CHAPTER 2

Daedalus and Proteus
Satire and Useful Knowledge in Seventeenth-Century England

What earlier technical writings were the mock arts mocking? The limits of written instruction were tested in a range of didactic texts written by prominent seventeenth-century projectors and natural philosophers. This chapter assesses the special relevance of some of them to later responses by eighteenth-century satirists. It does so with a reservation, though – that this might not be quite the right question to ask. The argument of the first two sections below is that a tendency to indirect, ironic, often self-parodic expression was present already in the early-modern literature of useful knowledge. The eighteenth-century mock arts exaggerated a prior characteristic of their seventeenth-century didactic targets, in other words. Their satirical position was not a distinct or negative one. It was present first and most conspicuously in the writings of Francis Bacon. Oblique and fiction-making expressions are especially characteristic of passages in Bacon's works that discuss technological expertise and mechanical innovation. They coalesce, moreover, around a specifically literary problem in practical scientific writing. The ingenuity and inventiveness of advanced mechanicians is caught up, as Bacon and his followers recognised, with certain habituated skills and bodily aptitudes that are nearly impossible to specify in words. These skills defy literary description, and they mark its limitations. The satirical, fantastical and elaborately reflexive affordances of utopian fiction offered Bacon and his acolytes a way to express this frustration. They also model some oblique strategies for writing and thinking one's way around it.[1]

The mock arts written by Swift and his circle were not direct or reactive parodies. The works discussed in the later chapters of this book tend not to burlesque particular didactic texts, in the way that Swift's 'Meditation on a Broom-Stick' (1708), for example, burlesqued the natural philosopher Robert Boyle's *Occasional Reflections* (1665) and was plausible enough in its absurdity to be taken as Boyle's work.[2] The intertextuality that connects mock-didactic satires with the early Enlightenment literature of useful

knowledge is more indirect than that.[3] It is true that 'Peri Bathous' (1727) tilted at the laborious poetical 'Arts' published by Alexander Pope's Grub Street contemporaries and that Jane Collier's *Art of Ingeniously Tormenting* (1757) mimicked the female conduct books of the day. Yet in neither case have modern editors of these works felt comfortable identifying direct sources or targets.[4] Swift and his circle seem to have been pre-imagining literary abuses that were consistent with modern writing practices but that happened not to have been committed yet. Their satire works creatively and proleptically. In other cases, as we will see in Chapters 3 and 5, there is an intertextual relationship with an accessible classical model – Horace's *Ars poetica* or Virgil's *Georgics* – where a secondary satirical component in the ancient original is isolated and emphasised. In none of these cases is the generic coding of the mock arts straightforward.

The Vexations of Art

The mechanical arts had an important place in Bacon's inductive methodology, and he was always conscious of the peculiar literary difficulties involved in their description. So he proposed a style for writing about them (the 'HISTORIE MECHANICAL') that corresponds with the doubleness and indirection, as he saw it, of craft practice. In a section of the *Advancement of Learning* (1605) that did much to set the agenda for the artisanal Enlightenment and its instructive literature, Bacon observes how the mechanical arts put a salutary but violent restraint on natural materials. The analogies that he uses are characteristically witty and conceited. They have more than a touch of satire about them:

> But if my iudgment bee of any waight, the vse of HISTORIE MECHANICAL, is of all others, the most radicall, and fundamentall towardes Naturall Philosophie, such Naturall Philosophie, as shall not vanish in the fume of subtile, sublime, or delectable speculation, but such as shall bee operatiue to the endowment, and benefit of Mans life: for it will not onely minister and suggest for the present, Many ingenious practizes in trades, by a connexion and transferring of the obseruations of one Arte, to the vse of another, when the experiences of seuerall misteries shall fall vnder the consideration of one mans minde: But furder, it will giue a more true, and reall illumination concerning Causes and Axiomes, than is hetherto attained. For like as a Mans disposition is neuer well knowen, till hee be crossed, nor Proteus euer chaunged shapes, till hee was straitened and held fast: so the passages and variations of Nature cannot appeare so fully in the libertie of Nature, as in the trialls and vexations of Art.[5]

As Bacon explained in his sketchbook of classical mythography *De sapientia veterum* (1609; tr. 1619), he took the figure of Proteus to represent the stuff of the world, the materials that makers work upon.[6] In Virgil's fourth *Georgic* the shepherd Aristaeus, who has lost his bees, is told by his mother Cyrene that Proteus can show him how to restore the hive but that he will try to avoid doing so by changing shape. Aristaeus must surprise Proteus in his sleep and bind his hands and feet.[7] Like Aristaeus, the natural philosopher grapples with protean matter by main force, Bacon explains, 'vexing, and vrging her with intent and purpose to reduce her to nothing'. He finds through experiment, however, that these violent manipulations do not annihilate the stuff at hand. Instead, matter 'doth change and turne her selfe into diuers strange formes and shapes of things' and returns at length to its original disposition.[8] Bacon draws a connection between Aristaeus's wrestling of Proteus and the natural philosopher's 'vexing' of matter by experiment.

There is also a sense in these passages that he plans to bind and discipline 'many ingenious practizes in trades' – the work of artisans and mechanicians – by the processes of scientific specification. In interdisciplinary description, in laboratory experiment and in mechanical practice, knowledge is produced by a kind of violence and bondage.[9] What brings Bacon's prose alive here is an extra dimension of moral and literary analogy.[10] A person's character is difficult to discern, writes Bacon, 'till hee be crossed' – such crossings being precisely the business of satirical writing. Bacon's talk of 'Vexations' suggests a further connection with satire. The word was associated particularly with Juvenal's satirical style. Vexations suffered and revenged occupy the opening lines of his first *Satire*. Swift later adopted 'vexing' as a keyword for his own Juvenalian agenda: 'to vex the world', as he wrote to Pope on 29 September 1725, while correcting *Gulliver's Travels*, 'rather then divert it'.[11] When Bacon describes the 'trialls and vexations of Art' his prose aligns itself briefly with the perversity of the satirist. In doing so, he seeks a way of imitating in his style the twisting and restraining actions of the mechanic.

