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# Shakespeare and Science, c. 1600

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THIS SPECIAL DOUBLE ISSUE EXAMINES Shakespearean drama in light of early modern practices and discourses of anatomy, cartography, botany, physics, cosmology, meteorology, experimental science, and early forms of “life science.”<sup>1</sup> Collectively, these essays aim to advance our understanding of a poet and playwright immersed not only in humanistic learning, theological debate, vernacular development, and popular culture, but also in the practices, theories, and conceptual lexicons of scientific knowledge in the making. While attending to the relative neglect of Shakespeare within scholarship on literature and science informed by recent developments in the history of science and science studies, the essays to follow also interrogate the relationships between art and science, nature and norms, religion and science, and experience and experiment in the early modern period. Let us begin, however, by defamiliarizing one of our two title keywords: science.<sup>2</sup>

As far as nomenclature is concerned, it was not until the 1650s that the word “science” first became synonymous with the natural and physical sciences, and it was not until almost two centuries later that the word “scientist” would be coined as a possible term through which to distinguish “students of the material world” from other knowledge practitioners, including the “artist” and the “economist.”<sup>3</sup> “Science” as a term has now accrued meanings and forms of cultural capital that would have made Shakespeare’s eyeballs start from their spheres.<sup>4</sup> This is not simply due to innovations in science from the mid-seventeenth century to the present day, nor due to changing social and economic conditions that would widen the chasm between the humanities and the sciences. It is due as well to the way in which “science” has moved from a more generalized domain of knowledge practice to highly specialized and professionalized forms of inquiry into both natural and artificial worlds. Were Shakespeare to magically float forth and set his eye on the prose above, containing the now commonplace phrase, “scientific knowledge,” he would find the phrase to be utterly redundant. From the Latin *scientia* or knowledge, science *was* knowledge, and only later became coterminous with the kinds of knowledge required of the natural and physical sciences.<sup>5</sup>

The word “science,” to Shakespeare’s ears and eyes, would have encompassed fields of knowledge including but also exceeding what was called, in the medieval period, the quadrivium (arithmetic, geometry, astronomy and music) *and* the trivium (rhetoric, grammar, and logic). Whereas it is now common to distinguish between the arts and sciences within university curricula, as a disciplinary rubric, “science” was often used interchangeably with “art.” That the “seven liberal arts” were also called, in the Renaissance, the “seven liberal sciences,” and that even Francis Bacon alludes, for example, to “Science of Grammar” as well as the “Art of Grammar,” and to that “Science, which wee call rhetoricke, or art of eloquence, A Science excellent, and excellently well labored,”<sup>6</sup> indicates a great deal of fluidity between the “arts” and “sciences” at the basic level of terminology. We might well recall Thomas Kuhn’s early observation not only that “little cleavage was felt between the sciences and the arts” in the Renaissance, but that “the term ‘art’ continued to apply as much to technology and the crafts [. . .] as to painting and to sculpture.”<sup>7</sup>

Nomenclature of course tells only part of a story, for one might distinguish, then as now, between the “science of rhetoric” and the “science of mathematics.” Thus to simply reify continuities between “arts” and “sciences”—or indeed “Shakespeare” and “science”—in the early modern period is as perilous as positing clear oppositions between them.<sup>8</sup> As the eighteenth-century philosopher David Hume once put it, “there is no subject, in which we must proceed with more caution, than in tracing the history of the arts and sciences; lest we assign causes which never existed, and reduce what is merely contingent to stable and universal principles.”<sup>9</sup> But in terms of more recent critical inquiry, as Caroline Jones and Peter Galison have stressed, the “focus on art and science as discrete *products*” rather than processes can easily obscure “the commonalities in the practices that produce them. Both are regimes of knowledge, embedded in, but also constitutive of, the broader cultures they inhabit.”<sup>10</sup> Despite the economic and institutional disparity that separates, say, the study of Shakespeare from the study of polymer physics today, from the perspective of practice and process, as Marjorie Garber observes, “the arts are far more analogous to the sciences than to the humanities.”<sup>11</sup> This is particularly so given forms of collaboration, investigation, *téchnē*, instruments and materials, experimentation and innovation involved in the making of art.

In the early modern period, the relation among various practices of art and science were all the more marked, for “science,” c. 1600, would have been aligned with spheres of labor, skill, or artisanal craftsmanship as

diverse as writing (the craft of the scrivener), baking, brewing, husbandry, falconry, shoe-making, sewing, and surgery. When a text from 1530, for example, alludes to the “sciences” and includes the “scyens of bakyng, bruyng, surgery, or wrytyng,” we find that the domains of the baker, the brewer, the surgeon, and the scrivener, no less than the astronomer, the alchemist and the natural historian, were variously constellated under the rubric of “science.”<sup>12</sup> Even “feates of armes” and “skill to ride,” in Edmund Spenser’s words, could “seeme a science, / Proper to gentle blood” while “others faine / To manage steed.”<sup>13</sup> This does not mean that this volume aims to encompass, or even focus on, Shakespeare’s relationship to the practices of the butcher, the baker, and the candlestick maker, nor to those of the scrivener, tailor, falconer, seamstress, or grammarian. It does mean, however, that “science” was not yet distinguished from artisanal practices and technologies through which cultural artifacts, be they words or things, were made, and through which various aspects of nature were subject to scrutiny.

If “the opposition between art and science as two different modes of engaging with nature may be true in some senses today,” write Pamela Smith and Paula Findlen, “in the fifteenth and sixteenth centuries, when the methods of the new science were being constructed, artist-artisans [. . .] articulated a body of claims about nature and about the nature of authority that helped form the basis of the new science.”<sup>14</sup> “Recent historiography of science,” moreover, “has found natural philosophy in new places, and has advanced the argument that entrepreneurial doctors, Spanish juntas, foreign artisans in England, and scholarly merchants all helped shape the habits of mind and action that became the new science.”<sup>15</sup> Although several essays within examine Shakespearean dramas in light of large-scale transformations—for example, from the sciences of antiquity to the modern fact-based science, or from predominantly medieval conceptions of nature to modern conceptions of norms—a teleological drive toward the “new science,” empiricism, or even post-Enlightenment science is not the central concern of the essays to follow. For such a task could easily lead to the privileging of scientism as an authorizing mode, and thus to problems of anachronism and disciplinary superimposition.<sup>16</sup> Rather, the essays cohere around a common if more modest concern with “science” and “art” as more capacious categories than we might otherwise imagine, and that, as such, merit more serious reconsideration with regard to Shakespearean drama.

In many ways these essays participate in a burgeoning arena within early modern literary scholarship in which, as Denise Albanese puts it, “there has been a growing interest among scholars and critics of early

modern literature in problematizing the origins of the current conceptual and institutional gap separating the sciences from the humanities. Although attention to the 'New Science' is at least as old as the influential studies of Marjorie Hope Nicholson, more recent inquiry has moved away from the way in which early modern texts thematized or contextualized astronomy or other physical sciences, and towards broader-ranging questions of epistemology and representation."<sup>17</sup> Indeed, if "science," as the physician John Securis defined it in 1566, "is an habite (that is) a ready, prompt, and bent disposition to do any thyng, confirmed and gotten by long study, exercise and use,"<sup>18</sup> then the challenge of this volume is to examine how particular "habits," "dispositions," and forms of practice or "doing" operated within but also across networks of scientific practitioners, intellectuals, theologians, and artist-artisans within Shakespeare's cultural surround. Accordingly, the essays are informed, if often implicitly, by conceptual developments in the past two decades in the history and philosophy of science.

