

Names and Numbers: “Data” in Classical Natural History, 1758–1859

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ABSTRACT

The late eighteenth and early nineteenth centuries saw the transition from natural history to the history of nature. This essay analyzes institutional, social, and technological changes in natural history associated with this epochal change. Focusing on the many posthumous reeditions of Carl Linnaeus’s *Systema Naturae* that began to appear throughout Europe and beyond from the 1760s onward, I will argue that Linnaean nomenclature and classification reorganized and enhanced flows of data—a term already used in natural history—among individual naturalists and institutions. Plant and animal species became units that could be “slotted” into collections and publications, reshuffled and exchanged, kept track of in lists and catalogs, and counted and distributed in new ways. On two fronts—biogeography and the search for the “natural system”—this brought to the fore new, intriguing relationships among organisms of diverse kinds. By letting nature speak through the “artificial” means and media of early systematics, I argue, new and powerful visions of an unruly nature emerged that became the object of early evolutionary theories. Natural history was an “information science” that processed growing quantities of data and held the same potential for surprising insights as today’s data-intensive sciences.

He gathered rocks, flowers, beetles of all kind for himself, and
arranged them in series in manifold ways.

—Novalis, *Die Lehrlinge zu Sais*, 1802¹

FROM NATURAL HISTORY TO THE HISTORY OF NATURE

It has long been a trope in the historiography of the life sciences that classical natural history underwent a massive transition, if not a revolution, around 1800. Key con-

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¹ Novalis (Friedrich von Hardenberg), *Novalis’ Schriften* (Berlin, 1802), 2:162: “Er sammelte sich Steine, Blumen, Käfer aller Art, und legte sie auf mannichfache Weise sich in Reihen.” Unless otherwise noted, all translations are my own.

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cepts such as species, distribution, or adaptation changed from designating stable forms to denoting fluid processes extending over generations and across populations. In its ancient sense of a trustworthy account, *historia* had of course always had to do with tradition and hence with the passage of time. This is reflected in the methods early modern naturalists used, which were essentially the same as those used by humanists and antiquarians.² But only in the latter half of the eighteenth century was the subject matter of natural history—the diversity of species, their properties and uses, and their geographic, temporal, and ecological distribution—infused with a sense of historicity.

This transition has been captured succinctly in the catchphrase “from natural history to the history of nature.”³ Explanations as to why it happened remain scant, however. Michel Foucault deliberately abstained from causal explanations in order to highlight the transition as a “mutation in the space of nature of Western culture.”⁴ In a similar vein, an older Anglophone tradition has emphasized paradigmatic shifts in metaphysical outlook as the precondition for the historicization of nature.⁵ An interesting early attempt to close the explanatory gap that such accounts left can be found in Wolf Lepenies’s book, *End of Natural History* (1976). Lepenies likewise regards natural history as going through a “crisis” around 1800 but identifies it as a self-inflicted “growth crisis.”⁶ Pointing to the series of new editions and supplements that eighteenth-century naturalists produced of their works, he explains how each attempt to reduce observations to a timeless classification system precipitated further observations that were at odds with the system adopted.⁷ Increasing “experiential pressure” thus ultimately exhausted the capacity of spatial classification systems and forced naturalists to open up a temporal dimension.⁸

Lepenies’s causal association of “experiential pressure” with far-reaching paradigmatic changes is highly suggestive for any attempt to historicize the contemporary discourse of “Big Data.” After all, this discourse is also rife with expectations—and fears—that “data-driven” science will be ushering in a new era in the history of knowledge.⁹ And there is indeed evidence that late eighteenth- and early nineteenth-century natural history can be understood as data driven since knowledge it accumulated grew at exceptional rates. While the number of species described by European naturalists has been rising ever since the Renaissance, the growth curve is steepest for the period between 1760 and 1840, before it experiences a slackening from the late nineteenth century onward.¹⁰ But there are also problems with Lepenies’s explanation. As suggestive

² Gianna Pomata and Nancy G. Siraisi, eds., *Historia: Empiricism and Erudition in Early Modern Europe* (Cambridge, Mass., 2005).

