Storied Objects, Scientific Objects, and Renaissance Experiment: The Case of Malleable Glass

VERA KELLER, *University of Oregon*

The career of storied objects can help highlight the agency of absence and historicize the notion of scientific objects more generally. Until the sixteenth century, lost, ancient flexible glass was studied separately from malleable glass. The latter appeared as a claimed chymical product and craft recipe. The bridging of social and epistemic registers merged these accounts. Malleable glass became a prestigious scientific object. Appearing in numerous utopias, it stimulated a participatory public of scientific amateurs. Such storied objects served as vectors for spreading experimental culture, yet declined as new professions emerged. The charisma that made malleable glass a seventeenth-century scientific object led to its rejection by newly professionalized eighteenth-century chemists and its replacement by a less evocative scientific object, "malleability."

INTRODUCTION: LOST THINGS AS SCIENTIFIC OBJECTS

TODAY'S HISTORY OF science has productively materialized the history of ideas through critical attention to objects. Historians of science regularly refer to various objects (boundary, mundane, or scientific) as a means of navigating between the Scylla of a disembodied history of ideas and the Charybdis of material determinism. The scientific object is a merger of matter and mind. It is not an everyday, unquestioned thing. Nor does it hover only in the ether. Rather, a concatenation of theories, interests, and the attention of a scientific community comes together via a set of shared material practices to embody it, for a time.[1] Scientific objects thus enjoy a peculiar ontological status. Their

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[1]Tresch; Star and Griesemer; Galison; Daston. A note on terms: to avoid a misleading binary opposition between *alchemy* and *chemistry*, I will use derivations of the more neutral *chymia* prior to the eighteenth century, unless referring to a period use of another term. *Alchimia* and *chymia* or *chimia* were usually indistinguishable. See Newman and Principe, 41. However, also note the important recent point that for some late seventeenth-century physicians, *chimia* refered to the making of medicine and *alchimia* to broader practices, including "artisanal productions of things such as paints, gems, or glass": Garber, 93. I will refer to *flexible glass* for the ancient substance, *malleable glass* for the substance of the alchemical and recipe traditions, and again to *malleable glass* (which became dominant) when the traditions have merged.

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strange vagueness "is inevitable because, paradoxically, epistemic things embody what one does not yet know."[2] Historically, I argue, this special status has been shaped by what one no longer knows, that is, by attention to vanished objects of ancient legend that I am calling "storied objects." Tracing the career of storied objects will highlight a critical phase of the making of publics for Renaissance experiments.

The resurrection of antiquity has long been identified as sharpening attention to natural objects and vice versa. Humanists honed techniques of textual observation that were also applied to the book of nature.[3] Courtly collectors, supplied with objects drawn both from antiquity and from around the world, competed with ancient projects of natural history.[4] Antiquarians paid as much attention to the material forms of shells and other collectible *naturalia* as to ancient coins and architecture.[5] The rising status of the artist and the mimetic competition between art and nature has been linked to the realist study of nature and artisanal ways of knowing.[6] Practices of observation, description, and collection focus upon the hard-edged, materially existing thing. The emergence of empiricism has attracted a great deal of attention, given the period's vast influx of new global species, the proliferation of collections, and the rising status of natural history. Yet recently, prodded by new interests in climate studies, scholars have begun to pay attention to period accounts of natural loss and devastation, rather than overabundance.[7] The relationship between an interest in nonextant objects and the speculative object of experiment offers a new way to connect the practices of exploring ancient and natural worlds in early modernity.

A case in point is the legendary flexible, ductile, or malleable glass. The story of its loss is set in the ancient Rome of Tiberius, where a monumental portico had lurched sideways.[8] Straightening it again appeared an impossible task, but "with the help of many Engines and a multitude of hands," one man "restored it to its former uprightness, contrary to the opinion of all men." The emperor refused to honor this man, and "caused his name to be unremembered in the Annals." Eager for fame, the man cast about for another way to impress Tiberius. He devised a wonderful glass vessel and carried it back to the court. "This Workman, more to amaze all the beholders by, and that he might make himselfe a farther way into the Emperours favour" took the glass, and threw it upon the

[2]Rheinberger, 28.

[3]Grafton; Blair; Pomata and Siraisi.

[4]Bredekamp; Findlen; Wolfe; Kenny.

[5]Feola.

[6]Smith, 2004; Bensaude-Vincent and Newman.

[7]Keller, 2014; Reeves, 2015.

[8]Ole Borch also situated malleable glass in ancient Egypt: Borch, 1674, 102.

ground, where it bent but did not shatter.[9] Having returned the glass to its original shape, he faced the emperor again. This was when the story took a chilling turn. As Henry Peacham (1578–ca. 1644) put it, "*Caesar* demanded, if any other knew the Art of making that kind of Glasse, but himselfe? Hee answered, None that he knew. Wherupon *Tiberius* commanded, That hee should be beheaded; for (quoth hee) if this Art were publikely knowne, Gold and Silver would be no more esteemed of then Clay."[10] The artisan and his studio were destroyed and the art was lost.

The utter loss of this substance and any account of its manufacture meant that malleable glass could be neither observed nor depicted. As one of Leibniz's correspondents pointed out to him, it could not be found in any princely *Kunstkammer*.[11] Innumerable *vanitas* works represented the fragility of glass. Glass's malleability, however, was not depicted, although many of Pliny's other anecdotes did inspire artworks.[12] Malleable glass, like other *deperdita* (lost objects), thus points to an area of experimentation that the current focus on material culture has obscured—that is, ways of thinking about matter that does not exist and was not depicted. At a time before the notion of a thought experiment emerged, the imagining of nonexistent objects encouraged experimental speculation more generally.[13] A host of other lost objects could offer similar narratives. Yet, perhaps few storied objects spoke so directly to early modern questions of scientific publics and their objects as malleable glass. The particular story attached to it dramatized how human nature, and its penchant for self-serving secrecy, endangered invention. Tiberius's political calculations most obviously threatened its survival, but so too did the self-interest of the nameless artisan. He was so eager for fame that he failed to share his great discovery with others. At the turn of the seventeenth century, when both the secrets of empire and the secrets of art and nature proved to be a newly popular genre, the story of malleable glass could illustrate the dangers of secrecy and the need for a shared knowledge repository.[14]

Storied objects were deployed in the long seventeenth century as a vector for encouraging a shift of knowledge (such as techniques for malleable glass) from the domain of secrets to the public. Malleable glass appears prominently in

[9]Wanley, 120.

[10]Peacham, 1638, 144–50.

[11]Adam Kochanski, SJ, to Leibniz in Leibniz, 12:469: "Nowhere in the *Kunstkammern* of princes is malleable glass, or some specimen of it, heard of." All translations are the author's except where otherwise noted.

[12]The episode does not appear among the 161 Plinian episodes studied in McHam.

[13]For another type of nonextant and, in fact, impossible object as the focus of experiment, see Goulding. On the anachronism of thought experiments, see Palmieri.

[14]Keller, 2012b.

several seventeenth-century attempts at scientific public making discussed below, such as the early seventeenth-century curricular development of *chymia* into a liberal discipline readily available in print, the Parisian Bureau d'Adresse of the 1630s, and late seventeenth-century projects such as the Royal Society's History of Trades program, which aimed to transfer craft knowledge from the domain of secrets to a putatively public repository.[15] Malleable glass, I argue, fell out of favor as the nature of the scientific public shifted in the eighteenth century. Newly professionalized chemists, rather than attempting to elicit widespread participation, strove to demonstrate their expertise to the public.[16]

SOURCES OF MALLEABLE GLASS

Early moderns inherited three distinct sources for malleable glass. First, classical authors including Pliny, Dio Cassius, and Petronius recounted the tragedy of the art's loss.[17] Their stories were laden with political and moral messages that continued to be repeated in medieval encyclopedic works.[18] In the twelfth-century collection of political exempla of John of Salisbury, for instance, the story offers a negative example.[19] Second, malleable glass also appeared in far more practical contexts. In works of *chymia* from at least the thirteenth century, malleable glass appears as one of the powers granted by the philosophers' stone.[20] The prominence of malleable glass as one of the vaunted powers of the philosophers' stone suggested that although it might be very difficult to achieve, malleable glass was not altogether lost.

Third, the art of making malleable glass, or "softening glass," also appeared in books of secrets, from at least the thirteenth through the eighteenth centuries.[21] These straightforward recipes, often calling for the blood of a goat, seemed to indicate that malleable glass, while a coveted secret, should be relatively simple to achieve. Recipes for malleable glass appeared often in the

[15]See Ochs.

[16]Golinski; Bensaude-Vincent and Blodel. Roberts differentiates the Dutch case. Jackson argues that in the nineteenth-century Giessen chemists deployed glass-blowing skills, rather than access to the expensive apparatus of Paris and London, to develop their professional personae.

[17]Pliny, 10:155; Dio Cassius, 175; Petronius Arbiter, 104–05.

[18]Isidore of Seville, 81^{v}; Bartolomeus Anglicus, [M3]^{v}.

[19]John of Salisbury, 221.

[20]*Clangor Buccinae*, 67; Llùl, 1572, 312; Llùl, 1659; Fabre, 406.

