Lorraine Daston

Observation as a Way of Life: Time, Attention, Allegory

THE HANS RAUSING LECTURE 2010
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Contents

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Introduction: "A Time for Every Matter under the Heaven..."

> "For everything there is a season and a time for every matter under heaven:
> a time to be born, and a time to die;
> a time to plant, and a time to pluck up what is planted:
> a time to kill, and a time to heal;
> a time to break down, and a time to build up;..."[1]

Observation creates time. The cycle of the seasons, the diurnal circles traced by the stars around the pole star, the annual journey of the sun through the zodiacal constellations along the ecliptic: already in Greek and Roman Antiquity, these were at once the chief markers of the passage of time and also the Ur-observations, attributed to Egyptian and Babylonian astronomers scanning the sky millennia earlier. Observation has not always been a learned activity – Aristotle for example associated it with animals lying in wait for their prey[2] and Cicero regarded it as a form of natural divination practiced by shepherds, mariners, farmers, and others constantly exposed to the elements.[3] But observation has always

[1] *Ecclesiastes*, 3:1–3. Revised Standard Edition. The theme of timeliness and the normative force of natural cycles is also prominent in Hesiod: see Laura M. Slatkin, "Measuring Authority, Authoritative Measures: Hesiod's Works and Days," in Lorraine Daston and Fernando Vidal, eds., *The Moral Authority of Nature* (Chicago: University of Chicago Press, 2004), pp. 25–49.

[2] For example, *Aristotle, Historia animalium,* 623a14, 629b24.

[3] Cicero, *De divinatione,* I.xviii, I.xlix.

defined time, whether by watching for the rising star that signals when to begin the chanting of vespers, or by monitoring the drip of a clepsydra, or by watching for the return of the swallows that portends summer. The times intoned by the biblical passage – "a time for every matter under heaven" – are marked by signs known by long observation of the heavens, the earth, and all of its inhabitants, animal, vegetable, and human.

Observation also fills time. In medieval Latin and in early modern European vernaculars, the words "observation" and "observance" are etymologically intertwined. One observes lunar eclipses and one observes the holy days of the church. Both observation and observance demand attention and vigilance, steadfastness and dedication. Keeping watch and keeping the faith both point to the Latin root, *servare*: to keep, to hold to, to persevere. Observation, like observance, demanded discipline, patience, and – above all – time. The vigil of the astronomer and the shepherd, the sailor's watch and the hunter's ambush, like the regimen of the monk and the rites of the pious, bore fruit only if pursued over the long term. It is no accident that the first people to spot the star of Bethlehem were shepherds and astronomers. To discern the signs that foretold a hard or mild winter, a fat harvest or lean, a fair wind or foul was the work of lifetimes and generations, just as faith was the work of countless repetitions of hallowed phrases and practices.[4] And just as the time created by observation divided up the hours of the day and the months of the year, so the clock and calendar drove observation and observance: when to sow, when to reap; when to furl and unfurl the sails; when to sing matins and celebrate Easter. To be observant, in both senses of the word, was to mark time, over and over again.

In this essay I would like to describe how this ancient link between observation and time survived the upheavals in early

[4] On the ancient traditions of observation, especially in astronomy and meteorology, see Daryn Lehoux, *Astronomy, Weather, and Calendars in the Ancient World: Parapegmata and Related Texts in Classical and Near-Eastern Societies* (Cambridge: Cambridge University Press, 2007), especially chs. 2–3.

modern European ideals and practices of natural inquiry. These upheavals, abbreviated by the phrase "the Scientific Revolution," were undeniably seismic. In the course of the sixteenth and seventeenth centuries, observation was transformed from an activity chiefly pursued by illiterate peasants and sailors into a prestigious form of learned experience, practiced by physicians and naturalists intent on reforming medicine and natural philosophy. Along with another new form of learned experience, the experiment, observation became a refined scientific logic that discovered new phenomena and generated new hypotheses about them. Yet despite the genuine novelty and significance of these developments in early modern science, the bonds between observation and time and between observation and observance were never severed. My aim here is to burrow beneath the new-fangled ways of making and talking about observations in early modern Europe in order to lay bare the ways in which observation remained a time-bound and time-consuming way of life and indeed one that continued to draw on much older models of cognition and vocation. In short, I hope to show how ancient ways of being observant persisted, albeit covertly, among the self-consciously scientific observers of the early modern period.

From Proverbial Wisdom to Learned Experience[5]

Consider these three accounts from sky-watchers, separated by centuries but united in monomaniacal devotion to observation. The first comes from the latter half of the eleventh century and is taken from Peter Damian's *On the Perfection of Monks*:

> "Let the one responsible for marking the hours know that no one in the monastery must be less forgetful than

[5] In this section I rely heavily and gratefully on the work of Katharine Park and Gianna Pomata in Lorraine Daston and Elizabeth Lunbeck, eds., *Histories of Scientific Observation,* (Chicago: University Press of Chicago, 2011), pp. 11–80.

> him, for if he fails to keep the hour of any sacred office, by anticipating it or delaying it, he will disturb the order of every subsequent office. Therefore, let him not lose himself in stories, nor engage in long conversation with another, nor, finally ask what those outside the monastery are doing, but – always intent on the responsibility entrusted to him, always attentive, always solicitous – let him observe the motion of the heavenly sphere, which never rests; the path of the stars; and the constant course of passing time."[6]

The second comes from an astronomical treatise of the late sixteenth century by the Danish nobleman Tycho Brahe:

> "First of all we determined the course of the sun by very careful observations during several years. We not only investigated with great care its entrance into the equinoctial points, but we also considered the position lying in between these and the solstitial points, particularly in the northern semicircle of the ecliptic since the sun there is not affected by refraction at noon. Observations were made in both cases and repeatedly confirmed, and from these I calculated mathematically both the apogee and the eccentricity corresponding to these times."[7]

The third is from the English natural philosopher Robert Hooke's late seventeenth-century report on the observation of the comets of 1664 and 1677:

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[6] Peter Damian, *De perfectione monachorum*, 17, in Paolo Brezzi (ed.): *De divina omnipotentia e altri opusculi*, trans. Bruno Nardi (Florence: Vallecchi, 1943), pp. 286–288; quoted in Katharine Park, "Observation in the Margins, 500–1500" in Lorraine Daston and Elizabeth Lunbeck, eds., *Histories of Scientific Observation,* (Chicago: University Press of Chicago, 2011), pp. 15–44, on p. 22.

[7] Tycho Brahe, *Tycho Brahe's Description of his Instruments and Scientific Work* [*Astronomiae instauratae mechanica*, 1598], trans. and ed. Hans Raeder, Elis Strömgren, and Bengt Strömgren (Copenhagen: I Kommission Hos Ejnar Munksgaard, 1946), pp. 110–111.

