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Wonders in the Academy: The Value of Strange Facts in the Experimental Research of Charles Dufay

ABSTRACT

What happened to wondrous phenomena during the European Enlightenment? A familiar answer is that the learned elites of the period, and especially those linked to the Royal Academy of Sciences in Paris, either ignored wonders or debunked them. Historians of science who have challenged this answer have so far paid little attention to one of the main sources of evidence usually invoked in its favor, namely the experimental reports of the chemist Charles Dufay (1698–1739). This paper considers Dufay's published articles, especially those on phosphorescence and electricity, and argues that far from disdaining wonders he valued them as a means of discovering new regularities and of correcting and confirming hypotheses. Moreover, his interest in wonders was due partly to three concerns that he shared with other members of the Academy, and especially with chemists such as Claude-Joseph Geoffroy and Jean Hellot. These concerns were the production of a large amount of empirical data, the practice of alchemy, and the need to write for an audience of non-academicians. One moral of this study is that Dufay had more in common with two of his seventeenth-century sources, Robert Boyle and Athanasius Kircher, than historians have so far supposed. Another is that the difference between lay and learned attitudes to wonders, insofar as it existed in the eighteenth century, lay not in the ejection of wonders from serious inquiry but in the shifting background of

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The following abbreviations are used: DD, Dufay Dossier, Folder Donner à M. l'abbé Nollet, Archives of the Royal Academy of Sciences, Paris, France; DSB, *Complete Dictionary of Scientific Biography* (Detroit: Charles Scribners Sons, 2008); HAS, *Mémoires de l'Académie Royale des Sciences*, Paris, France; HS, Hans Sloane manuscript collection, British Library, London, UK; MAS, *Mémoires de l'Académie Royale des Sciences*, Paris, France; MF, *Mercur de France*, Paris, France; PT, *Philosophical Transactions of the Royal Society of London*; PV, Procès-verbaux of the Royal Academy of Sciences.

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expectations against which different groups judged which facts were wondrous and which were mundane or unsurprising.

KEY WORDS: Royal Academy of Sciences, Charles Dufay, wonders, phosphorescence, electricity, Claude-Joseph Geoffroy, Robert Boyle, Athanasius Kircher

How astonished would be those who have written entire volumes singing the praises of the marvellous properties of this stone, if they saw today that it is almost impossible to find any material in the world that does not have the same qualities! Today it would be very unusual to find a substance that could not be made luminous, either by calcination or by dissolution.¹

The stone mentioned in the first sentence of this passage is the Bologna stone, and its “marvellous properties” included the ability to glow in the dark after being exposed to bright light. The passage appeared in a paper read to the Royal Academy of Sciences in Paris in 1730, and was published two years later in the *Mémoires* of that institution. The author was Charles Dufay (1698–1739), then an *adjoint* in the chemistry section of the Academy. Dufay argued that a large number of materials could be made to glow in the dark, just like the Bologna stone, through simple operations familiar to any chemist of the day.

It is perhaps no surprise that historians have seen Dufay’s article as evidence of the decline of wonders as respectable subjects of study by natural philosophers during the European Enlightenment.² For example, Lorraine Daston contrasted the “facts of regular phenomena” sought by Dufay with the “facts of strange phenomena” that fascinated his English predecessor Robert Boyle.³ In Daston’s view this contrast exemplifies a broader trend in which learned thinkers in the early eighteenth century turned up their noses at the rare, inexplicable, and one-of-a-kind phenomena that had been common currency among the “preternatural philosophers” of the seventeenth century, a group that included members of the Academy who took up Francis Bacon’s call for the study of all that was “new, rare and unusual in nature.”⁴ Daston does not

1. Charles Dufay, “Mémoire sur un grand nombre de phosphores nouveaux,” *MAS* (1730): 524–35, on 534 (henceforth “Phosphores nouveaux”). All translations are my own unless otherwise indicated.

2. Wonders as natural phenomena, and not wonder as an emotional response to nature, is the topic of this paper.

3. Lorraine Daston, “The Cold Light of Facts and the Facts of Cold Light: Luminescence and the Transformation of the Scientific Fact, 1600–1750,” *Early Modern France* 3 (1997): 1–27.

4. Lorraine Daston and Katharine Park, *Wonders and the Order of Nature, 1150–1750* (New York: Zone Books, 1998), chap. 5; Lorraine Daston, “Preternatural Philosophy,” in *Biographies of*

maintain that such phenomena disappeared altogether in the eighteenth century. Her claim is rather that they ceased to be of interest to the new philosophical elites, who followed their spokesman, Bernard le Bovier de Fontenelle, Perpetual Secretary of the Academy from 1697 to 1739, in admiring the exquisite harmony of nature rather than gawping at her unfathomable mystery. Similarly, Christian Licoppe has contrasted Dufay's interest in stable, invariable phenomena with the "pleasing, visual, surprising and singular" phenomena favored by his seventeenth-century predecessors in the Academy.⁵ For both authors, Dufay's article on phosphors signaled the arrival of "a new kind of fact and practice."⁶

This narrative has not gone unchallenged. Gaston Bachelard wrote long ago that experimenters in the eighteenth century were "filled with naïve curiosity . . . marvelling at any phenomenon instruments produce."⁷ Since then numerous historians have explored the theme of "science and spectacle in the European Enlightenment," to borrow the title of a recent collection.⁸ There is no

Scientific Objects, ed. Lorraine Daston (Chicago: University of Chicago Press, 2000), 15–41. In these works Dufay's article on phosphors is invoked as a key example on pp. 352 and 40, respectively. Cf. Lorraine Daston, "The Factual Sensibility," *Isis* 79, no. 3 (1988): 452–67; Lorraine Daston, "Strange Facts, Plain Facts, and the Texture of Scientific Experience in the Enlightenment," in *Proof and Persuasion: Essays on Authority, Objectivity, and Evidence*, ed. Suzanne L. Marchand, Elizabeth Lunbeck, and Josine Blok (Turnhout, Bel.: Brepols, 1996), 42–59; Lorraine Daston, "The Language of Strange Facts in Early Modern Science," in *Inscribing Science: Scientific Texts and the Materiality of Communication*, ed. Timothy Lenoir (Stanford, CA: Stanford University Press, 1997), 20–38. "New, rare and unusual" at Francis Bacon, *Novum Organon* (London, 1620), bk. 2, par. 29, in *The Works of Francis Bacon*, ed. Basil Montagu, 17 vols. (London, 1831), vol. 14, 138, quoted in Lorraine Daston and Katharine Park, "Unnatural Conceptions: the Study of Monsters in Sixteenth- and Seventeenth-Century France and England," *Past and Present* 92, no. 1 (1981): 20–54, on 20. Although *Wonders*, cited above, is cowritten with Katharine Park, Daston has written a number of single-authored papers supporting the view about eighteenth-century wonders put forward in that book, including a paper dealing in some detail with Dufay. Daston, "Cold Light" (ref. 3). Hence in this paper I attribute that view to Daston and not to Park. In one text Daston places the transition from "strange facts" to "plain facts" around 1730 rather than around 1700, and draws on Dufay's research for examples of both kinds of fact; but this is atypical. Daston, "Strange Facts, Plain Facts," cited above, on 49, 51, 55, and 56.

5. Christian Licoppe, *La formation de la pratique scientifique: Le discours de l'expérience en France et en Angleterre (1630–1820)* (Paris: La Découverte, 1996), 46, cf. 98, 113–16, and 118–19.

6. *Ibid.*, 113.

7. Gaston Bachelard, *The Formation of the Scientific Mind: A Contribution to a Psychoanalysis of Objective Knowledge*, trans. Mary McAllester Jones (Manchester: Clinamen, 2002), 39, cf. 40, 44, and 47.

8. Bernadette Bensaude-Vincent and Christine Blondel, eds., *Science and Spectacle in the European Enlightenment* (Aldershot, UK: Ashgate, 2008). Bachelard's ideas entered this literature

shortage of examples: the electrical demonstrations of the French academician Jean-Antoine Nollet;⁹ the coffee-house displays by John Theophilus Desaguliers and other English entrepreneurs;¹⁰ the parlor tricks invented by Benjamin Franklin and peddled in the New World by showmen such as his friend Ebenezer Kinnersley;¹¹ the explosive chemical lectures of Guillaume-François Rouelle at the King's Garden in Paris;¹² the freelance popularizers in England who profited from the discoveries of Joseph Priestley;¹³ the fondness for “baffling, theory-defying accidents” that the young Maximilien Robespierre shared with leading thinkers in France and England;¹⁴ and the scientific entertainments sold by a large cast of lesser-known figures including Italian army physicians and the Vienna-born lecturer Martin Berschitz.¹⁵

Absent from this list is Charles Dufay. Historians acknowledge that Dufay's successors in the domain of electricity used his findings for the purpose of “public demonstration and amateur amusement.” But it is thought that Dufay himself had no time for such things, or that the “professional” aspects

at Simon Schaffer, “Natural Philosophy,” in *The Ferment of Knowledge: Studies in the Historiography of Eighteenth-Century Science*, ed. G. S. Rousseau and Roy Porter (Cambridge: Cambridge University Press, 1980), 55–91, on 77 and 83.

9. Simon Schaffer, “Natural Philosophy and Public Spectacle in the Eighteenth Century,” *History of Science* 21, no. 1 (1983): 1–43, on 12–13; Geoffrey Sutton, *Science for a Polite Society: Gender, Culture, and the Demonstration of Enlightenment* (Boulder, CO: Westview Press, 1995), 300–19; Paola Bertucci, “Public Utility and Spectacular Display: Jean Antoine Nollet and the Royal Museum in Florence (1775),” *Nuncius* 21, no. 2 (2006): 323–36.

10. Larry Stewart, *The Rise of Public Science: Rhetoric, Technology, and Natural Philosophy in Newtonian Britain, 1660–1750* (Cambridge: Cambridge University Press, 1992), chap. 4; Michael Ben-Chaim, “Social Mobility and Scientific Change: Stephen Gray's Contribution to Electrical Research,” *British Journal for the History of Science* 23, no. 1 (1990): 3–24, on 17–21; Barbara Maria Stafford, *Artful Science: Enlightenment Entertainment and the Eclipse of Visual Education* (Cambridge, MA: MIT Press, 1996), 176–82.

11. James Delbourgo, *A Most Amazing Scene of Wonders: Electricity and Enlightenment in Early America* (Cambridge, MA: Harvard University Press, 2006), chap. 3.

12. Lissa Roberts, “Chemistry on Stage: G. F. Rouelle and the Theatricality of Eighteenth-Century Chemistry,” in Bensaude-Vincent and Blondel, eds., *Science and Spectacle* (ref. 8), 129–39.

13. Jan Golinski, *Science as Public Culture: Chemistry and Enlightenment in Britain, 1760–1820* (Cambridge: Cambridge University Press, 1999), chap. 4.

14. Jessica Riskin, *Science in the Age of Sensibility: The Sentimental Empiricists of the French Enlightenment* (Chicago: University of Chicago Press, 2002), 91 for “baffling” and chap. 4 for Robespierre.

15. Paola Bertucci, “Domestic Spectacles: Electrical Instruments Between Business and Conversation,” in Bensaude-Vincent and Blondel, eds., *Science and Spectacle* (ref. 8), 64–100; Oliver Hochadel, “The Sale of Shocks and Sparks: Itinerant Electricians in the German Enlightenment,” in *ibid.*, 89–101.

of Dufay's research were "dreadfully boring" and "had almost no direct effect on the study of electricity."¹⁶ The default view about Dufay remains that of Daston and Licoppe, according to which he was among those who "came to disdain both wonder and wonders in the first half of the eighteenth century."¹⁷ A critical study of this view is long overdue.

Two other features of the existing literature on eighteenth-century spectacles make Dufay a timely case study. One is that the most common explanations of the persistence of wonders in the eighteenth century are commercial and theatrical.¹⁸ Simply put, striking effects attracted clients more effectively than dull, predictable ones. Audiences of experimental spectacles sometimes paid for pure entertainment, as they paid for card games and bear baiting.¹⁹ More often they paid for entertainment plus instruction: as one of Desaguliers' pupils put it, "the man who combines usefulness with pleasure has covered every point."²⁰ In return the experimenter acquired money, social advancement, or the trust and attention of potential investors in his inventions. Dufay's published works suggest a different set of motives: they are rich with remarks on the value of wonders as starting points for empirical inquiry and as a means of discovering new regularities and confirming or correcting hypotheses. Dufay valued wonders as a means to his epistemic ends, much as "preternatural philosophers" had done for the previous two centuries.

