Introduction: making early modern science and literature

What is fact and what is fiction? This question may be philosophically vexed. Yet, we all feel confident in a day to day kind of way that we know what fact and fiction are, if not always which is which. While the categories of fact and fiction structure how we apprehend the world on a very basic level, much of what we think we know about fact and fiction may be little more than a fiction. First, these categories are historically and culturally specific, ones that are invented as we understand them sometime during the seventeenth century. Second, we have become used to thinking that what separates a lie from the truth, literature from science, is a question of content. The right dates and data can transform romance into history or alter a valid report into a scientific fraud. Literature is fiction and science is fact. Yet, as we shall see throughout this study, early modern writers recognize how knowledge involves form as well as content. The early modern period is an age of discovery: these discoveries include not simply new knowledge but new definitions of knowledge. For early modern writers, the existence of science depends on the possibility of fiction; literature acquires meaning and validity against the framework of fact. Early modern imaginative literature and experimental science are inventions of a startling new attention to knowledge: they represent new ways of thinking, new understandings of how man could create knowledge, and new ways of writing that try to recreate those ideas for readers.

Critics of the early modern period have recognized how closely allied the "inventions" of literature are with those of science.[1] Recent studies consider how literature and science, both as systems of thought and writing forms, intersect in the early modern period. These studies concentrate primarily on tracing a single idea or discipline of thought through a variety of texts. Jonathan Sawday, for instance, gives us a history of how the introduction of anatomical dissection opens up a "new image of the human interior" that informs both Donne's "Anatomies" and the *Blasons Anatomiques* of Clément Marot.[2] Dealing with the rise of vitalism in England in the period 1649–66, John Rogers demonstrates how the materialistic theories that William Harvey develops for the circulation

of the blood anticipate Milton's otherwise inexplicable assertions of a radical Christian materialism in *Paradise Lost*.[3] Gail Paster's account of early modern drama similarly requires that we expand traditional understandings of Jacobean comedy of humors to see how the assumptions of Galenic biology underwrite its staging of class and gender.[4] In focusing on single ideas or disciplines these studies have enriched our understanding of the epistemological texture of early modern thought and representation.

What is needed, though, is a more complete sense not of what ideas people had but of the intellectual grounds that allowed them to have those ideas in the first place. Shifting from local epistemological discussions to the ontological premises that structure these more particular arguments, *Science, Reading, and Renaissance Literature* redresses this critical problem by reading works of early modern science and natural philosophy by William Gilbert, Galileo Galilei, William Harvey, Johannes Kepler, Thomas Hobbes, and Robert Hooke alongside central texts of imaginative fiction from Philip Sidney, Edmund Spenser, and Margaret Cavendish. My examples come from the major categories of early modern science: that is, the disciplines of experimental and meditative natural philosophy, anatomy and embryology, astronomy, optics, and microscopy. At the same time, this study also takes in the genres that define the emergence of early modern imaginative fiction: narrative poetry, prose romance and utopia, as well as the poetic theory of these genres.[5]

What these texts demonstrate is that early modern science is practiced as an art and, at the same time, that imaginative literature provides a form for producing knowledge. Within this framework, literary texts become more than just topical commentaries on new scientific discoveries or intellectually (but not truly scientifically) interesting examples of the cultural work that literature might produce in the face of changing scientific knowledge. It is not just that fiction serves as a (more or less accurate) record of, as John Donne puts it, how the "new philosophy calls all in doubt."[6] Rather, literary texts gain substance and intelligibility by being considered as instances of early modern knowledge production. Early modern fiction needs to be looked at as more than just a kind of repository for new facts or errors. By the same token, scientific texts are not just realized through various literary devices or narrative and rhetorical forms. Scholars in science studies have concentrated on the rhetorical strategies and metaphoric devices of early modern scientific texts, but I will suggest that works in early modern science and philosophy do not align themselves with early modern poetry because of the ways in which they are written. Rather, science maintains strong affiliations with poetic fictions because, in ways that are rarely acknowledged, its practice emerges out of a central understanding of art as a basis for producing knowledge. A belief in the made rather than the found character of early modern knowledge unites poets and natural scientists.