[21]Beinecke, Mellon MS 6, fol. 10^{r}: "Ad molificandum vitrum" ("For softening glass"); di Marzo, 3:236: "Ad faciendum vitrum malleabile" ("For making malleable glass"); Pseudo-Fallopio, 279: "Modo da mollificare il vetro come pasta" ("A way to soften glass like dough"). Pseudo-Fallopio's work was ascribed spuriously by the printer to Gabriel Falloppio: Eamon, 166. For an extensive collection of medieval recipes for softening glass, see Cannella, 247–55.

so-called *Hausväterliteratur* (house-father literature, aimed in fact at both men and women) that flourished in German between 1600 and 1750. Such works, drawing on older books of secrets, billed themselves as guides for prudent household managers.[22] In their efforts to market their guides as improved and newly augmented, compilers of household guides continually added further recipes. It is not unusual to find up to nine different recipes for softening glass, all of them ineffectual, in such guides.[23] The continuing prominence of recipes for malleable glass was not confined to German-speaking lands. One can also find recipes for malleable glass in the manuscript recipe collections of founding fellows of the English Royal Society, such as Elias Ashmole (1617–92) and John Evelyn (1620–1706).[24]

Prior to the late sixteenth century, the prominence of malleable glass in both works of transmutational *chymia* and in recipe collections generally developed separately from the literature exploring the loss of the substance in antiquity. Neither of these practical traditions linked the substance to the ancient lost art. Conversely, fifteenth- and sixteenth-century commentators upon classical works compared ancient and medieval accounts of the glass, debated their veracity, and sometimes explored the moral messages of the story, but generally did not engage malleable glass as it appeared in chymical texts and collections of secrets.[25] The differences in the terms used to denote the substance followed this division

[22]Kruse. Thieme, for instance, addressed the "prudent father of the house and the careful mother of the house" in the extended title of his work.

[23]For example, "Ein ungesteint Glaß so weich zu machen als ein Tuch" ("To make an unlined [?] glass as soft as a cloth"), "Ein Glaß zu weichen" ("To soften a glass [two ways]"), and "Ein Glaß zu weichen" ("To soften a glass [four ways]"): Coler, 716, 729; collected from Antoine Mizauld and Pseudo-Falloppio, "Glass weich zu machen" ("To make glass soft [seven ways]"), and "Ein anders / Glass alss ein Teig so weich zu machen" ("Another, to make glass as soft as dough [two ways]"), in Hildebrand, 4:6–7; "Ein Glas weich zu machen" ("To make a glass soft [five ways]") and "Ein anders / ein Glas so weich zu machen / als einen Teig" ("Another, to make a glass as soft as dough [two ways]"), Thieme, 1517–18; "Glaß weich zu machen, wie Leder" ("To make glass soft like leather"), *Neues Handbuch vor Künstler*, 262–63.

[24]Recipes for softening glass calling for immersion in the oil of horsehooves can be found in two fifteenth-century collections of Elias Ashmole: "Ad vitrum mollificandum et colorandum" ("For softening and coloring glass"), Bodleian Library, MS Ashmole 1448, 43–44; and "Ad mollificandum vitrum" ("For softening glass"), Bodleian, MS Ashmole 1503, fol. 22^{v}. The latter collection previously belonged to John Dee. John Evelyn himself copied the receipt "Ad mollificandum vitrum" ("For softening glass"), British Library, MS Add 78340, 302, calling for the sap of "ligusticum" ("lovage"). A similar recipe can be found in Paracelsus, 325–26.

[25]Crinitus, 344; Dousa, 222–28, compared the accounts of Pliny and Dio Cassius with the more modern accounts of Isidore, John of Salisbury, and Crinitus; in a chapter on jealousy, Ricchieri, 769, gave the example of Tiberius's murder of the inventor; Vossius, 278, in a discussion of envy in a guide for orators, discussed Pliny, Dio, Isidore, Petronius, and John of Salisbury.

between the Plinian and the craft traditions. Fifteenth- and sixteenth-century commentators employed the terms of their classical sources, such as "ductile" (Pliny), "ductile and flexible" (Isidore), or simply unbroken glass (Petronius and Dio Cassius), rather than the "soft" or "malleable" glass of chymical texts and recipes.[26]

Given the separation that had largely persisted for centuries between the malleable glass of the practical tradition and the flexible or ductile glass of antiquity, it is thus noteworthy how, beginning in the mid-sixteenth century, some writers began to bring these two traditions together.[27] The merging of accounts of the glass's loss with the many current recipes for it would elicit doubts concerning the inherited bodies of both classical and practical traditions.[28] The doubts engendered by the comparison of classical sources and books of secrets encouraged attempts to resolve them through experiment.

THE MEANING OF GLASS AND THE FIRST BRIDGERS OF TRADITION, 1483–1561

The first step in resolving accounts of malleable and flexible glass was defining *glass*, which was difficult to do in early modernity, as it still is today.[29] Antonio Neri (1576–1614), the author of the first printed manual of glassmaking, noted that glass resembles rocks and minerals but differs in being a "compound, and made by art."[30] Christopher Merret (1614–95), in his commentary on Neri, described the contemporary confusion concerning glass's identity: some called

[26]Crinitus, 344, "vitrum flexile ac ductile" ("flexible and ductile glass"); Dousa, 222–28, "vitri ductilis seu flexilis" ("ductile or flexible glass"); Ricchieri, 769, "infractum illaesumque" ("unbroken and unharmed").

[27]There are a few exceptions. Trowbridge, 112, points to Heraclius's *De coloribus et artibus Romanorum* 3.6. The fifteenth-century MS Harl. 2261 describes "a man in the tyme of this Tiberius that founde the arte to make glasse flexible and malleable": qtd. in Lumby, 4:317. Agrippa, [X]^{v}, recounts Pliny's tale (via Isidore) in his account of alchemical products, but he does not connect it to a specific recipe or to *vitrum malleabile* as a claimed power of the stone.

[28]As the cameralist Georg Heinrich Zincke (1692–1769) would later write, "one can find many techniques in the common Art-Books for how to makes glass soft and workable with the hammer, but I can't say if they work. . . . One must reckon the art of that craftsman who presented himself to Emperor Tiberius . . . among the lost or still hidden arts, if that which has been recounted in ancient Roman texts is true": Zincke's commentary on Becher, 1754–59, 2:1440 ("Von dem Glas-Handel").

[29]Beretta, 2004; see the new research project of the Simons Foundation, "Cracking the Glass Problem," https://scglass.uchicago.edu/. For current attempts to engineer more flexible glass, see the German Science Foundation (DFG) funded project, "Topological Engineering of Ultrastrong Glasses," http://www.spp1594.uni-jena.de/.

[30]Neri, 1612, [A]^{r}.

it a "concrete juyce," others "a stone," and some considered it "amongst the Media mineralia, and the workmen, when it is in a state of fusion call it metall."[31]

Glass's meaning also encompassed moral and spiritual dimensions. Early modern writers often deployed glass's fragility as an emblem of human failings. While the transformation of the vile material of ash and sand into a shining and useful substance symbolized the height of human ability, glass's single failing of frangibility brought this evidence of human potential crashing back to earth. Alluding to the genre of the mirrors for princes, Girolamo Cardano (1501–76) wrote, "princes ought always contemplate, not just with their eyes, but also with their heart, glass's example of human fragility, for truly human life is far more fragile than glass."[32]

It was as part of a spiritual interpretation of glass that the classical story encountered the malleable glass of *chymia* and of recipe culture. The two appear in a sermon by the fifteenth-century Meissen priest Meffreth, who is known for incorporating stories, or exempla, in his homilies.[33] Citing Isidore incorrectly, Meffreth mistook the emperor of the story and noted that Julius Caesar killed the inventor of malleable glass. Meffreth also connected Isidore's classical tale to recipe literature, observing that "alchemists say that glass can be made malleable and flexible still today if you throw basilisk powder on it when it melts in the furnace, but whether this is true, I know not."[34]

The Lutheran preacher in the mining community of St. Joachimsthal, Johannes Mathesius (1504–65), related the art of rendering glass durable to the Second Coming of Christ and the increased perfection of all things. Dressed in a miner's costume, Mathesius preached sermons on mining topics each Carnival between 1553 and 1562 in an effort to lend meaning to practical processes. Mathesius's early unification of the various sources concerning malleable glass in his sermon "On Glassmaking" is but one example of the many bridges he built between practical and learned traditions. Bringing together moralizing sources and artisanal techniques, Mathesius also preached to his mining community on other lost objects, such as the mysterious alloy *electrum*, described by Pliny and Homer.[35] Conversely, his published sermons also introduced the substances, terms, and concepts of miners to literate chymists.[36] Mathesius repeated

[31]Neri, 1662, 211.

[32]Cardano, 1551, 122. In another work, Cardano would argue that the ductile glass described by Pliny was a myth, since the firing of glass removed the humidity necessary for it to remain ductile: Cardano, 1558, 94.

[33]Palmer.

[34]Meffreth, [x4]^{v}: "Et dicunt alchimiste quod vitrum potest et hodie fieri malleabile et flexibile si illud cum pulvere basilisci aspergatur quando liquescit in fornace. Sed utrum verum sit ignoro."

[35]Karant-Nunn, 97.

[36]Alfonso-Goldfarb and Ferraz; Haug.

