neer Paris in France," a recipe that would be much discussed among the group over the next decade. The recipe went as follows:

> In to two French pintes of rain-water, they did put a certain quantity of Cow-dung well-rotted, and as much Sheeps-dung and pigeons dung. This water they boiled, till but half a pinte was left, then they strained it

69 Gabriel Plattes, *The Discovery of Infinite Treasure* (London, 1639), 36.

70 Daryn Lehoux, *Creatures Born of Mud and Slime: The Wonder and Complexity of Spontaneous Generation* (Baltimore: Johns Hopkins University Press, 2017), 55–6 and 61; Principe, *The Secrets of Alchemy* 132. On these classical sources, see e.g., Varro, *De Agricultura* 3.16.4; Columella, *De Re Rustica* 9.14.6–7; Lucretius, *De Rerum Natura* 2.872, 2.1150–1, and 3.719–20. On early modern chymical attempts to return dead organic materials to life in the laboratory, see e.g., Joachim Telle, "Chymische Pflanzen in der deutschen Literatur," *Medizinhistorisches Journal* 8 (1973): 1–34; Jacques Marx, "Alchemie et Palingénésie," *Isis* 62 (1971): 274–89; and William Newman, *Promethean Ambitions: Alchemy and the Quest to Perfect Nature* (Chicago: University of Chicago Press, 2004), esp. 164–237.

71 Plattes, *Discovery of Infinite Treasure*, 42.

> through a linnen cloth, and in it dissolved 3 small handfuls of common salt, and as much Salt Peter. This brine they set in some vessel upon hot ashes, and in it they steeped their Seed-corn; which being so ordered, and at the usuall seed-time, being put into barren ground. produced unusuall increase, I my selfe have seen one hundred and fourteen eares upon one root, which, they told me, came from one single corn so prepared.[72]

He compared this to another recipe "found in an old manuscript" that had similar ingredients but included the step of letting the mixture sit for eight days in the sun, presumably to allow it to putrefy, though in this, too, boiling the mixture while constantly stirring could quicken the process, assuming one could stand the fetid stench. This recipe promised a similar multiplication of yields at one hundred stalks per individual seed grain. In "another Secret worthy to be tryed by all" who labored for the advancement of husbandry, Dymock elaborated on the possibilities of augmenting and prolonging the lives of seeds through a combination of organic and chymical ingredients. "In the production of plants," Dymock wrote

> the earth is considered as a female, whose sterility may be much helped by the extraordinary melioration of the seed; As if you take water, which hath bin made fat with horsdung wel rotted, and afterwards dissolve in it as many pounds of Sal terræ as you intend to sowe acres. In this water steep the aforesaid weighty seed for 24 hours. So shall you have a better crop, then usuall, though you sowe but halfe the usuall quantity of seed, and though your ground be not so often ploughed, nor be at all dunged; nay though it were barren of it selfe. Your harvest will be ripe sooner by a month, and by reason of the Salt-peter, this corn will be fitter for storehouses; for there it will lie ten years uncorrupted.[73]

In Dymock's interpretation, the female Earth acted as a womb for the male seed, which might need chymical enhancement. Not only did these ameliorated seeds steeped in horse dung and sal terræ generate higher-quality seeds, but they also produced a higher-quality grain ready for harvest up to a month early, which Dymock argued could also be stockpiled for a decade.

Experiments with various dungs and salts became increasingly common, as did chymical explanations for their efficacy. In the fall of 1656, Cheney Culpeper

72 Cressy Dymock, "A Discoverie For Division Or Setting Out Of Land," Cressy Dymock et. al. Part 2 (n.p., 1653), 13.

73 Ibid., 14.

and Samuel Hartlib exchanged several letters discussing when to steep cereal grains and how “moshing” manures the same way brewers malted grains was the best way to activate its fertility. From there Culpeper proceeded to “the imbibing of Corne,” presumably meaning the soaking of cereal grains in the dung mixture, “in such a contracted quintessence … [that] will serve, till the art of fermentation, shall have opened a wider door to the stupendious multiplication of all things.”[74] Though he did not mention Plat by name, Culpeper’s evocation of a quintessence highly suggests that his theory of fermentation and germination drew inspiration from his work. We do not have Hartlib’s response, but he likely informed Culpeper of a German recipe for fructifying water, as Culpeper mentioned it in a return letter in October. Culpeper did not give the full recipe, though the mixture must have contained saltpeter and lime, for he compared it to John Bate’s *Book of the Mysteries of Art and Nature* and the same French recipe related by Dymock that Hartlib had included in his own *Legacy of Husbandry*, which produced saltpeter for fertilizing “by the mosshing of quick lime with warme water, then vapouring away the water by the Sunne.”[75] What Hartlib’s German recipe, Bate’s recipe, and the anonymous recipe from Harlib’s *Legacy of Husbandry* all had in common were references to the creation of saltpeter by leaching lime-mortar and building stones and crystallizing the remnant, which would then be used to brine seeds. This was a rather common method of artificially producing saltpeter in the sixteenth century and had become a common starting point for cereal grain seed steeping by the middle of the seventeenth.[76]