Focusing on the period between 1580 and 1670, *Science, Reading, and Renaissance Literature* documents how what have become our two cultures of belief define themselves through a shared aesthetics of knowledge.[7] The works of natural philosophy and experimental science that comprise this study are: William Gilbert's *On the Magnet* (1600), a study of magnet "virtue" that stimulates English experimentalism; Galileo's *Starry Messenger* (1610), a work that opens up the scientific cosmos not just with the telescope but through a new way of recording the observational astronomy that goes with it; William Harvey's *Disputations Touching the Generation of Animals* (1651); a now largely neglected work on embryology and reproductive theory that was intended as a culmination to his more successful work on the circulation of the blood; Thomas Hobbes's *Leviathan* (1651); and Robert Hooke's wildly popular *Micrographia* (1665). While these texts have their own scientific and philosophical contexts, they are also part of a culture that included Philip Sidney's *The Defence of Poesy* (1595); Edmund Spenser's *Faerie Queene* (1590, 1596); and Margaret Cavendish's *The Description of a New World, Called the Blazing World* (1666). Instances of remarkable developments in early modern science and literature, these texts share a commitment to creating and expressing knowledge through the practice of art.

My reassessment of these texts focuses on the knowledge practices that define early modern science and imaginative fiction. Rather than thinking about the "constructedness of knowledge" simply as a social fact, I instead see Renaissance literature and science beginning in aesthetic acts – forms of "making" that are congruent with Sidney's definition of the poet as a "maker." This emphasis on making not only identifies a common ground between literature and science as early modern knowledge practices, it also makes clear how important readers are since, within this framework, knowledge cannot be simply given to readers but must in some way be produced by them. The end of poetic making that is fiction is the making of the reader. Sidney argues that fictions are for the reader a kind of Cyrus "to make many Cyruses" if he will "learn aright why and how that maker made him"; Spenser likewise hopes that for the reader his fiction will "fashion a gentlemen or noble person in vertuous and gentle discipline." Hobbes insists that reading philosophy is about learning to "read thy self," while Cavendish triumphs that she has made "a world" of her own and confides "it is in everyone's power to do the like."[8]

These arguments are not limited to fictional creations: similar claims are at the heart of the works of Gilbert, Kepler, Galileo, and Hooke. Even as early modern science increasingly moves towards an emphasis on scientific practices such as experimentation, scientific texts continue to need to create experience precisely as a way of creating knowledge for readers. Scientists who call for observation and experiment work to find ways to produce knowledge for readers. What we may see, though, as a gap between scientific practice and scientific writing is

one that early modern scientists instead understand as an extension of the acts of making, representation, and imitation that comprise their scientific practice. William Gilbert crafts globe-shaped magnets to create a "world" of virtue in his magnets and, as a model, for virtue he sees in England and his readers; William Harvey uses a generative theory of art to explain how ideas can be made for readers; Galileo and Hooke structure their texts to make reading into a form of perception that mimics the optic enhancements of the telescope and microscope. Readers bring together a dual emphasis on practice and form to the extent that reading is almost never simply understood as the acquisition of facts (dates, data) but rather as an act of doing or becoming that is achieved through the experience in some way provided by the text (modeling, repeating, verifying). That is, reading becomes an extension of the intellectual practices and creative acts that underlie texts. These acts of making knowledge in and through readers are part of a larger cultural history of authorship and reading in the early modern period. Such histories begin with the "making" that connects the intellectual acts of scientific practice and imaginative fiction to the forms in which they are written, published, and read.