Such developments have transformed the intellectual landscape for those interested in understanding points of consilience as well as contestation between literature and science, particularly in periods before the rise of the modern disciplines and forms of professional practice and specialization. Scholarship by Mario Biagioli, James Bono, Lorraine Daston, Peter Dear, Paula Findlen, Anthony Grafton, Bruno Latour, Simon Schaffer, Stephen Shapin, Pamela Smith, and others has opened up avenues for investigating, among other things, the distinctly narrative, literary, and hypothetical dimensions of experimental science and, conversely, the scientific dimensions of the literary or fictional experiment.<sup>19</sup> So too, early modern historians and literary critics have rightly challenged earlier assumptions that once positioned science as autonomous, proto-rationalist, and privileged with relationship to truth, and accordingly, models of interpretation that found literature merely "reflective" of scientific principles, or vice versa. In the most recent criticism of early modern science and literature, as Howard Marchitello puts it, "literary culture is no longer believed to exist in a merely reflective relation to the disciplines of science; instead, science and literature are set in a creative dialectic with each other that denies priority and scientism and helps to offer a more powerful understanding of the dynamic between these two complexly related cultural practices."<sup>20</sup>

Given these developments, however, it is curious that Shakespearean drama has not yet been fully explored or reimagined in light of these recent decades of scholarship or fully positioned within a broader network of scientific inquiry than twentieth-century scholarship allowed.<sup>21</sup>

With recent titles in early modern literary studies including, for example, *Engines of the Imagination: Renaissance Culture and the Rise of the Machine* (2008); *Science, Rhetoric and Literature in Early Modern England* (2007); *Science, Reading and Renaissance Literature: The Art of Making Knowledge, 1580–1670* (2004); *Humanism, Machinery and Renaissance Literature* (2004), and even *Science on Stage: From “Doctor Faustus” to “Copenhagen”* (2006),<sup>22</sup> this volume asks how Shakespearean drama may be approached both through and beyond such assessments about points of consilience, contestation, and dynamic interanimations between art and science, humanism and technology, and drama and the “laboratory.”

At the same time, *Shakespeare & Science*, the title of this volume, purposely carries a trace of a much earlier monograph, Cumberland Clark’s 1929 *Shakespeare and Science: A study of Shakespeare’s interest in, and literary and dramatic use of, natural phenomena; with an account of the astronomy, astrology, and alchemy of his day, and his attitude toward these sciences*.<sup>23</sup> It carries this trace in order to emphasize that the rubric, “Shakespeare and Science,” is not, in and of itself, new, and to call upon the reader to remember that readers of Shakespeare have long been interested in traditions and innovations in areas ranging from optics, cartography, and anatomy to cosmology and meteorology. Clark himself was indebted to Sir Sidney Lee’s 1917 acknowledgement of Shakespeare’s “debt to Ovid’s cosmic theory,” in which various strains of cosmological speculation were woven “dispersedly into the texture of his sonnets.”<sup>24</sup> That such early scholarship was of remarkably broad cultural as well as academic interest is worth noting. When, for example, in 1935, a public service announcement was issued by the Science Service for American radio and newspapers, it was to signal that “an Englishman, D. S. Hancock, has recently collected and turned over to the Royal Meteorological Society, in London, 642 references to the weather in Shakespeare,” a laborious task that resulted in Hancock’s *Meteorology in Shakespeare: Being an attempt to prove the poet’s success as an observer of meteorological phenomena by Copious Quotations from his Works* (1936).<sup>25</sup> Hancock, who contributed articles on meteorology to the *Quarterly Journal of the Royal Society of Meteorology* in 1935, 1936 and later,<sup>26</sup> was one of many scientific practitioners who composed works on science and Shakespeare from the nineteenth to the early twentieth century. In this early and largely unexplored genre of Shakespeare and science writing, practitioners of entomology, ornithology, horticulture, chemistry, medicine, and other sciences turned to Shakespeare to discover, and elaborate upon, his interest in science.<sup>27</sup> Among the plethora of books produced

was the wonderfully entitled, *Shakespeare as a Physician: Comprising every word which in any way relates to medicine, surgery or obstetrics, found in the complete works of that writer, with criticism and comparison of the same with the medical thought of today* (1884) by the American gynecologist J. Portman Chesney.<sup>28</sup> The burden of “proof” in this early period of interest was often met, as these titles suggest, through “copious quotations,” the tracking down of “every word which in any way relates to medicine, surgery or obstetrics,” and various thematic approaches and testaments to the poetic grandeur through which Shakespeare reflected or “used” material integral to various scientific domains.<sup>29</sup>

Yet we need not discount such scholarship simply because it was composed before the expansion of literary criticism through various strains of cultural materialism, feminism, deconstruction, new historicism, historical epistemology, and post-colonial criticism. For such studies may prove particularly valuable both in light of critical interest in the cultural uses of Shakespeare as well as in light of new formalist scholarship, with its interest in the historical specificity of formal properties of literary and other cultural texts.<sup>30</sup> This is simply to stress that the essays in this volume emerge out of a long if not yet fully articulated tradition through which critics have grappled with questions of science that contributed, in varying ways, to the cultural impact of Shakespeare’s words and worlds. In addition, well after the early twentieth-century, a broad range of essays and monographs surfaced with attention, for example, to Shakespeare and optics and psychoanalysis; hermeticism and magic; mathematics; geography and cartography; anatomy and skepticism, and alchemy and medicine.<sup>31</sup> Many of the essays to follow attempt to distinguish themselves from both early and later twentieth-century studies of “Shakespeare and Science.” While they do so in particular ways, with relation to particular historical materials and bodies of scholarship, the central feature of the essays is a prevailing interest in moving beyond forms of analysis focused largely on thematic traces of, or indeed linguistic reflections of, historically specific arenas of scientific practice. A heightened attention to procedures of thought, moreover—including the hypothetical and inferential as well as the analogical, operative in various humanist, scholastic, and artistic-artisanal traditions—is in part what distinguishes many essays in this volume from treatments of Shakespeare and science of the earlier twentieth century.<sup>32</sup> They aim, collectively, to examine coincident, correlative, or productively conflicting forms of thought and experiment integral to various forms of knowledge practice and production in the early modern period. In doing so, they call for a more nuanced understanding of historical relationships between dramatic and scientific practices, epistemologies, and mentalities.

The essays are arranged by related conceptual frameworks and areas of investigation rather than by dramatic chronology. The opening section, “Norms and Transformations,” for example, considers Shakespeare in light of transformations in the conception of “nature”; be they through the lens of developments in anatomy, cartography, experimental science, or botany. Elizabeth Spiller’s essay, “Shakespeare and the Making of Early Modern Science: Resituating Prospero’s Art,” argues that “art” functioned as the mechanism through which early modern culture shifted from Aristotelian scholasticism to modern fact-based experimental science, and then situates Shakespeare’s *The Tempest* within that larger epistemological shift. It provides an account of two developments that were important for the emergence of early modern science: first, the development of maker’s knowledge traditions, and second, changes in philosophical attitudes toward the meaning of accidents. Both art and accident had been excluded from the primary Aristotelian categories of knowledge, but they are central to *The Tempest* and to early modern culture more generally. Prospero’s “Art” expresses the remarkable power of this model of art as a knowledge practice; yet the play also suggests reasons why the Renaissance conception of art as knowledge was ultimately displaced by a modern science of facts. This essay explores the example of *The Tempest* to argue that we must reassess our understanding of what counted as knowledge in order to understand the role that art, poetry, and drama had on the early modern development of science.

Valerie Traub’s “The Nature of Norms in Early Modern England: Anatomy, Cartography, *King Lear*,” focuses on another pivotal moment of transformation, that between the concept of nature and the concept of norms. As Traub observes, many scholars have argued that *King Lear* draws inspiration from the early modern sciences of anatomy and cartography even as these scholars critique these modes of knowledge, for example, as violent and penetrative or rational and imperial. But taking her cue from the *conflation* of anatomical and cartographic tropes in Shakespeare’s play as well as in scholars’ accounts of it, Traub tracks the material and ideological interaction of anatomical illustrations of the human body and representations of human figures on maps, and then reinterprets the play in light of that confluence. Rather than offering judgment on the efficacy or pretensions of science, the play of anatomy and cartography in *King Lear* participates, Traub argues, in an emerging epistemology of human embodiment: a universalizing “logic of the grid” by which humans would be identified and differentiated, classified and compared. Read in relation to the play’s invocation of nature, *Lear*’s creation of an abstract, representative human reveals a genealogy of the modern concepts of norms and the normal. Whereas scholars have

contended that the logic of normality first emerged in the Enlightenment and gained traction over the nineteenth century, Traub argues that, from the prospect provided by *Lear*, we access a prehistory of the discourse of normality—one that shows the concepts of nature and norms interacting, not through shared prescriptions of bodily conduct, but through their common commitment to universalizing “styles of reasoning.” In addition to shedding light on the play and critics’ treatments of it, this genealogy of normality enables a reassessment of aesthetic appraisals of Shakespeare’s “greatest tragedy” as well as the critical controversy that long attended the play’s performance history. For Traub, *King Lear* bequeaths to us the terms of abstract universal humanity—a discourse of normality infused with and bolstered by appeals to our common nature—by which we still judge the play, and each other.