Cardano's idea of glass as a symbol of human fragility. Whether in Joachimsthal, in Venice, in the Bohemian forest, or elsewhere, all glasses retain their fragility despite attempts to render them durable, until a new master of the art will arise as there once was in the court of Caesar Nero [*sic*]. That monster ("der unmensch") tyrannically did away with the inventor just as he had murdered Saints Peter and Paul and many other Christian teachers and auditors. According to Mathesius, when this art would be revealed again, the Lord Christ would endow our fragile bodies with immortality.[37]

Robert Duval (before 1510–after 1584), a prolific chymical poet, compiler, and editor, appears to have been the first to connect the malleable glass of the philosophers' stone to the Plinian story. He did so in a 1561 groundbreaking work supporting the antiquity of *chymia* that would be included as the opening text in the popular compendium *Theatrum Chemicum*.[38] Duval's text purposely joined different literatures in an effort to defend *chymia* by linking it to the prestige of classical antiquity. At the very conclusion of the work, Duval notes merely that the philosophers' stone would render glass "flexible or malleable." The margin alerts the reader to "Plinius, l. 36, c. 26," the locus of the story of flexible glass in editions of the period, although Duval does not recount the tale.[39]

Meffreth, Mathesius, and Duval merged the classical source with more manual forms of knowledge, such as glassmaking and *chymia*, in an effort to build bridges between those endeavors and sacred and classical history. Neither of them developed these connections at length. Duval's reference to the story remained a taciturn marginal annotation, and Meffreth and Mathesius mistook the Roman emperor of the story. Meanwhile, other writers of the period whom one might expect to discuss flexible or malleable glass did not.[40] From these slight beginnings, malleable glass (along with other *deperdita*) would develop into a well-nigh inescapable commonplace at the turn of the seventeenth century.

MALLEABLE GLASS AS A SCIENTIFIC OBJECT, 1580s–1680s

The Courtly Deperdita, *1580s–1640s*

The vogue for studying ancient lost things, or *deperdita*, developed in the same courtly circles where extant remains of the ancient and natural worlds were collected. For instance, Guido Pancirolli (1523–99), a renowned legal humanist

[37]Mathesius, cclxxxviii[r].

[38]Kahn, 124–27; Duval, 1659, 7–28.

[39]Duval, 1561, [E9][r].

[40]For instance, Agricola, 470, discusses glassmaking at length in his *De Re Metallica* (1556), but although he touches on Pliny's comments about the extant glass of ancient Rome, he does not mention the lost flexible or malleable glass.

and professor at Padua, participated in a circle of antiquarians studying the past through collecting, philology, and artwork. His *Inventioni antiche, & moderne* of the 1580s, however, did not represent his erudition well. Dedicated to his princely patron, Carlo Emanuele (1562–1630), this was not intended for publication, but for circulation in the Turin court as a casual, vernacular *discorso*. Entirely unillustrated and scholastically slapdash, this posthumously published work (in two volumes in 1599 and 1602) playfully paired things lost, like "ductile glass," and things newly found, such as caviar. "Ductile glass" was Pancirolli's thirty-sixth lost object.[41] While also employed by Carlo Emanuele of Savoy in his Turin household, the Modenese poet Alessandro Tassoni (1565–1635) published *Pensieri Diversi* (1620), whose tenth book, "Ingegni Antichi, e Moderni," argued that modern abilities surpassed those of the ancients. Tassoni disagreed with the more evenhanded Pancirolli on many points. For instance, in a chapter on the "ancient and modern curiosity and subtlety," Tassoni discussed the question of flexible glass. He was confident that the artisans of Murano, who had shaped the most curious and bizarre works that the fantastic human intellect could imagine, should be able to achieve it if it were possible.[42]

Pancirolli's work informed antiquarian circles in Padua and Rome and helped consolidate the *deperdita* as a cateogry. Pancirolli's student Lorenzo Pignoria (d. 1631) passed his works on to a younger generation of Paduan antiquarians, such as Giacomo Filippo Tomasini (1595–1655) and Fortunio Liceti (1577–1657). And, as Ingo Herklotz has discussed, Pancirolli offered an important precursor to Cassiano dal Pozzo (1588–1657) in Rome.[43] Dal Pozzo receives ever more emphasis as a central trendsetter in the united material study of antiquity and nature.[44] Yet, individuals in his immediate setting and fellow Linceans—members of the Accademia dei Lincei—such as Fortunio Liceti, Francesco Stelluti (1577–1653), Fabio Colonna (1567–1640), and Federico Cesi (1585–1630), investigated not only extant works of art and nature, but also missing objects, such as malleable glass, perpetually burning lamps, the lost ancient purple dye, and the ancient wonder drug silphion and other medicaments.[45]

[41]Pancirolli, 1599, 238–40 ("De Vitro Ductili").

[42]Tassoni, 578. On Tassoni, see Osborne.

[43]Herklotz, 231.

[44]Moser; Décultot.

[45]On perpetually burning lamps and malleable glass (citing Pancirolli), see Liceti, 1640, 41; Liceti, 1652, 519; ibid., 8, 16, 27, cites Pancirolli, 1599; on silphion, cassia, true cinammon, amomum, and purple, see Stelluti, 1630, 72–73, 107–08; on silphion, see F. Cesi, 933, and Biblioteca dell'Orto Botanico di Padova, coll. Ar.B. XVIII, Cesi, *De laserpitio, et laserpitii pluvia*; on purple, see Colonna; on the Lincei, inter alia, see Findlen; on lost things and the Lincei, see Keller, 2014.

The category of lost things popularized by Guido Pancirolli flourished in settings in which learning was worn with flair, such as the Lincean Academy. Linceans deployed their material interests in lost things to distinguish themselves, on the one hand, from bookish pedants and, on the other, from incommunicative artisans. Fortunio Liceti argued, "what could be more admirable than flexible and malleable glass? Yet it was a common, uneducated man [*plebeius homo quidam indoctus*] that succeeded in discovering it, and it perished with him since he taught it to nobody." Likewise, many other desirable things, such as the oil required to fuel perpetually burning lamps, might have been discovered by unknown common folk who have not communicated their discoveries.[46] For Liceti, malleable glass symbolized the need to remain open-minded, to reach across social divides, and to communicate discoveries.

In early seventeenth-century England, Pancirolli's work was seen as a vehicle for shaping the English gentry into virtuosi. Henry Peacham, author of the *Compleat Gentleman* and the introducer of both the terms *virtuoso* and *liefhebber* (amateur) to English, claimed he had "intended a good while since, to have wholly translated" Pancirolli, but he decided against it.[47] Instead, Peacham drew on Pancirolli frequently in several works, including the *Valley of Varietie*, where he recounted the story of the lost malleable glass, and in his *Coach and Sedan*, where it appeared as an example of antiquity's preeminence.[48] Malleable glass was already a recognizable example of an impossible goal, as in John Webster's reference in the *Duchess of Malfi* to a man who strove "to make glasse maleable."[49] Making the investigation of malleable glass and other *deperdita* a part of virtuosic interests indicated, for English gentlemen as for the Linceans, an open-mindedness that eschewed both the heavy-handed erudition of the professional scholar and the self-interestedness of the artisan.[50]

Malleable Glass in Early Academic Alchemy

While *deperdita* served to identify an extramural, courtly fusion of the study of antiquity, art, and nature, they also figured prominently in academic reforms. The sixteenth-century French academic reformer Pierre de la Ramée, or Petrus Ramus (1515–72), deployed the story of malleable glass to encourage the joining of cultures of knowledge. Just as Tiberius thought the new invention would make gold and silver appear no longer praiseworthy or valuable, philosophers thought it would detract from the value of philosophy if they exposed the latter to mechanical arts: "'Gold would be cheapened,' said the Roman, 'if glass were

[46]Liceti, 1652, 41.
[47]Peacham, 1638, [A5]$^{r-v}$; Weststeijn, 97.
[48]Peacham, 1638, 144–50; Peacham, 1636, 27.
[49]Webster, [A2]^{v}.
[50]Shapin, 1991.

made flexible and malleable'; likewise the philosopher says, 'Philosophy will be cheapened if it be exposed to mechanic knowledge by the hands of workmen.'"[51] The real value to the common good lay precisely in such exposure and the new inventions it could produce, he argued. Even had Tiberius failed to memorialize and support the inventor of malleable glass, the craftsman's knowledge would have survived had it been recorded by men of learning. Scholars had to attend to menial persons such as craftsmen if the desirable knowledge of the latter were not to be lost.

Inspired by the reforming ideas of Ramus, rulers of small Protestant principalities established new, practically oriented curricula.[52] These included the first introduction of *chymia* into the academy, and perforce, the merger of practical forms of knowledge with the liberal arts. At the same time, *chymia* was attacked and condemned in the Sorbonne. Malleable glass and other ancient chymical achievements began to appear in a fierce debate between alchemy's attackers, such as Nicholas Guibert (1547–ca. 1620) and Jean Riolan the Younger (1577–1657), and its defenders, such as the early academic alchemist in Lutheran Coburg, Andreas Libavius (1555–1616).[53]

Academic alchemists strove to fuse learning and manual investigation and to establish *chymia* as an accessible art. This meant bringing it out of the realm of secrets and into print.[54] Just as Ramus had, Libavius deployed the story of malleable glass as a prominent emblem of the proper relations academic learning should maintain to the world of craft and to the public good. In his dedicatory letter to a 1611 model work illustrating how alchemical secrets should be brought to light, Libavius retold the tale. Speaking of Tiberius's murder of the inventor of malleable glass, Libavius seethed, "Who would not hate such a savage murderer and destroyer of art and artisan, and who reading of the affair will not boil with rage?" The true tragedy was that no learned man like himself had bothered to record the details of the discovery. If the art had been written down, it could have been restored despite the murder of its nameless inventor. This would be a heroic, even a political act. "There is great pleasure and glory in discovering something useful, but not a little in conserving and communicating it in one's writings," claimed Libavius. All those who hope "for a well constituted republic and a sound universal order" realize how necessary it is to publicize and celebrate the inventors of new arts or the restorers of lost ones.[55] His own new discipline of academic alchemy would address this problem by recording alchemical secrets and making them universally available within a liberal curriculum.

[51]Ramus, 18: "Vilesceret aurum, ait romanus, si vitrum flexibile malleoque tractabile fuerit: ita modo philosophus, Vilescet philosophia, si mathesis mechanicis opificum manibus exponantur."