> "For the Observators, 'tis not enough to know how to manage an instrument, or to have a good eye, or a dextrous and steady hand; but with these there must be joyned a skilfulness in the theorical and speculative part, and add to all a love and delight in the thing it self; and even all these will signifie but little, without convenient and accurate Instruments, such as may be easily manageable and sufficiently exact."[8]

These three accounts diverge in several obvious respects that signal dramatic changes in the status and methods of observation. For the monks admonished by Peter Damian, observing the heavens is a means to an end, the dutiful and punctilious fulfillment of the eight daily offices prescribed in the sixth-century Rule of Saint Benedict and the keeping of the annual round of commemorative feasts and fasts. The observing and observant monks are anonymous; they track the movements of the heavenly bodies with only the crudest of instruments, if any. In contrast, Tycho Brahe is not just the proud author of his observations; he is also their possessive owner, willing to part with his "rare and costly treasure" only to "distinguished and princely persons who might be especially interested in such matters ... but even then only on condition that they will not give them away."[9] Tycho's title of ownership to his observations came from the arduous labor invested in them over decades; he had moreover invested large sums of money in the construction of a purpose-built observatory and in the design and construction of sighting instruments of unprecedented size and accuracy.[10] **(Figure 1)** Hooke, writing

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[8] Robert Hooke, "Cometa, or Remarks about Comets," in *Lectiones Cutlerianae* [1679], reprinted in R.T. Gunther, *Early Science in Oxford*, vol. 8 (London: Dawsons, [1931] 1968), p. 239.

[9] Tycho Brahe, *Tycho Brahe's Description of his Instruments,* pp. 108–110.

[10] J.L.E. Dreyer, *Tycho Brahe: A Picture of Scientific Life and Work in the Sixteenth Century* (New York: Dover, [1890] 1963), pp. 320–336; Allan Chapman, *Astronomical Instruments and Their Uses: Tycho Brahe to William Lassell* (Aldershot: Variorum, 1996), pp. 1–15.

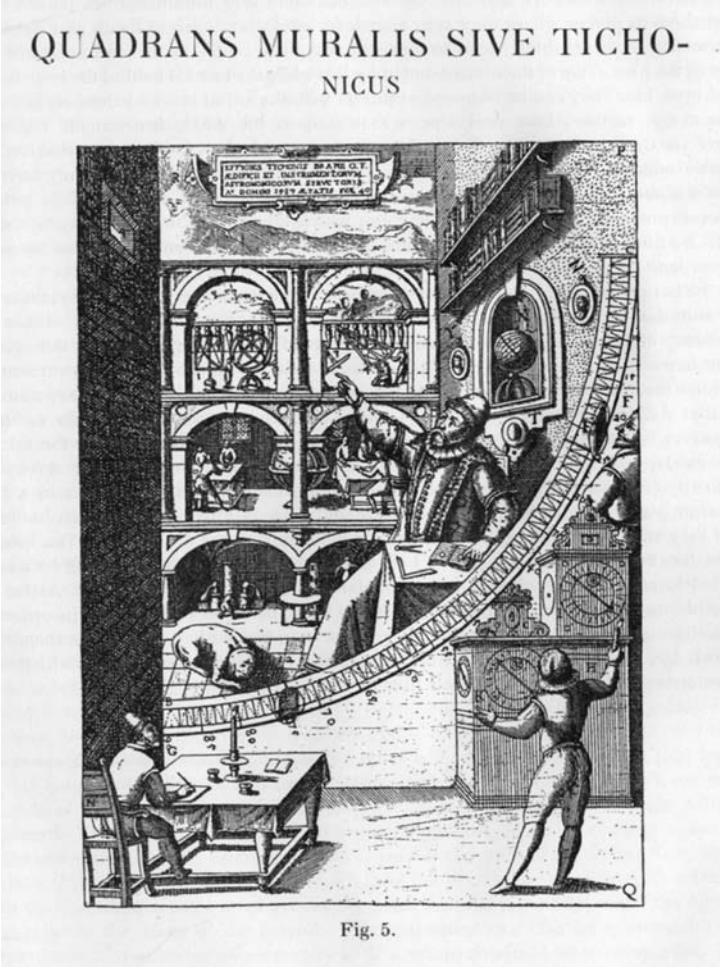

Figure 1: Tycho Brahe's mural quadrant, from his *Tycho Brahe's Description of his Instruments and Scientific Work* [*Astronomiae instauratae mechanica*, 1598], trans. and ed. Hans Raeder, Elis Strömgren, and Bengt Strömgren (Copenhagen: I Kommission Hos Ejnar Munksgaard, 1946), n.p. Courtesy of the Library of the Max Planck Institute for the History of Science, Berlin.

a century after Tycho, wielded still more accurate and probing instruments, the telescope and, still more important, telescopic sights, and published his observations for what was by the late seventeenth century a flourishing community of observers distributed over half the globe and in bustling communication with one another.

These contrasts bear witness to the profound changes that had transformed observation from an anonymous activity that stretched over centuries, performed in the service of other goals, instrumental but devoid of instruments, to an authored activity of a learned community dispersed over space as well as time, performed with ever more ingenious instruments at specially built sites like the observatory (or anatomical theater or botanical garden) as an end in itself. The emergence of observation as an epistemic category is too long and convoluted a story to retell here, except in barest bones summary.

Throughout the Latin Middle Ages, *observatio* was associated shepherds, sailors, farmers, and other outdoor workers who practiced what Cicero had called "natural divination": waiting and watching for correlations between the stars, the weather, fat and lean harvests, the migration of birds, and other natural phenomena. Observation on this model was slow, cumulative, and anonymous, handed down orally from generation to generation in the form of proverbs like "Red in the morning, sailors take warning". Only astronomical observations counted as part of the learned tradition and even these were made rarely; until well into the sixteenth century, European astronomers and astrologers relied largely on ancient observations. For medieval natural philosophers, observation was useful but not scientific: at best, it was a tool of the conjectural sciences like medicine and alchemy, condemned to deal with individual particulars rather than universal causes. Observation, since Antiquity linked with divination, was triply at the mercy of chance: the chance concatenation of causes, the chance opportunity of being at the right place at the right time,

and the chance accumulation and transmission of past wisdom. For Aristotelian natural philosophers, chance was most unpromising material for genuine science. They therefore regarded observation as at best raw material for knowledge, not knowledge per se.

Proponents of learned experience in the early modern period deliberately sought to minimize all these chance elements and thereby to accelerate the growth of knowledge. New collectives of space were to supplement traditional ones of time: instead of countless generations of occasional observers, global networks of coordinated observers would speed the work of looking, collecting, collating, and correlating. **(Figure 2)** In this spirit, Francis Bacon

Figure 2: Map of the world winds, compiled from multiple observers by Edmond Halley, from Edmond Halley, "An Historical Account of the Trade Winds, and Monsoons, observable in the Seas between and near the Tropicks, with an attempt to assign the Phisical cause of said Winds," *Philosophical Transactions of the Royal Society of London* 16 (1686), n.p.

hoped that by means of "learned experience" as yet undiscovered "secrets [of nature] of excellent use ... which will doubtless come to light in the circuit and lapse of many ages as others have before them, but in the way here set out, can be rapidly and simultaneously anticipated and represented."[11] What had throughout the Middle

[11] "Itàque sperandum omninò est, esse adhuc in naturae sinu multa excellentis usûs recondita, quae ... proculdubiò per multus saeculorum circuitus et ambages et ipsa quandòque prodibunt, sicut illa superiora prodierunt; sed per viam, quam nunc tractamus, properè et subitò et simùl representari, et anticipari possunt." Francis Bacon, *Novum organum* [1620], I.cix–cx, in Basil Montagu, ed., *The Works of Francis Bacon*, 17 vols. (London: William Pickering, 1825–34), vol. 9, pp. 261–263.