³ John Lyon and Phillip R. Sloan, *From Natural History to the History of Nature: Readings from Buffon and His Critics* (Notre Dame, Ind., 1981).

⁴ Michel Foucault, *Les Mots et les choses: Une Archéologie des sciences humaines* (Paris, 1966), 150.

⁵ Phillip R. Sloan, “Buffon, German Biology, and the Historical Interpretation of Biological Species,” *Brit. J. Hist. Sci.* 12 (1979): 109–53.

⁶ Wolf Lepenies, *End of Natural History* (Cambridge, 1980), 74.

⁷ *Ibid.*, 76.

⁸ *Ibid.*, 15.

⁹ See Elena Aronova, Christine von Oertzen, and David Sepkoski, “Introduction: Historicizing Big Data”; and Judith Kaplan, “From Lexicostatistics to Lexomics: Basic Vocabulary and the Study of Language Prehistory,” both in this volume.

¹⁰ Given how often growth in species number is invoked to explain historical developments in natural history, actual data are surprisingly scarce. I am relying on Sara T. Scharf, “Identification Keys and the Natural Method: The Development of Text-Based Information Management Tools in Botany in the Long Eighteenth Century” (PhD thesis, Univ. of Toronto, 2006), 31–42, who analyzes data for plants, mushrooms, insects, fish, birds, and mammals.

as the association is, mere quantitative growth of knowledge does not provide a compelling reason to adopt a particular worldview, whether historicist or not.¹¹ More interesting problems arise when we confront Lepenies's account with the following statement by the young Alexander von Humboldt (1769–1859):

Every plant is certainly not allocated to every rock as its domicile. Nature follows unknown laws here, which can only be investigated by means of botanists subjecting more data to induction [*Data zur Induction darreichen*].¹²

Humboldt's statement first of all shows that data talk is not a hallmark of modernity narrowly understood. The Latin past participle of *dare*, simply meaning "given," had long been in use in natural history to refer to any kind of information—a detailed description, a drawing, a preserved specimen, or just the name—that had been handed down about a particular subject.¹³ Second, and more important, it is notable that Humboldt employed the language of "data" not to complain about its overabundance, as one would expect from Lepenies's account, but on the contrary, to complain about its scarcity. Such a call for "more" data in a world that otherwise bemoaned "too much" data is not at all exceptional and only seemingly paradoxical. Naturalists like Humboldt were both creators and users of data and thus were involved in an endless cycle of consuming data for the sake of producing them. The crucial problem of any data-driven science is therefore not just to come to terms with ever-growing bodies of data but also to make those data applicable to as many contexts of inquiry as possible.¹⁴ The target of Humboldt's statement was a highly specialized subject—the distribution of plant species as a function of geological substrate, and hence their use as indicators in the search for mineral deposits—but it was hardly untrodden terrain; quite to the contrary, knowledge of correlations between particular plant varieties and particular types of rock had a very long and rich tradition in mining.¹⁵ Hence, if there was a scarcity of data, it was a scarcity of data produced in a manner that could readily be consumed and processed. Finally, Humboldt's statement also suggests that producing general knowledge from data through induction is not simply a matter of individual psychology and experience but relies on the results of a collective endeavor of trained specialists, a group that Humboldt himself was aiming to become part of.¹⁶ Naturalists were not passively exposed to a data deluge but collectively shaped the channels through which data

¹¹ Phillip R. Sloan, review of *Das Ende der Naturgeschichte*, by Wolf Lepenies, *Isis* 72 (1981): 123–4.

¹² Alexander von Humboldt, *Mineralogische Beobachtungen über einige Basalte am Rhein* (Braunschweig, 1790), 86.