[52]Hotson.

[53]Moran, 2007.

[54]Nummedal, 21.

[55]Libavius, 1611–15, 1:[(?)5]^{v}.

In his defense of *chymia* as an ancient art and a worthy member of the liberal arts, Libavius drew on Duval. Duval, and the ancient *chymia* he celebrated, thus became an important figure in Libavius's confrontations with his enemies. Jean Riolan, in a 1606 work attacking Libavius, noted that Duval himself, when the two were teaching in the same school, had attempted to convert him to the side of the alchemists by proving alchemy's antiquity.[56] Nicholas Guibert, himself a former alchemist from Lorraine, sided with the Sorbonne, and he too attacked Duval while aiming for Libavius.[57] Guibert specifically countered the use of Pliny's story of "flexible and ductile glass" as a testimonty to the truth and antiquity of *chymia* by the "Sophist Libavius" and other patrons of alchemy. Guibert explored ancient, medieval, and Renaissance sources, including Pliny, Isidore, Petronius, John of Salisbury, and Petrus Crinitus in his efforts to undercut the use of the ancient story by chymists.[58]

Libavius, who elsewhere also discussed malleable glass in a practical context devoid of Plinian references, was provoked into an extensive discussion relating malleable glass to the ancient heritage in a defense of alchemy against Guibert.[59] Libavius analyzed the same wide range of ancient chymical objects Guibert had attacked, including both malleable glass and perpetual lamps.[60] Aiming to show that alchemy could be a liberal and open discipline that touched on many other areas of the curriculum, Libavius's discussion of malleable glass purposefully encompassed a wide range of sources, including ancient texts, medieval compilations, chymical works, books of secrets, and humanist commentary. He expressly sought out "nine witnesses to malleable glass besides chymists."[61]

The arguments between the Lutheran Libavius and his Catholic opponents took place in the context of vigorous confessional disputes. The academic integration of *deperdita* into the formal study of nature did not, however, fall along predictable confessional lines. For the Jesuit Bernardo Cesi (1581–1630), a professor at Modena, for instance, malleable glass also dramatized the need for a skeptical open-mindedness. According to Aristotle's *problemata*, it should be

[56]Riolan, 17–18; Moran, 2007, 186.

[57]Kahn, 408n272; for affiliation with Paris, see Guibert, 1614b, 5–7. On Guibert, see Duveen and Willemart.

[58]Guibert, 1614a, 84–88.

[59]For a more practical context, see Libavius, 1595, 474–79 ("Epistola lxxx, De inhumatione & vitrificatione"); Libavius, 1611–15, 2:240–42 ("De molliendis mineralibus non metallicis, item lapidibus, vitris, gemmis, &c").

[60]Libavius, 1611–15, appendix:182–249 ("De Transmutatoriae metallorum hermeticae veritate contra interitum eius a Nicolao Guiberto temere assertum"); ibid., 219–22 ("De Lucerna perpetua").

[61]Libavius, 1611–15, appendix:225–28 ("de vitro malleabili"): "novem testes de malleabili vitro praeter Chymicos."

impossible.[62] However, the philosopher who loves truth more than his own stubborn experience will gladly submit to the burden of experience, if there is any testifying to the opposing view. Cesi reviewed the ancient sources, but left the decision to the reader. He did point out the chymical practice mentioned by Meffreth of softening glass with basilisk powder. Elsewhere he raised seven doubts concerning glass, one of which was the truth of Pliny's tale.[63]

Malleable Glass and Political Craftiness

The question of the desirability of academic alchemy, a discipline princes had previously both practiced personally or overseen, was a political one.[64] It was the princely belief in the political benefits of industry and invention that shaped the new Ramist curriculum. Thus, it is not surprising to find malleable glass in the early seventeenth century often discussed in works on the political importance of defending invention. The story offered a negative example of political cunning; it demonstrated the "craftie" disposition of Tiberius, who could seem so "friendly" to those "whose throats hee meant to cut."[65] The Habsburg politician Jakob Bornitz (1560–1625) argued in his 1610 *On Rewards* that although Tiberius appeared to be acting in a calculating manner by destroying the art of flexible glass, he was in fact quite imprudent. Bornitz noted how, according to Pancirolli, this art had yet to be restored. Princes ought rather to reward ingenuity, especially in the discovery and recovery of the mechanical arts.[66] That was the correct form of political craftiness. Citing Pancirolli and Bornitz, Hermann Lather (1583–1640) also offered the murder of the inventor of flexible glass as an example of poor policy.[67]

Bornitz's chapter on glass in a work on the necessary arts for a republic encompassed the full moral, spiritual, and technical range of available sources. The transformation from the vile and dark matter of sand and ashes to something transparent and shining was so wonderful that nobody would be persuaded by reason alone that it could be achieved by art. Only experience could prove it to be true. This transformation prefigured the clarification of our bodies in heaven, he said, continuing to recount the story of Tiberius's murder of the inventor of ductile glass. Bornitz pointed out how the Venetians possessed the best secret of making glass, imitated by everyone but surpassed by none. He referred the reader to a book of secrets with a recipe for softening glass using the blood of goats and geese.[68] Bornitz's trawling of the available resources

[62]Pseudo-Aristotle, 490.
[63]B. Cesi, 417–18, 528.
[64]Nummedal; Moran, 1991.
[65]Peacham, 1638, 144–50 (quotation at 149).
[66]Bornitz, 1610, 82–83.
[67]Lather, 995.
[68]Bornitz, 1625, 141–42; Bapst, 223.

concerning glass was so thorough that Christopher Merret would later observe, in his translation and commentary on Antonio Neri's *Art of Glass*, that he could only find two authors who ever mentioned Neri. One of them was Bornitz.[69]

The chancellor of Julius, Duke of Braunschweig-Lüneburg, Eberhard à Weihe (1553–1637), also covered an expansive range in his discussion of malleable glass in his *On the Origins of Mirrors, and Their Use and Abuse* (1622). A student of Pancirolli at Padua and a political writer praised by Bornitz, Weihe employed the contemporary expert on the secrets of empire, Arnold Clapmar, as his son's tutor.[70] Weihe was well positioned to appreciate the relationship between the secrets of empire and the secrets of art and nature. His *On the Origins of Mirrors* brought together craft and politics in its history of actual mirrors (and glass in general) as well as in its history of political mirrors for princes or books of advice.

Weihe criticized misplaced political calculations that prized immediate revenue over the longer-term benefits accrued through new inventions. He asked, what could have fascinated Tiberius, distorted his views, and lured him into such barbarity? Tiberius was a "monster of nature, arising from the art of simulation and dissimulation."[71] Many people had attempted to rediscover the art of flexible glass, but with no success. There are those who claimed to make it, said Weihe, repeating a recipe drawn from the "secrets of an acclaimed glassmaker" calling for the blood of a deer. Yet, the "result" ("eventus") shows that this part of the chymical art is false and, furthermore, that nearly all of *chymia* "is an art without art . . . whose beginning is to feign, whose middle is to deceive, and whose end is to beg."[72]

Despite such doubts, tales proliferated concerning the presentation of rediscovered malleable glass before contemporary political authorities. Both the Habsburg emperor Matthias and the Polish king Casimir were supposedly presented with malleable glass.[73] Shah Abbas reportedly sent Phillip III six goblets of malleable glass in 1610.[74] Sigismund, the elector of Brandenburg, himself alchemically produced a flexible glass, an example of which was offered to Philip II, Duke of Pomerania, by the art collector and diplomat Philip Hainhofer.[75] Robert Boyle heard of a piece of red, transparent glass "Hammer'd

[69]Neri, 1662, 205.

[70]Weihe, 177, refers to "my teacher Pancirollus" and the latter's discussion of specular stones. Bornitz, 1625, 168. Schwennicke, 112.

[71]Weihe, 194: "monstrum naturae ex simulandi & dissimulandi arte natum & constatum."

[72]Ibid. This recipe was drawn from Mizauld by Wecker, 405, from whence Weihe seems to have copied it.

[73]"Neue Invention das Glaß," 1723.

[74]Wanley, 226.

[75]Welsch, 57.

before the present Elector of Heidelberg." Not crediting the tale, Boyle's relator asked and was given leave "for his satisfaction, to lay the piece of Glass upon an Anvil, and to strike seven or eight strokes with a Hammer upon it," whereupon "it did really stretch under the Hammer."[76] The stories of gifts of malleable glass suggested an obvious question: did the recipients of such gifts act like Tiberius and keep them secret or share them for the public benefit? Contemporaries would have been well aware of the implications in a 1692 history of glass that recounted how Cardinal Richelieu had also been presented with malleable glass. Due to "raisons politiques" ("political reasoning"), he deemed it necessary to confine perpetually the inventor of this much-desired substance.[77]

Imagined Scientific Polities, 1620–70

Such political thinking about the benefits of bridging artisanal and learned cultures and of publicly awarding invention informed the development of new scientific polities. Writers of utopias imagined new institutional settings filled with storied objects. They stressed how in an ideal world, the discoverer of malleable glass would be honored. Some authors made the political valences of the object manifest. In Émeric Crucé's 1623 *New Cyneas*, a work proposing world peace and freedom of commerce, he states that "one ought to recognize artisans, and most of all the authors of beautiful inventions, and not do as Tiberius did who murdered he who discovered how to make glass malleable. This would be cutting off the path to industry."[78] Others were subtler. In the posthumously published *New Atlantis*, Francis Bacon (1561–1626) described many wonderful arts practiced within Salomon's House. These included "Glasses of diverse kindes; and amongst them some of Mettals Vitrificated, and other Materialls, besides those of which you make Glasse."[79] Rather than retelling the common Tiberian story, Bacon indicated a rather precise way in which malleable glass would be supplied—that is, through the vitrification of metal or some other materials not normally used in glass production. The 1631 French translator of Bacon's *New Atlantis* cut to the chase and simply rendered Bacon's vitrificated metals as "verre malléable" ("malleable glass").[80]

The novelist Charles Sorel (1602–74) likewise did not refer directly to Pliny's story, but his repeated interest in the valuation of malleable glass recalls Tiberius's concerns about the invention's projected effects upon the price of

[76]Boyle, 1691, 9–10.