Another myth that Bacon used to help think his way into the mechanical arts, and to write his way out of them, was that of Daedalus, the ancient world's legendary master artisan. Once again, Bacon's classical materials had a distinct tendency towards satire. Daedalus is 'a man ingenious, but execrable', wrote Bacon in *De sapientia veterum*, distinguished by his skill as an engineer but notorious for his 'works of mischeefe'.[12] He contrives the machine that allows Queen Pasiphaë to mate with the white bull of Poseidon, for example, and must then build a

labyrinth to house their offspring, the Minotaur. Bacon sees in the labyrinth

> an excellent Allegory, whereby is shadowed the nature of Mechanicall sciences: for all such handicrafte works as are more ingenious and accurate, may bee compared to a Labyrinth in respect of subtilty and diuers intricate passages, and in other plaine resemblances, which by the eye of iudgement can hardly be guided and discerned, but onely by the line of experience. Neither is it impertinently added, that hee which inuented the intricate nooks of the Labyrinth, did also shew the cõmodity of the clue: for Mechanicall arts are of ambiguous vse, seruing as well for hurt as for remedy, and they haue in a manner power both to loose and bind themselues.[13]

The 'line of experience' and the loosening or tightening intricacies of the maze are both allusions to 'that ingenious deuice concerning the clue of threed' invented by Daedalus and used later by Theseus to get out of the labyrinth once he has killed the Minotaur.[14] Bacon intends the 'cõmodity of the clue' here to include a contrast with Proteus, the figure of nature who cannot loosen his own bonds. The implied distinction between Protean materiality and Daedalean craft is an important one. Bacon writes in the 'Parasceve' attached to his *Novum organum* that practical arts dealing with the preparation of materials – paper-making, dyeing, agriculture, glass-making, and so on – are far more significant to natural philosophy than the more intricate technologies of machines and devices. His reason is that mechanical arts such as carpentry or clock-making 'consist principally in the subtle motion of the hands or instruments' and that these crafty motions are not retraceable.[15] Only the elusive and unreliable 'line of experience' leads from the machine back to its human elements.

Like the subtle passages of the craftsman's hands, the products of the mechanical arts resist complete codification, and it is not always possible, Bacon warns, to recover the clue of their principles by experiment. Earlier writers on the mechanical arts had made similar observations. The Huguenot ceramicist Bernard Palissy, whom Bacon may have met, made the allegorical figure of 'Practice' tell 'Theory' that 'if I used a thousand reams of paper to write down all the accidents that have happened to me in learning this art, you must be assured that, however good a brain you may have, you will still make a thousand mistakes'.[16] Bacon's 'line of experience' is a kind of knowledge that is similarly fallible and personal. It is a vanishing, Daedalean thread of knowledge and one that begins and ends with the unreliable craftsman himself. The new thing that Bacon proposes, however, is a literary style in which to attempt the 'historie mechanical'.

It must involve expressions as subtle as they are ingenious and mischievous, 'seruing as well for hurt as for remedy'. An effective 'historie mechanical', in other words, will have many of the characteristics of satire.

Without All Affectation of Strangeness

The early modern literary genre that dealt most consistently with this uncanny component in the mechanical arts was utopian fiction.[17] A common theme in seventeenth-century utopias is that objects of practical technology can in different contexts be experienced either as strange and unknown, or familiar and everyday. Many of these fictions ask how the citizens of an ideal but isolated community would respond to the introduction of technical innovations from abroad. One of the things that distinguishes the natives of Thomas More's *Utopia* (1516), for example, is their extraordinary capacity for working out the mechanical processes that lie behind foreign manufactures and inventions. None of the European fellow travellers with Raphael Hythloday (More's narrator) has the practical experience to explain the processes of printing or paper manufacture to the Utopians, who are yet to discover it. Yet when the travellers show them a book from the Aldine Press at Venice their hosts 'forthwith very wittily conjectured the thing' and rapidly develop their own versions of typefounding and letterpress work, designed backwards from the finished article, in a manner that Bacon would soon judge (as we have seen) to be methodologically topsy-turvey.[18] More takes printing as the representative modern European technology, and this allows him to locate a readerly dimension to the Utopians' ingenuity, in which divinity plays its part as well. The Utopians believe that their maker, 'according to the fashion of other artificers', has 'set forth the marvellous and gorgeous frame of the world for man with great affection inventively to behold'.[19] Wit, creativity and cognitive agility are at the heart of the Utopians' mechanical aptitude, which More also thinks of as related to a devotional capacity for reading the material world.

The Utopians' interpretative openness makes them especially kindly to ingenious travellers, whom they 'entertain wondrous gently and lovingly'. In Bacon's own utopia, the *New Atlantis* (published 1626), this assumption of technological superiority is reversed. When Bacon's traveller-narrator to the island of Bensalem visits Salomon's House, a utopian centre for scientific research, the institution's Father assures him that they have 'divers mechanical arts, which you have not; and stuffs made by them'.[20] Written codification and the making of books is once again a

distinguishing element of the Bensalemites' advanced technology. The 'patterns and principals' of any manufacturing processes invented are carefully recorded, in line with Baconian prescription. At first no reference is made to inventions from abroad. But when the Father lists the officers of Salomon's House, the first he mentions are twelve 'Merchants of Light' who travel to gather 'books, and abstracts, and patterns of experiments' from foreign parts.[21] The most peculiar thing about the research infrastructure of Bensalem, however, is that it includes a special facility for purifying knowledge through a sort of institutionalised satire. The last department of Salomon's House mentioned by the Father is a house 'of deceits of the senses',

> where we represent all manner of feats of juggling, false apparitions, impostures, and illusions; and their fallacies. [. . .] we do hate all impostures and lies: insomuch as we have severely forbidden it to all our fellows, under pain of ignominy and fines, that they do not show any natural work or thing, adorned or swelling; but only pure as it is, and without all affectation of strangeness.[22]

The decision both to forbid and to display this collection of impostures, whatever they may have been, seems paradoxical. Juggling, false adornment and illusion – each identifiable with the subtle dexterity, ingenuity and creative power of Daedalus, the execrable mechanician – have in the process been cordoned off, but also institutionalised. Bacon wrote in the *Novum Organum* about the uses of studying '*Deviating Instances*', a knowledge of nature's monsters tending both to 'fortify the intellect against custom and reveal common forms'.[23] His 'house of deceits' is something more dubious. It is artificially rather than naturally monstrous, devious rather than deviating. But it seems to offer a similar service. The 'house of deceits' is like a satire on the rest of Salomon's House. It is a dysfunctional annex to an otherwise luciferous and utopic institution, as though a negative, parodic structure were required to make clear the positive meaning of this fictional place. Bacon seems to be saying that the natural sciences and technical arts need satire, in the shape of an institution of deceiving mock arts, to give them definition.