Following Traub’s own cautionary words about the pitfalls of evaluating early modern literature and culture through the perspective of the modern, Jean Feerick opens her essay by highlighting the limits of modern species taxonomies—be they drawn from the works of Carl Linnaeus or Michel Foucault—as vehicles for approaching sixteenth-century conceptions of ethnic and species difference. “Botanical Shakespeares: The Racial Logic of Plant Life in *Titus Andronicus*,” demonstrates that the early modern epistemic overlap between plant and person can expand critical work on early modern race both in and beyond Shakespearean drama. It centers on an analysis of *Titus Andronicus* as a play that brings plant bodies and human bodies into dizzying dramatic collision. In contrast to critics of the Enlightenment who have argued that the drive to classify plants into phyla and species helped to shape epistemologies of human difference—both gendered and racialized—Feerick works backward, examining how the premodern logic of botany helped to constitute a different racial idiom. During this pre-Linnaean taxonomic moment, when natural history emerged as a discipline defined not only by its fascination with the particulars of nature but also by its reluctance to systematize nature, Renaissance naturalists espoused anthropomorphic classificatory principles, importing attributes of the social realm to define the relationships among plants. *Titus Andronicus*, Feerick argues, adapts many of these classifying principles to work through a set of social contradictions implicated in the production of competing notions of human difference. The argument is not merely that botanical imagery pervades the drama as a charged thematic. Rather, it suggests ways in which dramatic literature mobilizes the “natural” hierarchies thought to inform botanical and horticultural practices like grafting in order to resolve conflicting notions of how humans differ in kind. The

early modern category of race, Feerick emphasizes, has much more to do with bloodlines than criticism has thus far allowed and that attention to early modern theories of plant physiology can help scholars begin to appreciate this difference.

The next section, “Physics, Metaphysics, and the Vexations of Art,” centers on confounding historical questions that troubled scientists, theologians, and dramatic practitioners. William N. West’s “What’s the Matter in Shakespeare?: Physics, Identity, Playing,” opens by observing that during the religious reforms of the sixteenth century, traditionalists and reformers alike debated the physical nature of the Eucharist—which seemed to require two bodies to occupy the same place or a single body to be in multiple places, at one time—within a shared framework of Aristotelian physics.<sup>33</sup> In this tradition, any “thing” was a combination of underlying matter and a form that gave it shape and identity. Transubstantiation was of course the miraculous substitution during the Mass of Christ’s body for the matter of the bread and the wine, while their outward forms remained the same as before. But many reformers challenged transubstantiation on grounds not simply theological but physical—that it was physically nonsensical. In the second half of the century, West argues, this conundrum emerges as a quintessentially theatrical problem, embodied onstage in the recurring tropes of disguise, or of indistinguishable twins, even of the ordinary staging practices like the doubling of parts or the transvestite playing of women by boys. The plays of Shakespeare, his contemporaries, and their predecessors drew on these debates but also contributed to them through visible, and at times palpable, experiments in what West calls a “physics of performance.” The idea that one body might assume multiple identities was of course of particular interest to players, given the daily demands of their occupation. Rather than demonstrating that Shakespeare’s plays show a clear allegiance to any particular physical theory of the world, West instead emphasizes Shakespeare’s readiness to engage with a broad range of theories, depending on which offered the most dramatic force in any situation. The character of Richard III, however, argues West, provides a sustained engagement with Aristotle’s physics, and in particular with the possibilities that open in a world made of unformed matter that can be repeatedly reshaped into multiple identities.

Kristen Poole approaches religion, science, and Shakespeare from a different perspective. Her essay, “Physics Divined: The Science of Calvin, Hooker and *Macbeth*,” argues for a more productive relationship between Calvin and science, and thus “Calvinism” and *Macbeth*, than scholars have previously explored. According to scholarly tradition, John

Calvin was hostile to the science of his day. This notion, as has recently been demonstrated, is based largely on fabricated quotes by nineteenth-century scholars. In fact, Poole argues, Calvin was deeply interested in the astronomical innovations of his day, and the first book of the *Institutes of the Christian Religion* is steeped in astronomical and cosmological language. In crucial ways, the theology of the *Institutes* rests on Calvin's presentation of the physical machinations of the universe. The doctrine of predestination, in Calvin's writing, emerges from the notion of a radically contingent physical world. By contrast, the English theologian Richard Hooker bases his understanding of God on the notion of an utterly predictable and stable physical environment and cosmology. At the turn of the seventeenth century, then, competing English theologies were predicated on competing understandings of the material universe. In Shakespeare's *Macbeth*, Poole argues, we find a play, and a main character, trying to negotiate between these two irreconcilable models of physics and, by extension, two irreconcilable understandings of God. Over the course of the essay, Poole also attends to cultural approaches to Albert Einstein's physics that prove no less problematic than traditional views of Calvin's physics, or more aptly, lack thereof.

My essay, "'The History of the Air': *Hamlet* and the Trouble with Instruments," examines, as well, Shakespearean drama in terms of vexing problems of the natural world. It does so, however, by focusing on the elusive element of air as it confounded techniques of artistic and scientific "capture" in the sixteenth and early seventeenth centuries. It highlights not the efficacy but rather the limits of material instruments and technologies in the face of attempts to control, understand, represent or emulate the properties of air. In doing so, I emphasize how approaches to the history of science that focus on new instruments as central vehicles of conceptual innovation tell only a part of the story, and thus can obscure the productiveness of technologies and instruments that did not work, and overlook forms of innovation occurring at the limit of material advancement. Albrecht Dürer's famous *Melencolia I* and Shakespeare's *Hamlet* are both resituated in terms of the way in which they deploy their respective artisanal technologies to encode the problem of subjecting the element of air to capture, and yet reimagine technological limit as artistic and affective potential. The attention to affect in the works explored is seen, in part, as a byproduct of particular historical moments in which the agency of the air was as devastating and terrifying as the possibility of capturing or emulating it was exhilarating. As an invisible or quasi-visible phenomenon, the air posed fundamental challenges to emergent procedures of empirical observation, yet stimulated creative

alternatives in both the “arts” and “sciences” through which the air could be taken in anew.

The final section, “Laboratory Life,” closes with Henry Turner’s call for Shakespeareans to re-assess the concept of “life” at play in Shakespearean drama through the lens of contemporary interventions in the philosophy of science. Turner’s “Life Science: Rude Mechanicals, Human Mortals, Posthuman Shakespeare,” considers Shakespeare’s *A Midsummer Night’s Dream* in light of recent inquiry into the definition of “life” by philosophers of science, including Giorgio Agamben, Michel Foucault, Norbert Wiener, and Georges Canguilhem. As a sustained reflection upon contemporary methodological approaches to early forms of artificial life, this essay departs from those that precede it. Turner suggests that Shakespeare’s theater should be understood as a machine or technical device for generating artificial forms of life and compares it to twentieth-century experiments in computing and to twenty-first century new media technology. In *A Midsummer Night’s Dream*, Turner finds a metatheatrical treatment of the problem of “character” as a form of artificial life, a posthuman entity that challenges us to re-imagine our own post-Enlightenment categories, including the relationship between literary and scientific modes of understanding.

In the present climate, particularly with new media’s engagement with various forms of digital and nano technology, neuroscience, and bio-art, it may well be said that the arts and sciences are more interanimated than they have been since the Renaissance. The time is thus ripe for a re-assessment of Shakespearean drama in terms of the arts of science and sciences of art in, as well as beyond, the early modern period. For different reasons, scientific practitioners of the nineteenth and early twentieth centuries who composed tomes on Shakespeare and science may have felt the same. This is particularly so if we recall that the nineteenth-century professionalization and authorization of science—alongside the transformative developments within science and technology—occurred at a time when divisions between the humanities and the sciences were still, to a certain degree, porous.<sup>34</sup> But for our own cultural and sociological moment, the topic of “Shakespeare and science” may well grab the mind for wholly different sets of reasons.