Secondly and relatedly, current literature puts the accent on forces that acted *outside* elite institutions like the Royal Academy of Sciences. There is good reason for this. As Bachelard put it, eighteenth-century science was "rooted in everyday life."²¹ Many leading experimenters in the period—

16. Sutton, *Polite Society* (ref. 9), 294, 299.

17. Daston and Park, *Wonders* (ref. 4), 329. In challenging this view I am indebted to, but go beyond, the suggestive summaries of Dufay's experimental style at J. L. Heilbron, *Electricity in the Seventeenth and Eighteenth Centuries: A Study of Early Modern Physics* (Berkeley: University of California Press, 1979), 250–51, 261.

18. A recent exception is Riskin, *Age of Sensibility* (ref. 14), chap. 4, esp. 142–43, and 148. I shall extend Riskin's account by arguing that Dufay valued shining and variable phenomena, not just singular ones; and that his epistemic reasons for valuing wonders included, but were not limited to, their power to confound theory.

19. For example, Delbourgo, *Amazing Scene* (ref. 11), 121.

20. Cited in Stewart, *Public Science* (ref. 10), 131. On the theme of "rational entertainment" in the eighteenth century see also Golinski, *Public Culture* (ref. 13), chap. 4; Delbourgo, *Amazing Scene* (ref. 11), chap. 3; Roberts, "Chemistry on Stage" (ref. 12), 137; Stafford, *Artful Science* (ref. 10); Palmira Fontes da Costa, *The Singular and the Making of Knowledge at the Royal Society of London in the Eighteenth Century* (Cambridge: Cambridge Scholars Publishing, 2009), 49.

21. Bachelard, *Scientific Mind* (ref. 7), 34, cf. 38–39.

among them Nollet, Gray, Desaguliers, and Franklin—had one foot in a learned institution and the other in a court, coffeehouse, salon, or popular lecture-hall. And it may be that past work on eighteenth-century science has suffered from “an almost exclusive focus on academic memoirs and publications.”²² Nevertheless, learned bodies such as the Royal Society of London and the Paris Academy were purposeful, well-defined institutions that had their own interests and dynamics and that exerted distinctive pressures on their members. It is worth inquiring how these forces—and not just those of the wider world—shaped eighteenth-century attitudes towards wonders.²³

Dufay suits such an inquiry because he was a loyal academician from his election at the age of twenty-five until his death sixteen years later. Indeed, in some respects he was a more typical member of the Academy than were three of his colleagues whose attitudes to wonders or spectacles have been studied recently. Unlike Fontenelle, he carried out his own experimental research rather than summarizing and synthesizing the research of others.²⁴ Unlike his exact contemporary Pierre Maupertuis, all of his original published works appeared in the *Mémoires* of the Academy and with the full approval of that institution.²⁵ And unlike his student Nollet, he did not have a flourishing private career as a lecturer, demonstrator, and instrument maker.²⁶ Nollet’s entrepreneurial activities meant that he designed many of his experiments for a far larger audience than did the typical academician of the period. Those activities also encourage the view that academicians only valued wonders as personal business opportunities, and that *qua* academicians they treated wonders as outgrowths of “plebian credulity and superstition.”²⁷ Dufay certainly

22. Bensaude-Vincent and Blondel, eds., *Science and Spectacle* (ref. 8), 2.

23. Such forces have been studied in detail in the case of the Royal Society of London, in da Costa, *Singular* (ref. 20).

24. Fontenelle’s attitude to wonders is considered in Sutton, *Polite Society* (ref. 9), chap. 5. Fontenelle did some experimental research with fellow academicians, but it was not his main role in the Academy. Leonard M. Marsak, “Bernard De Fontenelle: The Idea of Science in the French Enlightenment,” *Transactions of the American Philosophical Society* 49, no. 7 (1959): 1–64, on 33.

25. Maupertuis’s use of books to cultivate a public persona, sometimes at odds with the Academy, is covered in Mary Terrall, *The Man Who Flattened the Earth: Maupertuis and the Sciences in the Enlightenment* (Chicago: University of Chicago Press, 2002), esp. 4–6, 30–34, 69–78, 83–87, 114–49, 154–64.

26. Nollet’s career is usefully summarized in Paola Bertucci, “Back from Wonderland,” in *Curiosity and Wonder from the Renaissance to the Enlightenment*, ed. Robert Evans and Alexander Marr (Aldershot, UK: Ashgate, 2006), 193–211, on 196–200.

27. This two-tiered attitude to wonders is attributed to Nollet at *ibid.*, 195, where the phrase “plebian credulity and superstition” occurs.

used wonders to appeal to a broader public. But this was the Academy's public rather than Dufay's own, and he had independent epistemic reasons for valuing wonders.²⁸

Dufay demands our attention not just for his attitude to wonders but also for his legacy to electricians and his high standing in the Republic of Letters. As one historian put it, Dufay discovered “the dominant electrostatic regularities.”²⁹ All of his chief findings in this domain—that electricity was more or less a universal property of matter, that electrical repulsion was a real effect, that electrified objects could deliver painful shocks to humans in their vicinity, that the electrical behavior of a body depended heavily on whether it was an “electric” (an insulator) or a “non-electric” (a conductor), and that there were two kinds of electrification (“resinous” and “vitreous”) such that two bodies endowed with the same kind repelled each other and two bodies endowed with opposite kinds attracted each other—were central to research on electricity in the two decades after Dufay's death. Nollet himself was Dufay's laboratory assistant before becoming the most well-known purveyor of electrical spectacles in France.³⁰ In England, Stephen Gray followed Dufay's electrical research closely and Desaguliers interpreted Dufay's findings for an English audience. Dufay found his way into German textbooks in the 1740s, and from there into the spectacular and important investigations of the Leipzig school of electricians.³¹ Much of the excitement surrounding the Leyden jar (invented in the mid-1740s) was due to its apparent violation of Dufay's rule that electricity was retained only by bodies that were isolated from surrounding non-electrics by a support made of an electric substance. Dufay's other posthumous contribution to the science of electricity came via his research on electric shocks, which led Benjamin Franklin to the experiment that persuaded him to see Dufay's vitreous and resinous electricities as the surfeit and deficit of a single electric matter.³²

28. One of Dufay's reasons (“[wonders] strengthened the explanatory power of natural philosophical systems”) was also one of Nollet's, as noted in Bertucci, “Back from Wonderland” (ref. 26), 211.

29. Heilbron, *Electricity* (ref. 17), 250.

30. For evidence of Nollet's debt to Dufay, see Sutton, *Polite Society* (ref. 9), 301, 304, 306, and 313.

31. On the reception of Dufay's results by Gray, Desaguliers, German textbook-writers, Bose and Hausen, see Heilbron, *Electricity* (ref. 17), 258–60, 295, 263, 264–65, and 271. Fontenelle celebrated the Dufay/Gray collaboration in his “Eloge de Dufay,” *HAS* (1739): 73–83, on 76.

32. Heilbron, *Electricity* (ref. 17), 314–16, 324–27; J. L. Heilbron, “A propos de l'invention de la bouteille de Leyde,” *Revue d'histoire des sciences et de leurs applications* 19, no. 2 (1966): 133–42.

During his lifetime Dufay won esteem for his twenty other academic papers, his prestigious appointments in Paris, his travels in Europe, and his influential friends.³³ He was the first academician to publish articles on all six of the disciplines recognized by the Academy; in the *Mémoires*, Fontenelle eulogized, “no name is more often repeated than his.”³⁴ Scientific success led quickly to other distinctions. Dufay became a *pensionnaire* in the Academy’s chemistry section in 1731 and Director of the institution in 1733 and 1738, as well as Director of the Academy’s laboratory. Thanks to his Academy contacts he also became head of the King’s Garden, a state consultant on textile dyes, and an intermediary between the Academy and the Département de Commerce.³⁵ In the 1730s he traveled with Nollet to visit the Royal Society of London and the University of Leyden, making contact with other leading experimental philosophers such as Desaguliers, Pieter van Musschenbroek, and Willem Jacob’s Gravesande.³⁶ These visits bore fruit in Dufay’s correspondence with Musschenbroek on meteorology, with Stephen Gray on electricity, and with the Royal Society on the standardization of English and French weights and

on 138; J. L. Heilbron, “Franklin, Haller, and Franklinist History,” *Isis* 68, no. 4 (1977): 539–49, on 542–43; Anonymous, “An Historical Account of the Wonderful Discoveries, Made in Germany, &c. Concerning Electricity,” *Gentleman’s Magazine* 15 (1745): 193–97, on 193–94; Dufay, “M3. Des corps qui sont les plus vivement attirés par les matières électriques, et de ceux qui sont les plus propres à transmettre l’électricité,” *MAS* (1733): 233–54, on 251–53; Dufay, “M6. Quel rapport il y a entre l’électricité et la faculté de rendre de la lumière, qui est commune à la plupart des corps électriques, et ce qu’on peut inférer de ce rapport,” *MAS* (1734): 503–26, on 518. As in the rest of this paper, “M#” stands for the #th of Dufay’s eight papers on electricity.

33. For a list of Dufay’s academic papers see Pierre Brunet, “L’oeuvre scientifique de Charles François du Fay,” *Petrus Nonius* 3, no. 2 (1940): 77–95, on 78 n.3.

34. Fontenelle, “Eloge de Dufay” (ref. 31), 76. The disciplines were geometry, mechanics, astronomy, chemistry, botany, and anatomy.

35. For the dates of Dufay’s Academy appointments see Mi Gyung Kim, *Affinity, That Elusive Dream: A Genealogy of the Chemical Revolution* (Cambridge, MA: MIT Press, 2003), 458–60. On Dufay’s role in the King’s Garden see Fontenelle, “Eloge de Dufay” (ref. 31), 77–79. On his dye tests see *ibid.*, 76–77 and the discussion and citations in Simon Schaffer, “Experimenters’ Techniques, Dyers’ Hands, and the Electric Planetarium,” *Isis* 88, no. 3 (1997): 456–83, on 459 and 479–82. Dufay’s positions at the Département de Commerce and as laboratory director are noted respectively at Marquis de Condorcet, “Eloge De M. Montigni,” *HAS* (1782): 108–21, on 117; Grace Chuang, “The Role of the Savant and the Académie Royale Des Sciences in Porcelain Research and Development in France, 1715 to 1772” (Master’s thesis, Bard Graduate Center, New York City, 2010), 54.

36. On Dufay’s foreign trips see Fontenelle, “Eloge de Dufay” (ref. 31), 78. The value of these visits for Nollet is noted in Jean Torlais, *L’Abbé Nollet, 1700–1770 et la physique expérimentale au XVIIIe siècle* (Paris: Librairie du Palais de la Découverte, 1959), 8; Jean-Paul Grandjean de Fouchy, “Eloge de l’Abbé Nollet,” *HAS* (1770): 121–35, on 123.

measures.³⁷ Emilie du Châtelet considered Dufay a close friend;³⁸ Voltaire ranked him alongside Maupertuis, Réaumur, Ortous de Mairan, and Alexis Clairaut as one of the “veritable savants” of his age.³⁹ For all of these reasons, Dufay’s views on wonders—and on empirical inquiry in general—should interest us as much as those of Desaguliers, Nollet, or Maupertuis.

The first section of this paper argues that Dufay valued three kinds of wondrous phenomena that he is said to have rejected. Wonders in early modern science could be *singular* in the sense of being anomalous: they fell outside or between existing categories and escaped explanation in terms of known causes, challenging both accepted wisdom and common experience.⁴⁰ Whereas singularities were one-of-a-kind phenomena, *shining* instances were vivid or striking instances of a kind, defined by their “sheer contrast with the prosaic and mundane.”⁴¹ Finally, wonders included *variable* phenomena: those that were rare, changeable, remote, or fleeting, and thereby “devilishly difficult to produce and reproduce.”⁴² The epistemic value that Dufay placed on these kinds of wonder is clear from his choice of research topics, his habits as an experimenter, the vocabulary of his published reports, and the methodological statements he scattered through those reports.

37. On the expansion of the King’s Garden see Fontenelle, “Eloge de Dufay” (ref. 31), 78. On Dufay’s correspondance with Musschenbroek see Pierre Brunet, *Les physiciens hollandais et la méthode expérimentale en France au XVIIIe siècle* (Paris: Albert Blanchard, 1926), 107–08; Dufay, “Observations Météorologiques faites à Utrecht,” *MAS* (1734): 564–66, (1735): 581–85, and (1736): 503–05; Dufay, “Mémoire sur la rosée,” *MAS* (1736): 354–55. On standardization see Charles Marie de la Condamine, “Nouveau projet d’une mesure invariable propre à servir de mesure commune à toutes les nations,” *MAS* (1747): 489–514, on 490; “An Account of the Proportions of English and French Measures and Weights, from the Standards of the Same, Kept at the Royal Society,” *PT* 42 (1742): 185–88, on 186, cited in Lesley Hanks, *Buffon avant l’Histoire Naturelle* (Paris: Presses Universitaires de France, 1966), 79 n.28.