[77]De Blancourt, 22.

[78]Crucé, 124.

[79]Bacon, 1628, 39. He had previously offered the superinduction of "tenacity upon glass" as an example of transmutation requiring the knowledge of forms, but also suggested that one should look for easier ways to achieve this goal. Bacon, 1620, 156.

[80]Bacon, 1631, 557.

gold and silver. In his *Science Universelle*, an ambitious attempt to collect all knowledge, Sorel argued that malleable glass should not be considered impossible.[81] An admirer of Crucé, Sorel also discussed malleable glass in several fictions.[82] An elaborate 1640 fable offered a way to imagine the reordering of knowledge, and in particular the union of nature and art through the personifications Physis and Tecnès. The two married, and Tecnès's workers developed inventions for the palace of Physis. One labored to discover "a secret" for making glass "able to bend, to spread beneath the hammer, and to remove all its fragility," hoping "that it would be valued more than the most exquisite materials."[83] Sorel imagined malleable glass again in a parodic newspaper, "La gazette heteroclite." There he reported on a ship voyaging beyond New Guinea to a land full of wondrous industries where malleable glass had become common and was used for coining money. The ship loaded its hold with malleable glass, a ware that doubtless would lower the price of porcelain and diminish the value of gold and silver.[84]

Several imitations of *New Atlantis* also described distant lands where malleable glass could be found. These included Samuel Gott's 1648 *New Solyma*, Johann Daniel Major's 1670 *Journey to a New World without a Ship or a Sail*, and the 1660 expansion of *New Atlantis* by one R.H. (probably not Robert Hooke, as some have surmised).[85] In the *New Atlantis*, Bacon had described galleries of statues celebrating inventors; in the 1660 *New Atlantis*, the galleries of statues now also included "the Effigies in transparent Christall of the unfortunate inventour of *Vitrum ductile* or malleable glass, whose invention *Tiberius* rewarded with death."[86] A little ark also preserved the lost objects themselves, including "that ducktile glass, which *Faber* [that is, "artisan"] the Inventour thereof first presented to *Tiberius Caesar* . . . which . . . we preserve as a sacred Relique in memory of the Inventour whom he put to death."[87]

Such utopias combined the longing for lost things with the optimistic envisioning of their recovery. It was not the case that in these alternative societies Tiberius had never murdered the artisan and malleable glass had never been lost. Rather, the art had seemed gone forever, but ideal social arrangements had succeeded in recovering not only the ability, but the original lost object itself. Its imagined passage through discovery, loss, and rediscovery endowed the fragment of glass with its charisma. Since Weber, we have associated charisma with

[81]Sorel, 1647, 3:74.
[82]On Crucé, see Sorel, 1667, 72.
[83]Sorel, 1640, 72.
[84]Sorel, 1644, 270–71.
[85]Gott, 34; Major, 1683, 59.
[86]R.H., 61; on R.H.'s identity, Freeman.
[87]R.H., 69.

celebrated individuals and their ability to galvanize large populations for political or cultural ends through a wondrous force or appeal. Yet Weber himself also employed the term for objects that could gather groups of people and elicit an emotive response.[88] While Weber stressed the force of a physical presence, it was an absence that haunted authors of utopian works.[89] Rather than merely the antonym of presence, absence can interact with material experience in complex and varying ways.[90] For those seeking to cobble together a new present from the ruins of the classical past, the absence of antiquity generated a particularly compelling cultural agency.[91] In this case, the celebrated lack of malleable glass engendered visions of new learned institutions that, by making knowledge public, might make it less subject to future losses.

Institutionalization, 1630–60

While malleable glass was appearing in numerous imagined scientific polities, it was also prominent in the often-imitated site of early scientific public making, the Bureau d'Adresse in Paris, founded by Théophraste Renaudot. The bureau held open conferences on a wide range of topics from 1633 to 1642.[92] There, the story of malleable glass was raised during a discussion of envy (16 April 1635)[93] and of glass (26 February 1636);[94] in answer to the question, "Were there more great men in a previous century than now?" (15 June 1637);[95] and in a discussion of the lost, ancient things, in answer to the question, "Would one rather know everything that men know now, or everything that they don't?" (7 June 1638).[96]

Samuel Hartlib, the London-based Prussian intelligencer who hoped to build a bureau on Renaudot's model, noted many accounts of malleable glass as part of his massive, continual collections from a wide range of informants. He copied "flexible or ductile glass" from a list Jakob Bornitz had composed of things that had been lost that should be found again.[97] In 1639, he noted that the follower of Bacon and Boehme, John Sparrow, was planning to "trie for malleablnes of glasse."[98] In 1650 he reported that his young protegé William Petty had

[88]Wingfield, 55. Cf. Jaeger, 8, who distinguishes between charisma for persons and aura for objects.

[89]Jaeger, 8.

[90]Bille, Hastrup, and Sørenson.

[91]Hui, 89–130.

[92]Mazauric; Wellman.

[93]Renaudot, 1636, 185.

[94]Renaudot, 1639, 25–29.

[95]Ibid., 350.

[96]Ibid., 474.

[97]Hartlib, [8/60/2A].

[98]Ibid., [30/4/6A].

successfully achieved it.[99] Evidently this was not so, for in late 1654 Hartlib was still on the hunt; he recorded that the chymist "Mr [Thomas] Smart learn't several secrets practised in a Glasse-house in Poland . . . of making malleable glasse, of which hee promised us the discovery."[100] Mr. Smart delivered a few months later, when Hartlib noted that "to quenche often Glasse when it is a making is said to make it malleable. But this must bee further tried."[101]

Few objects better dramatized the doubtful state of contemporary knowledge and the need for further trials than malleable glass. Many in the period, even chymists themselves, considered malleable glass to be impossible. According to the American adept George Starkey (1628–65), whose arcana were avidly sought by both Hartlib and Boyle, anyone who claimed to produce "malleable glass," and a number of the other "undiscoverable misteries of the Magi," should be considered a "praeposterous searcher after Natures secrets."[102] Some tried to warn investigators away from any further searching for malleable glass.[103] In his catalogue of errors, Thomas Browne chose a middle road, conceding that malleable glass might be possible: "He that would most probably attempt it, must experiment upon Gold," but the process "will prove no easie discovery."[104]

It was in part due to its tantalizing and debated position among potentially impossible things that malleable glass proved an alluring goal of experiment. The chymist, projector, and early cameralist Johann Joachim Becher (1635–82) recounted the visit of a know-it-all (*sciolus*) to his laboratory who lamented "the loss, among other things, of the malleability and ductibility of glasses." Becher, unable to satisfy him, mused that "it is human nature that we always aspire to the impossible and that we esteem those things which reek of impossibility."[105] In another work, Becher described malleable glass as one of the eight things for which "the learned and the curious" most often strove.[106]

The substance does indeed appear on a number of learned wish lists of the era, including those of Cassiano dal Pozzo's protegé, Georg Hieronymus Welsch (1624–77), and of founding fellows of the Royal Society and the Oxford Philosophical Society, such as, respectively, Robert Boyle (1627–91) and

[99]Ibid., [28/1/44B].

[100]Ibid., [29/4/26A].

[101]Ibid., [29/5/2B].

[102]Starkey, 59.

[103]Andreae, 259–61, "vitrum ductile"; Tollius, 37.

[104]Browne, 66.

[105]Becher, 1738, 207: "Sed ita natura comparati sumus, ut ad impossibilia semper adspiremus, eaque aestimemus, quae impossibilitatem redolent."

[106]Becher, 1682, 157–58.

Robert Plot (1640–96).[107] John Evelyn (1620–1706) composed a 1660 catalogue of trades discussed in the Royal Society as part of its early "History of Trades" project that aimed to move knowledge from secrets to the public.[108] Evelyn noted among the "Exotick & very rare searches," several lost arts such as "Malleable et more flexible Glasse" (a process for which Evelyn had also copied into a recipe collection).[109] In the eighteenth century, the editor of Bacon and Boyle, Peter Shaw (1694–1763), arguing that philosophers should survey and improve crafts, included on his list of desiderata, "Attempts to mollify Glass, or render it in some Degree ductile or malleable."[110]

Boyle selected malleable glass as an exemplary "optative" in his *On the Usefulness of Experimental Philosophy*, a work illustrating the ways philosophers could extend the comforts and powers of mankind beyond what common artisans would attempt. Boyle defined an "optative" (a Baconian term) as something that "should be propos'd, provided . . . that they be very difficult, & not impossible." Optatives like malleable glass were "not repugnant to the nature of things, nor the general Principles of Reason and Philosophie, and seem no otherwise to be Chymically or Mechanically impossible, than because we want Tooles or other Instruments and wayes to perform some things necessary to the compassing of the propos'd End."[111] Boyle begins by appearing to outline certain standards of impossibility: the "nature of things" and "general Principles." The standard for determining impossibility quickly fades away to shades of gray. In practice, there was often no way to distinguish between the reality and the appearance of impossibility. In the case of malleable glass, the ancient stories of Tiberius's murder of the inventor of the art might indicate the possibility of the invention. As Boyle himself argued, "the truth of that Story, if granted, would shew the retriving that Invention, a thing not to be despair'd of."[112] Yet this too was doubtful.