¹³ See, e.g., Carl Linnaeus, *Hortus Cliffortianus* (Amsterdam, 1737), "Bibliotheca botanica" (n.p.), who refers to Johannes Bauhin's *Historia Plantarum Universalis* (Yverdon, 1650–1) as containing "all that was given by [his] forebears" [*omnis data a praecessoribus*]. More specifically, Humboldt's language of "data" and "induction" reveals the influence of Immanuel Kant, who argued that empirical sciences are uncertain and incomplete because they rely on "data of intuition" [*datis der Anschauung*]; see Ursula Klein, "The Prussian Mining Official Alexander von Humboldt," *Ann. Sci.* 69 (2012): 27–68, on 54–5. For further discussion of the history of the word "data," see Aronova, von Oertzen, and Sepkoski, "Introduction" (cit. n. 9); and Markus Krajewski, "Tell Data from Meta: Tracing the Origins of Big Data, Bibliometrics, and the OPAC," in this volume.

¹⁴ Sabina Leonelli, "Integrating Data to Acquire New Knowledge: Three Modes of Integration in Plant Science," *Stud. Hist. Phil. Biol. Biomed. Sci.* 44 (2013): 503–14.

¹⁵ Ursula Klein, *Humboldts Preußen: Wissenschaft und Technik im Aufbruch* (Darmstadt, 2015), 95.

¹⁶ Klein, "Alexander von Humboldt" (cit. n. 13), 29.

flowed, thus themselves defining the conditions under which they perceived data as abundant or scarce.¹⁷

Humboldt's early call for "more data" thus reminds us that solutions to epistemological problems of "data-driven science"—whether in its early modern or contemporary incarnations—are not only conceptual or theoretical, but also technological and infrastructural. Taking this conclusion on board, the next section is going to explore social and institutional changes that natural history underwent in its classical period from Linnaeus to Darwin. In particular, I want to highlight the integrative role that Linnaean nomenclature and taxonomy played in this period, which otherwise saw a diversification of agents, institutions, and cultures of natural history. The third and fourth sections will then focus on how Linnaean names and taxa were used as tools to organize exchange and retrieval of data. I will show that the adoption of these tools not only enhanced data circulation but also had peculiar epistemic effects, by turning species and other taxa into objects that were numbered and counted to reveal intriguing patterns in the geographic and taxonomic distribution of life forms. Only then, in a concluding section, will I return to the question whether one can claim that a causal connection exists between the data-driven nature of classical natural history and the discursive ruptures it underwent.

THE CHANGING LANDSCAPE OF CLASSICAL NATURAL HISTORY

Late eighteenth- and early nineteenth-century natural history experienced social and institutional changes that involved both diversifying and centralizing tendencies. On the one hand, its base of practitioners grew massively and came to include non-university-trained men and women as well, both within and outside of Europe, and across social classes. Amateur naturalists not only engaged in collecting specimens, maintained epistolary exchanges, and eventually published their observations; they also began to organize themselves from the bottom up in local and regional associations that often maintained their own periodical publications.¹⁸ Rising levels of literacy and the spread of inexpensive print widened the potential audience for, and made it easier to contribute to, natural history.¹⁹ At the same time, there was an increasing demand for experts trained in natural history to fill a growing number of professional positions, in state bureaucracies like mining boards; within the management of agricultural, industrial, and commercial enterprises; and, as we will see next, in large collections and museums. Needless to say, this held in particular for organizations and enterprises engaged in long-distance trade and colonial expansion. Participation in the global "information economy" of natural history, and the "logistical power" this bestowed upon its practitioners, thus provided a stepping stone for the middling classes to enter various occupations and careers of an administrative, brokering, or entrepreneurial nature.²⁰

¹⁷ For the parallel case of early modern genealogy, see Markus Friedrich, "Genealogy as Archive-Driven Research Enterprise in Early Modern Europe," in this volume.

¹⁸ Ann B. Shteir, *Cultivating Women, Cultivating Science: Flora's Daughters and Botany in England, 1760 to 1860* (Baltimore, 1999); Roger L. Williams, *Botanophilia in Eighteenth-Century France: The Spirit of the Enlightenment* (Dordrecht, 2001); Bettina Dietz, "Making Natural History: Doing the Enlightenment," *Cent. Eur. Hist.* 43 (2010): 25–46.