38. Heilbron, *Electricity* (ref. 17), 260; and J. L. Heilbron, “Dufay, Charles François de Cisternay,” in *DSB*, vol. 4, 214–17, on 216.

39. Voltaire, “Alzire, ou les Américains,” in *Oeuvres complètes de Voltaire*, vol. 1 (Paris, 1835), 339–40, cited in Jacques Roger, *The Life Sciences in Eighteenth-Century French Thought*, trans. Keith Rodney Benson (Stanford, CA: Stanford University Press, 1997), 517 n.286.

40. The notion that wonders defied existing categories appears at Daston, “Cold Light” (ref. 3), 21–24 and Daston, “The Factual Sensibility” (ref. 4), 458, 456. On wonders defying explanation see Daston, “Preternatural Philosophy” (ref. 4), 22. Wonders are characterized as “anomalies” at Daston and Park, *Wonders* (ref. 4), 142; Daston, “Factual Sensibility” (ref. 4), 458; Daston, “Preternatural Philosophy” (ref. 4), 15.

41. Daston, “Factual Sensibility” (ref. 4), 458.

42. Daston, “Cold Light” (ref. 3), 26; cf. Daston and Park, *Wonders* (ref. 4), 238, 240, and 312.

The second section considers two features of Dufay's experimental style—bold generalizations and selective reporting—that historians have taken as evidence for his distrust of wonders. Certainly Dufay generalized often and broadly. But he was not shy about reporting exceptions to the laws he devised; and he often eschewed generalization, either because he found too many counter-instances or because he was more interested in understanding the phenomenon at hand than he was in establishing its ubiquity. Likewise, it must be conceded that Dufay omitted many details from his reports. But it does not follow that these omissions were due to a metaphysical faith in the uniformity of nature or to an effort to transmit this faith to the general public. Indeed, some of Dufay's omissions even had the effect of *adding* to the wondrous qualities of his reports. Alternative explanations for Dufay's omissions are the methodical arrangement of his reports and the sheer volume of data he produced.

Section three traces Dufay's interest in wonders to three features of the Academy of his day. Two of these were especially pertinent for the chemists at the Academy, a group that included some of Dufay's closest friends and collaborators. The first feature was a surfeit of experimental data. Dufay's solution to this problem—omitting details from his reports and focusing on novel or telling instances—was one he shared with his fellow chemists as well as with earlier academicians such as the botanist and physician Denis Dodart. Secondly, many of Dufay's fellow chemists were also alchemists. Like his friends Jean Hellot and Claude-Joseph Geoffroy, Dufay had a sincere desire to learn from the experimental reports of past adepts, no matter how fabulous they might appear at first glance. Finally, the Academy of Dufay's day was an outward-looking institution that strove to interest a broader public in its activities. Dufay wrote (in the *Mémoires*) and spoke (in the public sessions of the Academy) with his audience in mind. Two of his aims on such occasions were entertainment and audience participation, and both help to explain the wonders in his published articles.

The paper concludes with two suggestions for further research. The first is that the continuity between seventeenth-century and eighteenth-century attitudes to wonders was greater than historians have sometimes supposed. This can be seen by the links between Dufay and his predecessors Robert Boyle and Athanasius Kircher, both of whom have been advanced as exemplary members of the "culture of strange facts" of the seventeenth century. The second suggestion is that we should not dismiss too quickly the notion that the eighteenth century witnessed, at least in some domains, a divergence between lay and

learned attitudes to wondrous phenomena. We can retain this insight by insisting that the divergence, insofar as it occurred, lay not in the rejection of wonders by the learned but in the shifting background of expectations against which the learned judged which facts were wondrous and which were mundane and unsurprising.

SINGULAR, SHINING, AND VARIABLE PHENOMENA

Dufay's choice of research topics suggests that he had a taste for the singular. He published articles not only on phosphors and electricity but also on magnetism, salamanders, sensitive plants, luminous diamonds, figured stones, mock suns, and double refraction.⁴³ These phenomena accounted for sixteen of Dufay's twenty-eight academic papers, and all were considered by Dufay and his contemporaries to be strange, inexplicable, or marvelous.

These examples show at least that Dufay did not "ignore" singular phenomena.⁴⁴ Nor is it likely that Dufay studied these phenomena only to debunk them. True, he had little enthusiasm for the obscurity and hyperbole that he found in writings of past authors on, for example, the luminosity of diamonds. But he had nothing against well-verified marvels or well-described surprises. This epistemic filter helps to explain why Dufay could dismiss a report of a glow-in-dark carbuncle as a trumped-up marvel and in the same article praise an experiment by Francis Hauksbee as "one of the most astonishing paradoxes in physics."⁴⁵ He even warned experimenters not to dismiss

43. See, respectively, Dufay, "Observations sur quelques expériences de l'aimant," *MAS* (1728): 355–69, on 355; Dufay, "Observations physiques et anatomiques sur plusieurs espèces de Salamandres qui se trouvent aux environs de Paris," *MAS* (1729): 135–53, on 135; Dufay, "Observations sur la Sensitive," *MAS* (1736): 87–111 and Fontenelle, "Sur la Sensitive," *HAS* (1736): 73–79, on 52; Dufay, "Recherches sur la lumière des diamants et de plusieurs autres matières," *MAS* (1735): 347–72, on 347; Dufay, "Mémoire sur la teinture et la dissolution de plusieurs espèces de pierres," *MAS* (1728): 50–67, on 50. The aurora borealis is listed as a wonder at Daston and Park, *Wonders* (ref. 4), 244 and 250; Lorraine Daston, "Marvellous Facts and Miraculous Evidence in Early Modern Europe," *Critical Inquiry* 18, no. 1 (1991): 93–124, on 105; see also Dufay, "Observations sur les parhélies," *MAS* (1735): 87–97. On double refraction see Fontenelle, "Eloge de Dufay" (ref. 31), 81; Christian Huygens, *Traité de la lumière* (Paris, 1690), chap. 5, esp. "marvellous refractions" on 65.

44. "Ignore" at Daston, "Preternatural Philosophy" (ref. 4), 40; Daston and Park, *Wonders* (ref. 4), 361.

45. Dufay, "M6. L'électricité et la lumière" (ref. 32), 503, 507, 515, and 521–23. Cf. Réaumur's attitude to marvels as summarized in Jean Torlais, *Un esprit encyclopédique en dehors de L'Encyclopédie: Réaumur, d'après des documents inédits* (Paris: Albert Blanchard, 1961), 92.

the seemingly fabulous reports of past writers, lest one overlook the factual gems buried in their muddy prose.⁴⁶

Only in one of the nine cases listed above (the ability of salamanders to withstand fire) did Dufay deny the reality of the wondrous phenomenon in question. In all the other cases he accepted the wonder as real, examined it in detail, and tried to reduce it to rule—to “constant principles” and “exact laws,” as he proudly described the results of his electrical research.⁴⁷ The same applies to the singularities that he came across in the course of his investigations, whether these were the many “astonishing phenomena” of electricity or the “singular effect” of old phosphors that recover their glow after being plunged into water.⁴⁸ Indeed, he considered one of his most singular findings on electricity to be one of his most important. It was a great surprise, “remote from our most natural ideas,” that the objects hardest to electrify by rubbing were the easiest to electrify by the approach of an electrified glass tube. Despite its air of paradox, Dufay thought this observation could “shed more than light than any other on the nature of electricity.” His end may have been regularity, but his means included the close study of the singular.⁴⁹

The frequency of a writer’s use of words denoting wonder is often taken as evidence for his or her attitude to singular phenomena.⁵⁰ Dufay used such words often, usually with approval. Communication by approach was “singular”; an experiment with a tube and gold leaf was “singular enough to warrant attention”; Gray’s experiments on electrified humans had “certainly struck everyone who has heard of them.”⁵¹ Dufay praised Hauksbee for his “curious experiments,” Gray for his “singular discoveries,” and Robert Boyle and Otto

46. Dufay, “La lumière des diamants” (ref. 43), 347.

47. Dufay, “M6. L’électricité et la lumière” (ref. 32), 526.

48. Dufay, “Phosphores nouveaux” (ref. 1), 532; Dufay, “M3. Corps attirés” (ref. 32), 251.

49. Dufay, “M2. Quels sont les corps qui sont susceptibles d’électricité,” *MAS* (1733): 73–84, on 83.

50. “Curious,” “ingenious,” “new,” “remarkable,” “singular,” “unusual,” “extraordinary,” and “uncommon” appear on Daston’s lists of wonder words—*Wonders* (ref. 4), 218, 231; “Strange Facts, Plain Facts” (ref. 4), 50. Licoppe’s list is “curieux, singulier, merveilleux, prodigieux”—*Formation* (ref. 5), 168.

51. Dufay, “Corps susceptibles” (ref. 49), 81; Dufay, “M4. L’attraction et la répulsion des corps électriques,” 458–60. Other examples from Dufay: “M5. Des nouvelles découvertes sur cette matière, faites depuis peu par M. Gray,” *MAS* (1734): 341–61, on 341, 346–47; “M6. L’électricité et la lumière” (ref. 32), 503, 504, 507, 508, 510, 515, 518, 520; “M7. Quelques additions aux mémoires précédants,” *MAS* (1737): 86–100, on 87, 90; “M8. Huitième mémoire,” *MAS* (1737): 307–25, on 308, 309–10, 314.

von Guericke for their “singular” facts and experiments.⁵² He could think of no greater compliment to new marvels—whether they were the long-distance transmission of electricity, a hand glowing through a layer of wax, or a planetarium driven by electricity—than to say that they surpassed all the marvels hitherto encountered in the study of electricity, “that marvellous property of matter.”⁵³ If Dufay disdained wonders, it did not show in his vocabulary.

Why this fondness for singularities? For Dufay they were the ultimate justification for empirical inquiry, since discoveries of counter-intuitive facts were “due to experiments alone.”⁵⁴ Dufay also valued them for a reason that recalls Francis Bacon’s warnings about the dangers of premature generalizations.⁵⁵ “One cannot report too scrupulously the singular happenings in these experiments,” he wrote in his seventh paper on electricity, “especially when they appear not to agree with the principles one is trying to establish.”⁵⁶ Anomalies were valuable because they “put us on guard against the consequences that we are too often tempted to draw from experiments by the relation and analogy that we imagine we have found between them.”⁵⁷ Dufay practiced what he preached: the occasions for each of these statements were phenomena that appeared to contradict either common sense or Dufay’s preferred theory, and which he reported in detail.

Dufay also valued singular instances as a means of confirming hypotheses. This showed most clearly in his demonstration of a rule governing electrical attraction, communication, and repulsion. Dufay first stated the “ACR rule” as a hypothesis in need of verification:⁵⁸ “I imagined that any given electrified body attracts all non-electrified bodies, and repels all those that have been

52. Dufay, “M3. Corps attirés” (ref. 32), 235; “M7. Quelques additions” (ref. 51), 86; “M6. L’électricité et la lumière” (ref. 32), 503.

53. Dufay paid this compliment to the three marvels mentioned at “M1. L’histoire de l’électricité,” *MAS* (1733): 23–35, on 31–32; “M6. L’électricité et la lumière” (ref. 32), 507, 521; “M8. Huitième mémoire” (ref. 51), 309–10. “Marvellous property” at Dufay, “M6. L’électricité et la lumière” (ref. 32), 525. Cf. Dufay, “M3. Corps attirés” (ref. 32), 251; Fontenelle, “Sur l’électricité,” *HAS* (1734): 1–8, on 3.

54. Dufay, “M2. Corps susceptibles” (ref. 49), 83.

55. For example, Bacon, *Novum Organon* (ref. 4), bk. 1, par. 19, 20, 22, 25, 27, 29, 62, 84, 125; bk. 2, par. 27–32, 52. Cf. Daston, “Cold Light” (ref. 3), 22–23.