Another recipe offering a higher density of grain per acre came from Henry Jenney, an occasional correspondent with Hartlib and regular experimenter in all matters of husbandry. He had mentioned that after having read works about “multiplieing corn 200 fold” by Heinrich Cornelius Agrippa and Giambattista della Porta, and about the “fructifying experiments” of Hugh Plat and the Dutch-German chymist Johann Rudolf Glauber, he had concluded that “steeping seed in water impregnated with nitrum purified from its acid salt and calcining it in a crucible” was essential for improving yields. He added that he had failed thus far to replicate this, but he blamed himself rather than the process.[77] Here, Jenney referred to Hugh Plat’s recent, posthumously published

74 Cheney Culpeper to Samuel Hartlib, Fall [?] 1656, HP 70/3/1A-2.

75 Culpeper to Hartlib, 13 October 1656, HP 70/3/2A–2B. This is a partial copy of a longer letter in the Hartlib Papers, 42/15/1A–2B. See also, John Bate, *The Mysteries of Art and Nature* (London: Ralph Mab, 1634), 261; Hartlib, *His Legacy of Husbandry …*, 110.

76 Cressy, *Saltpeter*, 16, 28, and 31.

77 Henry Jenney to Samuel Hartlib, September 28, 1657, HP 53/35/3A.

work *The Garden of Eden*, an abridged and re-edited version of his *Floraes Paradise*, wherein Plat made reference to Agrippa's *De occulta philosophia libri tres* and della Porta's commentary on it.[78] Jenney wrote Hartlib requesting more information on these writings, imploring him to "procure a comment" on the works of Plat, Agrippa, and della Porta on the multiplication of grain.[79]

Members of the Hartlib Circle seeking a cohesive vegetable philosophy to explain germination, growth, and the ability to manipulate these, regularly cited the works of della Porta and Agrippa—much as they did Plat and Bacon—especially when natural magical explanations seemed to elucidate commonly observed but poorly understood chymical and physical processes.[80] The concept of "multiplication" was well represented in the pages of their major works. These works emphasized the economic importance of husbandry, the wholesale creation of new types of plants and animals through physical and chemical experimentation, and the confluence of empirical study and chymical techniques to understand "the riches and delights of the natural sciences."[81] Within a section of *Natural Magick* on the production of new plants, della Porta made claims about the efficacy and chymical context of grafting and seed steeping, like "one and the same Vine-branch … bring[ing] forth a black and a white grape together"[82] (Fig. 3). He suggested how "Lettice [*sic*] should grow, having in it Parsley, and Rocket, and Basil," how to produce an "Almond peach, which is outwardly a Peach, but within hath an Almond kernel," and how to grow a "Citron that hath a Limon in the inner parts."[83] Slightly less outlandish prospects included instructions on "hastening the fruits" of cucumbers, melons, figs, and quinces; how to ripen cherries, rape root, colewort, parsley, peas,

78 Plat, *The Garden of Eden*; Plat, *Floraes Paradise*; and Heinrich Cornelius Agrippa, *De occulta philosophia libri tres* (Paris, 1531; Cologne, 1533). It is unclear to which Giambattista della Porta text he refers, though it is likely a passage from his *Naturalis magiœ*.

79 Henry Jenney to Samuel Hartlib, September 28, 1657, HP 53/35/3A.

80 E.g., Cheney Culpeper to Samuel Hartlib, November 22, 1643, HP 13/13B; Marin Mersenne to Theodore Haak, March 20, 1640, HP 18/2/22A; Marin Mersenne to Theodore Haak, November 18/22, 1640, HP 18/2/27A; Dr. Brown's Miscellanies on Husbandry, in Hartlib's Hand, undated, HP 70/4/3A–4A; [?] to John Evelyn, October 25, 1659, British Library, Add. MS 15948 fol. 72*b*; Samuel Hartlib, *Ephemerides* (June/July) 1648, HP 31/22/18B; Gerald de Maylnes, Extract from *Lex Mercatoris*, in *The Reformed Commonwealth of Bees*, ed. Samuel Hartlib (London, 1655), 62.

81 Giambattista della Porta, *Natural Magick* (London: Printed by Thomas Young and Samuel Speed, 1658), "Preface to the Reader," [unpaginated].