Bringing together this range of materials and intellectual traditions does not involve a return to totalizing history or naive aestheticizing. Rather, reading these texts alongside one another contributes to our understandings of how science and fiction constitute themselves as disciplines. At the beginning of this period, the knowledge of literature and science is understood to be "made" in a way that distinguishes it from the truth ascribed to theology.[9] In this context, early modern literature and science share a language of making that grounds their claims to knowledge. "Invention," for instance, understands discovery and contrivance as integrally related: finding out results from acts of making that comprehend poetry and rhetoric as much as science and philosophy. Invention can be achieved in a poetic conceit: Philip Sidney's Astrophil thus looks to "inventions fine" to express his love for Stella.[10] At the same time, invention also encompasses the more familiar mechanical constructs: Francis Bacon famously identifies the transforming "inventions" of the age as gunpowder, printing press, and compass, while Thomas Hobbes brings together Sidney and Bacon when he insists that the invention of printing is "no great matter," but "the most noble and profitable invention of all other" is that of speech.[11] Poems, compasses, and printing presses, though obviously different in important respects, are alike in being intellectual devices that serve to create knowledge through acts of contrivance. Indeed, Astrophil marks himself as a "bad poet" and different from his authorial alter ego Sidney to the extent that he fails to comprehend this lesson. "Loving in truth and fain in verse," Astrophil experiences a gap between what is and what is made.[12]

Yet, as readers we are more like Astrophil than we are like Sidney. From our positions within the academic disciplines of contemporary intellectual culture,

we detach feigning from truth. Making is, for us, as an act of dissimulation or, at the very least, fundamentally distinct from the truth rather than a central means to achieving it. As we shall see, the ongoing relevance of this distinction is prominent in the "Sokal hoax" and other "science wars" controversies over science, truth, and social construction. Critics who assume that "science enjoys a special relationship to reality" found their arguments, as Richard Rorty makes clear, on distinctions between finding (science) and making (non-science). In adjudicating this debate between rationalists and constructionists, Rorty points out that much of the conflict is based on a confusion of the practice of science with an assessment of its results. For Rorty, the virtues of scientific practice – "willingness to hear the other side, to think through issues, to examine the evidence – have nothing to do with the fact that the objects natural scientists investigate are found rather than made. The same virtues, after all, are found among judges and classical philologists, who investigate objects that are made rather than found."[13] Throughout this study, we shall see how the confusion that Rorty identifies is crucially a historically specific one: early modern natural philosophy and science is understood by its own practitioners, if not always by subsequent readers, as a form of making.

Renaissance attitudes towards art as a component in the creation of knowledge contribute to what Timothy J. Reiss characterizes as a shift from "'being' to 'doing.'"[14] This shift changes how texts work – and, equally importantly, how they work on readers. Once science is understood as a practice for creating knowledge, the textual qualities to scientific texts cannot simply be understood as secondary to the scientific work that is at stake. Everything that comprises the physical existence of the text – its literary and rhetorical strategies; its illustrative and textual practices; the authors and the readers who create knowledge by making sense in and through texts – are expressions of the same practices for creating knowledge that define science itself. The intersection of science and literature is important not because scientific writing is like literary writing insofar as both are writing: it is not that science must necessarily (if, as some supporters of the Royal Society tended to suggest, unfortunately) be mediated through the books, letters, illustrations, and other textual forms in which it ends up being expressed. Scientific arguments do not become "literary" just because they are texts.[15] At the same time, my argument is not narrowly constructionist. Peter Dear's call for more sustained attention to the literary qualities of early modern scientific texts rests on these two premises: the literary structures of scientific texts require our attention because "language is not simply a transparent medium of communication, but a shaper (perhaps a realizer) of thought and an embodiment of social relations."[16] Whereas the first position understands the text as an imposition on an underlying truth, the second assumes that science can only be achieved through some kind of text and risks replacing material form and institutional context for intellectual content. In both cases, though, the

various components that make up the scientific text – science and text, content and form, intellection and representation – are described as if they work in opposition to one another.