¹⁹ Denise Phillips, *Acolytes of Nature: Defining Natural Science in Germany, 1770–1850* (Chicago, 2012).

²⁰ Simon Schaffer, Lissa Roberts, Kapil Raj, and James Delbourgo, eds., *The Brokered World: Go-Betweens and Global Intelligence, 1770–1820* (Sagamore Beach, Mass., 2009); Ursula Klein and

While these developments led to a growing diversification of both objects and sources of natural history, a counterbalance existed in the rise of a new set of central nodes around which natural history exchange revolved. Until the mid-eighteenth century, exchange of specimens, letters, and publications was centered upon individuals who presided over large collections, such as Sir Hans Sloane (1660–1753), Georges Buffon (1707–88), and Carl Linnaeus (1707–78). By the early nineteenth century, central and permanent institutions had taken over this role—the Jardin des Plantes and Muséum d’histoire naturelle in Paris, Kew Gardens and the British Museum in London, or Berlin University with its gardens and collections in Prussia, to name just a few. Two important structural features distinguished these “new” collections from their early modern counterparts.²¹ First, they represented collections of collections rather than collections *tout court*. Often starting out with the acquisition of a large, single collection—Sloan’s collection in the case of the British museum, or Linnaeus’s collection in the case of the Linnean Society (London)—these museums expanded by acquiring entire collections or commissioning naturalists to hunt for specimens on a global scale.²² The most striking case of this is provided by the Muséum d’histoire naturelle in Paris after the French Revolution, which received a boost to its possessions from the confiscation of aristocratic collections, whose provenances and contents were carefully noted in a card catalog.²³

Second, and concomitantly, museums were increasingly organized into specialized departments offering a hierarchy of positions for curators or “keepers” and various amanuenses who administered and enriched the collections. A new generation of professional naturalists emerged, often socialized through participation in long-distance natural history exploration, during which they collected for their patrons and then moved on to curatorial positions in metropolitan collections and libraries. Daniel Solander (1733–82), who accompanied Joseph Banks on Cook’s first circumnavigation as one of the many traveling students or “apostles” of Linnaeus, is often cited as the first exemplar. Robert Brown (1773–1858)—who went with Flinders’s expedition to Australia (1801–05), followed Solander as Banks’s librarian, and finally, after the latter’s death, became “Keeper of the Banksian Botanical Collection” at the British Museum in 1827—is another well-known example.²⁴

Emma Spary, eds., *Materials and Expertise in Early Modern Europe* (Chicago, 2010). For an intriguing case study, see Minakshi Menon, “Medicine, Money, and the Making of the East India Company State: William Roxburgh in Madras, c. 1790,” in *Histories of Medicine and Healing in the Indian Ocean World*, vol. 1, *The Medieval and Early Modern Period*, ed. Anna Winterbottom and Facil Tesfaye (London, 2015), 151–78. Menon borrows the concept of “logistical power” from Chandra Mukerji, “The Territorial State as a Figured World of Power: Strategics, Logistics, and Impersonal Rule,” *Sociol. Theory* 28 (2010): 402–24.

²¹ Dorinda Outram, “New Spaces in Natural History,” in *Cultures of Natural History*, ed. Nicholas Jardine, Jim A. Secord, and Emma C. Spary (Cambridge, 1996), 249–65.

²² On Sloane, whose collection already was a collection of collections, see James Delbourgo, “Collecting Hans Sloane,” in *From Books to Bezoars: Sir Hans Sloane and His Collections* (London, 2012), 9–23; on Linnaeus, see Paul White, “The Purchase of Knowledge: James Edward Smith and the Linnaean Collections,” *Endeavour* 23 (1999): 126–9. On traveling collectors, see Daniela Bleichmar and Peter C. Mancall, eds., *Collecting across Cultures: Material Exchanges in the Early Modern Atlantic World* (Philadelphia, 2011).

²³ Pierre-Yves Lacour, *La République naturaliste: Collections d’histoire naturelle et Révolution française, 1789–1804* (Paris, 2014).