56. Dufay, “M7. Quelques additions” (ref. 51), 100. Cf. Dufay, “M5. Augmentation et diminution” (ref. 51), 352.

57. Dufay, “M5. Augmentation et diminution” (ref. 51), 361.

58. “ACR rule” at Heilbron, *Electricity* (ref. 17), 255–58, where Dufay’s route to the ACR rule is summarized, but not with an emphasis on the role of wondrous phenomena in Dufay’s demonstration.

electrified by way of approaching the given body and contracting some of its electricity by communication.”⁵⁹ Dufay’s proof of this conjecture consisted largely in showing that it could explain phenomena that had previously been strange, mysterious, or paradoxical. As he put it in an English summary of his findings, the ACR rule was distinguished by “the Number of obscure and puzzling Facts it clears up.”⁶⁰

Consider one of those puzzling facts—the experiments on electrified threads carried out by Dufay’s English predecessor, Francis Hauksbee. From 1703–13 Hauksbee was the curator of experiments at the Royal Society, charged with providing “professional entertainments” to the Fellows who attended the weekly meetings of the Society.⁶¹ Early in his tenure Hauksbee presented experiments on the “extraordinary elistricity [sic] of glass,” a performance that was reported in the *Philosophical Transactions* of the years 1706–07.⁶² Hauksbee fixed a semicircle of wire above a horizontal glass tube, with lengths of pack-thread hanging from the wire at regular intervals. He excited the “effluvia” of the tube by pressing his hand on the glass while it spun around its long axis. The threads “from all parts seemed to Gravitate, or were attracted in a direct line to the Center of the moving Body [i.e., the excited tube].”⁶³

This experiment was already a fine spectacle. It showed the “Vigorous Action of the Effluvium,” since the latter held the threads in place despite the “wind” created by the whirling glass tube.⁶⁴ And Hauksbee’s comparison between the attraction of the effluvia and that of gravity added to the drama of his presentation.⁶⁵ A follow-up report introduced three new “Strange Effects of the Effluvia of Glass.” The effluvium surrounding the threads “seems very much to resemble or emulate a Solid,” allowing Hauksbee to push the threads

59. Dufay, “M4. L’attraction et la répulsion” (ref. 51), 458.

60. Dufay, “A Letter Concerning Electricity,” *PT* 38 (1734): 258–66, on 262.

61. J. L. Heilbron, “Hauksbee, Francis,” in *DSB*, vol. 5, 169–75. “Professional entertainments” at Heilbron, *Electricity* (ref. 17), 185.

62. Francis Hauksbee, “An Account of an Experiment Made before the Royal Society at Gresham-Colledge, Touching the Extraordinary Elistricity of Glass, Produceable on a Smart Attrition of It; With a Continuation of Experiments on the Same Subject, and Other Phenomena,” *PT* 25 (1706): 2327–35; Francis Hauksbee, “Several Experiments Shewing the Strange Effects of the Effluvia of Glass, Produceable on the Motion and Attrition of It,” *PT* 25 (1706): 2372–77.

63. Hauksbee, “Extraordinary Elistricity” (ref. 62), 2334. Cf. Hauksbee, “Strange Effects” (ref. 62), 2376, on the “centripetal” and “centrifugal” motion of the threads.

64. Hauksbee, “Extraordinary Elistricity” (ref. 62), 2329.

65. The theatrical value of invoking gravity in eighteenth-century experiments is noted in Schaffer, “Public Spectacle” (ref. 9), 7.

with his finger without touching them. Yet the same effluvia were subtle enough to act through glass, as Hauksbee inferred after repeating his experiment with the threads arrayed inside the glass rather than outside. But the effluvia also failed to act through muslin, a much thinner and lighter material than glass. Hauksbee did not try to explain this medley of marvels, “but sure I am ’tis very amazing.”⁶⁶

Dufay studied these experiments in the Italian translation of Hauksbee’s book *Physico-Mechanical Experiments* (1709).⁶⁷ Dufay admired Hauksbee’s work, and not least his more surprising discoveries, many of which Dufay reported in his short history of electricity.⁶⁸ Rather than dismissing Hauksbee’s “strange effects,” Dufay used two of them to confirm the ACR rule. In his words, “[t]o confirm even more my hypothesis I noticed that it explains in a most simple manner the famous experiment of M. Hauksbee.”⁶⁹

One effect that Dufay purported to explain was the remote action of a finger on Hauksbee’s threads. Dufay observed that the ends of the threads contained fine hairs that fanned out when the tube was excited. He inferred that the threads were themselves excited by the tube, and it was a short step to supposing that a finger approached to the excited tube became excited in the same way. The ACR rule predicted that these two excited objects—the finger and the threads—would repel each other, which is just what Hauksbee had observed.⁷⁰ In the same way the ACR rule predicted that the individual excited threads would repel each other, which in turn explained the divergence of the threads when they were attached to the center of the excited glass tube. Granted, by explaining these effects Dufay made them less amazing. But the fact remains that they performed the important epistemic service of confirming his hypothesis.

Dufay even hinted that singular phenomena could provide *unusually strong* confirmation of a hypothesis. In a later article he used the ACR rule to explain some experiments devised by Stephen Gray. He ended with an apology: “I have laboured a little the explanation of this experiment because, as we owe it to [Stephen] Gray, and as it appears so singular [singulière], I thought it important to show how well it accords with my hypothesis which has so far

66. Hauksbee, “Strange Effects” (ref. 62), 2374.

67. Dufay, “M1. Histoire de l’électricité” (ref. 53), 28.

68. *Ibid.*, 28–31.

69. Dufay, “M4. L’attraction et la répulsion” (ref. 51), 463.

70. Almost: Dufay did not mention that Hauksbee had also observed the threads to sometimes jump *towards* the finger. Hauksbee, “Strange Effects” (ref. 62), 2376.

not been contradicted by any experiments, and which, on the contrary, squares with all those that had appeared up to now the most difficult to explain [quadre avec toutes celles dont l'explication avoit paru jusqu'à présent la plus difficile].⁷¹ Here Dufay implied that Gray's experiment was important to explain precisely because it was singular; and that the ACR rule was well confirmed precisely because it had already explained singular phenomena, those "most difficult to explain." Given these views it is no surprise that Dufay emphasized the singularity of the electric planetarium as a prelude to explaining it using the ACR rule,⁷² or that he adduced other singular phenomena in support of principles other than the ACR rule.⁷³ Like the sixteenth-century Italian virtuosi discussed by Daston and Park, Dufay prided himself on "taking on the phenomena the most difficult to explain and therefore the most wondrous."⁷⁴

Whereas singular instances were one-of-a-kind, shining instances were unusually distinct or powerful instances of a kind. The term is due to Francis Bacon, who defined shining instances as those which "exhibit the nature in question naked and standing by itself, and also in its exaltation or highest degree of power."⁷⁵ Dufay may or may not have read Bacon's *Novum Organon*, in which this definition appeared. But he learned to value shining instances in his study of past experiments on electricity. In his abridged history of the topic he noted effects that had been observed by early investigators but which for lack of power or visibility had not been fully exploited until later. He reported, for example, that Boyle had observed the communication of electricity over half a century before Gray discovered the true extent of that phenomenon.⁷⁶ Why the delay? In Dufay's opinion, Gray's discoveries "required bodies that possessed this [electric] virtue in a greater degree [dans un degré plus éminent]." In particular, it required a better knowledge of glass, and of "the extent to which it could become [electric]."⁷⁷ Similarly, Hauksbee's thread experiments were more fruitful than those of Otto von Guericke because "the

71. Dufay, "M5. Augmentation et diminution" (ref. 51), 348.

72. Dufay, "M8. Huitième mémoire" (ref. 51), 309–10, 314–16.

73. Dufay, "M6. L'électricité et la lumière" (ref. 32), 507 and 521–23; Dufay, "M7. Quelques additions" (ref. 51), 90–91.

74. Daston and Park, *Wonders* (ref. 4), 171.

75. Bacon, *Novum Organon* (ref. 4), bk. 2, par. 25.

76. Dufay's source was Boyle's *De Mechanica Electricitatis Productione*, i.e., the Latin version of Boyle's 1675 book *Experiments and Notes About the Mechanical Origine or Production of Electricity*. Dufay, M1. Histoire de l'électricité (ref. 53), 25.

77. Dufay, "M1. Histoire de l'électricité" (ref. 53), 26–27.

effect is far more appreciable” in the former.⁷⁸ In Dufay’s history of electricity, shining instances were crucial to the progress of physics.

Dufay applied this lesson in his own research on light and electricity. Rather than describing all stones that could be made phosphors by calcination, he chose to “consider only those that make the most handsome effect [le plus bel effet].”⁷⁹ In his sixth paper on electricity, on the relationship between light and electricity, he gave special attention to precious stones because they were “the most luminous of all the other materials that I tried.”⁸⁰ And as preparation for sending the electric virtue over long distances, he carried out systematic trials on the electrical properties of different materials in order to examine “on a small scale which were the conditions most favorable to the transmission of electricity.”⁸¹ He had such applications in mind when he worked on a device for measuring “the degree of force of electricity.” The purpose of this device was not simply to measure, but to “choose the time and the circumstances that are most favorable for the experiments that require the *strongest* electricity.”⁸²

Like singular instances, shining instances sometimes had special efficacy as proofs. Consider two ways in which Dufay showed that “the faculty of producing light depends little on the electric virtue.” One was to examine a large number of precious stones and to show that some stones that were very luminous when rubbed were only weakly electric, and that other stones showed the opposite bias. A second test was to take a single stone, capable of considerable luminosity and electricity, to rub it to excite these virtues, then breathe on it and observe that its electricity was extinguished by the moist breath while its glow continued unabated. This second method was a “shining instance” insofar as it gave an especially stark illustration of the independence of light and electricity. And of the two methods, Dufay considered the second “a much simpler and more decisive proof” than the first.⁸³ Elsewhere Dufay expressed the same preference for simple, decisive proofs that used a commonplace operation (like breathing on something) to produce an unusually distinct or vivid instance of a phenomenon.⁸⁴

78. *Ibid.*, 30.

79. Dufay, “Phosphores nouveaux” (ref. 1), 529.

80. Dufay, “M6. L’électricité et la lumière” (ref. 32), 511. The study of precious stones is at 511–18.

81. Dufay, “M3. Corps attirés” (ref. 32), 245.

82. Dufay, “M7. Quelques additions” (ref. 51), 98–99, emphasis added.

83. Dufay, “M6. L’électricité et la lumière” (ref. 32), 516–17.

84. For example, Dufay, “M3. Corps attirés” (ref. 32), 239 and 242.

Variable phenomena were the third kind of wonder that Dufay is said to have abolished from philosophy.⁸⁵ In fact Dufay set great store on observing and reporting variability, both in the conditions that produced physical effects and in the effects themselves. His interest in the former is sometimes masked by his success in producing simple, robust recipes. Consider heat, one of the conditions that Dufay investigated in his 1730 article on phosphors. Dufay took a range of stones, roasted them over flames of increasing vigor, and concluded that the degree of heat made little difference to the brightness of the phosphor that emerged from the procedure. “It is almost impossible not to succeed,” he concluded, “in all these operations.”⁸⁶ This statement has been taken as evidence that Dufay was not interested in giving detailed instructions for reproducing experimental effects.⁸⁷

Certainly Dufay was not interested in making his instructions more complicated than they needed to be. He searched out simple experiments and railed against the “pompous and obscure” reports of past writers.⁸⁸ But nor was he interested in ignoring parameters he considered relevant, or even those that he had no *a priori* reason to consider relevant. He was just as likely to criticize past writers for the incompleteness of their instructions—for “circumstances omitted in their reporting of the facts”—as for their verbosity.⁸⁹ And far from being uninterested in the relationship between heat applied to a phosphor and its luminosity, he looked for the optimal heat “by all means that I thought practicable,” to the point of melting the pot in which the heating took place.⁹⁰ Moreover, heat was not the only parameter that Dufay investigated in “Phosphores nouveaux.” He also studied five others, from the light source to which the phosphor was exposed to the time lag between its confection and its exposure to light.⁹¹

These pains were characteristic of Dufay.⁹² When in 1724 he claimed to have extracted salt from lime, Fontenelle put his success down to his attention

85. Daston, “Cold Light” (ref. 3), 33; Licoppe, *Formation* (ref. 5), 113.

86. Dufay, “Phosphores nouveaux” (ref. 1), 531.

87. Daston, “Cold Light” (ref. 3), 32; Licoppe, *Formation* (ref. 5), 132.

88. Dufay, “Phosphores nouveaux” (ref. 1), 525, quoted in Daston, “Cold Light” (ref. 3), 36. Cf. Dufay’s search for simple experiments at “M5. Augmentation et diminution” (ref. 51), 355; “Mémoire sur les baromètres lumineux,” *MAS* (1723): 295–306, on 302.

89. Dufay: “M6. L’électricité et la lumière” (ref. 32), 503. Cf. “La lumière des diamants” (ref. 43), 347, 350; “M4. L’attraction et la répulsion” (ref. 51), 458.

90. Dufay, “Phosphores nouveaux” (ref. 1), 531. Cf. Dufay’s search for a “juste milieu” in “Les baromètres lumineux” (ref. 88), 302.