Ages been a specialized term linked to monastic timekeeping and astrometeorology spread to philology, medicine, jurisprudence, natural history, anatomy, and natural philosophy: by the turn of the seventeenth century, *observationes* and its vernacular cognates featured prominently in titles of scientific and medical treatises, travelogues, humanist compendia, and a great deal that defies ready description, an expansive trend that persisted well into the eighteenth century.[12]

But effective though these changes were in establishing a veritable empire of scientific observation by the mid eighteenth century, there is nonetheless a continuous thread that weaves through the sinuous history of observation: observation as observance. This is screamingly evident in the case of timekeeping in the medieval monasteries, but Tycho Brahe and Robert Hooke also rang the changes on the qualities of care, attention, perseverance, and dedication necessary to a good observer. It took Tycho and his assistants over twenty years to determine the positions of around a thousand fixed stars, in comparison with the mere twenty-odd determined by ancient observations; each observation was repeated multiple times, using different instruments and clocks to cross-check accuracy. Hooke, who observed everything from comets with telescopes to moss with microscopes, also emphasized that there was scarcely any subject that would not "require the whole time and attention of a mans life, and some thousands of Inventions and Observations" to do justice to it.[13] Observation was a way of life, and a demanding one at that.

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[12] Katharine Park, "Observation in the Margins, 500–1500," Gianna Pomata, "Observation Rising: Birth of an Epistemic Genre, 1500–1650," and Lorraine Daston, "The Empire of Observation, 1600–1800," all in Daston and Lunbeck, eds., *Observation* (Chicago: University of Chicago Press, 2011), pp. 15–44, 45–80, and 81–113. Based on a preliminary bibliography prepared by Sebastian Gottschalk, using the online catalogues of World Cat, the British Library, the Library of Congress, and the Herzog-August-Bibliothek Wolfenbüttel, and counting titles in Latin, French, Italian, German, and English, circa 82 titles were published 1550–1599, 98 from 1600–1649, 246 from 1650–1699, 681 from 1700–1750, and 1988 from 1751–1800. These figures of course give only a rough indication, but the relative increases are probably reliable.

[13] Robert Hooke, "To the Reader," in *Lectiones Cutlerianae* [1679], reprinted in R.T. Gunther, *Early Science in Oxford*, vol. 8 (London: Dawsons, [1931] 1968), n.p.

Yet a new note has crept into the remarks of Tycho and Hooke: observation is arduous and painstaking – but it is also a pleasure, even an obsessive, guilty pleasure. Hooke spoke of the "love and delight" that must drive the observer; Tycho recounted of how he had started observing on the sly as a teenager studying in Leipzig: "This I did in spite of the fact that my governor, pleading the wishes of my parents [who] wanted me to study law... , did not like it and opposed it... Often I stayed awake the whole night through, while my governor slept and knew nothing about it; for I observed through a skylight and entered the observations specially in a small book, which is still in my possession."[14] These themes of parental disapproval, stealth, and obsession recur repeatedly in early modern first-person testimonies of observers. No longer legitimated by a religious framework, the rigorous regimens of observation often aroused suspicion and alarm. Could such long, repeated vigils of star-watching and insect-squinting be reconciled with familial, civic, and religious obligations? Was it morally defensible to care more about a new comet or caterpillar than one's nearest and dearest? Whereas observation had begun as a way of keeping time, it had become a way of filling time – to the exclusion of all other pursuits, even eating and sleeping.

Observation as a Way of Life: Time Consumed

When Tycho Brahe reached the age of majority and could pursue his astronomical inclinations without bowing to the wishes of his parents or evading the surveillance of his tutor, he toyed with the idea of moving to the city of Basel, in part because of its proximity to France, Germany, and Italy, conducive to learned correspondence, but also in part because if he settled at his ancestral home of Knudstrup or some other part of Denmark, he would be besieged by "a continuous stream of noblemen and

[14] Tycho Brahe, *Tycho Brahe's Description of his Instruments*, p. 108.

friends [who] would disturb the scientific work and impede this kind of study." He only agreed to return to Denmark when the king promised him his own island, "where I could be rid of the disturbances of visitors...".[15]

In the annals of early modern scientific observation, complaints about "disturbances of visitors" resound like a basso continuo. Edmond Halley, reporting on a total eclipse of the sun exceptionally visible in England, regretted that John Keill at Oxford had seen nothing because of the clouds and "the Reverend Mr. *Roger Cotes* at *Cambridge* had the misfortune to be opprest by too much Company, so that, though the Heavens were very favourable, yet he miss'd both the time of the Beginning of the Eclipse and that of total Darkness."[16] Some years later, the French naturalist René Antoine Ferchault de Réaumur defended his decision to move out of central Paris in order to have more room for his beehives and natural history collections: he noted with satisfaction that his new country address would be inconvenient for visitors and therefore conducive to research.[17] By the mid-eighteenth century, the author of a French treatise on meteorological observations declared flatly that the regimen of the ideal weather observer was incompatible with any social life whatsoever, requiring the renunciation of "almost every occupation and all pleasure," since the observer would always have to be home at the same times every day, for years on end, in order to take comparable thermometer and barometer readings, neither paying nor receiving visits.[18]

The life of the dedicated observer could consume health and wealth, but mostly it consumed time. Early modern scientific observers went blind from squinting at the entrails of insects

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[15] Tycho Brahe, *Tycho Brahe's Description of his Instruments*, p. 109.

[16] Edmond Halley, ""Observations of the late Total Eclipse of the Sun on the 22d of April last past," *Philosophical Transactions of the Royal Society of London* 29 (1714–16): 245–262, on pp. 253–254.

[17] Letter from René-Antoine Ferchault de Réaumur to Jean-François Séguier, Paris, 25 April 1743, in Académie des Belles-Lettres, Sciences et Arts de La Rochelle, *Lettres inédites de Réaumur* (La Rochelle: Veuve Mareschal & Martin, 1886), p. 15.

[18] Louis Cotte, *Traité de météorologie* (Paris: Imprimerie Royale, 1774), p. 519.

under powerful lenses in the noonday sun and notoriously squandered family fortunes on specimens and instruments. But from the standpoint of their contemporaries, the observers' most disturbing eccentricities were their tyrannical schedules, which yielded to neither courtesy nor obligation and often dictated the waking and sleeping hours of the entire household. Early modern scientific observation was not only time-consuming; it was literally timed – by the motions of the sun and planets, by the dripping of a clepsydra, by the beating of a pulse, by the ticking of a clock or pocket watch. Time, sliced ever more thinly, became the universal grid imposed on phenomena as diverse as the ebb and flow of the tides, the undulations of an aurora borealis, the departures of bees from the hive, and the return of the swallows.