²⁴ Edward Duyker, *Nature’s Argonaut: Daniel Solander 1733–1782: Naturalist and Voyager with Cook and Banks* (Melbourne, 1998); David J. Mabberley, *Jupiter Botanicus: Robert Brown of the British Museum* (Braunschweig, 1985).

The knowledge networks that underwrote natural history were thus not just expanding and diversifying. At the same time, central institutions emerged that provided positions for “information brokers” who saw their task primarily as serving an imagined community of naturalists by mediating and organizing flows of data.²⁵ This double process of diversification and centralization turned natural history into an increasingly disparate field. Classical natural history never constituted a homogeneous and uniform knowledge regime, governed by a common paradigm or episteme. Peter F. Stevens coins the interesting phrase “continuity in practice” to highlight how naturalists discarded the idea of one timeless and universal system in which every conceivable species would find its place and began to join species one by one into open-ended series instead.²⁶ The urge to synthesize particulars, to be sure, persisted, but increasingly found expression in the development of highly specialized “tools of conjecture” deployed in narrowly defined subject areas.²⁷

There is one element of unity to classical natural history, however, that has been recognized widely ever since the late eighteenth century. Within two decades of their introduction in *Philosophia Botanica* (1751), the two innovations that formed the cornerstones of Linnaeus’s self-styled “reform” of natural history—the naming of plant and animal species by “trivial” names composed of genus name and specific epithet (as in *Homo sapiens*) and their ordering by variety, species, genus, order (or family), and class, the so-called Linnaean hierarchy of taxonomic ranks—had been universally adopted by naturalists, even by prominent opponents of Linnaeus like Buffon or Jean-Baptiste de Lamarck (1744–1829).²⁸ It is telling, however, that these innovations have habitually been characterized as being of pragmatic value only. According to the botanist Frans Stafleu, author of the most comprehensive history of the reception of Linnaean taxonomy, Linnaeus conceived of natural history “primarily as a device to register and to remember, to store and to retrieve.”²⁹

Such claims imply that stable, arbitrary names and a nested hierarchy of taxonomic units are of obvious practical value in communication, but neutral with respect to the knowledge they transport. And indeed, precisely this feature seems to have made both innovations so attractive to naturalists in the first place.³⁰ Yet it seems highly improbable, after all we know from work in the history and philosophy of science, that

²⁵ The dynamic continues. On citizen science in twentieth-century ornithology, see Etienne Benson, “A Centrifuge of Calculation: Managing Data and Enthusiasm in Early Twentieth-Century Bird Banding,” in this volume; see also Geoffrey C. Bowker, “Biodiversity Datadiversity,” *Soc. Stud. Sci.* 30 (2000): 643–83; Sabina Leonelli, “Classificatory Theory in Data-Intensive Science: The Case of Open Biomedical Ontologies,” *Int. Stud. Phil. Sci.* 26 (2012): 47–65.

²⁶ Peter F. Stevens, *The Development of Systematics: Antoine-Laurent de Jussieu, Nature and the Natural System* (New York, 1994), 153.

²⁷ On “tools of conjecture,” see Lorraine Daston, “The Empire of Observation, 1600–1800,” in *Histories of Scientific Observation*, ed. Lorraine Daston and Elizabeth Lunbeck (Chicago 2011), 81–113, on 104–6.

²⁸ On the reception of Linnaeus in France, see Pascal Duris, *Linné et la France (1780–1850)* (Geneva, 1995).

²⁹ Frans A. Stafleu, *Linnaeus and the Linnaeans: The Spreading of Their Ideas in Systematic Botany, 1735–1789* (Utrecht, 1971), 33.

³⁰ William T. Stearn, “The Background of Linnaeus’s Contributions to the Nomenclature and Methods of Systematic Biology,” *Syst. Zool.* 8 (1959): 4–22; Lisbet Koerner, *Linnaeus: Nature and Nation* (Cambridge, Mass., 1999), chap. 2.

their adoption should have had no epistemic consequences at all.³¹ In the following section, I will adopt a perspective that looks at binary names and the Linnaean hierarchy as tools to process information on paper. This will prepare the ground for my argument in the subsequent section that the way in which information brokers in classical natural history deployed these tools—both in order to collect and process data on plants and animals and in order to navigate the increasingly complex social landscape of natural history—did have epistemic consequences by turning species and other taxa into objects that could be counted and whose numbers mattered.