91. Dufay, “Phosphores nouveaux” (ref. 1), 530–33.

92. Cf. Heilbron, *Electricity* (ref. 17), 251, on Dufay’s “thorough investigations of possible complications.”

to detail. After all, “so many operations in chemistry depend on circumstances that it would be natural to consider irrelevant, and that it would be even more natural not to consider at all.”⁹³ Dufay showed the same care in his articles on electricity. There he gave detailed instructions for finding out whether a given body possessed “resinous” or “vitreous” electricity, for transmitting electricity over long distances, and for getting an electrified glass tube to repel pieces of cotton and feather launched upon it.⁹⁴ Even an elementary operation, such as the electrification of a cat, required choosing a species with rough hair rather than smooth, keeping the animal cold and dry, and placing it on an insulator such as a block of amber.⁹⁵ Echoing Fontenelle, Dufay explained that “these attentions are all so crucial, that the omission of some of them diminishes considerably, or completely prevents the success” of electrical experiments.⁹⁶

Dufay was no less attentive to variability in *effects*. “How different things behave that seemed so similar,” he wrote, “and how many varieties there are in effects that seemed identical!” Nor was this merely a private sentiment that Dufay concealed from his readers in order to “create the impression of uniformity in nature which Boyle’s scruples precluded.”⁹⁷ The statement appeared in print, in the course of Dufay’s 1735 article on the luminosity of diamonds.⁹⁸ Again he practiced what he preached, ending that article with a list of “facts that seem to me almost impossible to explain, and that even seem contradictory.”⁹⁹ A similar list appeared at the end of “Phosphores nouveaux.”¹⁰⁰ There Dufay reminded the reader of the experimental conditions

93. Fontenelle, “Sur le sel de la chaux,” *HAS* (1724): 39–40, on 39. Cf. Fontenelle, “Sur l’électricité,” *HAS* (1737): 1–6, on 6.

94. Dufay: “M3. Corps attirés” (ref. 32), 245–48; “M4. L’attraction et la répulsion” (ref. 51), 465–66, 471–74. Cf. “M5. Augmentation et diminution” (ref. 51), 348–49; “La lumière des diamants” (ref. 43), 353–54; “M7. Quelques additions” (ref. 51), 92.

95. Dufay, “M6. L’électricité et la lumière” (ref. 32), 519–20.

96. Dufay, “M4. L’attraction et la répulsion” (ref. 51), 474.

97. Daston, “Cold Light” (ref. 3), 33–34; cf. Daston, “Preternatural Philosophy” (ref. 4), 40.

98. Dufay, “La lumière des diamants” (ref. 43), 371–72; cf. Brunet, “L’oeuvre scientifique” (ref. 33), 91.

99. On Dufay’s failure to reduce the luminosity of diamonds to rule see Fontenelle’s summary, “Sur la lumière des diamants et de plusieurs autres corps,” *HAS* (1735): 1–4, on 3. Daston suggests that Dufay abandoned the study of luminescence when he found electricity easier to reduce to rule. Daston, “Cold Light” (ref. 3), 35. But his paper on the luminosity of diamonds appeared in 1735, a year *after* he had completed the bulk of his research program on electricity. Dufay, “M7. Quelques additions” (ref. 51), 86.

100. Dufay, “Phosphores nouveaux” (ref. 1), 534–35.

he had varied, and of the “considerable varieties” he had observed in the color, intensity, and duration of the resulting phosphors. He thought that those varieties “warrant very careful observation,” and that they promised nothing less than “a much more exact knowledge of the nature of light.” Granted, Dufay also encouraged his followers to take “all phosphors in general as their object.”¹⁰¹ But once again it is important to distinguish ends from means. Dufay’s end was a general understanding of phosphors and, ultimately, of light. But his means of achieving this end, in “Phosphores nouveaux” and elsewhere, was painstaking attention to the variety of nature’s effects.

Dufay learned firsthand the value of such scruples in his study of the relationship between the color of a body and the strength of the electrical attraction it exerted on other bodies. In a letter published in the *Philosophical Transactions* of 1732, Gray reported a “Discovery I made the last Year concerning the Attraction of coloured Bodies, shewing that they attract more or less, according to what Colours they are of.”¹⁰² In his third article on electricity, Dufay carried out a number of experiments while assuming this correlation between color and electrical attraction.¹⁰³ He was nevertheless perturbed by “some varieties in these experiments,” and by following up these discrepant results he showed to his satisfaction that Gray was wrong: it was the substances used in the dyeing of his materials, and not their color per se, that was responsible for their different electrical properties.¹⁰⁴ The moral for Dufay was that “these experiments require a much more scrupulous attention than one first imagines.”¹⁰⁵ The moral for the historian is that Dufay did not believe that “nuances and variability . . . hardly merited mention in a scientific article.”¹⁰⁶

GENERALIZATION AND SELECTIVITY

Dufay’s tendency to make broad generalizations is one source of the view that he preferred “the facts of regular phenomena” to “the facts of strange phenomena.” It has been suggested, for example, that he omitted known negative

101. *Ibid.*, 534. Cf. Daston, “Cold Light” (ref. 3), 20.

102. Stephen Gray, “A Letter to Cromwell Mortimer, Containing Several Experiments Concerning Electricity,” *PT* 37 (1731): 18–44, on 44.

103. Dufay, “M3. Corps attirés” (ref. 32), 234–37.

104. *Ibid.*, 237–39. Cf. Heilbron, *Electricity* (ref. 17), 254.

105. Dufay, “M3. Corps attirés” (ref. 32), 233.

106. Daston, “Cold Light” (ref. 3), 33.

instances when he reported his generalizations.¹⁰⁷ This is true in a few cases but false in many others.¹⁰⁸ He not only mentioned the bodies that he could not electrify—metals, fire, and soft bodies—but gave special attention to fire and metals precisely because they were exceptions.¹⁰⁹ And the reason we know that he did not make all materials glow in the dark is that he gave us a list of the ones that failed.¹¹⁰

A more plausible claim is that Dufay thought that the negative instances he reported would eventually be seen to be positive instances. Dufay did indeed take this line, for both electrics and phosphors. It is also true that on these two topics his generalizations were broader than those of Boyle (whom Daston contrasts to Dufay on this point). But it does not follow that Dufay was, in general, a more confident generalizer than Boyle. Perhaps he was confident about electrics and phosphors simply because he found more positive instances of those phenomena than Boyle had. As Daston notes, thanks to Dufay “the handful of phosphors known to Boyle had almost overnight been multiplied by a factor of a hundred or more.”¹¹¹

Did Dufay find these instances because he adopted special measures that allowed him to detect very small amounts of light and electricity? An alleged example is Dufay’s practice of keeping one eye closed when exposing phosphors to light, and the other eye closed when observing them in the dark.¹¹² This method of dark-adaptation does appear to be original to Dufay.¹¹³ But it cannot explain the large number of phosphors he found in “Phosphores nouveaux,” for the simple reason that he probably did not use it in his research for that article. “Phosphores nouveaux” was published five years before the article in which he described the one-eye technique, and the only dark-adaptation

107. Daston, “Preternatural Philosophy” (ref. 4), 41.

108. Dufay omitted exceptions when he summarized his findings at “Phosphores nouveaux” (ref. 1), 534 and “M2. Corps susceptibles” (ref. 49), 74. A manuscript page includes Arabic gum on a list of substances that Dufay could not electrify—the only item on the list that is not either a metal, a soft substance, or one that Dufay mentioned in public (“Corps électriques,” DD, Subfolder Notes sur l’électricité).

109. Dufay, “M2. Corps susceptibles” (ref. 49), 80–81 and 84. Cf. Dufay’s summaries of his results at *ibid.*, 84; “M3. Corps attirés” (ref. 32), 233; “M6. L’électricité et la lumière” (ref. 32), 503; “Letter Concerning Electricity” (ref. 60), 258. All of these summaries mention exceptions.

110. Dufay, “Phosphores nouveaux” (ref. 1), 528.

111. Daston, “Cold Light” (ref. 3), 32.

112. *Ibid.*, 33–34.

113. Dufay, “La lumière des diamants” (ref. 43), 533–35. The procedure worked because, as Dufay noticed, the effect of light on one eye is independent of its effect on the other eye.

technique that Dufay mentioned in “Phosphores nouveaux” was the simpler one of holding both eyes closed for a while after exposing them to light.¹¹⁴ As Dufay implied in his description of this technique, experimenters had been using it for some time before Dufay employed it to extend the list of phosphors.¹¹⁵

Sometimes Dufay was less keen to generalize. He found a number of precious stones that glowed in the dark after being exposed to sunlight, but he did not insist that all other precious stones had this property;¹¹⁶ he thought that emeralds did not exhibit double refraction, despite finding many other stones that did so;¹¹⁷ and the single counter-instance of silk saved him from the tempting conclusion that all animal substances were endowed with “vitreous” electricity and all vegetable substances with the “resinous” kind.¹¹⁸ He thwarted Gray’s rule relating color and attraction, as we have seen. He also took exception to Gray’s analogy between electricity and gravity.¹¹⁹ On other occasions he was simply not interested in generality. All materials may well glow after being rubbed, but “this fact is not important enough in itself, to take the trouble of verifying it.” After all, “there remain a rather large number of curious facts to observe in bodies for which light can be very perceptibly excited.”¹²⁰

Dufay’s selective reporting of experimental data is another practice sometimes advanced as evidence for his disdain of wonders. There is no doubt that Dufay was selective. But this practice does not overturn the evidence presented so far for Dufay’s interest in singular, shining, and variable phenomena. To begin with, Dufay usually made his omissions explicit. Indeed, the reason we know that he left things out of his articles is because he said so in those very articles. So even when he did omit data, it is unlikely that he did so in order to convince the reader that nature’s effects were simple and uniform. Secondly, Dufay’s omissions do not explain why he was the first to claim that phosphorescence and electricity were universal properties of matter. For as far as we

114. Dufay, “Phosphores nouveaux” (ref. 1), 529.

115. Edmund Harvey, *A History of Luminescence from the Earliest Times until 1900* (Philadelphia: American Philosophical Society, 1957), 311, 325.

116. Dufay, “La lumière des diamants” (ref. 43), 356–59.

117. Fontenelle, “Eloge de Dufay” (ref. 31), 81.

118. Dufay: “M2. Corps susceptible” (ref. 49), 77; “M4. L’attraction et la répulsion” (ref. 51), 473.

119. Dufay, “M8. Huitième mémoire” (ref. 51), 309–23.

120. Dufay, “M6. L’électricité et la lumière” (ref. 32), 511.

know he did not omit any key details that he or his predecessors would have treated as evidence against those claims. On the contrary, we have seen that he frequently reported anomalies and exceptions.

A third point is that what appear to be omissions are sometimes simply reorganizations. As Daston and others have pointed out, Dufay took care to organize his reports in the way that seemed most rational to him.¹²¹ He told his readers that past electricians had reported their results more or less in the order they performed them.¹²² By contrast, Dufay planned in advance his first six articles on electricity, arranging his data into six topics that he listed before reporting his first experiment.¹²³ Even when he departed from this self-imposed schedule he clearly distinguished between the unexpected additions and “the plan that I proposed to follow.”¹²⁴ As a result of this practice, different findings from what was essentially the same experiment can sometimes be found in more than one article.¹²⁵

This slicing and dicing means that a detail omitted in one part of a report may appear somewhere else in Dufay’s writings. In “Phosphores nouveaux,” for example, he devoted three pages to listing the materials that did and did not succeed as phosphors.¹²⁶ If one read only those pages one might well conclude that Dufay was interested only in the most simple effect (whether or not the materials glowed in the dark) and the most simple conditions for producing that effect (the methods of dissolution and calcination). But, as we have seen, later in the same article Dufay examined the different effects of a range of experimental conditions on different stones. Indeed, Dufay devoted more text to those variations than to his search for new phosphors.¹²⁷ Similarly, in his second article on electricity Dufay skipped over the “great variety” he found in his early trials on the electricity of stones.¹²⁸ But we have seen that in his other

121. Daston, “Cold Light” (ref. 3), 32. Cf. Brunet, “L’oeuvre scientifique” (ref. 33), 83–84.

122. Dufay, “M3. Corps attirés” (ref. 32), 235–36.

123. Dufay, “M2. Corps susceptibles” (ref. 49), 73–74. A diagram of all six articles, and the main findings of each, survives in manuscript form, DD, Subfolder Notes sur l’électricité. Cf. Dufay, “M6. L’électricité et la lumière” (ref. 32), 523–25.

124. Dufay, “M5. Augmentation et diminution” (ref. 51), 341, 348.

125. For example, Dufay’s three reports of experiments on electric shocks, at “M3. Corps attirés” (ref. 32), 250–53; “M4. L’attraction et la répulsion” (ref. 51), 461–62; “M6. L’électricité et la lumière” (ref. 32), 518–20. Cf. Dufay: “M5. Augmentation et diminution” (ref. 51), 352; “M6. L’électricité et la lumière” (ref. 32), 503, 507–08.

126. Dufay, “Phosphores nouveaux” (ref. 1), 527–28, 534.

127. *Ibid.*, 530–33.