Two observation notebooks, separated by approximately a century, convey some idea of the advancing time consciousness of scientific observers in early modern Europe. The first was kept by John Locke, from September 1666 to April 1703, and entitled "Adversaria physica" or "memoranda on physic".[19] It is a large-ish (ca. 8" X 12") calf-bound volume, written in ink, and continuously paginated. The entries, written in Latin, English, and French, relate mostly to medical but also to some natural philosophical matters, mingling excerpts from reading (with references), recipes for medications (e.g. Lady Chichley's eye ointment but also Mrs Walker's oatmeal pudding), practical tips (e.g. where to get the best French olive oil), and some of Locke's own observations, initialed "JL". At the back of the volume is a weather diary, presenting daily thermometer, barometer, hygrometer, and wind observations for a period of almost thirty-seven years. **(Figure 3)** These are the only dated entries; insofar as there is another order, it is spasmodically alphabetical, with an elaborate but incomplete index at the front and back of the volume; most of the entries

[19] "Adversaria physica", Bodleian Library, Oxford University, MS Locke d.9. "Adversaria" in classical Latin originally meant a merchant's waste-book or journal, in which items are entered as they occur, for later use.

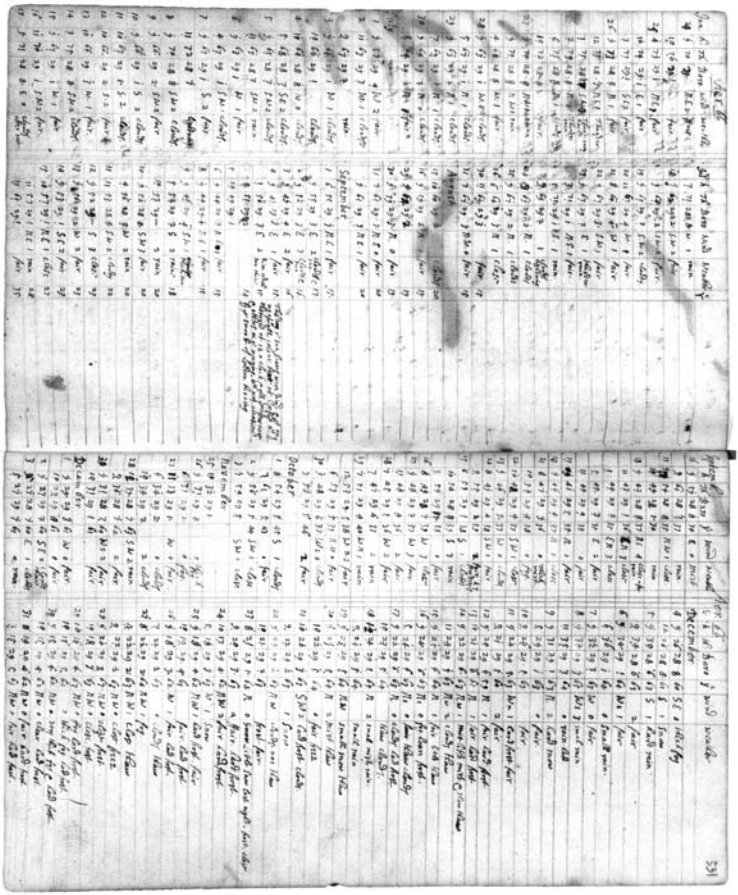

Figure 3: John Locke's weather table, from his commonplace book "Adversaria physica", Bodleian Library, Oxford University, MS Locke d.9, n.p. (final page of volume). Courtesy of the Bodleian Library, Oxford University.

are flagged with marginal keyword (e.g. "Reason", "Fulmen" "Palpitatiocordis").[20] Not only were the dates and hours noted for all instrument readings; Locke also dated seasonal events like the return of the swallows and even his own descriptive practices: "1692 May 23 Fair from henceforward signifies more of the skie (as far as it can be seen out of my chamber window) clear of clouds than covered with them."[21] In contrast, all other observations (for example, one on the differing speeds of light and sound[22]) were simply interleaved among Locke's reading notes, undated excerpts from books mingled indiscriminately with undated excerpts from the book of nature.

Now let us look at a notebook from about a century later. On 10 July 1774 the Genevan naturalist Horace-Bénédict de Saussure began a little yellow notebook (circa 5" X 7"), which he labeled "Voyage autour du Mont Blanc en 1774, 10e Juil. Brouillard en crayon No.1. Extraits de l'Agenda". Each page was headed with the day of the week and the date, followed by a lettered (a, b, c, etc.) sequence of short observations, beside each of which was noted the time, often to the minute. Saussure recorded everything that caught his eye along the way and exactly when he saw it: a ruined château, the strata of slate that struck him as displaced from their original position, the nickname of his local guide, barometer and thermometer readings, a terrifyingly steep mountain pass traversed in the snow in mid-July, holding on to the tails of the mules, a solitary dinner in a village inn. The timed entries and the execrable handwriting suggest that the entries were made in real-time, bouncing along on a bumpy mountain road. **(Figure 4)** There are no thematic indices or reading notes. The model is the journal, more specifically the travel journal kept en route, rather than the

[20] Locke himself published an article on how to organize commonplace books: [John Locke], "Méthode nouvelle de dresser des recueils," *Bibliothèque universelle et historique* 2(1686); 315–328. Locke seems to have followed his own method in the "Adversaria physica", at least in the index at the back of the volume.

[21] "Adversaria physica", Bodleian Library, Oxford University, MS Locke d.9, n.p. (final page of volume).

[22] "Adversaria physica", Bodleian Library, Oxford University, MS Locke d.9, p. 42. Locke's own observations (as opposed to those collected from the writings of or communications from others) are initialed "J.L.".