The importance of understanding the “disciplinary ecology” within which one works and writes—meaning the network of institutional, socio-economic, ideological, and material forces informing the practice of any given discipline—has recently been stressed by Mario Biagioli.<sup>35</sup> This constellation of essays might be grouped less under a specific “disciplinary ecology” than under something more like “interdisciplinary

ecologies.” “Interdisciplinary ecologies” aptly describes conditions of “literary” study focused on a period in which “science” was not fully separable from “art,” and in which drama was produced on a continuum with the “maker’s knowledge tradition” as well with more lofty arenas of reflection within natural philosophy drawing upon Platonism, Aristotelianism, ancient skepticism, and hermeticism.<sup>36</sup> Although with “the relegitimation of interdisciplinarity, the borders between disciplines and divisions of knowledge have become increasingly porous,” as Susan Stanford Friedman has put it,<sup>37</sup> the focus of our research of course entails a series of dramas produced before porosity became re-invented through interdisciplinary scholarship or developments in new media.

I emphasize this point in closing to simply counterbalance deeply skeptical sociological accounts of the burgeoning field of literature-science studies, in which the turn to science may be understood as disguising, or perhaps feeding into, the increasing ecological nourishment granted to the sciences in the present day. Since the cultural and economic capital of the sciences continues to flourish while the humanities remain in the balance, there is always the risk, as a title such as *Shakespeare & Science* might suggest, of making even that mainstay literary study a bit more “dwarfish” (to quote *Macbeth*) in the process of wrapping itself in another “giant’s robe.” But there are no giants here. Just as Michel Foucault’s famous “author function” has worked within criticism for decades now to unsettle reified conceptions of “Shakespeare” as an author, so too, recent scholarship on literature and science has, in the best of worlds, questioned and resisted something like a “science function.”<sup>38</sup> By this I mean the authorizing potential of “science” at work within an increasingly diverse disciplinary arena under significant pressure to define its scope and basis of authority in new ways.<sup>39</sup> Appeals to “science,” that is, can function to authorize literary study as a field that has become less and less aligned with unity, authority, or disciplinary definition. So too, science as a growing interest among literary scholars may be seen to suggest—through pressures of professionalization and the need to discover new forms of intellectual capital—a turn to something “new” that may not be new at all.

Such concerns have a long and variegated history, as do concerns about how a drive toward science itself might lead to intellectual impoverishment or worse: “*Eudoxus*,” wrote Michel de Montaigne, “wished, and praid to the Gods, that he might once view the Sunne neere at hand, to comprehend his forme, his greatnesse and his beautie; on condition he might immediately be burnt and consumed by it. Thus with the price of his owne life would he attaine a Science, whereof both vse and posses-

sion shall therewith bee taken from him; and for so sudden and fleeting knowledge, loose and forgoe all the knowledges he either now hath, or ever hereafter may have.”<sup>40</sup> This may seem an appropriate cautionary note for all who endeavor to reach into the sciences as a means through which to understand literary, and specifically Shakespearean, texts anew. But we have come a long way since Montaigne, not to mention Eudoxus; one need not be blinded by science even or especially in the process of being illuminated by it, nor need the student of Shakespeare and science leave “all the knowledges” or traditional tools and aims of literary study to be consumed in the pyre. Indeed, the point of this volume is not to disrobe or displace the humanist Shakespeare, the formalist Shakespeare, the materialist Shakespeare, or even the phenomenological Shakespeare—for all of these Shakespeares surface in the essays to follow. It is, rather, to allow ourselves to be inhabited by the multiplicity of habits, of representation, thought processes, and actions, through which Shakespearean drama might be understood, in part, as both an art of science and a science of art. The consilience implied by such a swift and all too easy chiasmus is, importantly, but a starting point. Since drama of course thrives upon vigorous contestations between characters, cultures, lexicons, and epistemes, it is with the uneasy juncture between science and art, in and around the world of Shakespearean drama, that we shall begin.

## NOTES

1. This volume, a product of collaboration, began as the Shakespeare Association of America seminar on “Shakespeare and Science” that I directed in 2005. All those present during that seminar deserve great thanks for their insights, encouragement, and brilliant participation. In addition to the contributors within, I thank participants including Lara Bovilsky, Douglas Brooks, Adam Max Cohen, Mary Thomas Crane, Katherine Eggert, David Hillman, Howard Marchitello, Ian MacInnes, Katherine Maus, Gail Kern Paster, Erin Minear, Melinda Pearson, Duke Pesta, Rebecca Totaro, Robert E. Wood, and Marie Rutkoski. The active auditor-interlocutors in that seminar, particularly Sabiha Ahmad, Mary Floyd-Wilson, Michael Schoenfeldt, and Stephen Mullany, are to be thanked as well.

Among the above scholars alone, we have a rich and varied bibliography for developing approaches to Shakespeare and science, or early modern drama and science more broadly construed. Books or articles that have subsequently appeared include Lara Bovilsky’s “Race, Science, and Aversion,” in *Barbarous Play: Race on the English Renaissance Stage* (Minneapolis: Minnesota University Press, 2008): 135–58. David Hillman’s *Shakespeare’s Entrails: Belief, Skepticism and the Interior of the Human Body* (New York: Palgrave Macmillan, 2007); Adam Max Cohen’s *Shakespeare and Technology: Dramatizing Early Modern Technological Revolutions* (New York: Palgrave Macmillan, 2006); and Katherine Eggert’s “*The Alchemist* and Science,” in *Early Modern English Drama: A Critical Companion*, Eds. Garrett A. Sullivan, Patrick Cheney, and Andrew Hadfield (Oxford: Oxford University Press, 2006): 200–12. Ian MacInnes is working on

a book on literature and veterinary medicine in the early modern period; Lara Bovilsky is developing a book on automata, speaking animals, and early modern literary culture, and Sabiha Ahmad completed “Technologies of Mettle: The Acting Self and the Early Modern English Culture of Metals,” treating Shakespeare and metallurgy (PhD Dissertation, Michigan, Ann Arbor, 2007).

In addition, earlier scholarship by those involved in the seminar includes: on Shakespeare and humoralism, Gail Kern Paster, *Humoring the Body: Emotions and the Shakespearean Stage* (Chicago: University of Chicago Press, 2004) and Mary Floyd-Wilson, *English Ethnicity and Race in Early Modern Drama* (Cambridge: Cambridge University Press, 2003); on Shakespeare and cognitive science, Mary Thomas Crane, *Shakespeare's Brain: Reading with Cognitive Theory* (Princeton: Princeton University Press, 2000); on literature and physiological self-fashioning, Michael Schoenfeldt, *Bodies and Selves in Early Modern England: Physiology and Inwardness in Spenser, Shakespeare, Herbert and Milton* (Cambridge: Cambridge University Press, 1999); on the narrative logic of early modern visual culture, with a treatment of Shakespeare's *Othello*, Howard Marchitello, *Narrative and Meaning in Early Modern England* (Cambridge: Cambridge University Press, 1997); and on mathematics and early modern drama, Carla Mazzio, “The Three-Dimensional Self: Geometry, Melancholy, Drama,” in *Arts of Calculation: Numerical Thought in Early Modern Europe*, eds. David Glimp and Michelle R. Warren (New York: Palgrave Macmillan, 2004): 39–65. For further scholarship by contributors to *Shakespeare & Science*, see the contributor notes at the end of this volume. The volume contributors also deserve enormous thanks for proving to be such invaluable collaborators, for exchanging their essays with each other as well as with me, and for drafting abstracts that I have adapted for this volume. Finally, and last but not least, Amishal Modi, the Editorial Assistant at *South Central Review*, and Nicholas Lawrence, the journal's Managing Editor, have been steadfast and remarkably patient collaborators in the process of copyediting this volume, and deserves our infinite thanks.