Where Bacon's vignette of the 'house of deceits' is discreetly set to one side in his account of Bensalem, a third, slightly later utopic fiction also concerned with the applications of natural philosophy – Margaret Cavendish's *Description of a New World, Called the Blazing World* (1666) – is contrastingly extravagant in its satirical gestures. It is fantastic, diffusive and aggressively parodic. Cavendish turns to the Menippean satire of Lucian of Samosata for her literary model, applying his comedy

of diminishing scales and perspectives to modern optics and microscopy some sixty years before Swift made a similar satirical connection in *Gulliver's Travels*.[24] In Lucian's *Icaromenippus, or the Sky-Man*, philosophers' squabbles over the nature of the heavens bore the hero Menippus. Deciding to inspect them himself from the moon, he mimics Daedalus' invention of artificial wings, borrowing those of a vulture and an eagle, which magically give him an eagle's telescopic vision. From space he makes a survey of the earth, where cities appear like anthills, and the great estates of the rich like Epicurean atoms.[25] Cavendish adapts several of these narrative elements to even more outlandish effect. The court of the Empress of the Blazing World is attended by various animal-human hybrids, including flying bird-men (representing astronomers) and bear-men (natural philosophers). The microscopes and telescopes used by these creatures cause arguments, much to the irritation of their monarch:[26]

> for, said she, now I do plainly perceive, that your glasses are false informers, and instead of discovering the truth, deluded your senses; wherefore I command you to break them, and let the bird-men trust only to their natural eyes, and examine celestial objects by the motions of their own sense and reason. The bear-men replied, that it was not the fault of their glasses, which caused such differences in their opinions, but the sensitive motions in their optic organs did not move alike, nor were their rational judgments always regular: to which the Empress answered [. . .] nature has made your sense and reason more regular than art has your glasses, for they are mere deluders, and will never lead you to the knowledge of truth.[27]

The bear-men end up begging the empress to spare their instruments from destruction. They make comic confessions to their love of disputes, and to their taking 'more delight in artificial delusions, than in natural truths'.[28] Cavendish alludes here to Bacon's reflections in the *New Atlantis* on sensory deception and to passages on optical experimentation, telescopy and microscopy as well. In addition to the department of deceits, Bacon describes 'perspective-houses, where we make demonstrations of all lights and radiations', together with 'all delusions and deceits of the sight, in figures, magnitudes, motions, colours', representing 'things near as afar off, and things afar off as near' and, he continues, 'all manner of reflections, refractions, and multiplications of visual beams of objects'.[29] Cavendish echoes this last passage directly (she writes of 'refractions, reflections, inflections, and the like').[30] But the Menippean element in *The Blazing World* transforms Bacon's shadowy ironies into the most extravagant satire.

In May 1667, a year after its publication, Cavendish made her much-publicised visit to the Royal Society at Arundel House, where she met the

originals for her bear-men and bird-men. Her suspicion of their experiments was provoked by what she saw as their artificiality and by their relative failure to be 'ingenious and witty in the invention of profitable and useful Arts'.[31] Cavendish writes from within the Baconian tradition, this suggests, in support of such natural and productive science 'as may be beneficial to the publick'.[32] It just happens that she does so satirically and fantastically and in defiance of natural philosophers who also considered themselves Bacon's inheritors. This apparent conflict in *The Blazing World* between fanciful mockery and 'profitable and useful' intention is one that appears again in the eighteenth-century mock arts.

Bare Words Being Not Sufficient

When early-modern writers imagined special material cultures for their utopian fictions, they dreamed up alien orders of technology to go with them. As we have seen, their handling of this subject tended to irony, indirection and even satire. In part this was about trying for the first time to police an area of expertise usually left by polite and learned people to ungentle artisans. In part it was a response to a difficulty that they found in their understanding of those arts. They saw that modern natural philosophers would need to vex their materials as manual operators do and that Daedalean cunning, or perhaps even Daedalean deceitfulness, would be a component of their methods. These writers turned to mythography, satire and utopian fiction to evoke a part of the mechanical arts that eluded more specific description: the Baconian 'thread' of personal knowledge and haptic expertise. Satirists and writers of utopian fictions were not, however, the only thinkers of their time looking for a way to get at this topic. More straightforward articulations of the problem can be found in the writings of seventeenth-century educational theorists, early-enlightenment encyclopaedists and other contemporary information specialists.

At least one representative of this class, the agricultural reformer Gabriel Plattes, tried his hand at utopian fiction. His *Description of the Famous Kingdome of Macaria* (1641) is modelled on Bacon's *New Atlantis* but avoids the genre's main source of strangeness by insisting on an English setting. It describes how an emissary from utopic Macaria arrives unexpectedly at the Royal Exchange in London, as though one of Bacon's 'Merchants of Light' were coming to offer his services, rather than to poach local technologies. 'Traveller' has brought with him a revolutionary agricultural manual from his homeland.[33] This seems to be a plug for the *Treatise on Husbandry* that Plattes completed in the late 1630s, a work now

lost but presumed to be the basis of his later *Practical Husbandry Improved* (1656), which does survive.[34] The emphasis that Plattes puts on Traveller's precious book, the contents of which are not described, indicates a special concern about the communicability of technical and operational knowledge. Plattes was a practical agronomist, a highly operational type.[35] The straightness and shortness of his utopia *Macaria* is less remarkable than his decision to write at all in what is usually such an oblique literary genre.[36]