128. Dufay, “M2. Corps susceptibles” (ref. 49), 76.

seven articles he took very seriously the varieties of electrical effects that resulted from various experimental conditions. Granted, he sometimes omitted data altogether from the sum of his articles on electricity. But usually this was not because he considered them unimportant but because they lacked “direct relevance to the subject in question.”¹²⁹

Fourthly, some of Dufay’s omissions *added* to the wondrous quality of his reports. We have seen, for example, that he sometimes omitted dull or commonplace examples of a phenomenon in favor of “shining instances” of the phenomenon. He edited other people’s discoveries in the same way, omitting all authors from his abridged history of electricity who had not made “some singular discovery.”¹³⁰ Some of his omissions even show his sensitivity to the third kind of wondrousness, variability. Such is the case when Dufay refrained from reporting precise results of an experiment because of his awareness of the many sources of experimental error. For example, the reason he gave only a cursory report of the effect of air temperature on the electricity of a rubbed tube was that he had identified no less than seven confounding variables that prevented him from “making these observations with as much exactitude as I had intended.”¹³¹ Here he withheld a detailed report of his trials not because he was convinced of nature’s uniformity but because he was resigned to her complexity.

Finally, Dufay’s omissions can be partly explained by the large amount of data he generated. Dufay has long been noted for the “extraordinary thoroughness” of his investigations.¹³² He found not only a large number of phosphors but over eighty different kinds of electric. He then systematically tested many of these materials under different conditions. For example, in “Phosphores nouveaux” he varied five different parameters relating to the production of phosphors. And he implied that for *each* value of *each* of these

129. Dufay: “M8. Huitième mémoire” (ref. 51), 323; cf. “M6. L’électricité et la lumière” (ref. 32), 510–12, 515–17, 523.

130. Dufay: “M1. Histoire de l’électricité” (ref. 53), 35; cf. “M8. Huitième mémoire” (ref. 51), 308.

131. Dufay, “M5. Augmentation et diminution” (ref. 51), 348–49. Cf. *ibid.*, 358–59, for another example of Dufay discarding a result that he considered small enough to be explained by experimental error.

132. Roderick Weir Home, *The Effluvial Theory of Electricity* (New York: Arno Press, 1981), 49. Cf. Patricia Fara, *An Entertainment for Angels: Electricity in the Enlightenment* (New York: Columbia University Press, 2002), III; Brunet, “L’oeuvre scientifique” (ref. 33), 83; and Friedrich Steinle, “Explorative Experimentieren: Charles Dufay und die Entdeckung der zwei Elektrizitäten,” *Physik Journal* 3, no. 6 (2004): 47–52.

variables, he tested a number of different classes of stone. To mention just one of those variables, he immersed each of four kinds of phosphor (marble, limestone, gypsum, and alabaster) in each of five kinds of liquid (water, acid, alkali, alcohol, and oil).¹³³ The result, as Dufay put it elsewhere, was “a large number of combinations” that required him to “suppress all the detail.”¹³⁴ There is every reason to take him at his word when he wrote that he simply had too much data to report it all.¹³⁵

ARGUMENT, ALCHEMY, AND AUDIENCE AT THE ACADEMY

Dufay was not alone in reporting less than he observed. Chemists at the Academy had been collecting more data than they could publish from the very first years of the Academy’s existence.¹³⁶ Consider the natural history of plants led by the chemist Samuel Duclos and botanist Denis Dodart.¹³⁷ Between 1668 and 1694, they and other academicians examined the external features, physiology, and chemical properties of hundreds of species of plants, systematically recording the results. Only a fraction of these results appeared in the project’s chief publication, the *Mémoires pour servir à l’histoire des plantes* (1676).¹³⁸ As Dodart put it in that work, “it would be too time-consuming, and often unproductive, to observe everything, and to give the public everything one observes.”¹³⁹ Dodart gave his readers an argument rather than a narrative, and this involved both reorganization and selection. He separated a general account of his experimental procedure from the data for particular plants, and he gave separate accounts of the more specific tests that he and his

133. Dufay, “Phosphores nouveaux” (ref. 1), 532–33.

134. Dufay, “M3. Corps attirés” (ref. 32), 244. Cf. Heilbron, *Electricity* (ref. 17), 254, on cross-variation in Dufay’s research on colors.

135. Dufay: “Phosphores nouveaux” (ref. 1), 529; “M2. Corps susceptibles” (ref. 49), 79.

136. Frederic L. Holmes, “Argument and Narrative in Scientific Writing,” in *The Literary Structure of Scientific Argument: Historical Studies*, ed. Peter Dear (Philadelphia: University of Pennsylvania Press, 1991), 164–81.

137. Yves Laissus, “Les Plantes du Roi: Note sur un grand ouvrage de botanique préparé au XVIIe siècle par l’Académie Royale des Sciences,” *Revue d’histoire des sciences et de leurs applications* 22, no. 3 (1969): 193–236; Alice Stroup, *A Company of Scientists: Botany, Patronage, and Community at the Seventeenth-Century Parisian Royal Academy of Sciences* (Berkeley: University of California Press, 1990), chap. 7.

138. I have used the edition published with minor changes in the *Mémoires*: “Mémoires pour servir à l’histoire des plantes,” *MAS* (1731): 424–44.

139. *Ibid.*, 432–33.

assistants carried out. He selected a small sample of thirty-nine plants for special attention, abstracted general principles that held across large classes of plants, and gave a five-page explanation of why he had chosen to focus on certain details and omit others.¹⁴⁰

As in Dufay's case, Dodart's selectivity cannot plausibly be explained by his indifference to the details of experimental effects or conditions. Dodart observed with pride that the details of the Academy's chemical tests had been carefully recorded in unpublished notes. "We are writing up these analyses like minutes [procès-verbal], because we believe we will be able to derive new knowledge from these particulars, or new topics to research." The point of the published summary was not to suppress these details but to "aid the memory, and save the mind from the confusion into which it is thrown by this great multitude of circumstances."¹⁴¹ Like Dufay, Dodart complained as often of the vagueness of past authors as he did of their verbosity.¹⁴² And although his summaries were coarse-grained, they included both exceptions to general principles and lists of differences between the behavior of different plants under different conditions.¹⁴³ This is not to say that it was easy for Dodart to reconcile the contrary demands of brevity and attention to detail.¹⁴⁴ But there is no doubt that he tried.

There is a direct line from Dodart's plant project to Dufay's research on phosphors. By 1700 the plant project had fallen out of favor in the Academy, as had the general idea of large-scale collaborative projects.¹⁴⁵ But academicians produced as much data separately as they had collectively, and it showed in their experimental reports. In the early decades of the eighteenth century, an elite group of chemists emerged whose reports resembled those of Dodart insofar as they emphasized novel discoveries rather than routine procedures, favored logic over chronology, and left out the details of failed

140. General principles at, for example, *ibid.*, 467, 476–78; five-page explanation at *ibid.*, 430–34.

141. *Ibid.*, 483–84. Cf. Holmes, "Argument and Narrative" (ref. 136), 170.

142. *Ibid.*, 442–43.

143. Dodart noted exceptions on *ibid.*, 467, and differences between plants on 454, 456, and 520–21.

144. On this point Stroup is less optimistic than Holmes, noting the "unmanageability of the data" generated by the project. Stroup, *Company of Scientists* (ref. 137), 92.

145. On the decline of the plant project see Laissus, "Les Plantes du Roi" (ref. 137), 204–10; Stroup, *Company of Scientists* (ref. 137), 104–15. On the decline of collaborative projects in general see David Sturdy, *Science and Social Status: The Members of the Académie des Sciences, 1666–1750* (Woodbridge, UK: Boydell Press, 1995), 286.

experiments.¹⁴⁶ These chemists were Dufay's mentors, friends, and teachers. Wilhelm Homberg and Louis Lémery died before Dufay entered the Academy in 1723, but Nicolas Lémery and Etienne-François Geoffroy were the two senior members of the chemistry section before Dufay replaced the latter as a *pensionnaire* in 1731.¹⁴⁷ With them Dufay attended the twice-weekly meetings of the Academy, and the topics of his early articles—notably salts, phosphors, and glass—reflected this chemical apprenticeship.¹⁴⁸ Claude-Joseph Geoffroy, the younger brother of Etienne-François, considered Dufay a “good friend” and joined him in investigating phosphors and in befriending another chemist at the Academy, Jean Hellot.¹⁴⁹ The selectivity and reorganization in Dufay's reports owed a lot to this tight-knit community of chemists.

Alchemy was another concern of this community. Dufay shared with other chemists at the Academy an interest in reading the works of past alchemists and reproducing their experiments.¹⁵⁰ These chemists include three named above—Etienne-François Geoffroy, Claude-Joseph Geoffroy, and Jean Hellot—as well as Dufay's mentor René Réaumur and his collaborator Henri

146. Holmes, “Argument and Narrative” (ref. 136); Frederic L. Holmes, *Eighteenth-Century Chemistry as an Investigative Enterprise* (Berkeley: Office for History of Science and Technology, 1989), 34. On this community see also Frederic L. Holmes, “The Communal Context for Etienne-François Geoffroy's ‘Table des Rappports,’” *Science in Context* 9, no. 3 (1996): 289–311, and Kim, *Affinity* (ref. 35), chap. 3.

147. See the list of chemists at the Academy in Kim, *Affinity* (ref. 35), 458.

148. On salts see Dufay, “Sur le sel de chaux,” *MAS* (1724): 88–93; Holmes, *Investigative Enterprise* (ref. 146), chap. 2. Academic precursors to Dufay's study of phosphors are noted in Brunet, “L'oeuvre scientifique” (ref. 33), 93. On glass see Claude-Joseph Geoffroy, “Nouvelles expériences sur quelques espèces de verre dont on fait des bouteilles,” *MAS* (1724): 380–99; and Dufay's follow-up article “Expériences sur la dissolubilité de plusieurs sortes de verres,” *MAS* (1727): 32–39.

149. “Good friend” at Geoffroy to Sloane, 17 Aug 1739, HS, Ms. 4056 ff. 112–13. Phosphors at Geoffroy to Sloane, 29 Mar 1737, HS, Ms. 4055 ff. 80–82; Fontenelle, “Observations chimiques,” *HAS* (1728): 36–43, on 37. Dufay chose Hellot as his literary executor; Fontenelle, “Eloge de Dufay” (ref. 31), 82. Geoffroy married Hellot's niece and helped Hellot into the Academy. Geoffroy to Sloane, 29 Mar 1737, HS, Ms. 4055 ff. 80–82; and Geoffroy to Sloane, 17 Aug 1739; n.d.; 9 Feb 1740 all in HS, Ms. 4056, ff. 112–13; 114; 187–89, resp.

150. Rémi Franckowiak, “Chimie et alchimie dans les papiers de Jean Hellot,” paper presented at workshop entitled “Alchemy and Chemistry: Continuities and Fractures,” held at University of Oxford, 28 May 2011. The alchemical interests of the previous generation of academic chemists, especially Wilhelm Homberg, are summarized in Lawrence Principe, “The Revolution Nobody Noticed? Changes in Early Eighteenth-Century Chymistry,” in *New Narratives in Eighteenth-Century Chemistry*, ed. Lawrence Principe (Dordrecht, Neth.: Springer, 2007), 1–22, on 7–13.

Louis Duhamel du Monceau.¹⁵¹ Evidence for their pursuit of alchemy comes primarily from some four thousand pages of notes that Hellot took down of his own research and that of his fellow chemists. Scattered among Hellot's notes on more orthodox topics are a large number of references to experiments carried out by academicians on the universal solvent, the transmutation of gold, drinkable gold, the generation of metals, and other topics usually associated with alchemy. Occasionally these interests surfaced in academic articles: "I think it would be very worthwhile," Hellot wrote in a paper on zinc, "to verify certain singular procedures of [alchemical authors]."¹⁵²

This statement appeared in the *Mémoires* for 1735, a volume that also contained Dufay's article on luminous diamonds. There Dufay wrote that he "could cite several other examples of facts that, after having been for a long time considered falsehoods . . . were found to be true in every detail."¹⁵³ The "examples" that Dufay had in mind may well have included the strange facts of alchemy. Like his grandfather, and like his friends Geoffroy and Hellot, he was a practitioner of the "great work."¹⁵⁴ Hellot's notes record Dufay's efforts to transform base metals into gold, as well as a report of at least one metallic transmutation carried out by Dufay. These and other manuscripts show that Dufay was "engaged in alchemical research until his death."¹⁵⁵ He may also have drawn on this research in his three gold-related contributions to the *Histoire* of the Academy: one on the purification of gold extracted from mines, another on recovering the nitric acid used to separate gold from silver, and a posthumous report on the preparation of gold for use in decorative sculpture.¹⁵⁶ The profit he drew from the marvelous reports of past

151. On Réaumur's role in Dufay's election to the Academy see "Lettres de Dufay à Réaumur," *La correspondance historique et archéologique* 5 (1898): 306–09. Cf. Heilbron, *Electricity* (ref. 17), 251. On Dufay's collaboration with Duhamel see Dufay, "Observations sur la Sensitive" (ref. 43), 87; Fontenelle, "Sur la Sensitive" (ref. 43), 73; and the list of Duhamel's friends in Condorcet, "Eloge de Duhamel," *HAS* (1782): 131–55, on 131–32.