2. Our other keyword, “Shakespeare,” has of course been productively defamiliarized through decades of scholarly attention to Michel Foucault's famous “author function”—in which fetishes of literary authorship can function as a means of bypassing a complex network of cultural and historical factors, including persons, textual aporias, and material conditions informing the production of any work of art (Foucault, “What Is an Author?,” in *Language, Counter-memory, Practice*, ed. Donald F. Bouchard, trans. D. F. Bouchard and Sherry Simon [Ithaca, NY: Cornell University Press, 1977]: 113–380). But it is equally important to address what might be called a “science function,” by which I mean how the rise of attention to “science” in early modern literary—and in this case Shakespearean—scholarship might be understood as an authorizing fetish of sorts, particularly given the present capital of the sciences in relationship to the humanities and the problems that literature currently faces with disciplinary (or interdisciplinary) self-definition. In the most skeptical of terms, the recent turn to the history of science within early modern literary study might be sociologized as a product of the asymmetrical relationship between literary and scientific scholarship in the present day (see, for example, the heavy-handed and much challenged *Intellectual Imposters* by Alan Sokal and Jean Bricmont [London: Profile Books, 1998]). The use of “science” as opposed to “natural philosophy” alongside “Shakespeare” in this title might thus be imagined to wittingly or unwittingly bypass the perils of literary scholarship at a time when institutional and socio-economic forces are further enhancing the capital of the sciences when literary scholarship hangs, to a certain degree, in the balance. It is thus important to point out

that the purpose of this volume is not to prioritize scientism, nor to borrow robes richer than even Shakespeareans can afford. There are a few simple reasons why this volume title draws on the term “science.” First, Shakespearean drama was not so remote from the domains of knowledge practice that we would, even now, allude to as early “science.” Indeed, “science” is not so much a lexical straw man but rather a term through which we can begin to put serious pressure on the relationship between Shakespearean drama and modes of knowledge production and apprehension that are central, for example, to physics, botany, or experimental science. These same modes are likewise central to much early modern literary scholarship informed by recent work in science studies and the history of science that have not yet impacted the study of Shakespeare to the same degree. Second, the point of the title is not to (re)reify either Shakespeare or science, nor to imply novelty by an invocation of an apparent distinction cleverly undone. For as we shall soon see, this volume emerges, even as it departs, from a long tradition of scholarship interested in scientific cultures and Shakespearean drama. Third, “science” as opposed to “natural philosophy” expands rather than contracts our domain of inquiry: not least of all given the capaciousness of the word c. 1600, which extended well beyond the study of the natural sciences. Thus it is with the word that we shall begin.

3. For the coining of “scientist” by William Wehwell in 1834, see *The Quarterly Review* 51 (1834), 58–61. This term was proposed in order to unify and legitimate an admittedly diverse body of scientific practitioners otherwise long clumped together under the rubric of “philosopher.” Here we read that “science,” upon examination, “loses all traces of unity. A curious illustration of this result may be observed in the want of any name by which we can designate the students of the knowledge of the material world collectively. We are informed that this difficulty was felt very oppressively by the members of the British Association for the Advancement of Science, at their meetings [. . .] in the last three summers [. . .] *Philosophers* was felt to be too wide and too lofty a term [. . .] *savans* was rather assuming [. . .] some ingenious gentleman proposed that, by analogy with *artist*, they might form *scientist*, and added that there could be no scruple in making free with this termination when we have such words as *sciolist*, *economist*, and *atheist* but this was not generally palatable” (59). On the historical and rhetorical surround as well as the sociological effects of the word “scientist,” see especially Sydney Ross, “Scientist: The Story of a Word,” *Annals of Science* 18.2 (1964): 85–102, and Robert K. Merton, “Le molteplici origini e il carattere epiceno del termine inglese Scientist,” *Scientia: L’Immagine e il Mondo* (Commune de Milano, 1989): 279–293. The historicity of this term aside, we should note that various practitioners of science existed well before the word. As Toby E. Huff has put it in broader terms in *The Rise of Early Modern Science: Islam, China, and the West* (Cambridge: Cambridge University Press, 2003), “Given the fact that all the conventional accounts of the scientific revolution would place it in the sixteenth and seventeenth centuries, we need to take a broader look at the nature and sources of those intellectual commitments (prior to the seventeenth century) that made the production and pursuit of scientific knowledge a matter of honor as well as urgency” (22).

4. Indeed, “science” might now evoke all manner of specialized fields such as molecular biology, quantum chemistry, polymer physics and seismology. In the nineteenth century, “science” might have evoked physics, chemistry, and biology—perhaps Lamarckian evolution at the century’s outset or the isolation of radium at the century’s end. So too, earlier periods stretching back, even, to the mid-seventeenth century, were beginning to witness distinctions between “science” and what we now call “arts” that

would have seemed to Shakespeare and his contemporaries to be comparatively radical.

5. And so “prescience” meant, for Shakespeare and others, foreknowledge; “conscience,” inward knowledge aligned with moral conviction. See Francis Bacon, who wrote in 1604 that “the question is between Science and Conscience” (*Certaine considerations touching the better pacification, and edification of the Church of England dedicated to His most excellent Maiestie* [London, 1604]), D4r.

6. Francis Bacon, *The twoo bookes of Francis Bacon. Of the proficience and advancement of learning, diuine and humane* (London, 1605), 60r, 66r–v. I have here put particular phrases in lower case.

7. Thomas S. Kuhn, *The Structure of Scientific Revolutions* (Chicago: University of Chicago Press, 1962), 161.

8. In his recent book, *Time, Space and Motion in the Age of Shakespeare* (Cambridge: Harvard University Press, 2007), Angus Fletcher warns against all too easy conflations between the literary and the scientific, suggesting that “most literary people who try to talk about Renaissance science and literature tend to superimpose unduly positivistic evidence on debates whose interest, for literature, *in principle*, was metaphysical and spiritual” (8). Fletcher’s cautionary approach is of course important, even as his observation does injustice to the sophistication of much recent scholarship in the field of early modern studies (see, for example, Howard Marchitello’s survey of the field in “Science Studies and English Renaissance Literature,” *Literature Compass*, 3.3 [2006]: 341–65). Interestingly for a book with “Shakespeare” in the title, Fletcher’s text deals primarily with non-Shakespearean texts, including the poems of Donne, Milton, and others that have themselves long been subject to nuanced (as opposed to positivistic) analyses with regard to early cultures and theories of science. Nonetheless, it is important to point out that the essays in this volume aim to examine particular sets of relationships between “art” and “science” without falling back on default oppositions between the two; they largely resist positivism and evince skepticism about various forms of retrospective superimposition, and they attend to particular modes of distinctly dramatic effect and affect, some with sustained attention to questions of metaphysics as well as religion.

9. David Hume, “Of the Rise of the Arts and Sciences” (1742), printed in *Selected Essays By David Hume*, eds. Stephen Copley and Andrew Edgar (Oxford: Oxford University Press, 1998), 58.

10. Caroline A. Jones and Peter Galison, eds., *Picturing Science, Producing Art* (New York: Routledge, 1998), 2.

11. Marjorie Garber, *Patronizing the Arts* (Princeton: Princeton University Press, 2007), 141.

12. *An Acte conyrynng Bakyr, Bruers, Surgeens, and Scryveners* (London, 1530), reprinted in *Memorials of the Craft of Surgery in England*, eds. John Flint South, D’Arcy Power, James Paget (London: Cassell & Co Ltd., 1886), 89. I here signal a more expanded conception of “science” than that of Deborah Harkness in her informative monograph, *The Jewel House: Elizabethan London and the Scientific Revolution* (New Haven: Yale University Press, 2008), where she nonetheless helpfully observes that a “wide range of Elizabethans collectively used the term *science* to describe their interest in properties of the natural world or their efforts to manipulate and control those properties” (xvi). Quentin Skinner’s well-known concept that ideas and practices can exist before the words that describe them is nicely invoked by Harkness in order to position her use of “science” as less than anachronistic (xvii). She also notes that although the word “scientist” was

not yet extant in Elizabethan English, various terms including, of course, “alchemist,” “apothecary,” “surgeon,” “mathematician,” “naturalist,” and even “botanographer” were, as were phrases describing particular practices including, for example, the “clock-maker,” “furnace maker,” and “maker of gun stocks” (xvi–xvii).

13. Edmund Spenser, poem printed in *Englands Parnassus: or the choyest flowers of our moderne poets, with their poetickall comparisons Descriptions of bewties, personages, castles, pallaces, mountaines, groues, seas, springs, riuers, &c. Whereunto are annexed other various discourses, both pleasaunt and profitable* (London, 1600), 133.

14. Pamela H. Smith and Paula Findlen, “Commerce and the Representation of Nature in Art and Science,” Introduction to *Merchants and Marvels: Commerce, Science, and Art in Early Modern Europe*, eds. Pamela H. Smith and Paula Findlen (New York: Routledge, 2002), 1–25, 17. For an earlier and important approach to literature and the “New Science,” see Marjorie Hope Nicholson’s *Breaking the Circle: Studies in the Effect of the “New Science” on Seventeenth Century Poetry* (New York: Columbia University Press, 1960).