The interval that separates us from early modern understandings of how knowledge is made can be charted in the shifting history of terms such as "fact," "experience" and "experiment," as well as "natural philosophy" and "science." For us, facts typically point towards questions about what is, but for early modern readers they instead mark that which is made. Early modern facts differ, as Lorraine Daston suggests, from Aristotelian universals in that facts are "historical particulars about an observation performed at a specific time and place by named persons."[17] As the products of a particular situation and dependent on specific acts of observation, "matters of fact" are in some important sense manufactured: universals are for Aristotle always true, but facts are created as such only within or through a particular moment. Emphasis on facts coincides with what, for Peter Dear, is the movement from a dominant Aristotelian theory of "experience" (what happens, generally) to a post-Baconian interest in "experiment" (what happened, then).[18] What is perhaps most surprising about this shift, though, is how qualities that had been associated with theology are then transposed onto works of science and literature. In a mixing of categories that would have been incomprehensible in the medieval period, the degree of truth attributed to a particular work ends up being based precisely on determinations about how such works are "made." Yet, recognition that facts are "made" is occluded as soon as those facts become associated with new claims to truth: for Daston, "one of the most striking features of the new-style scientific facts of the seventeenth century is how swiftly and radically they broke with the etymology that connected them to words like 'factory' and other sites of making and doing."[19]

To claim that in the early modern period science and imaginative fiction "make" knowledge is not to suggest that their knowledge is "made up."[20] Rather, when William Gilbert and Philip Sidney present themselves as being engaged in acts of "making," it is precisely this "made" quality that constitutes the source of the knowledge they create. *Science, Reading, and Renaissance Literature* investigates this understanding of knowledge by looking at issues of intellectual content as well as theory and practice: William Gilbert's disagreements with Johannes Baptista de la Porta over whether the magnet has "force" or "virtue"; Edmund Spenser's reliance upon Aristotle as well as Galen in his creation narratives; Galileo's accounts of star irradiation and what they suggest about the reliability of the telescope; Margaret Cavendish's advocacy of vitalism over mechanism – these topics are all taken up and considered in detail. I am less interested in tracing specific ideas, though, than in seeing how those ideas are produced through understandings of "art" as a common source of scientific inquiry and imaginative fiction.

Science in the early modern period becomes an art in the sense that much of what makes "the New Science" new follows from the manner in which it comes to be understood as a practice, a skill, a process of doing. As a corollary, the knowledge of this science is in some important way made. Whereas *sapientia* simply is, science fabricates. Regardless of how true, what science makes is artificial in the sense that it is a product of human creation. The rise of experimentalism – which has often been regarded as a defining feature of seventeenth-century natural philosophy and science – provides one familiar instance of the "made" quality to early modern scientific practice. Experimentation depends on creating artificial situations for the purpose of discovering universal scientific laws. From most premodern philosophical and historical perspectives, this goal represents an epistemological paradox, yet by the end of the seventeenth century claims for the power of experiments are becoming widely accepted along with new assumptions about the existence of universal scientific laws that they point to. In a similar manner, dissections of the anatomy theatres reject old notions of *sapientia* as a "body of knowledge": individual cadavers, as much as Aristotle, are used as the basis for abstracting new models of the body. The centrality of artifice to the various methods and emerging fields of the New Science can further be seen in the widespread intellectual excitement and controversy that surrounds a whole range of new tools – the telescope, microscope, air-pump, the watch, camera obscura, and print itself – that make it possible to discover knowledge but to do so only by means of artifice.