152. Jean Hellot, "Analyse chimique du zinc, 2e mémoire," *MAS* (1735): 221–43. Cf. Arthur Birembaut and Guy Thuillier, "Une source inédite: Les cahiers du chimiste Jean Hellot (1685–1766)," *Annales: Histoire, Sciences Sociales* 21, no. 2 (1966): 357–64.

153. Dufay, "La lumière des diamants" (ref. 43), 347.

154. "Grand oeuvre" at Fontenelle, "Eloge de Du Fay" (ref. 31), 73.

155. Franckowiak, "Chimie et alchimie" (ref. 150), 10.

156. Fontenelle, "Observations chimiques," *HAS* (1727): 31–36, on 31–32; "Observations chimiques," *HAS* (1728): 36–43, on 39–43; Jean-Paul Grandjean de Fouchy, "Sur la manière d'appliquer aisément des bas reliefs en or sur l'or & sur l'argent," *HAS* (1745): 45–47. Dufay presented the second of these findings at a private meeting of the Academy, and a copy of his talk is preserved in the minutes. "Manière de purifier l'or aigre," PV, 22 Mar 1727, 113r–14v. These

alchemists—whether in the form of new facts or useful applications—helps to explain the tolerance for the singular that we find in his articles in the *Mémoires*.

A third reason for academicians to omit boring details and emphasize novel and striking phenomena was to engage their non-academic audience. A number of authors have noted the “centrifugal” or outward-looking tendency in the Academy in the early decades of the eighteenth century.¹⁵⁷ Jean-Paul Bignon, the President of the Academy for over four decades from 1691, saw the institution as a means to foster learning among the French royalty and aristocracy.¹⁵⁸ It was Bignon who chose Fontenelle as chief public spokesperson of the Academy.¹⁵⁹ Fontenelle was already a public figure when he became the Perpetual Secretary of the Academy in 1697, and he remained an eloquent promoter of the institution until he wrote his last *éloge* (Dufay’s) in the *Histoire*, one of the many academic publications he edited.¹⁶⁰ It was also Bignon who oversaw the Academy’s first formal constitution in 1699. Bignon’s reforms included a number designed to raise the public profile of his favorite academy. Aside from inaugurating the *Histoire* and the *Mémoires*, he introduced regular prize competitions open to non-academicians and biannual public meetings in which articles and obituaries were read to audiences at the Academy’s new quarters at the Louvre.¹⁶¹

Dufay fit neatly into Bignon’s plan to “see the taste for science spread in society.”¹⁶² As a scion of a distinguished military family, and a retired soldier himself, he was at ease among aristocrats and government ministers. His noble acquaintances included the Cardinal de Rohan (with whom he toured Italy in

reports have so far gone unnoticed by historians of Dufay, probably because they appeared in the *Histoire* and not the *Mémoires*. On gold in decorative art, see also Filippo Buonanni, *Traité des vernis*, trans. Dufay (Paris, 1723), chaps. 5, 17, and 22.

157. “Centrifugal” is a term borrowed from Licoppe, *Formation* (ref. 5), 89–94.

158. Sturdy, *Science and Social Status* (ref. 145), 222–26 and 367–69. The years of Bignon’s presidency and vice-presidency (the last of which was 1734) are listed in *ibid.*, 421–22.

159. J. A. Clarke, “Abbe Jean-Paul Bignon, ‘Moderator of the Academies’ and Royal Librarian,” *French Historical Studies* 8, no. 2 (1973): 213–35, on 217. “Taste for science” quoted in Leonard M. Marsak, “Bernard De Fontenelle: In Defense of Science,” *Journal of the History of Ideas* 20, no. 1 (1959): 111–122, on 120.

160. Fontenelle’s public profile is discussed in Sutton, *Polite Society* (ref. 9), chap. 5, and Marsak, “In Defense of Science” (ref. 159). His editing feats are listed at Sturdy, *Science and Social Status* (ref. 145), 199.

161. Sturdy, *Science and Social Status* (ref. 145), chap. 17; James McClellan, *Science Reorganized: Scientific Societies in the Eighteenth Century* (New York: Columbia University Press, 1985), 62–66.

162. Quoted in Marsak, “In Defense of Science” (ref. 159), 120.

his youth), the Duke of Richmond (with whom he exchanged curious objects as well as reports on electricity and earthquakes), and the Duchesse of Maine, one of Louis XIV's daughters-in-law (who asked Dufay for access to a private meeting of the Academy).¹⁶³ Fontenelle recorded the mixture of tact, charm, and integrity that Dufay displayed when courting funds for the King's Garden: "Happily, he was well known by the ministers; he had easy access to them, and a liberty and familiarity with them which a soldier or a man of the world comes by more easily than a simple academician . . . he had the gift of pleasing them, and that is a great help in persuading; but [the ministers] also knew that they had nothing to fear from his art which tended only to useful ends and glory for themselves."¹⁶⁴

Dufay put these qualities to good use during the biannual public meetings of the Academy, both as a speaker and organizer. These meetings were attended by royals, nobles, and other notables from France and the rest of Europe, and their contents were reported in newspapers in Paris and elsewhere.¹⁶⁵ Hence it is noteworthy that Dufay presented his research at eight such meetings during the 1730s, making him one of the most visible academicians of his day. As Director of the Academy in 1733 and 1738 he organized the public meetings in those years, some of which included letters or papers on the high-profile question of the shape of the earth.¹⁶⁶ Most importantly, his own public presentations included the text of "Phosphores nouveaux" as well as reports of each of his first six articles on electricity. All seven of these articles were given lengthy coverage in the magazine *Mercure de France* and in the Academy's *Histoire*, the latter being the layperson's guide to the *Mémoires*.¹⁶⁷

163. Fontenelle, "Eloge de Dufay" (ref. 31), 75; Heilbron, *Electricity* (ref. 17), 251, 260; Fontenelle, "Observations de physique générale," *MAS* (1734): 15–38, on 17–18; Geoffroy to Sloane, n. d., HS, Ms. 4056 f. 114; Sturdy, *Science and Social Status* (ref. 145), 370.

164. Fontenelle, "Eloge de Dufay" (ref. 31), 79, quoted in Marsak, "Idea of Science" (ref. 24), on 58. The translation is Marsak's.

165. Roger Hahn, *The Anatomy of a Scientific Institution: The Paris Academy of Sciences, 1666–1803* (Berkeley: University of California Press, 1971), 73–74; Sturdy, *Science and Social Status* (ref. 145), 293–96.

166. For example, PV, 14 Nov 1733, 192v–201v. On the April 1738 meeting see Terrall, *Maupertuis* (ref. 25), 139. Dufay's years as Director are listed in Sturdy, *Science and Social Status* (ref. 145), 422.

167. *MF*, Dec 1730, 268i–83 and PV, 15 Nov 1730, 226r; *MF*, Jun 1733, 1348–53 and PV, 15 Apr 1733, 78r; *MF*, Dec 1733, 2615–21 and PV, 14 Nov 1733, 211v; *MF*, May 1735, 961–65 and PV, 20 Apr 1735, 70v–80r. For Dufay's presentations on magnetism, colored marble, dew, and colors, see *MF*, Apr 1730, 703; *MF*, Apr 1732, 828; *MF*, Dec 1736, 2826–30; *MF*, Dec 1738, 2647–49. Fontenelle described the public function of the *Histoire* in his "Preface," *HAS* (1699): i–xix, on iii.

A letter from Bignon suggests that Dufay became an accomplished performer. In October 1733, the President wrote to Dufay about the preparations for the upcoming November meeting, where Dufay was to present his third and fourth articles on electricity. “I hope that the different topics about which you spoke to me will meet the expectations of the public. At least I am sure that if your article on electricity is as curious [curieux] as the last, it will make a strong impression [fort bon effect].”¹⁶⁸ The public was not disappointed: Dufay’s third article included the first recorded experiments on the electric shock, a finding that the *Mercur de France* described as “even more singular” than the discoveries that Dufay had so far revealed.¹⁶⁹ Dufay’s displays may not have been quite as gripping as Maupertuis’s report in 1737 of his perilous geodetic expedition to Lapland, or of Nollet’s rendition of the Leyden jar experiment in 1746.¹⁷⁰ But Dufay shared with those men a talent and enthusiasm for public displays of academic research.

Another letter from Bignon hints at how the demands of public performance could mold Dufay’s experimental reports. Bignon wrote to Réaumur in 1727 asking “that M. Dufay shorten his piece a little and make it more digestible [plus moelleuse]” for a public meeting.¹⁷¹ No doubt Dufay’s singular and shining instances also contributed to the digestibility of his public talks. To be sure, spectacle was not the only way in which the Academy appealed to the tastes and values of its audience. Even in its public meetings the President drew on the rhetoric of sobriety: “it is enough that this truth is useful, for [the Academy] can dispense with attractiveness,” as Bignon declared at the first of those meetings.¹⁷² But sobriety on its own would have had limited appeal to an audience accustomed to the gossip, plays, and poems that filled the pages of the

168. Bignon to Dufay, 3 Oct 1733, Bibliothèque Nationale de France, Manuscrits Français, Ms. 22235 f. 240r.

169. *MF*, Dec 1733, 2620.

170. Maupertuis’s report was summarized at *MF*, Nov 1737, 2461–73. Cf. Terrall, *Maupertuis* (ref. 25), 134. Nollet’s report of the Leyden jar is at *PV*, 20 Apr 1746, 87; cf. Nollet, “Observations sur quelques nouveaux phénomènes d’électricité,” *MAS* (1746): 1–23.

171. Quoted in Jean Torlais, *Réaumur* (ref. 45), 209. On the rise of abridgments in the Republic of Letters in general, see Stephen Gaukroger, “The Académie des Sciences and the Republic of Letters: Fontenelle’s Role in the Shaping of a New Natural-Philosophical Persona, 1699–1734,” *Intellectual History Review* 18, no. 3 (2008): 385–402, on 393–94.

172. Cited in Clarke, “Bignon” (ref. 159), 219. On sobriety and related virtues see also Marsak, “In Defense of Science” (ref. 159); Hahn, *Anatomy* (ref. 165), 58–59; Charles B. Paul, *Science and Immortality: The Éloges of the Paris Academy of Sciences (1699–1791)* (Berkeley: University of California Press, 1980). Cf. Marsak’s remarks on the seriousness of Fontenelle’s writings at “The Idea of Science” (ref. 24), 59–61.

Mercure de France. The task of the public academician was to combine entertainment with instruction, and Dufay's personality and social status helped him meet this challenge.¹⁷³

Dufay aimed not only to amuse and educate his Paris public, but also to encourage them to continue his own research, which they sometimes did.¹⁷⁴ "Nothing is more apt to increase our knowledge in natural philosophy," he wrote, "than the shared work of several people on the same topic."¹⁷⁵ This presents a puzzle: if wonders are defined as local and particular, how could a large group of people work on the same wonder?¹⁷⁶

The answer is threefold. Firstly, an effect could be shining and singular without being local and particular. By using glass rather than amber as a source of electricity, Gray turned Boyle's feeble, fleeting experiment on communication into a robust and reproducible phenomenon. But the same development made the experiment *more* of a shining instance, and it did not make it any less singular since it was no easier to explain than before.¹⁷⁷ Secondly, the pursuit of stable, reproducible phenomena was compatible with an interest in singular, shining, and variable phenomena as a means to achieving that end. Indeed, Dufay thought that it was precisely his attention to the variability of effects and conditions that enabled him to design reproducible experiments. Thirdly, the purpose of collaboration was not just to replicate existing effects but to discover new ones.¹⁷⁸ As Dufay put it in the last sentence of his 1730 article on phosphors: "I dare say that the field is large enough to occupy several natural philosophers, and to produce a large number of new discoveries and observations all the more curious and singular."¹⁷⁹ Far from thwarting collaborative research, Dufay's interest in wonders motivated and facilitated his project of spreading the taste for experimentation among *amateurs de physique* in France and abroad.

173. On rational entertainment in the eighteenth century in general, see note 20.

174. Examples of such encouragements are *MF*, Dec 1730, 2683; *PV*, 20 Apr 1735, 80r. Evidence of public participation is at Dufay, "La lumière des diamants" (ref. 43), 355.

175. Dufay, "M6. L'électricité et la lumière" (ref. 32), 516.

176. This question is implied at Daston, "Cold Light" (ref. 3), 36 and Licoppe, *Formation* (ref. 5), 88, 124.

177. Cf. Hauksbee, who offered both "large-scale, striking effects" and "reproducible, dependable results" to the Royal Society of London. Heilbron, *Electricity* (ref. 17), 229.