15. *Ibid.*, 13. As the historiography of science expands in new directions, it is notable that literary and cultural historians have in fact long explored, in varying ways, the relationship between artistic-artisanal activity and the rise of experimental science in the sixteenth and seventeenth centuries. See, from this large body of scholarship, Giorgio Santillana, “The Role of Art in the Scientific Renaissance,” *Critical Problems in the History of Science*, ed. Marshall Clagett (Madison: University of Wisconsin Press, 1959), 33–65; John W. Shirley and F. David Hoeniger, eds., *Science and the Arts in the Renaissance* (Washington D. C.: Folger Shakespeare Library, 1985); Caroline Jones and Peter Galison, eds., *Picturing Science Producing Art* (New York: Routledge, 1998); Diederick Raven, Wolfgang Krohn, and Robert S. Cohen, eds., *The Social Origins of Modern Science*, Studies in the Philosophy of Science (Dordrecht/Boston: Kluwer Academic Publishers, 2000); and Pamela H. Smith, *The Body of the Artisan: Art and Experience in the Scientific Revolution* (Chicago: University of Chicago Press, 2004).

16. For a trenchant critique of “body criticism” operative in literary and Shakespeare studies in which “inquiries about the body represent criticism’s furtive return to empiricism,” see Dymna Callahan, “Body Problems,” *Shakespeare Studies* XXIX (2001): 68–71, 70.

17. Denise Albanese, Review of *Science, Reading and Renaissance Literature: The Art of Making Knowledge, 1580–1620* and *The Arts of Calculation: Numerical Thought in Early Modern Europe*, *Shakespeare Survey*, 35 (January 2007), 256. Albanese’s own work pivots on particular attention to broader questions of epistemology and representation; see her *New Science New Worlds* (Durham: Duke University Press, 1996), esp. “Admiring Miranda and Enslaving Nature,” 59–91.

18. John Securis, *A detection and querimonie of the daily enormities and abuses committed in physick* (London, 1566), B4v. “Science” here is of course entwined with “exercise” and “use,” and both terms are pivotal for an understanding of the necessary interanimation of theory and practice. As in any definition of science, however, context is key: Securis’s attention to “long study” is informed by his belief that medical practitioners should be learned in Latin, since he found English medical books wanting. He declaimed it folly, for example, “when syr John Lack Latin, a pedler, a weaver, or oftentimes a presumptuous woman, shall take upon them (yea and are permytted) to minister Medicine to all menne, in every place, and all tymes,” and stressed the more common observation that the “sciences” are “not infused in us at our byrth, but are gotten afterward” (B4v).

19. See especially Peter Dear, *Revolutionizing the Sciences: European Knowledge and its Ambitions* (Princeton: Princeton University Press, 2001), where he maps out two phases of Renaissance science, from the fifteenth- and sixteenth-century revival and restoration of ancient scientific knowledge to the seventeenth-century drive away from recovery toward innovation. See also Paula Findlen, *Possessing Nature: Museums, Collecting, and Scientific Culture in Early Modern Italy* (Berkeley: University of California Press, 1996); Dear, *Discipline and Experience: The Mathematical Way in the Scientific Revolution* (Chicago: University of Chicago Press, 1995); James Bono, *The Word of God and the Languages of Man: Interpreting Nature in Early Modern Science and Medicine* (Madison: University of Wisconsin Press, 1995); Steven Shapin, *A Social History of Truth: Science and Civility in Seventeenth-Century England* (Chicago: University of Chicago Press, 1994); Mario Biagioli, *Galileo, Courtier: The Practice of Science in the Culture of Absolutism* (Chicago: University of Chicago Press, 1994); Anthony Grafton, *New Worlds, Ancient Texts: The Power of Tradition and the Shock of Discovery* (Cambridge: Belknap Press of Harvard University, 1992); Steven Shapin and Simon Shaffer, *Leviathan and the Air Pump: Hobbes, Boyle and the Experimental Life* (Princeton: Princeton University Press, 1989); and Bruno Latour, *Science in Action* (Cambridge: Harvard University Press, 1987). See also the more recent *Cambridge History of Science*, Vol. 3, *Early Modern Science*, eds. Katharine Park and Lorraine Daston (Cambridge: Cambridge University Press, 2007), and Lorraine Daston and Peter Galison, *Objectivity* (New York: Zone Books, 2008). For a comparative sample of much earlier work in this arena, see Marie Boas, *The Scientific Renaissance: 1450–1630* (New York: Dover, 1962).

20. Howard Marchitello, “Science Studies and English Renaissance Literature,” *Literature Compass* 3.3 (2006): 341–65. Or as George Levine puts it in *Realism, Ethics and Secularism: Essays on Victorian Literature and Science* (Cambridge: Cambridge University Press, 2008): “What characterized most study of science and literature until recently was its preoccupation with the way scientific ideas shaped literary ones. The traffic was all one way, the whole subject tended to be set within a traditional history of ideas [. . .] That is to say, scientific texts were not ‘texts,’ as that word has come to be used in recent critical discourse, but sources. The model was background-and-foreground, and for students of literature, important works of science were ‘background.’ For students of science, important works of literature were, at best, what they are now—diversion. That model implicitly separated the worlds of art and the worlds of knowledge, and at the same time it implicitly affirmed the intellectual authority of science over literature” (167–68).

21. Notable monographic exceptions include the recent *Shakespeare and Technology* (New York: Palgrave Macmillan, 2006) by Adam Max Cohen, which focuses on drama and the “technology boom” in Elizabethan and Jacobean England; *Green Shakespeare: From Eco-politics to Eco-criticism* (New York: Routledge, 2006); Gabriel Egan’s treatment of “biological nature” and “supernature” in Shakespeare in terms of eco-criticism and contemporary concerns about the environment; and *Shakespeare’s Double Helix* (New York: Continuum, 2008), an experimental book by Henry Turner that aims to approach Shakespeare’s *Midsummer Night’s Dream* from the lens of twentieth- and twenty-first century science. See also B. J. Sokal, *A Brave New World of Knowledge: Shakespeare’s The Tempest and Early Modern Epistemology* (Madison, N.J.: Farleigh Dickenson Press, 2002); Paula Blank, *Shakespeare and the Mismeasure of Renaissance Man* (Ithaca: Cornell University Press, 2006), which examines problems of quantitative measurement as

an arbiter of both human value and poetic verse; Arthur F. Kinney, *Shakespeare's Webs: Networks of Meaning in Renaissance Drama* (London: Routledge, 2004), which examines material objects including mirrors, maps, and clocks in Shakespeare in terms of cognitive science; Kinney's *Shakespeare and Cognition: Aristotle's Legacy and Shakespearean Drama* (New York: Routledge, 2006), on Shakespeare and Aristotelian metaphysics; and Todd Howard James Pettigrew, *Shakespeare and the Practice of Physic: Medical Narratives on the Early Modern English Stage* (Delaware: University of Delaware Press, 2007).

22. Jonathan Sawday, *Engines of the Imagination: Renaissance Culture and the Rise of the Machine* (London: Routledge, 2008); Juliet Cummins and David Burchell, eds., *Science, Literature, and Rhetoric in Early Modern England* (Aldershot, Hampshire: Ashgate, 2007), especially Anne Sutherland's contribution to this volume, "Mapping Regeneration in *The Winter's Tale*," 33–52; Elizabeth Spiller, *Science, Reading and Renaissance Literature: The Art of Making Knowledge, 1580–1670* (Cambridge: Cambridge University Press, 2004, paperback, 2007); Jessica L. Wolf, *Humanism, Machinery and Renaissance Literature* (Cambridge: Cambridge University Press, 2004); and Kirsten Shepherd-Barr, *Science on Stage: From "Doctor Faustus" to "Copenhagen"* (Princeton: Princeton University Press, 2006).

23. Cumberland Clark, *Shakespeare and Science: A study of Shakespeare's interest in, and literary and dramatic use of, natural phenomena; with an account of the astronomy, astrology, and alchemy of his day, and his attitude toward these sciences* (Birmingham: Cornish Brothers Ltd., 1929).