In reconnecting early modern science to its origin in various kinds of art, my approach differs crucially from social histories of science. Such histories of science have, as I do, focused on the "made" quality to early modern scientific practices. The project of rethinking traditional positivistic histories of science has been instructive and, in borrowing from recent literary scholarship (e.g., Mario Biagioli's debt to Stephen Greenblatt), has even called attention to the role of texts in the invention of the new scientific cultures of the seventeenth century.[21] Analysis, though, has been largely limited to two main "textual" features of scientific texts: first, the rhetorical devices and metaphorical tropes within particular texts that provide forms of argumentation or persuasion (e.g., Steven Shapin, Simon Schaffer, Peter Dear, Biagioli); second, the print culture that developed around early scientific texts (e.g., Adrian Johns).[22] Taken as a group, these approaches have made the claim that the ideas and innovations of science only achieve the status of science when they become available and persuasive to others. On my view, such conclusions remain limited for two reasons: they do not go far enough in arguments about the "made" qualities of scientific texts and they are too narrow concerning the kinds of textual evidence that they can consider. Social histories of science redefined traditional history of ideas-oriented scientific history by emphasizing social context over intellectual

content. Historians such as Dear or Shapin never say (contra Paul Gross, Norman Levitt, and, as we shall see, Alan Sokal) that the merit of an intellectual idea is not relevant to its acceptance as a new scientific standard. Nonetheless, this line of argument does unintentionally create a dichotomy between what scientists say and the contexts in which they say it. Because "making" is, for social historians, always primarily directed towards the ultimate persuasion of an audience, such histories rarely start early enough in identifying the various acts of making that inform what a solitary scientist (if we can provisionally imagine such a thing) does upon first identifying a new scientific problem or subject. By detailing how art is a basis for an act of making that begins when Gilbert shapes a terrella on his lathe or Galileo pieces together a new version of the telescope, I instead argue that there is no gap between an initial content and its later context. Second, my approach also redresses an imbalance between science and literature that typifies social history. Literary or rhetorical analysis of scientific texts may provide new insights into old problems, but it also reduces literature and rhetoric to being only a tool for the progress of science. That is, literature has a place in new histories of science only by replicating current disciplinary boundaries. As a result, these new histories fail to recognize how early modern science and literature instead share related interests in making as a form of knowledge production.

In saying that our attention to and understanding of scientific "making" must encompass more than the process of making others believe, my goal is not to claim that such histories reify distinctions between the production of scientific ideas and their intellectual content. Yet, historians such as Dear and Shapin, among others, have largely limited the types of textual analysis that they undertake to rhetorical readings because that form of interpretation coincides with broadly Marxist interests in science as a communal practice. My approach adds other kinds of textual analysis in order to show how literary analysis (if pursued through a broader range of kinds of analysis) can give us insight not simply into the discursive forms (what might be called the "narratives of persuasion" and acts of "rhetorical justification") used by early modern scientists but precisely into the intellectual content of early modern science itself. In keeping with the book's overall argument about the art of science and the making of knowledge, that is, my approach uses the tools of literary analysis not so much to consider how early modern philosophers write about science but, more fundamentally, to explore how they practice it.

The philosopher of science Bruno Latour has given us the most important and sustained account of how "facts" are made through the practices of science. His influential but often contested work provides a framework for seeing both the great strengths and limitations to constructivist approaches to science. His arguments are worth examining in detail because they demonstrate how literature lacks a place in most accounts of the social construction of knowledge.

Latour challenges traditional histories of science for depending on a realistic model of reference, under which knowledge is in some way "out there" to be discovered and found through the investigations of science. Under this model, he concludes, "we have mistaken science for realist painting, imagining that it made an exact copy of the world."[23] Latour works to reconnect the split between reality (out there) and representation (in here) by showing how facts are not only made, but indeed gain truth, become more "real," through the process of being made. Rejecting critics who would identify him as a skeptical constructivist or even an out and out relativist, Latour insists of scientific facts that "it is not just that they are both made up *and* real. Rather, it is precisely *because* they have been artificially made up that they gain a complete autonomy from any sort of production, construction, or fabrication" (*Pandora's Hope*, p. 127). Instead of thinking of science as a necessary but always impossible attempt to reach reality, Latour suggests that knowledge is created not by getting to reality but by tracing a chain of representations: between matter and facts, a process of repeated gaps, a series of mediations that take you from matter to form. This account, persuasive in its own right, is particularly compelling when applied to the early modern period. We shall see that Gilbert, Harvey, Kepler, and Galileo do not simply do what Latour says but, indeed, articulate their own versions of his arguments. Indeed, if Harvey or Gilbert anticipate Latour, they do so precisely because they emerge out of a larger humanistic and artistic context that shares assumptions about making that become foundational for science as a discipline.