Plattes was a member of the correspondence circle run by the 'intelligencer' Samuel Hartlib, whose work placed an increasingly practical emphasis on Baconian ideas about the significance of the mechanical arts, particularly regarding educational reform and the project of creating an encyclopaedic history of trades.[37] A familiar set of nagging reservations about the communicability of personal knowledge is evident in many of their writings. For the Moravian educationalist Johannes Comenius, whose *Reformation of Schooles* was translated into English by Hartlib in 1642, one of the great problems with pre-modern scholastic learning is its lack of solidity, its failure to present knowledge to the hands and eyes of students.[38]

Comenius thought that educational reform and radical changes in book design would follow one from another – 'in the case of men, we should begin by reforming schools which are the factories of men', he wrote in his *Panorthosia*; 'in the case of schools, we should reform books, as being the appropriate instruments for the formal education of men'.[39] Both must refer back to practical experience in the world as part Comenius's larger scheme of Pansophism, or universal education corresponding with the harmony of nature.[40] As Hartlib's collaborator John Dury expressed the idea to the agriculturalist Sir Cheney Culpeper, 'books though never so well penned are but dead instruments by themselves (witnesse the Holy Scriptures, which few make good use of now adaies) but if those instruments be in the hand of an understanding workeman, and applyed to a fit subject, then some good effect may be wrought by them'.[41] Dury argues that instruction manuals require a certain quotient of prior knowledge and practical experience from the reader in order to be interpretable. His conspicuously artisanal metaphor for book learning corresponds with the analogy Comenius makes between his proposed reforms for academic education and the model of trade apprenticeships, which 'make serious exercises the preparatives of serious employments':

> For seeing no man becomes a Smith, but by hammering, nor a Scribe, but by writing, nor a Disputant, but by disputing; children also must be framed

> to be men by handling humane things; [. . .] that it may be a lively image of things, and a secret fitting and dressing of mens minds for the business of this life.[42]

It is interesting that Hartlib should make Comenius use a poeticism – the 'secret fitting' of philosophy to business – when describing the mental processes by which practice transforms itself into knowledge. There is an acknowledgement here that those cognitive processes are obscure, for all their commonness.

Towards the end of the 1640s Hartlib's attentions turned increasingly to his projects for the compilation of a Baconian 'History of Trades' and for the parallel establishment of an 'Office of Address' at which tradesmen could register, buy or swap technical information, in the manner attempted by the 'Traveller' of Plattes's *Macaria*. It was to be a sort of stock exchange for intellectual property on the lines of Théophraste Renaudot's Parisian bureau d'adresse.[43] Hartlib was unable to develop his Office of Address beyond the planning stage, but the idea was taken up by a younger member of his circle, the physician William Petty. In *The Advice of W. P. to Mr. Samuel Hartlib* (1647) Petty sketches a method for a 'history of arts and manufactures',

> wherein should be discribed the whole Processe of Manual Operations and Applications of one Naturall thing (which we call the Elements of Artificials) to another, with the necessarie Instruments and Machines, whereby every peice of worke is elaborated, and made to be what it is, unto which work bare words being not sufficient, all Instruments and tooles must be pictured, and colours added when the discriptions cannot be made intelligible without them.[44]

Petty, who insists that he is not 'at leasure to frame Utopias', is straightforward about the limitations of his literary technology, acknowledging at once that verbal description cannot record a manual technique adequately – 'bare words being not sufficient'. Like Comenius before him Petty placed more faith in graphic illustration, sometimes brought to life by a tincture of colouring, which 'in many cases performeth what by words is impossible'.[45] Thomas Sprat would later claim that the Royal Society, in pursuing its purpose of creating 'faithful Records, of all the Works of Nature, or Art', did so successfully by separating 'the knowledge of Nature, from the colours of Rhetorick'.[46] Petty's reaching for a non-metaphorical colouring palette shows his consciousness of what an austerely denotative system of technical description must leave out. Petty doubted that any man 'by the bare light and instruction of the Book could

attaine to a dextrous practice of a trade, whereunto hath been required seven years Autopsia'.[47] The word autopsy is used here in its etymological sense, meaning the action of experiencing a thing with one's own eyes. One condition of adequate literary description is that the real human hours involved with the practice and with its acquisition should be calculated justly.

The Recreation of a Recreation

The writings of Hartlib and his circle had a practical cast that contrasts with the playfulness of Baconian mythography and utopia. Among the publications of their contemporaries, however, the most widely circulated mid-century instructional manual of all shows a marked tendency to satire, albeit of a peculiarly genial type. Izaac Walton's *Compleat Angler* (1653) came from a sequestered Cavalier and Church of England culture that was far removed from Hartlib's puritan milieu. Both parties were concerned, however, with a shared worry that the strict discipline enforced by most contemporary educationalists was counterproductive. 'The holy Scripture commends Wisdome, and the study thereof to be delightfull', Comenius insisted in *A Reformation of Schooles*, 'and the Ancients seeme to have so esteemed them, terming Schooles *Scholas, & ludos literarios*, meaning, that the study of learning was but a pleasant paines-taking, or serious recreation.'[48] In a different context Walton made a similar conjunction of 'that pleasant labour which you enjoy when you [. . .] dedicate a day or two to this *Recreation* [of fishing]'.[49] Also like Comenius, Walton was concerned about the difficulty of writing manual instructions to help readers refashion a practical art for themselves. As he warns in the prefatory address 'To all Readers of this Discourse',

> in writing of it I have made my self a *recreation* of a *recreation*; and that it might prove so to him, and not read *dull* and *tediously*, I have in several places mixt (not any scurrility, but) some innocent, harmless mirth.[50]

That odd expression '*recreation* of a *recreation*' has an obvious primary meaning. The process of writing about a holiday activity (or perhaps feast day activity – 'recreation' also means eating) has for Walton been a holiday in itself. But there is an extra element of conceit to the phrase as well. Walton has taken on the doubly subtle work of representing or re-creating a subtle and elusive art. This is an Edenic kind of labour, restoring the reader to the scene of his or her own creation and to the first place of work.[51] Also Edenic in its innocence is the satirical humour that Walton promises to blend into his didactic.

In all this Walton recognises a problem of transmission like the one identified by Petty in his letter to Hartlib seven years before – 'bare words being not sufficient' for its instructive end. How can a novice turn into a proficient artist, Walton asks himself, merely by reading a book?