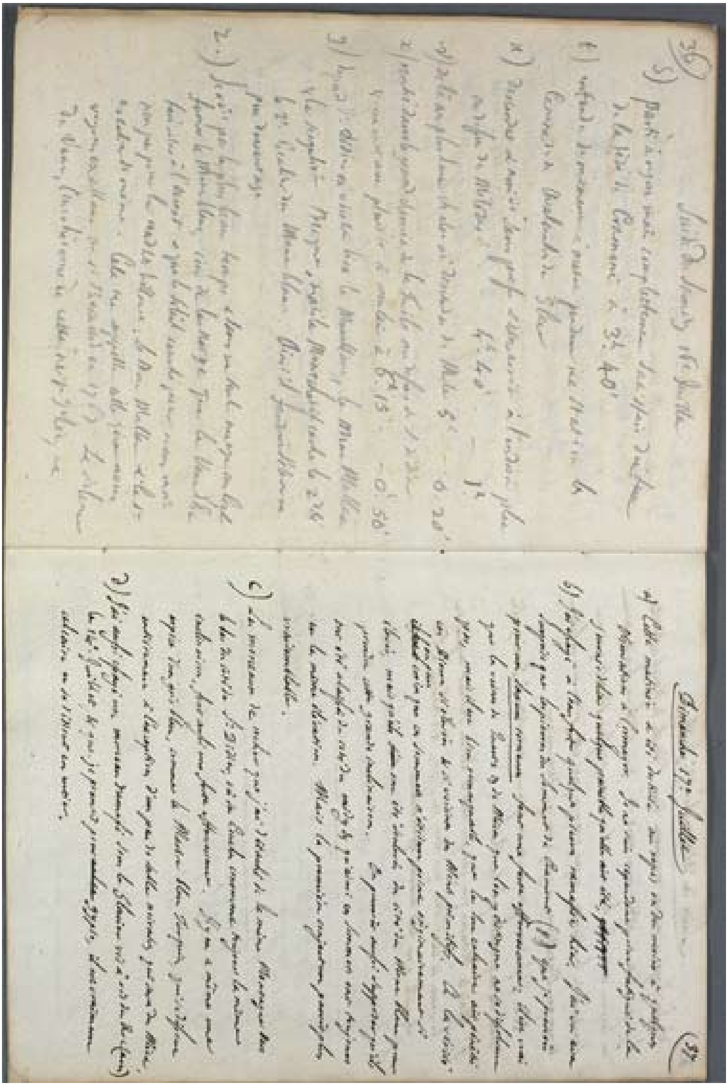

Figure 4: Horace Bénédict de Saussure's timed notebook entries, from his notebook "Voyage autour de Mont Blanc en 1774 10e Juil. Brouillard en crayon No.1. Extraits de l'Agenda". Courtesy of the Bibliothèque publique et universitaire de Genève.

commonplace book filled by the desk-bound scholar: Saussure's cardboard-bound notebook was small and light enough to be carried along everywhere; when Locke traveled to the Continent, he left the bulky "Adversaria physica" at home.

Above all, the axis of organization has shifted, from the topical to the temporal. Locke's notes were assembled with an eye to collation by subject matter; his commonplace book recycled material from old books into the stuff of new books and was itself a proper book, hefty and leather-bound; the entries (with the exception of the weather tables) are as timeless as the pages of a book. Saussure's record is in contrast driven by the calendar and his pocket-watch. The ancient principle of astronomical and meteorological observations (including Locke's own) structures the whole of Saussure's notebook, an ephemeral format for recording ephemerides. By the eighteenth century, time is almost always the vertical dimension of tables of observation, whether the object of observation is lunar perturbations, the temperature, incidence of smallpox, or the reproduction of aphids.

Certainly, these were among the more modern of early modern developments, made possible by the increasing sophistication and reliability of timepieces: it is no accident that Switzerland was simultaneously an important center of both scientific observation and the manufacture of clockwork. Yet beneath the fancy new-fangled casing (to enlist clockwork as metaphor), the inner workings of observation were still governed by the older, medieval associations with observance. Saussure's journal reflects the degree to which the demands of making observations had infiltrated or rather invaded the daily life of naturalists. There are records of weather observations interspersed with diaries as early as the late sixteenth century[23], and by the late seventeenth century scientifically-minded gentlemen all over Europe were interrupting

[23] Ioannis Telelis, "The Climate of Tübingen A.D. 1596–1605, on the Basis of Martin Crusius' Diarium," *Environment and History* 4 (1998): 53–74.

their daily routines to take thermometer and barometer readings to record in diaries and journals.[24] Weather-watching, especially if pursued at fixed times of day, could become a way of life, a regimen that set schedules, shooed guests to the door, and fostered clock-consciousness.

Still more extreme were the naturalists who flaunted obligation and convention in order to devote themselves entirely to what Saussure's uncle, the Genevan naturalist Charles Bonnet, called the "delights of observation." At circa 5:00 pm on 20 May 1740, Bonnet took an aphid that had "been born before my eyes", put it in a glass jar with a few leaves, upended the jar in a flowerpot of soil, and resolved to keep "an exact journal of its [the aphid's] life." For twenty-one days he dedicated every waking hour from circa 5:30 am to 11:00 pm to the observation of a single aphid (*mon puceron*, later *ma pucerone* after it bore offspring) in order to determine whether the species could reproduce parthenogenetically. "Not only did I observe it every day, from hour to hour, beginning at 4:00 or 5:00 am and continuing until 9:00 or 10:00 pm; but I even observed it several times during the same hour, always with a magnifying glass, in order to render the observation more exact, and to inform myself about the most secret actions of our little solitary."[25] **(Figure 5)** Even in the age of the stopwatch, observation remained observance, the observer "always intent on the responsibility entrusted to him, always attentive, always solicitous" – if only to an aphid.

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[24] Jan Golinski, "Barometers of Change: Meteorological Instruments as Machines of Enlightenment," in William Clark, Jan Golinski, and Simon Schaffer, eds., *The Sciences in Enlightened Europe* (Chicago: University of Chicago Press, 1999), pp. 69–93; Vladimir Jankovic, *Reading the Skies: A Cultural History of the English Weather* (Manchester: Manchester University Press, 2000); Jan Golinski, *British Weather and the Climate of Enlightenment* (Chicago: University Press of Chicago, 2007).

[25] Charles Bonnet, *Traité d'insectologie, ou Observations sur les pucerons* [1745] in idem, *Oeuvres d'histoire naturelle et de philosophie*, 18 vols. (Neuchâtel: Chez Samuel Fauche, 1779), vol. 1, pp. 18–20.

Figure 5: Charles Bonnet's observation of an aphid in an upended flowerpot, from his *Traité d'insectologie, ou Observations sur les pucerons* [1745], in Charles Bonnet, *Oeuvres de l'histoire naturelle et de philosophie,* 18 vols. (Neuchâtel: Samuel Fauche, 1779-83), vol. 1, p. 19. Courtesy of the Bibliothek der Freien Universität Berlin.

Observation as Devotion: Time Obliterated

The medieval rationale for such unswerving observational dedication, as in the case of Peter Damian's admonitions to vigilant monks, had been religious. A strong current of natural theological devotion certainly informed the intertwined early modern regimens of observation and observance: to immerse oneself in the glories of creation, whether the starry heavens above or the humblest insect below, was to glorify the creator, as the observers never tired of repeating, especially when they came under fire for neglecting their professional or familial duties. Yet the very intensity of the observers' observances could render them religiously suspect. One of Bonnet's correspondents, the Lutheran pastor Adam Schirach from Saxony, featured the text from Psalm 150 ("Praise the Lord! Praise God in his sanctuary; praise him in his mighty firmament!") in the frontispiece of his treatise *Melitto-Thelologia* (1767) and hotly defended his observations of bees as fully compatible with his duties as pastor, the books of scripture and nature read side-by-side. **(Figure 6)** But even Schirach had his doubts and offered up a prayer, lest he come to praise bees at God's expense: "O Lord, extinguish all the hidden, exaggerated creature-love in my heart, so that I do not thereby displease you. It is true that whoever has once clearly seen the charm of the beauties of nature ... will be carried away [and] foreswear all other delights...".[26]

Schirach and other early modern observers feared that the rapt attention that they lavished on naturalia might border on idolatry, a form of observance in competition with rather than in the service of true religion.[27] Attention could be a sign of devotion, but it could also become an act of devotion in itself, especially if spiced

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[26] Adam Gottlob Schirach, *Melitto-Theologia. Die Verherrlichung des glorwürdigen Schöpfers aus der wundervollen Biene* (Dresden: Waltherischen Hof-Buchdruckerey, 1767), p. 204.