82 Ibid., 67–8.

83 Ibid., 70–2.

FIGURE 3 Giambattista della Porta, *Natural Magick* (London: Printed by Thomas Young and Samuel Speed, 1658), frontispiece
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and vetches "before their time;" how to grow roses in the month of January; and how to enlarge apples, pears, apricots, mulberries, onions, garlic, citrus fruits of all kinds, and so on.[84] Similar lists could be found among the works of mid seventeenth-century agricultural reformers and vegetable philosophers, including Hartlib's and Dymock's *Cornu Copia* and Adolphus Speed's "General Accommodations" from the early 1650s.[85]

Country parson, apple orchard proprietor, and horticultural experimenter, John Beale became one of the most vocal supporters of all manner of chymical experiments to test the value of fructifying waters on cereal grains, as well as fruits and vegetables.[86] He and Hartlib exchanged a long series of letters in 1656 and 1657 discussing the most effective ingredients of fructifying waters, the operative principles at work, and on which seeds they functioned best. In the first letter, dated 23 February 1656, Beale thanked Hartlib for "the 6 bottles of Fructifying water" he had sent him and noted that he planned to "trye it upon all kinds of Lentgraine, as wee call barly, oates, fitches, pease, beans, kidney, Lupines, and garden seedes."[87] He then went on to describe a wheat-steeping experiment, different substances he had used in the steeping liquid, including "bloud of a tub of beefe in it, & urine draind through salt peter earth, & a rich fold water of sheepe dung, horse dung, & cowe dung, & pigeons dung," and the poor weather that had hindered his progress "for 8 or 10 dayes."[88] He steeped, or "swild," half in the "fold water" while another third he "rolled in lime" to keep from clumping. The result was the wheat seed, "which was not swild from *th*e salt, came up a weeke sooner than the other; & both seeme nowe much better than other corne."[89] This suggested to Beale that lime imparted something perhaps more important than salt.[90]

In the next letter, dated less than a week after the previous one, Beale reported his assessment of Hartlib's fructifying water:

84 Ibid., 75–8 and 82–6.

85 Samuel Hartlib, *Cornu Copia, A Miscellanium* (?London, ?1652), 1–11; Adolphus Speed, "General Accommodations," undated, HP 57/3/8/1A–8B.

86 Stubbs, "John Beale, Philosophical Gardener of Herefordshire, Part I: Prelude to the Royal Society (1608–1663)," 463–89; Stubbs, "John Beale, Philosophical Gardener of Herefordshire, Part II: The Improvement of Agriculture and Trade in the Royal Society (1663–1683)," 323–63; and Michael Leslie, "The Spiritual Husbandry of John Beale," in *Culture and Cultivation*, 151–72.

87 John Beale to Samuel Hartlib, February 23, 1656, HP 62/22/1A.

88 Ibid.

89 Ibid., 1B.

90 On the evolving uses of lime in place of saltpeter, particularly from the late seventeenth century onward, see Smith and Secoy, "A Compendium of Inorganic Substances Used in European Pest Control before 1850," 1184 and 1186.

> One bottle I have opened, I find the water cleare, of a light yellowish color, of an odious smell, and (as it were) of putrid fish. I have steepd in it seedes of gellyflowers of divers sorts, kernells of apples, lupins, smaller kidney-beanes, & Roman beanes. but w*i*th some jealousy, That all thiese are unfit; for heretofore I haue found them hurte by swelling in fat water. My people are nowe sowing fitches oates, beanes, & pease; And till I have further directions, I dare not adve*n*ture on the*m*.[91]

Beale looked forward to the results of the experiment but politely doubted that Hartlib's mixture would do much to improve his crops because in Herefordshire, his native county, they already had "the richest Corn" that he had ever seen in England.[92] Nevertheless, he promised to withhold judgment until the harvest came in. Unlike others who had presumably embellished their successes with various steeping liquids, Beale appears to have been honest to Hartlib about his failures. Multiple attempts to replicate the fructifying waters of Hartlib, Plattes, and others either disappointed in their enrichment or prevented the seeds from sprouting altogether.

Beale also hoped to determine "Howe the seede-corne may bee soe composted, as to make a very considerable improvem*en*t upo*n* weak land," in the same manner as the unnamed Parisian experimenter mentioned in the works of Dymock and Hartlib, though the effectiveness of the method had been called into question by Plattes, whom Beale and Hartlib considered an authority on agricultural chymistry.[93] Beale referred to "honest Gabriel," who had written about the method and denied its efficacy.[94] However, Beale was not so sure that it had no merit. The improvement consisted of steeping wheat seeds or other grains in a clay-bottomed container filled with putrefied water in the sun until the seeds had almost absorbed all of the liquid, at which point lime was sprinkled on them and the seeds were planted. "You will save ten times as much labour in carriage of your dung," Plattes reported, "so farre as this labour cometh too, and as for your crop, though you shall not have so much increase as some have Mountebanklike reported of it … you shall have good material increase for one crop."[95] Though he remained skeptical of Plattes's statements about putre-

91 Beale to Hartlib, February 27, 1656, HP 62/22/3B. Underlining in the original, though it is not known whether this is the work of Beale or Hartlib.