Boyle and his peers listed flexible, malleable, or ductile glass among things to be wished for not because they were certain that they could be found. Fellows of the Royal Society emphasized in print the seeming impossibility of this and other research goals. Boyle, for instance, argued that his laboratory phenomena would

[107]For Welsch, see Bayerische Staatsbibliothek, Munich, Clm 24122, 2^{v}, "XLIV. Vitrum malleabile, flexile, ductile, tractabile." For Boyle, see Royal Society, Boyle Papers, vol. 8, 208^{r}, "The making of Glass malleable." For Plot, see Bodleian, MS Ashmole 1810, 201^{r}, "To make glass malleable." For more on lost things and wish lists, see Keller, 2012a and 2015.

[108]Eamon, 343–47.

[109]Royal Society, London, Classified Papers, vol. 31, item 1. Evelyn, John. "The History of Arts, Illiberal and mechanick."

[110]Shaw, 39.

[111]Boyle, 1671, 2:24.

[112]Boyle, 1663, 2:174.

appear incredible to the vulgar. Shapin argues that, here, "it was the vulgar who suffered from an illegitimately and immorally restricted sense of the possible, not Boyle from credulity."[113] In this context, storied objects (while perhaps originally invented by a plebeian craftsman) were wondrous and seemingly impossible and, therefore, far from common. The storied object became a scientific one. Malleable glass could hardly achieve a more prominent position as a scientific object than securing a place on the research agenda of a new society. It became a prestigious research goal because it offered the model natural philosopher a means to demonstrate his open-minded skepticism and to differentiate himself from the vulgar, uncritical, and close-minded approaches of others.

HYALOMANIA AND THE ADVENT OF MALLEABILITY, 1660–90

In 1685, the physician Rosinus Lentilius (1657–1733), a recently elected member of the Academia Naturae Curiosorum, had just taken up a new position as city physician in Nördlingen.[114] That year he diagnosed in the pages of that academy's journal a contemporary glass craze, or "*Hyalomania*."[115] Evidence for *hyalomania* lay in the widespread research into a variety of curious glasses, such as the anaclastic glasses (vases blown with a thin bottom that could spring in and out without breaking) to which Lentilius's article was devoted. Anaclastic glasses, Lentilius argued, might be considered a form of flexible glass, as could, perhaps, flexible glass rods or broken glass embedded in a flexible matrix. Others researched various particular qualities of glass, such as its "porosity, malleability, rupturing by the human voice, or [the breaking of] glass tears."[116]

The *hyalomania* Lentilius diagnosed corresponds to an actual transformation of glass technology across Europe in the 1670s, including the making of lead crystal and the development of ruby glass.[117] In this heady period, glass researchers entertained a wide variety of possibilities for malleable glass. This range offers evidence of the opportunistic bridging of differing cultural streams, in contrast to prior divisions between classical, chymical, and practical sources discussing malleable glass. Lentilius himself surveyed the relevant ancient and modern sources and also explored a wide range of possible means, both mechanical and chymical, for rendering glass flexible or malleable. From the 1660s to the 1680s, the period of Lentilius's *hyalomania*, several accounts summarized a century of investigation into malleable glass.

[113]Shapin, 1994, 302.
[114]Heß,18:262.
[115]Lentilius, 490.
[116]Ibid.
[117]Von Kerssenbrock-Krosigk, 16.

Lentilius noted as well the proliferation of a wide range of new scientific objects, such as porosity and malleability, heralding the arrival of a new focus for scientific inquiry. Malleability would replace malleable glass as a central research preoccupation by the middle of the eighteenth century. This account of malleability is in contrast to Ursula Klein's argument that in the eighteenth century chemists shifted from a preoccupation with invisible entities to a greater emphasis on material substances allied to the world of craft.[118] The alliances to the world of craft were built much earlier (with the impressive seventeenth-century chymical advances in glassmaking to show for it). Meanwhile, many ostensibly material eighteenth-century scientific objects, such as malleability, are also qualities, and thus not material objects themselves.[119] The very same material substance, horn silver (discussed below), would be attached to varying scientific objects (malleable glass and malleability) across the seventeenth and eighteenth centuries.

The 1662 commentary of physician Christopher Merret, Fellow of the Royal Society, on the 1612 glass-making treatise of Antonio Neri contributed to the rise of malleability as a category and to a rash of defenses of malleable glass as a research goal. Neri mentioned malleable glass very early in his treatise, on the second page of his foreword to the reader. Thus Merret's opposition to malleable glass arrived early in his lengthy commentary and served to position him vis-à-vis the chymical tradition of glassmaking and prior attempts at bridge building between *chymia* and antiquity. Merret categorically denied malleable glass's possibility based on his view of matter. He argued that "diaphaneity" and "malleability" could not coexist within malleable glass. "Malleability" required a close adhesion of parts, whereas the ingredients of glass (salt and sand) were made up of sharp, pointed parts, which only touch in a few points, thus allowing for the pores that enable "diaphaneity."[120]

In his discussion of "the malleability of Glass," Merret berates the "Chymists" for not differentiating between the "flexibility" reported by Pliny and "malleability," as "if there were no difference betwixt flexible and malleable, whereas all bodies are in some degree, or other flexible, though none but metalls malleable."[121] This claim of chymical inattention to malleability is counterintuitive, since the quality of malleability first appeared among chymical writers. Michael Maier (1568–1622), for instance, discussed the malleability of metals such as gold and silver in a work of 1618.[122] For Becher, "fluid earth," a compound of simple particles, supplied the

[118]Klein, 2007; Klein and Spary; Klein, 2012; Newman.

[119]Klein and Lefèvre, 128, 164, for malleability as a central classification for metals in eighteenth-century chemistry.

[120]Neri, 1662, 237–38.

[121]Ibid., 231, 235.

[122]Maier, 14, 70, 87. Fabre, 544–45, likewise deployed "malleabilitatis" but prefaced it with "malleo extensibilia" ("extendable beneath the hammer").

principle of "malleability."[123] The term then shifted into Cartesian discussions and redefinitions of qualities. The Cartesian Henricus Regius (1598–1679) explored a long list of "qualities," which he defined as "the disposition of insensible particles." These included flexibility, fragility, ductility, and malleability (through the striking of a hammer, "ictu mallei") as in copper, gold, and iron. They also included transparency ("pelluciditas") as in air, water, ice, and glass.[124] Before Merret, *malleability* rarely appeared in connection to malleable glass. Only the linguistically inventive Thomas Urquhart referred in 1653 to the "malleability of glass" as one of the *deperdita*.[125]

Merret connected malleability to Pliny, arguing that it was based on the malleability of glass that the "Chymists build the possibility of making their Elixir, take [*sic*] their weak foundations from Pliny."[126] He exempts Pancirolli from blame, asserting that Pancirolli quoted the ancient sources "as a hear-say." However, "Mathesius, Goclenius, Valensis [Robert Duval], Quatriami, Libavius, and all the tribe of the Chymists, assert it with great confidence, affirming that it was done by the vertue of the Elixir."[127] The "tribe of the Chymists" Merret cites was composed of relatively recent authors, most of whom I have already discussed.[128] Guibert had likewise argued that chymists based arguments for transmutation on Pliny's lost glass, but chymical writers and recipe collectors did not generally refer to the glass mentioned by Pliny until the late sixteenth century. Merret's contention that chymists had long relied on Pliny's account is a misconception based on the particular debates surrounding academic alchemy a mere sixty years before.

Some contemporaries considered the neologism *malleability* awkward. In a 1668 history of *chymia*, the physician and professor at Copenhagen Ole Borch (1626–90) responded to Merret. He rendered Merret's phrase the "nature of malleability" in Latin as "natura malleabilitatis," but immediately apologized for the term as one that was convenient for his translation, but not classically

[123]Chang, 2015.

[124]Regius, 170, 179, 182.

[125]Urquhart, 32, "amongst the *antiqua deperdita*, as the malleability of glass, liquability of stone, or incombustibility of linen." The *Oxford English Dictionary*, s.v. "malleability," dates the first appearance to 1644.

[126]Neri, 1662, 231.

[127]Ibid., 232.

[128]A discussion of Pliny's account of rendering glass ductile appeared in a basic physics textbook edited by the Calvinist Rudolph Goclenius Sr. (1547–1628). Seidel and Goclenius, 350. Evangelista Quattrami (1527–after 1602), a botanist and distiller in service to the Este family of Ferrara, refers to malleable glass several times as a product of the red tincture, but does not connect it to the Plinian story. Quattrami, 14, 54, 66; on Quattrami, see Egmond, 91–95, 97, 104.

acceptable ("in order to express myself in a manner that is convenient, if not classically acceptable").[129] Borch proved an ardent defender of malleable glass. In a later oration at the University of Copenhagen on the *deperdita* of Pancirolli, he would argue that the moderns had succeeded in recovering many of the lost things. Their recovery of such objects as the ancient glass proved how they could compete with the ancients.[130] In his 1668 history, Borch stressed the antiquity of the substance, contributing as it did to the ancient pedigree of *chymia* he was attempting to defend, like Duval before him.