[27] For more on the potential competition between attentive observation and religious worship, see Lorraine Daston, "Attention and the Values of Nature in the Enlightenment," in Lorraine Daston and Fernando Vidal, eds., *The Moral Authority of Nature* (Chicago: University of Chicago Press, 2004), pp. 100–126.

Figure 6: Adam Gottlob Schirach, *Mellito-Theologie: Die Verherrlichung des glorwürdigen Schöpfers aus der wundervollen Bienen* (Dresden: Waltherischen Hof-Buchdruckerey, 1767), frontispiece.

with delight. Observation as observance could become an end in itself denatured as religion because naturalized both by its objects and its subjective states. The emotions evoked by deep observation veered dangerously close to those associated with religious experience: admiration, wonder, rapture, reverence, awe – all states of mind and soul that annulled the consciousness of time passing. This was the other side of early modern scientific observation as observance: on the one hand, extreme awareness of the passing of time, measured by the day, the hour, the

minute; on the other, time, like the observer, frozen stock still in motionless contemplation. In order to resolve this paradox of time simultaneously monitored and forgotten by the early modern scientific observer, we must probe the nature of the faculty of attention at the root of both modes of temporal perception.

Attention is by definition exclusive, the faculty of creating foreground and background, focus and fringes. But economies of attention differ not only in their preferred objects, but also in their specific practices. We still lack anything like a full-dress history of attention[28], but some sense of the diversity of practices can be gleaned from the rich literature on the history of spiritual exercises in ancient philosophy and religious meditation. There is for example the question of the favored physical posture: certain ancient schools of philosophy recommended that discussions between masters and pupils be conducted while walking to stimulate attention (hence the term "peripatetic" to designate the tradition stemming from Aristotle's Lyceum); others, like the Stoics, commanded disciples to lie down in order to let the events of the day pass before mind's eye in review[29] – a posture also adopted in Christian meditation and visionary trance, as in the case of Boethius, followed by Christine de Pisan.[30] **(Figure 7)** Then there is the matter of the object of

[28] Studies of various special topics in the history of attention include: for general bibliography, see Lemon L. Uhl, *Attention. A Historical Summary of the Discussions concerning the Subject* (Baltimore: The Johns Hopkins Press, 1890); on the place of absorption in eighteenth-century French art criticism, see Michael Fried, *Absorption and Theatricality: Painting and Beholder in the Age of Diderot* (Berkeley/Los Angeles/London: University of California Press, 1980) and on links between forms of attention and modernism in art, Jonathan Crary, *Suspensions of Perception: Attention, Spectacle, and Modern Culture* (Cambridge, Mass./London: MIT Press, 1999); in literature, Roger Chartier, "Richardson, Diderot et la lectrice impatiente," *Modern Language Notes* 114(1999): 647–666, and Adela Pinch, *Strange Fits of Passion: Epistemologies of Emotion, Hume to Austen* (Stanford: Stanford University Press, 1996), esp. pp. 152–163; in pedagogy, Christa Kerstig, *Die Genese der Pädagogik im 18. Jahrhundert. Campes 'Allgemeine Revision" im Kontext der neuzeitlichen Wissenschaft* (Diss. Freie Universität Berlin, 1992); in medicine, Michael Hagner, "Psychophysiologie und Selbsterfahrung: Metamorphosen des Schwindels und der Aufmerksamkeit im 19.Jahrhundert," in Aleida Assmann and Jan Assmann, eds., *Aufmerksamkeiten* (München: Wilhelm Fink Verlag, 2001), pp. 241–264; in early modern science, Lorraine Daston, *Eine kurze Geschichte der wissenschaftlichen Aufmerksamkeit* (Munich: Carl Friedrich von Siemens Stiftung, 2001).

[29] Michel Foucault, *Histoire de la sexualité*, III: *Le Souci de soi* (Paris: Éditions Gallimard, 1984), pp. 84–87; Pierre Hadot, *Philosophy as a Way of Life*, ed. Arnold I. Davidson, trans. Michael Chase (Oxford: Blackwell, 1995), pp. 81–144.

[30] Mary Carruthers, *The Craft of Thought: Meditation, Rhetoric, and the Making of Images, 400–1200* (Cambridge: Cambridge University Press, 1998), pp. 173–179.

Figure 7: The Cumean Sibyl advises Christine de Pisan, *Le Chemin de longue estude* (1403). Courtesy of the British Library, MS Harley 4431.

attention: allegorical ornaments? the stations of the cross? a drunken man? the smooth beads of the rosary fingered one by one?[31] In the long history of Christian meditation, there were multiple points of departure for the deepening and brightening of attention, each appealing to a different sense and bodily habitus. A broader survey of

[31] Carruthers, *The Craft of Thought*, pp. 167–169; Frank Livingstone Huntley, *Bishop Hall and Protestant Meditation in Seventeenth-Century England: A Study with Texts of the Art of Divine Meditation (1606) and Occasional Meditations (1633)* (Binghamton, NY: Center for Medieval and Early Renaissance Studies, 1981); François Lecercle, "Image et médiation: Sur quelques recueils de méditation illustrés de la fin du XVIe siècle," in Cahiers V.L. Saunier, *La Méditation en prose à la Renaissance* (Paris: Ecole Normale Supérieure, 1990): 44–57.

other meditative traditions would no doubt expand still further the repertoire of possible postures, objects, and disciplines. Hence merely to gesture towards the central role of attention in early modern observation tells us too little; we must examine the particular practices of attention with the naturalists' own magnifying glass.

Although many early modern naturalists made observations in the field, the pose associated with the actual making of an observation was frozen immobility, whether seated or standing. The French naturalist Réaumur related how during a leisurely promenade along the Loire he had stood stock-still to watch red ants copulate[32]; his Genevan disciple Bonnet spent hours mesmerized by a caterpillar spinning its cocoon.[33] **(Figure 8)** If the characteristic posture of the attentive Enlightenment naturalist was motionless, hunched, and peering, it was in part because the characteristic objects of attention were often small, and made smaller still by the naturalist: the veins of a leaf, the entrails of a caterpillar, the spores of a mushroom. If thirteenth-century scholastic philosophers had argued about how many angels could dance on the head of a pin, seventeenth-century natural philosophers examined the head of a pin with equal ardor. **(Figure 9)** To see like a naturalist was to analyze, to decompose the small into the minute.