> *[H]e that undertakes* [to write such a book] *shall undertake a harder task, than Mr*. Hales (*a most valiant and excellent Fencer*) *who in a printed book* (*called*, A private School of Defence) *undertook to teach that art or science, and was laugh'd at for his labour. Not but that many useful things might be learnt by that book, but he was laugh'd at, because that art was not to be taught by words, but practice: and so must Angling* [. . .] *For* Angling *may be said to be so like the* Mathematicks, *that it can ne'r be fully learnt; at least not so fully, but that there will still be more new experiments left for the tryal of other men that succeed us*.[52]

The art of angling can be transmitted from adept to novice without the intervention of the written word, Walton acknowledges, but doing so involves processes of imitation and guided practice that are essentially personal and extra-literary. It can be taken in hand (or 'undertaken' – a word repeated three times in the first three lines here) by manual experiment and practice, but that is a different kind of skill acquisition. In the *Advancement of Learning* Bacon had described the seven liberal sciences of the old scholastic curriculum as being like idols – doctrines complete in their ancient conception (the 'first Author goeth furthest') but degraded at every point of communication ('time leeseth and corrupteth').[53] The mechanical and mathematical arts, by contrast, start out 'burdensome as a rule, and ugly', but through reiteration 'acquire new virtues and a certain handiness'.[54] Walton says the same thing about angling: that it is in its way a modern, progressive art, subject to infinite improvements, never to be '*fully learnt*'. Characteristically, it is the potential comedy of mistaking these two kinds of learning (derived from authority or from experience) that Walton picks up on, incorporating it into his own mirthful didactic. Although far removed from the Hartlib circle in cultural and confessional terms, Walton shares with them a modernistic idiom of ideas. It is worth noticing as well that it is the 'printed book' that takes on the burden of his auto-satirical reflections. *The Compleat Angler* was itself a peculiar bibliographical object, self-conscious from the first edition about its illustrations and later increasingly satura-like in its incorporation of recipes, ballad lyrics, musical annotations and black-letter legal essays into its textual mix.[55] Walton's manual shows how easily the terms of seventeenth-century didactic literature could turn over from serious instruction to genial self-mockery.

The Literary Technologies of Robert Hooke

In 1652, a year before Walton published *The Compleat Angler*, Petty was appointed physician to the Cromwellian army in Ireland. By the end of 1654 the government had accepted his proposal for the 'Down survey' of Irish lands, a scheme underpinned by the introduction of technical skills to Ireland by a circle of Petty's Hartlibian associates.[56] Work on the history of manufacture was put to one side. A year later Hartlib was visited in London by someone who had the financial independence, the expertise and (apparently) the inclination to pursue the great descriptive trades project begun by Petty. This was the diarist and virtuoso John Evelyn. By the time of Hartlib's death in 1662, however, Evelyn too had abandoned it, put off by 'the infinite subjections, which I cannot supporte', as he confessed to Boyle, 'of conversing with Mechanicall persons'.[57] It could be said that Evelyn gave up the project just as it was becoming compassable. In the extraordinary figure of Robert Hooke – philosopher, mechanical inventor, architect and first professional scientist – the division between 'mechanick' artisans and genteel scientists was closed up, and those two apparently unreconcilable aspects of the new science, technical and theoretical, were almost reconciled.

It was with Hooke's emergence after 1664 as curator of experiments at the Royal Society that the mechanical initiative began to move away from amateur virtuosi.[58] In August 1665 Evelyn was astonished by the mechanical inventions contrived by Hooke, John Wilkins and William Pettit during their retirement from the plague at Durdens, Surrey, including 'contriving Charriots, new rigges for *ships*, a Wheele for one to run races in, & other mechanical inventions, & perhaps three such persons together were not to be found else where in Europ, for parts and ingenuity'.[59] Hooke conversed freely, in coffee-house and atelier, with technical experts of every social class, from illiterate clockmakers to learned mechanical gentlemen such as Petty and Sir Christopher Wren.[60] Often he recorded both the information that he received and that which he had imparted in his diary, creating what Rob Iliffe has described as a 'deeply enriched account of locally available techniques and skills which are either put into practice immediately or saved for his use a few months later'.[61] As an artificer Hooke directed special energy to the development of a new spring-driven clock mechanism that he hoped would allow accurate calculations of the longitude at sea and to the manufacture of compound lenses that would facilitate the shortening of telescopes.[62] Other inventions included an innovative equatorial quadrant, helioscopes, mechanisms for regulating

the supply of fuel to heating implements, machines for sounding deep water and a 'whale-shooting engine'.[63] He was especially skilled at modelling his inventions, both as mechanist and architect. He was keen to produce 'modules' because, as he explained to the Earl of Conway in 1680, they allowed him 'to explain my meaning to y^{r} L^{dp} which without them it would have been very difficult to have done intelligibly by words'.[64] Models communicate information about materials and designs that books or verbal plans can only indicate.

Hooke's combination of talents as natural philosopher, manual technician and public demonstrator had no obvious precedent. This makes his comments as an author on the difficulty of creating a literary technology that could do justice to the mechanical arts especially significant to the history of useful knowledge. Through much of the 1660s Hooke's salary at the Royal Society was paid by the financier Sir John Cutler, on condition that Hooke give annually a series of sixteen lectures, named for the benefactor, on the history and improvement of trades and mechanical craft. Hooke's funding by Cutler coincided with the Royal Society's formation of a committee 'to consider and improve all mechanical inventions', with Robert Moray, Boyle, John Graunt, Petty and Hooke among its members.[65] In November 1664 they made a list of ancient and modern authors on mechanics, 'to collect what is delivered in Books, and practised; [and] to take notice of what is practised and not found in Books', as Bacon had directed.[66] In a letter to Boyle of 6 October 1664 Hooke reported that he was at work 'compiling a history of trades and manufactures [. . .] a very hard, difficult, and tedious task' – a lecture on salterns and another fragment on felt manufacture are the only surviving traces of this work.[67] When Hooke published his *Lectiones Cutlerianæ* in 1679 none of them was on trade or manufacture as such. Despite the ultimate disappointment of Cutler's expectations, however, that practical agenda did leave an impression on Hooke's most famous publication, *Micrographia* (1665).