178. On the value of replication see Dufay: "M5. Augmentation et diminution" (ref. 51), 345; "Observations sur la Sensitive" (ref. 43), 87. Some of Dufay's own replications are at "M8. Huitième mémoire" (ref. 51), 312, 317; "M6. L'électricité et la lumière" (ref. 32), 514, 521.

179. Dufay: "Phosphores nouveaux" (ref. 1), 535; cf. "M6. L'électricité et la lumière" (ref. 32), 526.

CONCLUSION

Dufay's disdain for singular, shining, and variable phenomena has been greatly exaggerated. He was genuinely interested in finding an optimum level of heat for making phosphors; he rarely omitted exceptions and sometimes gave them special attention; he probably did not use a new method of dark-adaption for finding phosphors; and he publicly declared his amazement at "how many varieties there are in effects that seemed identical." His choice of research topics, his vocabulary, his methodological statements, and his confirmation of the ACR rule, all reflect his interest in singular phenomena as a source of new discoveries, a check on premature generalization, and a powerful means of confirming hypotheses. His history of electricity shows how he learned the value of shining instances, and his articles on light and electricity show how he applied this lesson. Experience also taught him the importance of attending to the many *variétés* that arose from the different *circonstances* of his experiments.

Can we conclude that Dufay was just as keen on wonders as Robert Boyle, to borrow Daston's seventeenth-century foil to Dufay? Not without a closer comparison with Boyle. But this paper suggests three lessons for such a comparison, and indeed for any comparison between alleged friends and foes of wonders. One is to beware of confounding factors. For example, Dufay's belief in the generality of phosphors might suggest that he had greater confidence than Boyle in the uniformity of nature. But that belief could instead be explained by observing that Dufay found many more phosphors than Boyle did. New facts, as well as new kinds of fact, can help to explain Dufay's new regularities. Another lesson is that different kinds of wonder could easily come apart. For example, an experiment can be singular (surprising and hard to explain) and shining (vivid or powerful) without being variable (hard to reproduce). Thirdly, as stressed throughout this paper, an early modern experimenter could insist that regular phenomena were the only legitimate ends of empirical inquiry while embracing wondrous phenomena as a means to that end.¹⁸⁰

No doubt there were important differences between Dufay and Boyle, not least at the level of biography and personality. Dufay wrote as his father was said to have talked: "He used words sparingly, and never blabbered, but spoke

¹⁸⁰. This is the inverse of Daston's point that a fondness for strange facts among preternatural philosophers did not prevent them from pursuing general laws and deep causes as the ends of inquiry. Daston, "Language of Strange Facts" (ref. 4), 29–30 and "Cold Light" (ref. 3), 35.

as if he had thought out everything beforehand.”¹⁸¹ Dufay’s terseness and worldliness, due partly to his father’s influence and his military career, may be contrasted with the painstaking verbosity that Boyle acquired from his youthful literary interests, his practice of moral casuistry, and his idiosyncratic method of revising his texts.¹⁸² But these contrasts make the commonalities all the more intriguing. The two chemists shared an interest not just in singular, shining, and variable phenomena, but also in the transmutation of metals and the “concurrence” of results found by independent means.¹⁸³ Dufay drew on Boyle’s research on electricity and the luminosity of diamonds, praising the Englishman’s “exactitude” and his “large number of fine discoveries.”¹⁸⁴ It may be no accident that one of Boyle’s bywords for experimental rigor, “scrupulosity,” was also one of Dufay’s.¹⁸⁵

Another of Dufay’s seventeenth-century sources was Athanasius Kircher, the Jesuit polymath who aimed to “emulate the wonders of nature and glorify their ‘wondrousness.’”¹⁸⁶ The two men were connected via a work that has so far escaped the notice of nearly all historians of Dufay, namely his translation of a well-known book on lacquers by the Italian naturalist Filippo Buonanni. Published in 1723 as *Traité des vernis*, Dufay’s translation contained new, simple recipes intended for the use of artisans and amateur chemists, as well as extensive reports of recipes described by past authors—just like the papers that Dufay started publishing in the *Mémoires* when he became an academician in the year the *Traité des vernis* appeared.¹⁸⁷ Dufay met Buonanni when he

181. Quoted in Heilbron, *Electricity* (ref. 17), 250.

182. See esp. Lawrence M. Principe, “Virtuous Romance and Romantic Virtuoso: The Shaping of Robert Boyle’s Literary Style,” *Journal of the History of Ideas* 56, no. 3 (1995): 377–97, on 396; Michael Hunter, *Robert Boyle (1627–91): Scrupulosity and Science* (Woodbridge, UK: Boydell & Brewer, 2000), esp. 69, 86.

183. On Boyle’s alchemy see especially Lawrence Principe, *The Aspiring Adept: Robert Boyle and His Alchemical Quest* (Princeton, NJ: Princeton University Press, 1998). On “concurrence” compare Rose-Mary Sargent, *The Diffident Naturalist: Robert Boyle and the Philosophy of Experiment* (Chicago: University of Chicago Press, 1995), esp. 55–56, 197, and 207–08, with Dufay, “M5. Augmentation et diminution” (ref. 51), 345.

184. Dufay: “M1. Histoire de l’électricité” (ref. 53), 25–27; “M6. L’électricité et la lumière” (ref. 32), 512–14; “La lumière des diamants” (ref. 43), 351–52.

185. Hunter, *Scrupulosity and Science* (ref. 182), esp. 69. Cf. Dufay: “M3. Corps attirés” (ref. 32), 233; “M4. L’attraction et la répulsion” (ref. 51), 473; “M5. Augmentation et diminution” (ref. 51), 352, 361; “M7. Quelques additions” (ref. 51), 100; “M8. Huitième mémoire” (ref. 51), 321.

186. Thomas L. Hankins and Robert J. Silverman, *Instruments and the Imagination* (Princeton, NJ: Princeton University Press, 1995), 5, cf. 43–44, 73–74, 89, and chap. 2.

187. Buonanni, *Traité des vernis* (ref. 156). A second French edition appeared as Buonanni, *Traité des Vernis*, trans. Charles Dufay (Paris, 1733), with the translator’s “Avis au lecteur”

traveled to Italy with his mentor, the Cardinal de Rohan. The young tourist was impressed by the “curious and knowledgeable works” of the old naturalist, and by his knowledge of ancient coins and monuments.¹⁸⁸ Probably he was also impressed by the famous Jesuit museum in Rome, which Buonanni had catalogued and renovated during his time as curator.¹⁸⁹ Kircher was Buonanni’s teacher, the father of the museum, and an important source of the recipes in *Traité des vernis*. Thus Dufay’s trip to Rome, and his translation of Buonanni’s text, link him to one of the most prodigious collectors of wonders in the early modern period.

A final moral may be drawn about the distinction between lay and learned attitudes to wonders in the eighteenth century. The thesis that eighteenth-century natural philosophers disdained wonders requires a distinction between lay and learned spheres to account for the continued fascination for wondrous phenomena among the general populace after 1700. More recent literature has followed Bachelard in its stress on the flexibility and permeability of the membrane that separated professors and academicians from their enlightened audiences. One way to split the difference between these two positions is to suppose that lay and learned groups both valued wondrous phenomena in the

replaced by a new “Avis au lecteur” referring to the translator in the third person. Dufay is identified as the translator in *Dictionnaire de biographie française* (Paris: Letouzy et Ané, 1967), vol. 2, 1387. This attribution can be verified by comparing the first page of the “Avis au lecteur” of the 1733 edition with Fontenelle, “Eloge de Dufay” (ref. 31), 75, and chap. 17 of the *Traité des vernis* with Fouchy, “Bas reliefs en or” (ref. 156). Cf. the copy of the translation surviving in Dufay’s hand in DD, Ms. titled “Vernis,” and the attribution of the translation to Dufay in *Catalogue des livres et estampes de la bibliothèque de feu Monsieur Pajot, Comte d’Onsenbray* (Paris, 1756), item no. 3742. I am grateful to Madeleine Pinault-Sorensen for drawing my attention to the latter citation. On the character of Buonanni’s text see Flavia Perugini, “Filippo Bonanni and the Treatise,” in Filippo Bonanni, *Techniques of Chinese Lacquer: The Classic Eighteenth-Century Treatise on Asian Varnish*, ed. Flavia Perugini (Los Angeles: Getty Publications, 2009), ix–xii, on x.

188. “Avis au lecteur,” in Buonanni, *Traité de Vernis* (1723), ii–iii, and “Avis au lecteur” in the 1733 edition of the same work, iii–v. Cf. Fontenelle, “Eloge de Dufay” (ref. 31), 75. On the wonders encountered by eighteenth-century travelers to Italy, such as Dufay’s student Nollet, see Bertucci, “Back from Wonderland” (ref. 26).

189. On Buonanni’s renovation of the museum see Paula Findlen, “Scientific Spectacle in Baroque Rome: Athanasius Kircher and the Roman College Museum,” in *Jesuit Science and the Republic of Letters*, ed. Mordechai Feingold (Cambridge, MA: MIT Press, 2003), 225–84, on 272–73; Paula Findlen, *Possessing Nature: Museums, Collecting, and Scientific Culture in Early Modern Italy* (Berkeley: University of California Press, 1994), 34, 126–28. On the wondrous quality of the museum see Findlen, “Scientific Spectacle,” 231; Findlen, *Possessing Nature*, 43. On Buonanni as a disciple of Kircher see Findlen, *Possessing Nature*, 34; Pietro Franceschini, “Buonanni, Filippo,” in *DSB*, vol. 2, 591–92, on 591.

eighteenth century, but that they disagreed over which wonders were facts and which were fictions. Another compromise is to say that different groups valued wonders for different reasons, some as pedagogy or entertainment or edification and others as an aid to empirical inquiry. There is truth in both of these options, but the Dufay case suggests a third compromise that deserves further study.

Crudely put, this third position is that the differing expectations of lay and learned groups meant that they disagreed over which facts were wondrous and which were mundane or unsurprising. This is a natural extension of an idea that Daston and Park have done much to develop, namely the relativity of wonders. A seasoned traveler may be bored by a creature that astounds the homebound reader; likewise, a seasoned experimenter may be unmoved by a lay spectacle.¹⁹⁰ The crucial point is that the principle also applies in reverse: an event that astounds an expert may seem banal to the uninformed onlooker.¹⁹¹ For example, those uninitiated in electricity would not have been greatly impressed by the fact that gold leaf was attracted to excited copal gum after being repelled by an excited glass tube, a finding that stunned Dufay.¹⁹² Similarly, the discovery that objects easily electrified by rubbing were the hardest to electrify by approach was both important and paradoxical to Dufay, but it was too esoteric to be mentioned in the summary of his third paper that appeared in the *Mercur de France*.¹⁹³ Only seasoned electricians, schooled in Dufay's rules of insulation, were surprised to find in 1746 that a glass jar filled with water could "hold" electricity while held in the hand. To the dabbler who made the discovery, thus co-inventing the Leyden jar, it was just what he had expected.¹⁹⁴

The example of the Leyden jar also shows the degree of overlap that still existed between lay and learned expectations in the middle of the eighteenth century, at least in the study of electricity. The same instrument astonished everyone, confounding the lay assumption that jars filled with water were painless to the touch, and the learned assumption that they only held their electricity when placed on a block of glass, pitch, or amber. Similarly, Dufay's

190. The example appears at Daston, "Preternatural Philosophy" (ref. 4), 27. Cf. Daston and Park, *Wonders* (ref. 4), 34–35.

191. Daston makes this point in "Language of Strange Facts" (ref. 4), 32–35, but does not apply it to Dufay or to eighteenth-century savants in general.

192. Dufay, "M4. L'attaction et la répulsion" (ref. 51), 464.

193. *MF*, Dec 1733, 2615–21.

194. Heilbron, *Electricity* (ref. 17), 313.

discovery of the electric shock drew wonder for reasons that were nigh-on universal: Dufay was as surprised as anyone by the pain and numbness he experienced when he approached his finger to his assistant after electrifying the latter by the approach of a rubbed glass tube. But the very same discovery was doubly surprising for electricians, like Dufay, who had spent years drawing *glows* from glass tubes and globes without ever noticing a *shock*.¹⁹⁵

How great was this overlap in the eighteenth century, and how did it vary across time, place, social spheres, and domains of inquiry? Was there an overall pattern of divergence between lay and learned expectations of the natural world during this period? How easily could those who were neither professors nor academicians acquire the expectations of the experts, and hence share their appreciation of esoteric anomalies? Such questions gain fresh interest from the recognition that Dufay, an exemplary member of a leading learned institution in the early Enlightenment, valued wonders not just to pull a crowd but also as an aid to serious inquiry.

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195. Dufay, “M3. Corps attires” (ref. 32), 252.