The peculiar economy of attention cultivated by early modern naturalists was pointillist, magnifying, and therefore deliberately repetitive. Visually and intellectually, the observer pulverized the object into a mosaic of details, focusing first on one, then another. Even if observers worked without a lens or microscope, they imitated with the naked eye the circumscribed, pinpoint field of vision imposed by such optical instruments. Only the narrowness of focus could sufficiently concentrate attention to the level of

[32] René Antoine Ferchault de Réaumur, *Histoire des fourmis*, introduction de E.L. Bouvier, avec notes de Charles Pérez (Paris: Paul Le Chevalier, 1928), pp. 51–52.

[33] Bonnet, "Observation XXIII: Particularités sur l'industrie de la grande Chenille à tubercules du Poirier," *Traité d'insectologie* [1745] in idem, *Oeuvres d'histoire naturelle*, vol. 1, pp. 230–237.

Figure 8: Charles Bonnet's watercolor of a cocoon, with notes. Courtesy of the Bibliothèque publique et universitaire, Geneva.

intensity required for exact observations, as a parabolic mirror might fortify the intensity of a reflected light beam at the focal point. The metaphor of the burning glass is used advisedly: the exercise of attention was supposed to burn [*ébranle*] even the most trivial details into the observer's senses and memory.[34]

[34] Jean Senebier, *L'Art d'observer*, 2 vols. (Geneva: Chez Cl. Philibert & Bart. Chirol, 1775), vol. 1, p. 165.

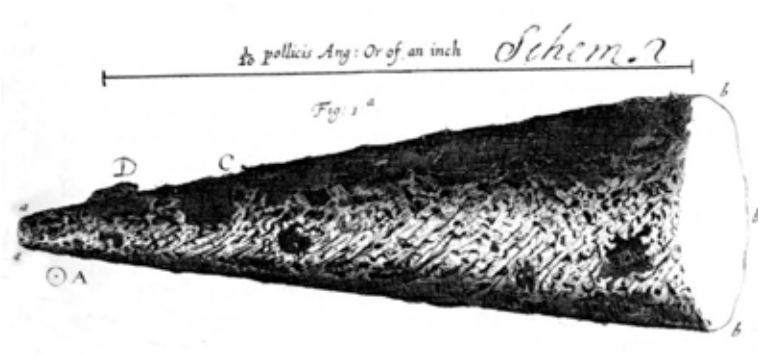

Figure 9: Magnified needle, Robert Hooke, *Micrographia: Or some Physiological Descriptions of Minute Bodies Made by Magnifying Glasses* (London: John Martyn and James Allestry, 1665), n.p. Courtesy of the Library of the Max Planck Institute for the History of Science, Berlin.

So pencil-thin and intense was the beam of attention that it could hardly be sustained over long periods. Hence the observer must return over and over again to the same object, picking out different details, different aspects each time and multiply confirming what had already been observed.[35] Still better was the repetition of observations by several observers, not because the veracity of the initial observations was in doubt, but rather to widen the panorama of different perspectives on the same object[36] – a kind of institutionalization of the blind-men-and-the-elephant procedure, in which one reports on the tail, another on the tusks, still another on the ears. Bonnet urged Italian naturalist Lazzaro Spallanzani to repeat the observations of others, including his own: "Nature is so varied that we can hardly vary our attempts too much."[37] The most ingenious efforts of early modern observers were directed towards the discernment of the most fleeting details, the finest nuances.

[35] Senebier, *L'Art d'observer*, vol. 1, p. 188.

[36] Benjamin Carrard, *Essai qui a remporté le prix de la Société Hollandoise des Sciences de Haarlem en 1770 sur cette Question. Qu'est-ce qui est requis dans l'Art d'Observer & jusques-où cet Art contribue-t-il à perfectionner l'Entendement?* (Amsterdam: Marc-Michel Rey, 1777), p. 207.

[37] Bonnet to Spallanzani, 27 December 1765, in Bonnet, *Oeuvres d'histoire naturelle*, vol. 5, p. 10.

Saussure invented an instrument called the cyanometer to measure the shades of blue of the sky, ranging over fifty-three graduations, from milky white to midnight blue.[38] Every simple perception – the sky is blue – fanned out into an array of ever more exquisite distinctions, each duly marked and named. **(Figure 10)**

There is an analogy between the form of attentiveness cultivated by early modern scientific observers and their meticulously timed

Figure 10: Horace Bénédict de Saussure, Cyanometer for measuring the blueness of the sky. Courtesy of © Musée d'histoire des sciences de Genève.

[38] Jean Senebier, "Mémoire historique sur la vie et les écrits de Horace Bénédict Desaussure," in Horace-Bénédict de Saussure, *Voyages dans les Alpes* [1779-96], 4 vols. (Geneva: Éditions Slatkine, 1978), vol. 1, p. 28.

Figure 11: Claude Aubriet, Primula, late 17th century. Courtesy of the Muséum national d'histoire naturelle, Paris, MS 675

journal entries: both fragmented wholes into parts and those parts into still smaller elements. Days dissolved into minutes; a flower splintered into petals, leaf, pistils, and stamens. **(Figure 11)** The bronchia of a caterpillar, the proboscis of a bee, the faint glow of a phosphor expanded to fill the entire field of the observer's consciousness. Each second swelled to a brief eternity, for as long as the observer's whole being was fixed upon the minute detail. The observer's time expanded and contracted like an accordion, keeping and losing time in rapid alternation.

Yet even the most zealous devotés of detail sometimes felt engulfed and overwhelmed. The miniscule object of observation – the horns of an aphid, the proboscis of a bee – swelled to fill the entire visual field, only to disintegrate into still more minute minutiae, until the observer lost sight of the object altogether. The practices of taking notes and paying attention as they were cultivated by early modern observers tended to fragment the object of inquiry: numbered, dated notebook entries chopped up time into slices; narrowly focused attention dissolved wholes into tiny parts. The challenge to what I will call the practices of synthesis was to glue all these fragments back together again into a coherent mosaic – but not thereby to reconstitute the actual object of observation. Instead, the result of the synthesis was a general object – variously described as an archetype, an ideal, an average, or a pure phenomenon – that was more regular, more stable, more universal, more *real* than any actually existing object.

Medieval observers had also confronted a challenge of synthesis, but of a different sort. Theirs was the challenge of integrating many observations of many objects over unimaginably long stretches of time, in order to detect processes that unfolded over centuries rather than human lifetimes, like the precession of equinoxes in astronomy, or to discern subtle correlations, like the stilling of birdsong before an earthquake. Individual observations and individual observers merged in the anonymity of eons. Observations were rarely dated or authored; detail disappeared in the pithy rhyme of the proverb that summarized the fruits of generations of watching and waiting. In contrast, from the mid sixteenth century onwards, observations were dated, recorded, repeated, and collected by named individuals who prided themselves on exactitude in perception and description.