Hooke affirms his commitment to the Cutlerian trades project in the preface to *Micrographia*, reporting his patron's observation that the 'Arts of life have been too long imprison'd in the dark shops of Mechanicks themselves, & there hindred from growth, either by ignorance, or self-interest: and he has bravely freed them from these inconveniences' – through Hooke's agency, it goes without saying.[68] Cutler is numbered among the 'men of Converse and Traffic' who both Hooke and (using the same phrase) Sprat considered specially capable of bringing 'word to action'.[69] This desired movement from philosophy to practice is

anticipated in *Micrographia*'s preface by Hooke's well-known rejection of Cartesian reasoning in scientific research:

> There is not so much requir'd towards it [the advancement of philosophy], any strength of Imagination, or exactness of Method, or depth of Contemplation (though the addition of these, where they can be had, must needs produce a much more perfect composure) as a sincere Hand, and a faithful Eye, to examine, and to record, the things themselves as they appear.[70]

It is usually understood that Hooke's 'sincere Hand' is a writing hand, dedicated to the business of truthfully registering experimental data. But this is an operating hand as well, co-ordinated by practice with the eye and now set to a new kind of work by the altered scale of microscopical research.[71] To be useful in the realm of 'human Industry' natural philosophy 'is to begin with the Hands and Eyes', wrote Hooke, 'and to proceed on through the Memory, to be continued by the Reason; nor is it to stop there, but to come about to the Hands and Eyes again, and so, by a continual passage round from one Faculty to another, it is to be maintained in life and strength'.[72] The order of 'beginning' is significant. Mechanical operations and experiments precede the examination of the eye, precipitating a recirculation of information from the shaping, directing hand to the attentive mind.[73] Manual processes lock knowledge deep into practice. The 'sincerity' of the hand – that is, its innocence of doubleness or sophistication – implies a cultivated and yet content-less dedication to unspecified processes of making and doing. It also acknowledges implicitly a Daedalean, insincere bias in the crafts to be recorded.

Hooke stressed the importance of practical habituation and passive knowledge in experimental science. But he was conscious of how habit or other workings of the cognitive unconscious might hoodwink the 'faithful Eye' as well. In the 'General Scheme or Idea of the Present State of Natural Philosophy', published posthumously in 1705, Hooke returns to the skilled operations of the 'sincere Hand', this time using them as a figure for the mental processes involved in natural philosophy, rather than as their practical ground:

> 'Tis with the Exercises of the Mind as with the Operations of the Body; one that has been bred up, and well skill'd in any Trade, shall go much more readily and handily about it, and make a much better piece of Work of a quite new Design in that Trade, than one that has not been at all us'd to such kind of Operations; there must be a time to bring and fix the Mind to a Regard and Heedfulness of this kind of Contemplation, and a time also to accustom it to Meditations and Contrivance, and a time to acquaint it with

> rationating from material Observations before it can go about such a design dexterously.[74]

Quite apart from inhibiting originality in natural philosophy, accustomed skill will allow the philosopher to reason with the mental dexterity and readiness that are necessary for innovative thinking. Above all, it is only through habituation that an experimentalist is able to draw up a 'Scheme' of appropriate research questions, a crucial step for determining whether his inquiries will be 'more or less useful for a Philosophical Treasury'.[75] On the other hand, habituation is an impediment to the compilation of a treasury of natural and artistic knowledge because the skilful practitioner always leaves out what to him are the most obvious things in any given operation.[76] The most important skill for the natural philosopher is a facility for keeping his curiosity simultaneously 'weakned and rous'd'. He must cultivate both a facility for suspending his expertise and a complete understanding of the object or process that is being described: 'For as the one will make him inquisitive, so the other will inable him to solve his Doubts.'[77] In other words, the operator must be able to sublimate his practical expertise into a tacit dimension of thought. This willed self-limitation must enter the realm of the habitual and there manifest itself as another kind of tact or skill.

The Literary Technologies of Robert Boyle

Hooke evokes the operative intelligence of mechanics in metaphors that define the progressive thinking of natural philosophers. This is a distinctive rhetorical move, as becomes clear when it is contrasted with his associate Boyle's comments on a similar subject. Hooke understood that mechanical expertise is complex at a cognitive level, but his irksome obligations to Cutler (to 'compile mechanicks though already hee know them') are a constant reminder that natural philosophy is universal and permanent, 'whereas the mechanicke is mostly pro hic & nunc & will not as the other, bee a part of natural history'.[78] Boyle understood all this too, but he had a real taste for compiling practical information and an interest in straightforwardly instrumental ends. In 1671 he published a large collection of this material in the *Second Tome of Some Considerations touching the Usefulnesse of Experimental Naturall Philosophy*. The aim of the volume was rather 'to convince than barely inform my reader' of the 'usefulness' of empirical inquiry. But the useful knowledge of the mechanic was excluded from the start:

> For I have found by long and unwelcome experience, that very few Tradesmen will and can give a man a clear and full account of their own Practices; partly out of Envy, partly out of want of Skill to deliver a relation intelligibly enough, and partly (to which I may add chiefly) because they omit generally, to express either at all or at least clearly some important circumstance, which because long use hath made very familiar to them, they presume also to be known to others: and yet the omission of such circumstances, doth often render the Accounts they give of such practices, darke and so defective, that, if their experiments be anything intricate or difficult (for if they be Simple and easy, they are not so liable to produce mistakes) I seldom thinke my self sure of their truth, and that I sufficiently comprehend them, till I have either tryed them at home, or caused the Artificers to make them in my presence.[79]

Boyle is not completely innocent of skipping over the details of common procedures himself, despite his notorious long-windedness: When 'treating of things which Use had render'd very familiar to me', he confesses, apparently unselfconsciously, 'I may have, to shun Prolixity, unawares slipt into the Contrary Extream'.[80] 'Verbosity' was a crucial part of what Steven Shapin calls Boyle's 'literary technology', the process of thick description with which Boyle bolstered the realism of his reports.[81] But this verbosity does not extend to the practical and manual component of the procedures that he describes. Boyle's exclusion of the knowledge of mechanical operatives, and his distaste for its dark defectiveness, is more radical than Hooke's.