Borch offered several ways to understand malleable glass. The glass might be made with a "ductile salt," such as the one he had himself discovered in Leiden. Or, referring to the chymical tradition, Borch recalled how Ramon Llùl had testified to the production of a chymical gem, or a "ductile Chemical mass," which Borch thought might have been horn silver (*luna cornua*). Horn silver is a ductile, malleable, transparent crystal either found naturally or made of silver, aqua fortis, and salt. It began to be known as "horn silver" in the sixteenth century and is today called "silver chloride."[131] Some of the earliest mentions of "horn-colored silver" ("hornfarb Silber") are to be found in the sermons of Mathesius, who introduced many mining terms to a literate audience.[132] Borch thought that whether horn silver could be formed into a ductile vessel and thus supply the object of Pliny's story could be shown through an "easy experiment."[133]

Structural changes to glass also offered a way to understand the ancient story. Descartes had suggested that glass was inflexible since its particles only touched in a few places; therefore, Borch suggested, one might search for a way to render the particles of glass smaller, so that they would come in contact in more places.[134] Flexible glass certainly did exist, Borch asserted, as he had seen a demonstration of it by one of the more ingenious performers in the public fair in Lyons, who, melting glass with a lamp, spun it into a most slender thread, revolving it around a wheel about thirty times. After it cooled it formed a glass that would bend under the hammer.[135] Natural materials, such as "muscovy glass" (mica, a flexible and transparent or translucent mineral), were also candidates.[136]

[129]Borch, 1668, 117: "ut ita expressiùs reddam quàm politiùs." Furthermore, he considered it necessary to define the term in simple language in an additional aside. This definition took issue with Merret, as it combined what the latter would have distinguished as ductility and malleability: "malleability . . . (that is, a ductile giving way beneath the hammer)": ibid.

[130]Borch, 1715, 2:97–144, 122–23 ("Oratio de deperditis Pancirolli" [1685]).

[131]Nye.

[132]Mathesius, xl^{r}; Waterhouse.

[133]Borch, 1668, 114.

[134]Ibid., 116.

[135]Ibid., 113–15.

[136]Ibid., 119, "for what is that Muscovite talc . . . but a very thin and flexible natural glass?"

Daniel Georg Morhof (1639–91), professor of poetry at the University of Kiel, assessed Borch's 1668 arguments in a 1672 tract, *De Scypho Vitreo per Certum Humanae Vocis Sonum Ruptô* (On the glass cup broken by the sound of a human voice). Morhof had witnessed this feat in Amsterdam, performed upon a *roemer* glass by the wine merchant and wrestling master Nicolaes Petter (1624–72). Continuing on to London in 1670 in order to meet the fellows of the Royal Society, Morhof eagerly brought this phenomenon to their attention. His presentation of this tavern entertainment to the society indicated his willingness to draw on a wide social register for natural-philosophical speculation and experiment. Morhof himself tested the phenomenon and, on his return home via Amsterdam, brought along several admiring friends to observe Petter repeat the feat.[137]

Morhof's exploration of the acoustic shattering of glass included a thorough review of the question of malleable glass. He thought Christopher Merret and others were right to raise doubts about the substance. He was not certain about Borch's claim that animal materials such as horns could count as malleable glass, since they were very different from glass. A metallic malleable glass could be made if the transparent, incombustible, and viscous metal, of which the possessors of great arcana boasted, really existed.[138] But flexible glass seems like it should be possible without the secret of the elixir, as numerous experiments have shown, he said, recounting several reports. Many recipes, however, were false. He recounted one for malleable glass that, he suspected, "like many others piled up here and there, deceives the greedy."[139] Morhof had more reliable sources. In London, he heard from Robert Boyle himself, "who admitted me to his most learned conversation," that it was possible to produce glass without the fire that gave it its fragility. With his own hands, Boyle claimed, he had prepared false gems made not through fire, but with water, that were so beautiful they appeared real."[140] Morhof would also later report that Henry Oldenburg informed him how malleable glass had been produced in England.[141]

Johann Daniel Major (1634–93), to whom Morhof had dedicated his 1672 letter on the acoustic breaking of glass, also submitted that year an observation on "salts concreted into a glassy, flexible plate" to the journal the *Miscellanea Curiosa*. Major, Morhof's Cartesian colleague at the University of Kiel, argued that it would be possible to have transparent, flexible matter if curved corpuscles

[137]Morhof, 1672, [A4]^{r}.

[138]Chymical writers suggested such an oily material as a means of countering the fragility brought on by glass's drying by fire: e.g., Fabre, 534.

[139]Morhof, 1672, [B]^{v}: "Sed vereor, ne & hoc cum plurimis aliis illic congestis corvos deludat hiantes."

[140]Ibid., [A4]^{v}–[B]^{v}.

[141]Morhof, 1747, 2:415 (book 2, part 2, chapter 24: "De Vitro & Gemmis artificialibus").

were linked together as in a coat of mail; such a structure would allow one to explain "flexibility, softness, coherence, malleability, tensility, and retension, without recourse to I don't know what unctuous principle [a denigrating allusion to the chymical tradition]." Proof for this lay in sheets of muscovite talc (which he termed "natural flexible glass"), in artificial flexible glass, in membranes, horns, beaks, and other animal parts, as well as in many of the curved structures of nature.[142] Malleable glass was thus theoretically underdetermined. One could, based upon invisible corpuscular structures, argue either for its possibility (as did Borch and Major) or against it (as did Merrett and others).[143]

More important than any empirical or theoretical findings in accepting or rejecting malleable glass was the desired persona of the investigator. Merret's rejection of malleable glass as a fiction of chymists was unusual among active members of the early Royal Society. Peers such as Robert Boyle, Henry Oldenburg, and William Petty all urged or were said to have already discovered the art, which was equally prestigious in the Oxford Philosophical Society. They participated in a widespread, sociable pursuit of nonextant objects dreamed of in utopias and wished for in collaborative research agendas. Merret's Central and Northern European opponents also explored a notably wide range of sources and did not hesitate to draw, for instance, on tavern and fairground performances for phenomena to investigate. Perhaps Merret's position speaks more to the other battles he was waging as a fellow of a different organization, the Royal College of Physicians, attempting to define its professional expertise against encroachments from apothecaries and surgeons.[144]

HORN SILVER: FROM EVIDENCE FOR MALLEABLE GLASS TO EVIDENCE AGAINST IT, 1689–1823

Lentilius, Borch, Morhof, and Major all treated the question of malleable or flexible glass at length in works ostensibly devoted to other topics. The question had become too prominent to ignore. By contrast, the qualities of glass such as flexibility or malleability were only just beginning to achieve prominence as scientific objects unimpeded by a storied past. The very same material, horn

[142]Major, 1672, 430–31.

[143]For Chambers, 2:489–90 (s.v. "Malleable"), the differing placement of the "pores" of "ductile" and "transparent" bodies proved malleable glass a "popular error." Likewise, one could later argue for or against malleable glass based on the eighteenth-century theory of phlogiston. Phlogiston supported Macquer's contention that something could not be both transparent and malleable: P. Macquer, 2:582. Meanwhile, the unorthodox glassmaker Bosc d'Antic, 2:84, argued that the theory of phlogiston meant that malleable glass was "not a chimera, and should not be placed among the impossibles." On Bosc d'Antic, see Beretta, 2012.

[144]Koin.

silver, which had previously offered a possible identity for malleable glass, came to be seen as a hard fact proving the falsity of the ancient story. The new role of horn silver had its origins in a throwaway remark by Johann Kunckel (1630–1703). In 1689, Kunckel, one of the great glass innovators of the period, translated Merret's commentary upon Neri, this time into German. Kunckel remained easygoing concerning the question of glass's flexibility, noting that he himself could make a transparent, bendable vessel out of horn silver. "As for the softness of glass, I let everyone think what he will. I myself think that such a thing never existed in the realm of nature. This, however, I do believe: that something exactly like glass (as far as appearance goes) which can yet be bent and hammered, could be discovered or prepared, for that is known to me. Moreover, I can make a transparent goblet out of silver with all sorts of figures engraved, carved, or even hammered upon it."[145]

Anyone who had read Borch's discussion of Merret would also have encountered there horn silver (as evidence for malleable glass). Indeed, Kunckel continued to acknowledge, "perhaps someone will say it is nothing new to make a *Luna Cornua*; but he should first try to bring it into such clarity and transparency in the form of a goblet through which one can see the wine and beer; you'll find plenty of novelty in that."[146] Kunckel did not make a rigorous point about the malleability of glass, nor did he linger upon the differences between metal and glass.[147] Rather, he claimed priority in invention for an object that perfectly answered Pliny's story—that is, a goblet. This offhand remark metamorphosed into a rejection of the ancient story of malleable glass, pinned to authorities within the newly configured discipline of chemistry, Johann Friedrich Henckel (1678–1744) and Caspar Neumann (1683–1737). Henckel and Neumann were students of Georg Ernst Stahl (1659–1734), the academic who attempted to recast *chymia* into a professionalized, more clearly defined field of study.[148] In the generation before Stahl, roving chymists and

[145]Kunckel, 312: ""Was die Geschmeidigkeit deß Glases betrifft / lasse ich einen jeden davon glauben / was er will / halte aber meines Theils davor / daß dergleichen niemals in Rerum Natura gewesen; dieses aber glaube ich / daß wohl etwas / so dem Glas (dem Gesicht und Ansehen nach) gleich und ähnlich / welches sich doch biegen und hämmern lässet / könte gefunden oder bereitet werden; wie mir denn dergleichen selbst bewust / ja ich will einen ganz durchsichtigen Becher aus dem Silber machen / welcher sich docht mit allerhand Figuren soll stechen und graben / ja guten Theils hämmern lassen."

[146]Ibid., 312–13.

[147]Kunckel skipped over the difference between metal and glass, defining glass as a composed stone made of sand and salt. Ibid., 312.