PAPER TOOLS AND PAPER EMPIRES

One of the most astonishing aspects of Linnaeus's taxonomic publications is the success they enjoyed in terms of print runs, especially if one considers that these were not books made for leisurely reading, but catalogs filled with names of genera and species, references to earlier literature, short morphological descriptions, and cryptic remarks about geographic and ecologic distribution. Linnaeus himself counted twelve editions of his *Systema Naturae* (which grew between 1735 and 1768 from an eleven-page folio volume to four octavo volumes of 2,441 pages in all), six editions of *Genera Plantarum* (1737–64), and two editions of *Species Plantarum* (1753, 1762).³² But the success went far beyond Linnaeus as a person. From the late 1760s onward, but especially after his death in 1778, other naturalists began to publish editions, translations, and adaptations of these works, often adopting their main title and citing Linnaeus as author on the title page, or acknowledging their debt to his work in subtitles or prefaces. The most complete bibliography of Linnaeana lists about fifty posthumous items of this kind for *Systema Naturae* alone.³³

The lasting success of Linnaeus's taxonomic works is often explained by claiming that they provided naturalists with the means to refer unambiguously to the various kinds of plants and animals, thus clearing the previous chaos of synonymy and conflicting classifications.³⁴ But what allows for unequivocal reference in modern taxonomy are not binary names as such but the type method, that is, the method of associating taxonomic names with fixed taxon elements, such as type specimens deposited in museums, and this method only began to emerge in the second half of the nineteenth century.³⁵

³¹ For the same reason, it is unlikely that contemporary digital technologies will result in nothing but a “scaling-up of pen-and-paper methods”; see Hallam Stevens, “A Feeling for the Algorithm: Working Knowledge and Big Data in Biology,” in this volume.

³² See Carl Linnaeus, *Systema Naturae*, 12th ed., 4 vols. (Stockholm, 1766–8). See Ratio editionis in vol. 1 (1766), n.p., for a list of “authorized” editions of *Systema Naturae*.

³³ B. H. Soulsby, *A Catalogue of the Works of Linnaeus (and Publications More Immediately Relating Thereto) Preserved in the Libraries of the British Museum (Bloomsbury) and the British Museum (Natural History) (South Kensington)*, 2nd ed. (London, 1933), nos. 64–169, 284–327, 480–529, 573–619. Linnaeus's works were also printed in North and South America, and one of the editions listed by Soulsby for the twelfth edition of *Systema Naturae* was printed in Jakarta in 1783 (nos. 104–5). A search of the online Linnaeus Link Union Catalogue (<http://www.linnaeuslink.org/> [accessed 22 April 2017]), which builds on Soulsby's *Catalogue*, produces thirty-eight results for titles containing the words “systema” and “naturae” published between 1768 and 1859.

³⁴ For a succinct statement of this view, see the epilogue in Stafleu, *Linnaeus* (cit. n. 29), 337–9.

³⁵ Joeri Witteveen, “Suppressing Synonymy with a Homonym: The Emergence of the Nomenclatural Type Concept in Nineteenth-Century Natural History,” *J. Hist. Biol.* 49 (2015): 135–89.