24. Sir Sidney Lee, *A Life of William Shakespeare* (London: Macmillan, 1917), 180.

25. C. Fitzhugh Talman, "The Weather in Shakespeare," American Meteorological Society, public service announcement for the Science Service, composed for release on radio and newspapers (March 12, 1935). Located in the archives of the American Meteorology Society public service announcements at the National Oceanic and Atmospheric Administration's National Oceanographic Data Center Library: <http://docs.lib.noaa.gov/rescue/whytheweather/whytheweather.html>. See also an announcement of D. S. Hancock's findings in *Quarterly Journal of the Royal Meteorological Society*, 61.258 (1935): 43; and Hancock's *Meteorology in Shakespeare: Being an attempt to prove the poet's success as an observer of meteorological phenomena by Copious Quotations from his Works* (Bognor Regis: 1936) in the archives of the British Library.

26. For D. S. Hancock's contemporaneous scientific writing, see his "General sunshine values England and Wales, Scotland, Ireland and the British isles for the period 1909–1933," *Quarterly Journal of the Royal Meteorological Society*, 61.258 (1935): 45–52; and, with John Glasspoole, "The distribution over the British Isles of the average duration of bright sunshine: Monthly and annual maps and statistics," *Quarterly Journal of the Royal Meteorological Society*, 62.264 (1936): 247–59.

27. From this early genre of Shakespeare and science writing by scientific practitioners, see the Irish naturalist Robert Patterson's *The Natural History of the Insects Mentioned in Shakespeare's Plays, With Upwards of Eighty Illustrations* (London, 1841); the English physician John Charles Bucknill's *Remarks on the Medical Knowledge of Shakespeare* (London, 1860); the American physician Charles W. Stearnes's *Shakespeare's Medical Knowledge* (New York: Appleton and Co., 1865); the English naturalist James Edmund Harding's *The Ornithology of Shakespeare* (London, 1871); the vicker and horticulturist Henry Nicholson Ellacombe's *The Plant-Lore and Garden-*

*Craft of Shakespeare* (London, 1884); the Glasgow physician John Moyes's *Medicine and Kindred Arts in the Plays of Shakespeare* (Glasgow: James MacLehose and Sons, 1896), originally submitted as his M.D. Thesis for Glasgow University in 1886; the German chemist Edmund O. von Lippman's *Abhandlungen und Vorträge zur Geschichte der Naturwissenschaften* (Leipzig: Viet, 1906); the American mineralogist, founder of the New York Mineralogical Club, and member of various scientific societies, George Frederick Kunz's *Shakespeare and Precious Stones: Treating of the Known References of Precious Stones in Shakespeare's Works, with Comments as to the Origin of his Material, the Knowledge of the Poet Concerning Precious Stones, and References as to Where the Precious Stones of his Time came from* (Philadelphia: J. B. Lippincott Company, 1916); and the physician Herman Pomeranz's *Medicine in the Shakespearean Plays, and Dickens's Doctors* (New York: Powell Publications, 1936). See also the fascinating early nineteenth-century study by the English life insurance expert, George Farren (Director of the Asylum Foreign and Domestic Life Insurance Company), *Observations on the Laws of Mortality and Disease, and on the Principles of Life Insurance. With an Appendix Containing Illustrations of the Progress of MANIA, MELANCHOLIA, CRAZINESS, AND DEMONOMANIA, As Displayed in Shakespeare's Characters of LEAR, HAMLET, OPHELIA, and EDGAR* (London, 1829); Bessie Mayou's compilation of passages from Shakespeare under the title, *Natural History of Shakespeare: Being Selections of Flowers, Fruits, and Animals* (London, 1877); the unattributed essay, "The Meteorology of Shakespeare," contributed to *The Kansas City Review of Science and Industry*, 6.1 (1882): 580–82; the unattributed review essay, "Plant Names," in *The Quarterly Review*, 183 (1886): 230–54, which engages with heated debates about botanical knowledge in Shakespeare, Milton, and others; Felix E. Schelling's later *Shakespeare and "Demis-Science"*: *Papers on Elizabethan Topics* (Philadelphia: University of Pennsylvania Press, 1927), esp. 1–19; and the bibliography in Moyes (1896) for further works produced on medicine and Shakespeare pre-1886. For a recent and excellent study of medicine in Shakespeare that integrates a range of scholarship on the medical body, see Todd Howard James Pettigrew, *Shakespeare and the Practice of Physic*. Although pervasive *allusions* to Shakespeare and within nineteenth-century science writing have been well studied (on Victorian naturalists and English literature, for example, see especially Gowan Dawson, *Darwin, Literature and Victorian Respectability* ([Cambridge: Cambridge University Press, 2007]), I do not believe that this early genre of books and articles on Shakespeare and science by scientific practitioners has yet been studied in depth.

28. J. Portman Chesney, *Shakespeare as a Physician* (Chicago: J. H. Chambers and Co, 1884). Lest we feel that our particular historical vantage point gives us an analytic legup in assessing such early works, it is worth observing that even a contemporary of Chesney's found his book to be methodologically "peculiar" and "a trifle crude," endorsing only Chesney's laborious efforts as opposed to his results (Egbert H. Grandin, Review of Chesney's *Shakespeare as Physician* in *The American Journal of Obstetrics and Diseases of Women and Children* 17 [1884]:767–68).

29. Among late nineteenth- and twentieth-century approaches to Shakespeare and alchemy, astronomy, or medicine, see, for example, Thomas Lowe, *Shakespeare Under the Stars* (London: Marshall Brothers, 1887); E. B. Knobel, "Astrology and Astronomy," in *Shakespeare's England: An Account of the Life and Manners of his Age*, Vol. 1 (Oxford: Clarendon Press, 1916); C. G. Abbot, "Astronomy in Shakespeare's time and in ours," *Smithsonian Institution*, 3405 (1937): 109–22; Caroline Spurgeon, *Shakespeare's Imagery* (Cambridge: Cambridge University Press, 1953); Irving I. Edgar, *Shakespeare*,

*Medicine, and Psychiatry* (London: Vision Press, 1970); S. K. Heninger, Jr., *Touches of Sweet Harmony: Pythagorean Cosmology and Renaissance Poetics* (San Marino, CA: The Huntington Library, 1974) and *The Cosmographical Glass: Renaissance Diagrams of the Universe* (San Marino, CA: The Huntington Library, 1977); Charles Nicholl, *The Chemical Theatre* (London: Routledge & Kegan Paul, 1980); Luminita Niculescu, *Shakespeare and Alchemy: Let Us Not Admit Impediments* (Berlin: De Gruyter Press, 1984); and T. McAlindon, *Shakespeare's Tragic Cosmos* (Cambridge: Cambridge University Press, 1991). On magic and hermeticism, see also K. M. Briggs, *Pale Hecate's Team: An Examination of the Beliefs on Witchcraft and Magic Among Shakespeare and his Contemporaries* (London: Routledge, 1962); Frances Yates, *Shakespeare's Last Plays* (London: Routledge, 1975); John S. Mebane, *Renaissance Magic & the Return of the Golden Age: The Occult Tradition and Marlow, Jonson, and Shakespeare* (Lincoln: University of Nebraska Press, 1989); and more recently, Katharine Eisaman Maus, "Sorcery and Subjectivity in Early Modern Discourses of Witchcraft," in *Historicism, Psychoanalysis and Early Modern Culture*, eds. Carla Mazzio and Douglas Trevor (New York: Routledge, 2000), 325–48.

30. On the New Formalism, see especially Stephen Cohen, ed., *Shakespeare and Historical Formalism* (Aldershot, Hampshire: Ashgate, 2007); Douglas Bruster, "Shakespeare and the Composite Text: The New Formalism," in *Shakespeare and the Question of Culture* (New York: Palgrave Macmillan, 2003), 167–80; Mark David Rasmussen, ed., *Renaissance Literature and Its Formal Engagements* (New York: Palgrave Macmillan, 2002); and Heather Dubrow, *A Happier Eden: The Politics of Marriage in the Stuart Epithalamium* (Ithaca: Cornell University Press, 1990).