[148]Lawrence Principe and others see Stahl as a central figure in a disciplinary transformation of eighteenth-century chemistry, with the development of a newly professionalized persona of the academic chemist. Principe; Chang, 2007.

projectors such as Becher and Kunckel (as well as Johann Rudolf Glauber and Johann Christian Orschall) effected a great leap forward in glass production.[149] Stahl admired the achievements of these figures, but not their projecting personas. Stahl and his students inherited and recast the researches of Becher for the new academic disciplines of the cameralist sciences.[150]

In the works of Stahl's students and admirers, Kunckel's casual and ambivalent remarks on horn silver came to serve a new role, differentiating the professional chemist from the credulous pursuers of malleable glass. Henckel, in a discussion of Merret and Kunckel, repeated the latter's suggestion that horn silver might be malleable glass.[151] In a lecture for students, Caspar Neumann noted that through horn silver one might make a pliable silver that was to some degree malleable. He mentioned that the great "chymic, metallurge, and philosopher, the mining councilor Henckel [believed] that this could be the famous malleable glass of the ancients."[152]

The philosophe Paul-Henri Thiry, Baron d'Holbach (1723–89), a collaborator on Diderot's *Encyclopédie*, specialized in translating works of German chemists into French. In 1752, he combined Neri, Merret, and Kunckel with a slew of more recent publications on glass, enamel, and porcelain. D'Holbach placed an asterisk next to Kunckel's description of his transparent goblet directing the reader to the views of Neumann and Henckel on horn silver.[153] The author of the article on glass in the *Encyclopédie* called malleable glass "a chimera that judicious physics absolutely denies," suggesting that Pliny's glass might have been horn silver.[154] In a note to his 1823 English translation and methodization of Neumann's works, William Lewis, Fellow of the Royal Society (1708–81), remarked that Kunckel's discovery suggested what "gave rise to the notion of malleable Glass."[155] Horn silver, from a viable understanding of the famous malleable glass, became evidence deployed against it.

[149]Hunt.

[150]Smith, 1994, 19–21.

[151]Henckel, 469.

[152]Neumann, 502.

[153]D'Holbach, 1752, 303. The next year, d'Holbach published his translation of the mineralogy of Waller (a professor of chemistry at Uppsala), who also suggested that horn silver could explain malleable glass. Wallerius, 234; Beretta, 2012, 376; Chang, 2015, 124–25. The review of the work in the *Journal des sçavans* also drew attention to Kunckel's, Neumann's, and Henckel's views of malleable glass. See *Le journal des sçavans* (1752), esp. 652. Johann Wilhelm Baumer (1719–88), professor of chemistry and natural history at Giessen, likewise described in a 1783 textbook chapter on horn silver how Johann Friedrich Henckel suspected that this was the malleable glass of the ancients; Baumer, 517, also drew attention to Boerhaave and Neumann's accounts of horn silver.

[154]Diderot, 17:92, "une chimere que la saine physique dément absolument."

[155]Lewis, 72.

When storied objects served as scientific objects, the substance of malleable glass might be anything that fit the parameters of the story. In the seventeenth century, therefore, horn silver, a cutting-edge chymical product, offered a plausible candidate for malleable glass. When storied objects became reclassified as common knowledge external to scientific discourse, the object mentioned in the story was also assumed to be mundane. The glass in the story was therefore assumed not to be a metallic glass, but what was commonly understood to be glass. Then, a more exotic chemical object such as horn silver (which had previously transitioned from a miner's term to a material in cameralist chemistry) appeared as a deus ex machina, offering a scientific explanation demonstrating the falsity of the common story. Malleability ousted malleable glass as the scientific object to which the material substance of horn silver was related.[156]

CONCLUSION: THE VULGARIZATION OF A SCIENTIFIC OBJECT

This account of the scientific object malleable glass has tracked its fortunes alongside constantly shifting assumptions concerning the borders of disciplines, the persona of the ideal investigator, and the intended audience for science.[157] It has sought to show how attention to nonextant, storied objects like malleable glass has much to tell us about scientific objects more generally. The latter, by definition, are also not extant in a mundane, hard-edged way, but require attention to come into being. That attention can be centuries in the making. While epistemic things or scientific objects have been historicized in the past, they have been embedded within particular experimental systems or networks.[158] The case of malleable glass reveals how much more tectonic shifts merged separate cultural streams, slowly consolidating malleable glass as a focus of research. Rather than emerging abruptly from within an experimental system, malleable glass helped constitute a new scientific public through the gradual union of a storied object with experimental practice. Not all scientific objects, however, are storied objects. The tenure of this storied object as a scientific object lasted for a century. Given the length of time malleable glass could be found in the popular realm (from the first through the nineteenth centuries), this was relatively brief, but, I argue, consequential.

Storied objects encouraged speculation about the material world. It was their peculiar position between materiality and imagination that, I contend, gave malleable glass and other *deperdita* a role in the development of experimental

[156]Duchesne, 3:716, referring to Kunckel, Neumann, and Henckel on horn silver, claimed that "the state of malleability is in contradiction with the state of vitrification." Porter, 111, drew on Duchesne and in turn informed other reference works.

[157]Daston has suggested that we see such accounts as biographies.

[158]Ibid., 12–13.

targets from ca. 1580 to ca. 1690. Storied objects showed how objects of experimental interest were not divorceable from the moral, political, and spiritual meanings with which they had become encrusted. In the seventeenth century, when a broad, participatory experimental culture was desirable, those multiple valences and varying registers allowed bridges to be built between disciplines and audiences. Spiritual ends motivated the merger of practical and classical traditions. The introduction of *chymia* to the academy and the later political deployment of the object activated the full register of its associations (practical, moral, historical, and spiritual). This union highlighted the absence of ancient bendable glass and cast the many currently circulating recipes and claims to the *vitrum malleabile* of the philosophers' stone into doubt. Efforts to resolve the question experimentally drew on the social aspects of the storied object in order to inform the institutions for the collection and circulation of all experimental knowledge.

The doubts that attended ancient, storied objects encouraged debate. The realm of doubtful, nonextant objects was not as separate from the empirical testing of extant materials as might at first appear. New and emerging inventions such as telescopes were also understood in terms of storied lost objects, such as Archimedes's enormously powerful burning glass.[159] On the other hand, seemingly practical recipes for everyday household objects might not have been regularly performed or tested, as the centuries-long duration of ineffectual recipes for softening glass indicates. The malleable glass of the recipe tradition only masqueraded as a mundane, material object, but was in fact a fiction. The same textual processes of collecting and transcribing kept both the recipe for malleable glass and the commonplace of the ancient flexible glass in circulation.[160]

Storied objects fell out of the scientific realm due to the changing persona of the professional chemist. Elusive and celebrated goals were seen as eliciting a widespread culture of experiment, but scholars increasingly distanced themselves from this popular excitement. In his rejection of malleable glass as a physical impossibility, the chemist and glass innovator Pierre-Joseph Macquer (1718–84) argued that it is "advantageous that men should be excited" by insoluble problems like malleable glass, since other discoveries (such as metallic and colored glasses) have emerged from their researches. It is even "useful to present these problems as though they were soluble in order to better animate emulation." "True scholars," however, would not waste their time on these vain quests.[161] The academician René-Antoine Réaumur (1683–1757), who

[159]Reeves, 2008.

[160]Blair discusses the transformation of the commonplacing tradition, from mainly classical texts to contemporary and natural knowledge.

[161]P.-J. Macquer, 5:339–40. He extended the remarks on the topic previously made in the dictionary edited by his brother, P. Macquer, 2:580–81.

invented a technique of spinning flexible glass threads, objected strenuously when others cast him as a defender of malleable glass.[162]

One might argue that the decline of the ancient *deperdita* was purely a function of declining respect for antiquity. These objects, however, long endured outside the realms of newly professionalizing scientific disciplines.[163] Space does not permit extending this longue durée survey that far, but one anecdote will illustrate both the longevity of malleable glass and its rejection as a sign of chemical professionalism. In the late nineteenth century, the popular orator Wendell Phillips (1811–84) traveled around the United States speaking nearly two thousand times on the "Lost Arts," and among them, malleable glass.[164] According to Phillips, one evening in New Haven no less an auditor than Benjamin Silliman (1779–1864), professor of chemistry at Yale, approached the podium, informing Phillips that malleable glass was "nearly a natural impossibility, and that no amount of evidence could be brought would make him credit it."[165]

The scientific career of the storied object could be compared with that of monsters, which drew on similar emotions of wonder and excitement, and which enjoyed a brief heyday as scientific objects.[166] By the mid-eighteenth century, malleable glass no longer appeared scientific because the storied object, like monsters, had gained a vulgar status. This is also when, according to Daston, "that which is made edged closer to that which is made up, to fabrication or invention in the pejorative sense."[167] This unease with the role of imagination or legend in discovery "still haunts our discussion of scientific objects."[168] Newly professionalized chemists "began to associate continuing belief in several entities and phenomena that previously had been acknowledged as within the bounds of nature, with the lower strata of society, foreigners and the mentally ill."[169] Malleable glass was one prior learned interest recharacterized as a vulgar fiction.[170] Rather than being praised as exemplary bridge builders, scholars who persisted in aiming for seemingly impossible goals drawn from far different social registers were themselves accused of acting below their status. In 1716, Johann Burckhardt Mencke (1674–1732) would criticize the "charlatanry" of naturalists who thought everything researchable, including the "rediscovery of the art of making glass soft."[171]

[162]Réaumur, 1:154–56.
[163]E.g., Dutens.
[164]Yablon, 179.
[165]Phillips, 13.
[166]Daston and Park, 240.
[167]Daston, 4.
[168]Ibid., 5.
[169]Fjors, 5.
[170]Krämer.
[171]Mencke, 201, citing Johann Joachim Becher.

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