Boyle's experimental histories are in theory reducible from book to laboratory because their dependence on the description of processes involving personal skill has been minimised.[82] The natural explanation of matter's action upon matter is enough. This corresponds with Boyle's Baconian conviction that the advancement of knowledge will involve easy natural processes rapidly replacing painful manual ones. In the essay 'Of Doeing by Physical Knowledg what is wont to require Manual Skill' (1671) he makes a collection of such processes, including the extraction of gold and silver from ore using quicksilver, the making of sculptures using plaister (life-masks, basically), the measurement of height by means of pendulums, the marbling of paper, the catching of fish by drugging them with dogwood and so on. He is careful to recommend these labour-saving practices as positive manifestations of inventive energy: They 'may be justly look'd upon as so many Trophies of Humane Knowledg, and so many Incitements to Humane Industry'.[83] As such they are reducible to relatively straightforward literary description, unlike the laborious skills of craftsmen. Boyle's minimalist approach to mechanical processes

corresponds with the minimalism of his preferred didactic methods. Explaining the abrupt and fragmented form of his *Occasional Reflections* (1665), Boyle points out the disadvantage of didactic writing that tires the reader with 'uneasie Preparation'. He prefers instructions to be 'suddenly, and as it were out of an Ambuscade, shot into our Mind, from things whence we never expected them'.[84] The aim is to refine discourse to an entirely punctual act of communication, an instruction immediate and without cognitive depth.

Hooke retained a principle of operational dexterity in his idea of scientific expertise. Boyle's contrastingly severe exclusion of mechanical skill from his own scheme of useful knowledge indicates a willed disconnection of experimental investigation from the everyday scene of practical application. This is a similar break of imagination that Swift would attribute to the bungling architects of Laputa in *Gulliver's Travels*, who despise the practical branch of their art as 'vulgar and mechanick' but replace it with instructions 'too refined for the Intellectuals of their Workmen; which occasions perpetual Mistakes'.[85] At its most heightened it is the operating principle of '*the universal Artist*' at the Academy of Lagado, who according to Gulliver's reports uses Boylean physical knowledge to soften marble for use in pillows and to turn the hooves of living horses into stone. Boyle tried to purify his natural philosophy by removing an unreproducible, human, personal component – mechanical dexterity and expertise – from his operations. In the Baconian mythography of science this component was represented by the turbulent and cunning figure of Daedalus. But in the process of purification Boyle left an empty space where the skilled operator once stood. Later, Swift's satirical imagination rushed back in to fill the vacancy.[86]

The Doctrine of Handy-crafts

The search made by Bacon's seventeenth-century followers for a literary technology adequate to the composition of a 'historie mechanical' ran into the sidings with Hooke's aborted Cutlerian lectures and with Boyle's project to substitute manual skill for physical knowledge. On 31 December 1677, however, Hooke heard a paper (on the humble trade of the blacksmith, as it happened) by a writer who was on the point of finding a path through the difficulties they had encountered.[87] This was the globe maker and manufacturer of scientific instruments Joseph Moxon, who was known also as a translator and compiler of technical handbooks on astronomy and architecture. A year later in 1678 he was elected Fellow

of the Royal Society, the first tradesman to receive that distinction. Moxon was a printer by profession who specialised in the production of intricate mathematical texts and of instruction manuals for technical instruments.[88] In 1662 he had been appointed 'Hydrographer' to Charles II, gaining a royal warrant to make maps, globes and sea-charts. His friend Samuel Pepys bought expensive globes from him for use at the naval office.[89] In Moxon's shop at the sign of the Atlas, print amalgamated with scientific instruments (including printed planispheres and the abacus rods known as 'Napier's Bones'), demonstrations aids (decks of astronomical cards) and topographical devices such as charts and globes.[90] Moxon was a bookseller and author whose interests extended beyond the codex, taking in a much wider range of engineered and printed things. He published his paper on smithing a year after he read it to Hooke, as the first issue of a new kind of publication, a periodical compendium titled *Mechanick Exercises: Or, the Doctrine of Handy-Works*. By the time its sections were ready to be collected into volumes, the *Mechanick Exercises* had grown into something like the encyclopaedia of trades plotted before by Hartlib, Petty and Evelyn. It took a practising tradesman to bring that project to fruition.

Moxon also read an essay for Hooke that later became the preface to the *Mechanick Exercises*, in which the latter may have recognised verbal echoes of Boyle's *Usefulnesse of Naturall Philosophy*. Like Boyle, Moxon commented on the incommunicability of certain craft practices and the insufficiency of describing them 'by words alone'. There is a new and subtle pragmatism, however, to the approach Moxon takes. He writes of how

> I thought to have given these Exercises, the Title of *The Doctrine of Handy-Crafts;* but when I better considered the true meaning of the Word *Handy-Crafts,* I found the *Doctrine* would not bear it; because *Hand-Craft* signifies *Cunning,* or *Sleight,* or *Craft* of the Hand, which cannot be taught by Words, but is only gained by *Practice* and Exercise*;* therefore I shall not undertake, that with the bare reading of these Exercises*,* any shall be able to perform these *Handy-Works;* but I may safely tell you, that these are the *Rules* that every one that will endeavour to perform them must follow; and that by the true observing them, he may, according to his stock of Ingenuity and Zeal in diligence, sooner or later, inure his hand to the *Cunning,* or *Craft* of working like a *Handy-Craft*.[91]

Boyle had written that handicrafts are 'not to be learned from Bookes, but [. . .] obtained by imitation and use', which is less absolute than Moxon's warning that they 'cannot be taught by words, but [are] only gain'd by Practice and Exercise'. Moxon doubts the usefulness of any verbal communication of craft skills, written or spoken, and he writes of 'imitation'

rather than 'Practice'. These differences are significant for the *Mechanick Exercises*. Before Moxon, it was assumed that craft knowledge was a progressive historical accumulation, passed on as a body from master to apprentice. But practice had revealed to Moxon that craft knowledge was, at a personal level, a more fluid and self-generating body of information than even Bacon or Boyle had thought. He argued that the main components of craft knowledge were not tradition or example but constant and personal processes of reasoning, experimentation and rule-based practice.