What Latour does for the relationship between science and facts, however, is achieved at the expense of literature and art. Latour is not a realist about science, but he is a realist about fiction. Fiction consequently provides a framework against which he puts forward his arguments for science studies. Latour solves the philosophical impasse that he sees between reality and science by taking an anti-representational approach. Having rejected realist painting as a model for science, Latour introduces theatrical performance as a metaphor to describe Louis Pasteur's strategy for convincing members of the Royal Academy of his claims about fermentation. In Latour's account, Pasteur becomes a kind of stage manager directing a performance in which the lead actor is lactic acid fermentation (*Pandora's Hope*, pp. 122–33). If Pasteur's readers are persuaded, what they see is an autonomous object with an independent reality and existence. If Pasteur fails to persuade them, by contrast, he "will be made the sole and only author of a work of *fiction*" (p. 132). Unlike the science-as-realist-painting approach, this performative model emphasizes how what you get is a kind of artificial performance in which attention is simultaneously focused on two planes at once, both the play and the performance. The performance does not ever quite disappear and indeed it is precisely the "trembling presence" of this second plane, at once "constantly felt and happily forgotten," that constitutes

much of the pleasure that the audience experiences (p. 135). Within the larger context of arguments about the "made" quality of facts, Latour's stage metaphor provides a useful corrective to the twin traps of constructivism and naive realism.

Yet, however well Latour's model may explain science, it falls short for any study of literature and science as interrelated practices. What Latour does for science by demonstrating how it succeeds as a practice of knowledge also needs to be done for imaginative fiction. The problem here is not Latour's casual assumption that when science is not true it becomes a "fiction." Rather, what we need to pay attention to is the inevitable point at which Latour must draw back from the theatrical metaphor. As Latour concludes, "this metaphor, borrowed from the world of art, has the unfortunate consequence of *aestheticizing* the work of science and weakening its claim to truth . . . we are not looking for pleasure but for a truth independent of our own making" (p. 136). Not so much depending on a post-Newtonian science to frame his claims, Latour postulates a post-Romantic aesthetics. For early modern writers such as Sidney, though, pleasure was not the primary goal of fiction: following Horace, poetry had to entertain and educate, to produce use along with pleasure. This emphasis on use makes clear, as we have seen, that readers cannot simply be thought of as being acted upon by texts. Early modern fictions are like Latour's facts in that they are not made up, but made: Philip Sidney's assertion that the poet "never lieth" because he "nothing affirms" is part of a larger argument that literature produces knowledge precisely because it is not true.[24] What a writer like Sidney wants to happen to his readers is not unlike what Latour sees happening to Pasteur's. As Latour describes it, an experiment moves beyond "fiction" to become science at precisely the narrative moment when the author in a way loses authority over his act of making, transferring it to his subject and his readers: "Who is the author of the whole process and who is the authority in the text are themselves open questions, since the characters and the authors exchange credibilities" (p. 132). This emphasis on how authors only become successful by allowing readers to "make" their fictions within themselves will be a recurring aesthetic and intellectual principle for Sidney, Spenser, and Cavendish. More than just an "escape" to or from art, early modern literature presents knowledge as both its invention and its argument.

Looking at early modern book catalogues provides an alternative manner of seeing how "making" is involved in both the categories of literature and science. In a recent review, Elizabeth Eisenstein laments that scholars working on the intersections of book history and history of science have neglected the key importance of booksellers' sales catalogues. Such texts, she notes, crucially "helped to reorganize the world of learning by developing new subject headings such as 'the Sciences.'"[25] As an explicit act of category-making, catalogues give us evidence about not just whether literature and science really are accepted categories, but also about how they come into being. In 1595, William