31. On Shakespearean drama and, for example, Renaissance optics, comedy, and psychoanalysis, see Barbara Freedman, *Staging the Gaze: Postmodernism, Psychoanalysis, and Shakespearean Comedy* (Ithaca: Cornell University Press, 1991); medical theories and practitioners, see F. David Hoeniger, *Medicine and Shakespeare in the English Renaissance* (Newark: University of Delaware Press, 1992), and Todd Howard James Pettigrew, *Shakespeare and the Practice of Physic*; mathematics and zero, see Brian Rotman, *Signifying Nothing: The Semiotics of Zero* (Stanford: Stanford University Press, 1993); geography, see John Gillies, *Shakespeare and the Geography of Difference* (Cambridge: Cambridge University Press, 1994), Robert J. Mayhew, "Was William Shakespeare an Eighteenth-Century Geographer?: Constructing Histories of Geographical Knowledge," *Transactions of the Institute of British Geographers*, 23.1 (1998): 21–37; and Jean Howard, "Shakespeare, Geography, and the Work of Genre on the Early Modern Stage," in *Shakespeare and Historical Formalism*, ed. Stephen Cohen (Aldershot, Hampshire: Ashgate, 2007), 49–67; ocular anatomy and physiologies of looking, see Sergie Lobanov-Rostovsky, "Taming the Basilisk," in *The Body in Parts: Fantasies of Corporeality in Early Modern Europe*, eds. David Hillman and Carla Mazzio (New York: Routledge, 1997), 193–317; narrative dimensions of visual culture, see Howard Marchitello, "Shakespeare's *Othello* and Vesalius's *Fabrica*: Anatomy, Gender and the Narrative Production of Meaning," in *Narrative and Meaning in Early Modern England*, 10–38; "mechanical philosophy" and the "New Philosophy" in relation to theology in *Hamlet*, see John Guillory, "To Please the Wiser Sort": Violence and Philosophy in *Hamlet*," in *Historicism, Psychoanalysis and Early Modern Culture*, eds. Carla Mazzio and Douglas Trevor (New York: Routledge, 2000): 82–109; Shakespeare, Lucretian materialism, and historicism, see Jonathan Gil Harris, "Atomic Shakespeare," *Shakespeare Studies* 30 (2002): 46–51; and anatomy and skepticism, see David Hillman, *Shakespeare's Entrails*.

Alongside such studies, we might also consider the resurgence of attention to the history of the senses and the materiality of language in the Renaissance as a topic of potential scientific interest. As Margreta de Grazia observes, “a word is a thing in the sixteenth but a nonthing in the seventeenth century. In the domain of rhetoric, whose purpose was persuasion and not representation, a word was permitted to retain its materiality, for it was the source of this power. There is no better evidence of this than Puttenham’s discussion of the sensory quality of words and figures in his *The Arte of English Poesie* (1589). Words, he insists repeatedly, need to possess physicality in order to impress the mind: ‘the minde being no less vanquished with large loade of speech, than the limmes are with heauie burden.’ The understanding is reached via the ‘sensible approaches’ of the ear and eye. A term was borrowed from the Greek in order to single out this physical power: *energia*, defined as ‘forcibleness’ by Sidney and as ‘a strong and virtuous operation’ by Puttenham. It is through rhetoric then that energy enters the language before becoming, along with matter, the subject of physical science or physics. Possessing both matter and energy, words might themselves have been the object of scientific inquiry” (“Words as Things,” *Shakespeare Studies* XXVII [2000]: 231–235, 234; see also Gary Tomlinson, “The Matter of Sounds” and Rayna Kalas, “The Language of Framing” in the same volume: 236–39, 240–47). On rhetoric and science, see especially Juliet Cummins and David Burchell, “Ways of Knowing: Conversations Between Science, Literature and Rhetoric,” *Science, Literature and Rhetoric in Early Modern England*, 1–14; and on acoustics and materialism with some attention to the science of sound, see Gina Bloom, *Voice in Motion: Staging Gender, Shaping Sound in Early Modern England* (Philadelphia: University of Pennsylvania Press, 2007), and Bruce Smith, *The Acoustic World of Early Modern England: Attending to the O-Factor* (Chicago: University of Chicago Press, 1999). For further recent works treating Shakespeare and aspects of science, see especially notes 1 and 21 above.

32. For more on the hypothetical in literary studies, see Carla Mazzio, “Anatomy of a Ghost: History as Hypothesis,” *Literature Compass* 3.3 (2006), 2–17. See also, on procedures of thought operative in early science and the law, Rose-Mary Sargent, “Scientific Experiment and Legal Expertise: The Way of Experience in Seventeenth-Century England,” *Studies in the History and Philosophy of Science*, 20.1 (1989): 19–45.

33. On Shakespeare and Aristotle’s metaphysics, see Arthur Kinney, *Shakespeare and Cognition: Aristotle’s Legacy and Shakespearean Drama*.

34. As Robert Patterson wrote in 1841, “for all the sciences are so connected, that, although we distinguish them by several names, we cannot understand one, without paying homage to many others on the same vigorous and graceful stem (*The Natural History of the Insects Mentioned in Shakespeare’s Plays*, 255). On the growing divide, in the 1950s, between the humanities and the sciences, see C. P. Snow’s famous *The Two Cultures and the Scientific Revolution* (Cambridge: Cambridge University Press, 1960), and for a recent attempt to bridge these cultures, see the biologist Edward O. Wilson’s *Consilience: The Unity of Knowledge* (New York: Knopf, 1998). Importantly, for the limits of a simple “One Culture” model of arts and sciences (and particularly literature and science) on a formal and conceptual continuum in the early nineteenth century, see Helen Small, *Medicine, the Novel, and Female Insanity 1800–1865* (Oxford: Clarendon Press, 1996).

35. Mario Biagioli, “Rights or rewards?: Changing Frameworks of Scientific Authorship,” in *Scientific authorship: Credit and Intellectual Property in Science*, eds. Mario Biagioli and Peter Galison (New York: Routledge, 2003): 255–279, 274.

36. On the “maker’s knowledge tradition,” see Antonio Perez-Ramos, *Francis Bacon’s Idea of Science and the Maker’s Knowledge Tradition* (Oxford: Oxford University Press, 1998). On ancient skepticism and the rise of new scientific methods, see especially Richard Popkin, *History of Skepticism from Erasmus to Spinoza* (Berkeley: University of California Press, 1979).

37. Susan Stanford Friedman, “Definitional Excursions: The Meanings of Modern/Modernity/Modernism,” *Modernism/Modernity* 8.3 (2001): 501. On the current economic divide between the arts and sciences, see especially Marjorie Garber, *Patronizing the Arts*.

38. It is worth noting that over the past few years, Shakespeare scholarship has witnessed a potential rebirth of that “author” once pronounced dead by Foucault and those who followed in his wake. On the return of the “author” in recent studies of Shakespeare, see the Special Forum, “The Return of the Author,” in *Shakespeare Studies*, 36 (2008), edited by Susan Zimmerman and Garret Sullivan, and organized and introduced by Patrick Cheney.

39. In “What is an Author?,” Foucault argued for a grand historical chiasmus: as literary authorship emerged out of earlier traditions of relative anonymity, scientific authorship (with its earlier reliance upon authorities such as Aristotle, Galen, Pliny and others) waned and became replaced by relative anonymity as a guarantor of credibility. To invert this chiasmic logic and adapt it for the present moment, it may well be said that as “authors” have become, at least in part, de-functionalized within literary scholarship, “science” has emerged as a potential authorizing function or fetish in which some problems of defining literature as a discipline might be bypassed, and an illusion of credibility, stability, and functionality restored to forms of practice within a discipline in which literature has often become secondary to another authorizing discourse (such as history/historicism, or a variant of that, science/scientism). So too, in contrast to the nineteenth-century attention to Shakespeare by scientific practitioners that I discussed above, in which Shakespeare may well have granted respectability and cultural capital to a series of sciences, scientists or scientific communities only gradually establishing creditability (on such techniques of cultivating “respect,” see esp. Dawson and Small books cited above), now the inverse may be seen to be the case, with literary scholars turning to the sciences as one mode of establishing capital.

40. Michel de Montaigne, *Essays written in French by Michael Lord of Montaigne, Knight of the Order of S. Michael, gentleman of the French Kings chamber . . .* Trans. John Florio (London: 1613), 285. On the perils as well as the possibilities of science in the early modern period, see Jonathan Sawday, “The Renaissance Machine and its Discontents,” *Engines of the Imagination*, 1–30.