There is a progressive structure to Moxon's exercises and the outline of an historical anthropology of trade practices. That is why the paper on blacksmithing that he read to Hooke was published first. 'Without the Invention of Smithing primarily', he writes, 'most other Mechanick Inventions would be at a stand: The Instruments or Tools that are used in them being either made of Iron, or some other matter, form'd by the help of Iron.'[92] He orders his collection hierarchically, so the trade that depends upon a combination of the greatest number of simpler antecedent crafts comes last in a sequence of explanation. This terminal art is printing, one of Moxon's own trades, which involves not only presswork but the manufacture and maintenance of the hand-press, the making of ink and paper, the design and founding of type, the composition of the page, warehousing and so on.[93] Moxon took it as given that 'one Trade may borrow many Eminent Helps in Work of another Trade'.[94]

However, the acquisition of such knowledge at a personal level is a different matter. This is because the attainment of complex techniques, contrary to common intuition, often precedes the mastery of simple ones. The sections of the *Mechanick Exercises* on jobbing carpentry come after the description of fine joinery, for example, because 'he that knows how to work curiously, may when he lists work slightly; whenas they that are taught to work more roughly, do with greater difficulty perform more curious and nice work'.[95] Unexpectedly, the tradesman's expertise descends from reason, curiosity and accomplishment to everyday repeated practice. This practical principle rationalised Moxon's own extravagant tendency to leap from the basic functions of trades to their most ornamental refinements. His section on lathe-work, for example, moves rapidly from the basics of wood turning to the art 'Of Turning long and slender Work of Ivory', a process for which the optical instrument maker Richard Reeve was celebrated in this period.[96] Moxon describes this showy process in a paratactic sentence of appropriately curious tenuity:

> And thus by placing Collers where ever they find the Work buckle, they (as aforesaid) with Sharp Tools, tender touches, somewhat a loose and fine String, weak bow, and great care and diligence work the whole Cilinder down as small as they list.[97]

The chapter on ivory straws is followed by instructions on how 'To Turn several Globes or Balls of Ivory within one another, with a Solid Ball in the middle', among other techniques for making things 'more admirable to the ignorant Spectator'.[98] This bias towards ingenuity was a life-long tendency. Moxon's *Treatise on Mechanick Dyalling* (1678), for example, which appeared first in his *Tutor to Astronomy* (1665), includes eccentrically elaborate instructions on how to make a sundial 'on the Ceeling of a Room, where the Direct Beams of the Sun never come', using appropriately positioned mirrors.[99] However curious and sympathetic seventeenth-century natural philosophers were about mechanical artists, invariably they insisted on a Vitruvian division between 'fabrica' and 'ratiotinatio', between manual and scientific knowledge. Even in the rare instance of an operator–philosopher who united the two, as Hooke did, there was an expectation of personal progress from the former to the latter. Moxon showed in the *Mechanick Exercises* that in complex trades rational method and haptic expertise are in practice so closely related as to be caught up with each other and that their sequencing is more likely to run from reasoned curiosity towards unconscious mastery than in the other direction.[100]

Moxon claimed in the *Mechanick Exercises* that reason was the basis of the trades he described and that typography should be classed as a 'science' with foundations in geometry and mathematics. These claims have been adduced as evidence that he went about his trade like a philosopher, faithful to the Royal Society's methodological standards.[101] That is certainly the impression that he wanted to create in 1683. But what is distinctive about *Mechanick Exercises* is that it remains true, at the same time, to the elements of 'cunning or slight' in Moxon's craft. He supports his claim to the dignity of the scientist by referring to a passage in John Dee's 'Mathematical Preface' for Humphrey Billingsley's translation of Euclid (1570), in which Dee, referring to Vitruvius in turn, 'hath worthily taken pains to make Architecture a Mathematical Science'.[102] A rational occupation with design distinguishes the work of architects from the banausic trades of carpenter and mason. By analogy, says Moxon, the 'Typographer', or 'Master Printer, who is the Soul of Printing', exercises authority over his workmen through a reasoned command of all the

subordinate trades practised in his shop.[103] The important thing to notice here is that the authority of Moxon's 'Typographer' comes from the equitable integration of manual and mathematical expertise. It does not come primarily from luciferous knowledge, as Hooke or Boyle would have preferred. Moxon proposes that the most extravagantly curious mechanical work – the sort of work that can seem like a mockery of regular trade production – is not an ornament at the height of an art, but a foundation for its ordinary mastery.

Moxon's *Mechanick Exercises* is the seventeenth-century treatise that plots out at last a role for rational fabricators in the manual trades. It does so by describing at the level of practice how scientific method and haptic finesse come together in the expertise of advanced operators. John Dee had insisted that a 'speculatiue Mechanicien [. . .] differreth nothyng from a Mechanicall Mathematicien', and Joseph Moxon agrees with him that the rational and practical components of his trades had to be kept in a more dynamic relation than the sceptical empiricism of contemporary natural philosophy would allow.[104] It is a fitting coincidence that the treatise doing all this, the *Mechanick Exercises,* should culminate with the early-modern period's most exhaustive account of the manufacture of books, given that books and printed texts have featured in every one of this chapter's sources as talismanic, indispensable and notably problematic instruments.

Moxon's explanations show books to be complex manufactured objects that mark out with their textual contents the limits for the transmission of mechanical technique. Often the seventeenth-century literature of useful knowledge dwells on how Bacon's 'line of experience' gets lost at the scene of writing: with Petty's processes for which 'bare words' are insufficient, with Boyle's sense of what is 'not to be learned from Bookes' and with Moxon's of 'what cannot be taught by words'. There is ever-present potential for comic failure and descriptive misdirection in these discussions. Explications of the mechanical arts describe a front between the realms of the implicit and the personal at which writers turn back on themselves as they meet the limits of the literary medium for their didactic ends. Sometimes this makes them cast about for fictional or even satirical expressions, following the example of Francis Bacon's mythographic and utopian experiments. Sometimes the satirical tone is more genial and comic, as with Walton's piscatorial guidebook. Sometimes they try eccentric innovations of graphic illustration or format like the ones considered by Petty, Walton and Moxon. All of them presented to a later generation of eighteenth-century satirists as much material for imitation as they did for mockery.