The aim of medieval observation as an activity had been to produce observation in the sense of a rule or precept: a guide for when to reap and when to sow, when to furl and unfurl the sails of

a ship at sea, when to celebrate Easter in the spring and when to stable the herds in the winter. One can still catch a faint echo of this sense of observation as precept in seventeenth-century texts: Locke hoped weather tables like his own would eventually yield "Rules and Observations concerning the extent of winds and rains ... to the great advantage of Mankind."[39] But the more exact and detailed and numerous the observations became, the harder it was to compress them into a brief maxim. The techniques of synthesis practiced by early modern observers aimed to forge a general object out of particulars – but one that preserved the concreteness and specificity of the individual observations that had gone into making it.

Francis Bacon championed the cause of particulars in his visionary program for a reformed natural philosophy based on a compendious natural history, but he also worried that observers might drown in them. His solution to the problem of synthesis echoed the medieval meaning of the word *observatio* as rule or precept. Throughout his natural histories ("A History of Comets," "A History of Quicksilver," "A History of the Ebbs and Flows of the Sea", "A History of Flying Creatures," "A History of Wines," "A History of Life and Death"[40]), Bacon interspersed what he called "observations" as guides to possible generalizations, so that "the interpretation of nature may be prepared."[41] For example, after listing thirty-two numbered items relating to "Length or Shortness of Life" in the *History of Life and Death* (including that vultures can live to be a hundred but that sheep rarely attain the age of ten years), Bacon appended twelve numbered "greater observations" [*Observationes majores*], including the claim herbivores

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[39] John Locke, "A Register of the Weather for the Year 1692, Kept at Oates in Essex," *Philosophical Transactions of the Royal Society of London* 24 (1704):1917-1937, on p. 1919.

[40] Bacon lists 130 such histories as desiderata in the *Parasceve ad historiam naturalem et experimentalem* that accompanied the *Novum organum*: Montagu, ed., *The Works of Francis Bacon*, vol. 11, pp. 427–436. Only a few were ever even begun, including the *Historia ventorum, Historia vitae et mortis*, and *Historia densi et rari*.

[41] "Observationes nostras super Historiam et Experimenta subtextimus, ut Interpretatio Naturae magis sit procinctu." "Norma historiae praesentis," in Montagu, ed., *The Works of Francis Bacon*, vol. 10, p. 10.

are generally more short-lived than carnivores.[42] Elsewhere, Bacon recommended these interspersed "observations" (allegedly modeled on those of Pliny) as pointing the way to rules or "canons", such as the fact that Mercury is never more than twenty-three degrees from the sun, "which are only general and catholic observations".[43]

The process of how particulars were forged into generalities is most graphically displayed in the observation notebooks. Under the rubrics of "Reflections" or "Results" or "Remarks" were recorded the digestion of first impressions into second (and sometimes third) impressions. These were observations upon observations, the refinement and distillation of raw materials into what Francis Bacon had evocatively called "vintages". Here the older Renaissance practices of Humanist note-taking were preserved in spirit if not in substance: what sixteenth-century scholars had done for the writings of Cicero and Livy, eighteenth-century naturalists did for oysters and aphids. A first round of observations selected the noteworthy; a second round winnowed these further by comparisons and cross-correlations, seeking patterns and regularities; a third synthesized the features now understood to be the most significant or essential into the general observation. Whatever the metaphysics of individual naturalists might have been, there was nothing Platonic about this process. It required long and deep immersion in natural particulars, the exercise of sustained and analytical attention, and multiple stages of sieving and sifting. The general object could no more be extracted from a Platonic ideal than 24-karat gold could be refined out of the idea of gold.

Yet if the process of early modern observation was not necessarily metaphysical, it was often ontological. It created, or rather crafted, the objects of inquiry. The final stage of observation was very rarely intended to preserve a particular event or thing

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[42] *Historia vitae et mortis*, in Montagu, ed., *The Works of Francis Bacon,* vol. 10, pp. 134–145.

[43] *Parasceve ad historiam naturalem et experimentalem,* in Montagu, ed., *The Works of Francis Bacon,* vol. 11, p. 423.

in all its peculiarity. Although the observances of early modern scientific observation emphasized the meticulous investigation of minutiae, recorded minute by minute and detail by detail, the goal was an object that could be seen only with the eye of the mind. The general object abstracted from the idiosyncracies of the specific observations made with the eye of the body – but without becoming abstract. Moreover, it collapsed all the carefully timed and dated observations set down in notebooks into a single, timeless observation, as ageless as the medieval proverb.

The distinctive kind of knowledge that early modern observation produced was a fusion of the particular and the universal. Medieval observers employed a very different repertoire of practices to still more divergent ends. Yet they would have recognized the predicament of their early modern successors and have even been able to put a name to it. The closest literary analogue to the embodiment of the timeless and universal in the concrete here-and-now would be the allegory, in which an abstraction like nature or reason is minutely and lavishly described, right down to emblemata and details of dress, but nonetheless remains an abstraction, not a concrete individual. **(Figure 12)** Transposed to observation, this was where the eye of the body and the eye of the mind met, reversing the process of incarnation: the flesh made word.

Figure 12: Allegory of Nature at the forge hammering out the species, from an illuminated manscuript of the *Roman de la rose* (Paris, circa 1405). Courtesy of the J. Paul Getty Museum, MS Ludwig 7 (MS 83.MR.177).

Author's biographical sketch

Lorraine Daston has published on a wide range of topics in the history of science, including the history of probability and statistics, wonders in early modern science, the emergence of the scientific fact, scientific models, objects of scientific inquiry, the moral authority of nature, and the history of scientific objectivity. She is currently completing a book on "Moral and Natural Orders." *Histories of Scientific Observation*, co-edited with Elizabeth Lunbeck (Vanderbilt University), was published by the University of Chicago Press in 2011.

She has taught at Harvard, Princeton, Brandeis, and Göttingen Universities, as well as at the University of Chicago, where she is Visiting Professor in the Committee on Social Thought. She has also held visiting positions in Paris and Vienna and given the Isaiah Berlin Lectures at the University of Oxford (1999), the Tanner Lectures at Harvard University (2002), and the West Lectures at Stanford University (2005). In 2010 she was a Fellow of the Siemens-Stiftung in Munich. She has twice won the Pfizer Prize of the History of Science Society and is a Fellow of the American Academy of Arts and Sciences, a Corresponding Member of the British Academy, as well as a Member of the Berlin-Brandenburg Academy of Sciences and the Leopoldina. She is currently a director at the Max Planck Institute for the History of Science in Berlin.

SALVIA SMÅSKRIFTER

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In 2002 the Hans Rausing Professor of History and Science Tore Frängsmyr took the initiative to inaugurate a publication series *Salvia Småskrifter* with the aim to publish lectures arranged by the Office for History of Science at Uppsala University. The coinage *Salvia* is meant in memoriam of Sweden's first scientific book printer *Lars Salvius* (1706-1773) as well as that it refers to a wild growing Swedish plant, *Salvia pratensis*.

Salvia Småskrifter no. 1-9 had been published under the auspices of Tore Frängsmyr. In 2007 the newly installed Hans Rausing Professor at Uppsala University, H. Otto Sibum, took over the editorship.

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