92 Ibid.

93 John Beale to [?]Samuel Hartlib, 13 March [?]1657, HP 62/16/3A.

94 Ibid.

95 Plattes, *A Discovery of the Infinite Treasure*, 36–7.

faction, his own experiences with liming seeds actually suggested that these steps were well worth taking.

Beale's last letter to Hartlib on the topic of fructifying waters deferred to the judgment of the chymist Robert Boyle, who had remarked that seed steeps and fructifying waters appeared to be promising avenues of fertilization, though he thought that they were not a panacea for general improvement and likely only worked for certain crops.[96] Most recipes found in husbandry manuals were for use on grains and pulses, but Beale and Boyle both thought they might be more useful for fruit trees and plants that produced pitted fruits. Beale wrote that he concurred with "much of Mr Boyles judgem*en*t concerning fructifying Waters: but their proper use is for delicate fruite, in the very time, when the seede or kernell does first putrify tow*ar*ds [generation; for then it] acquires a speciall kind. For the delicacy of apples, peares, & some other fruite, is like a diversion fro*m* the strength & vigor of nature, & is therefore of weaker woode & lesse lasting, than the crabstoc or wilde fruite."[97] The less hardy the plant, the argument went, the more it needed fructification.

This assessment matched other descriptions from husbandry writers who had compared the utility of seed steeps and fructifying waters for different types of seeds and plants and for different parts of the plant, including not only seeds, but also roots, stems, leaves, and buds after the plant had begun to grow. An undated letter from Dymock to Hartlib on the "precious fructifying liquor" of an otherwise unknown individual named "Dr Robinson" or "Dr Robertson" (the manuscript is unclear) stipulated different steeping durations and separate locations of application depending on the type of plant.[98] Although the contents of the liquid remained unspecified in the letter, the instructions for steeping included: mixing barley with dry, crumbled, fertile earth and soaking for twenty-four hours before planting; soaking the roots only of fruit tree saplings for ten to twelve days, but for older trees, soaking a wool cloth and wrapping the roots to keep them moist for two weeks; and steeping the roots of flowers and small plants for twenty-four hours but observing each closely,

96 It is unclear to what work by Boyle Beale was referencing. It may refer to Boyle's experiments with clover seeds, as relayed to Hartlib by Cheney Culpeper. See Cheney Culpeper to Samuel Hartlib, July 6, July 12, and August 16, 1648, in Michael J. Braddick and Mark Greengrass, "The Letters of Sir Cheney Culpeper, 1641–1657," *Camden Miscellany* 33 (1997): 335, 337, and 342; Samuel Hartlib, "Ephemerides," February–May 1650, HP 28/1/51B. On Beale's interest in these, see Clericuzio, "Plant and Soil Chemistry in Seventeenth-Century England," 567–8.

97 John Beale to [?]Samuel Hartlib, November 3, 1657, HP 52/14A.

98 Cressy Dymock to Samuel Hartlib, "Dr [Robinsons/Robertsons?] Method of Fructifying Corn," (undated), HP 65/16A.

as some individual plants needed slightly less or slightly more time depending on their absorption rate.[99] Even though some of these seed steeps and fructifying waters likely did little to aid in germination time or plant growth, many of them did, and by the mid seventeenth century, agricultural improvers and manual writers could give nuanced instructions about the ratio of ingredients, the time intervals for steeping, and the site of implementation.

5 Conclusions

Seed steeps and fructifying waters were the province of farmers at all social levels. Though we have the best evidence of their composition from farmers like Henry Jenney and John Beale, their profusion in husbandry manuals, agricultural pamphlets, and other instructional booklets strongly suggests that many English farmers commonly steeped wheat and other seeds before planting. Historians of agriculture have noted this for a very long time. Less noted but no less important, however, are the similarities that seed steeps and fructifying waters shared with recipes for chymical liquors, menstrua, and solvents that contained organic matter as part of their composition. Agrarian reformers indebted to chymical interpretations of physical material change sought a unified theory of growth that could explain that change across metallic, mineral, saline, botanical, and biological realms. Those involved in the augmentation of wheat seeds and other grains through seed steeps and fructifying waters connected these theories to their practices. For the agricultural reformer, it was the *manipulable* nature of seeds, plants, manures, salts, and the steeping liquids that could be made from them which suggested that scientific control of the processes of germination and plant growth was possible for agricultural improvement.

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99 Ibid., 16A–B.

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