Linnaeus himself, when introducing binary names and the five-tiered hierarchy of taxonomic ranks, advertised an advantage that was quite different from disambiguation, namely, decontextualization. Traditional species names were composed of the genus name and a diagnostic phrase spelling out traits by which the named species differed from all other known species of the same genus. The function of such names was thus not only to designate a species, but also to distinguish it from already known species; without this context, legitimate names did not make much sense. The “trivial” or binary name, in contrast, just added a “single word . . . freely adopted from anywhere” to the genus name, usually in the form of an adjective. Hence, as Linnaeus emphasized, it was not only shorter and more easily reproduced, but above all more stable, since it did not have to be changed with the discovery of new species.³⁶ With his “systematic” arrangement by class, order, genus, species, and variety, Linnaeus created a series of multiple taxa nested within higher taxa. A class, for example, could contain ten orders, each of these orders another ten genera, and so on, in the same way that countries or armies form nested hierarchies of multiple administrative and military units. The meaning of the ranks constituting the Linnaean hierarchy was thus likewise not determined by any particular differences they exhibited, but by what they contained and came to contain.³⁷ Linnaean names were mere indexes or labels, whereas the Linnaean hierarchy simply provided a nested set of containers, or “boxes within boxes,” defined extensionally only by the set of objects they contained.³⁸ In short, Linnaean nomenclature and taxonomy emphasized equivalence, not difference, a point to which I will return.

To gain a better understanding of how binary nomenclature and the hierarchy of ranks facilitated communication among naturalists, it is useful to look at the role they played in the creation of paper tools—devices made from paper and ink, whether in manuscript or print—that were employed in practices of extracting and processing written information like note taking, listing, cataloging, or tabulating.³⁹ Up to the early eighteenth century, the predominant methods scholars used for annotation had been marginalia and topically organized commonplace books, that is, media that tended to fix information in relation to a relevant (con)text.⁴⁰ The late seventeenth and eighteenth centuries witnessed a transition to more flexible paper tools, like loose files and card catalogs, and to more complex techniques of extracting, rearranging, and display-

³⁶ Carl Linnaeus, *Philosophia Botanica* (Stockholm, 1751), 98. Linnaeus indeed chose trivial names quite “arbitrarily,” i.e., from a wide variety of sources, including vernacular languages; see Alexandra Cook, “Linnaeus and Chinese Plants: A Test of the Linguistic Imperialism Thesis,” *Notes Rec. Roy. Soc. Lond.* 64 (2010): 121–38.

³⁷ Linnaeus, *Philosophia Botanica* (cit. n. 36), 202. For an English translation of the relevant aphorisms on trivial names and the five-tiered system of ranks, see *Linnaeus’ Philosophia Botanica*, transl. Stephen Freer (Oxford, 2005), 99–100, 207–8.

³⁸ I am borrowing the language of labels and containers from Sabina Leonelli, “Packaging Small Facts for Re-use: Databases in Model Organism Biology,” in *How Well Do Facts Travel? The Dissemination of Reliable Knowledge*, ed. Peter Howlett and Mary S. Morgan (Cambridge, 2010), 325–48. For an eighteenth-century case study that employs similar analytic categories, see Anke te Heesen, “Boxes in Nature,” *Stud. Hist. Phil. Sci.* 33 (2000): 381–403.

³⁹ On the concept of paper tools, see Christine von Oertzen, “Machineries of Data Power: Manual versus Mechanical Census Compilation in Nineteenth-Century Europe,” in this volume; Anke te Heesen, “The Notebook: A Paper-Technology,” in *Making Things Public: Atmospheres of Democracy*, ed. Bruno Latour and Peter Weibel (Cambridge, Mass., 2005), 582–9; Volker Hess and Andrew Mendelsohn, “Paper Technology und Wissensgeschichte,” *NTM* 21 (2013): 1–10.

⁴⁰ Ann M. Blair, *Too Much to Know: Managing Scholarly Information before the Modern Age* (New Haven, Conn., 2010); Richard Yeo, *Notebooks, English Virtuosi, and Early Modern Science* (Chicago, 2014).

ing information, like forms, tables, diagrams, and maps, often employed for highly idiosyncratic purposes.⁴¹ Linnaeus participated in this transition by experimenting throughout his career with a variety of annotation and filing systems, different forms of lists and tables, and, toward the end of his life, paper slips that resemble index cards. In all of these media, Linnaean taxa carved out an allocated paper space, labeled with the name of a genus or species, and then used to collect pieces of information contained under that name. Because the name itself was a mere label, the resulting packages of data could be freely extracted from their context, and their contents inserted, or even redistributed, elsewhere, without losing their identity, as long as the label stuck.⁴² As Linnaeus put it in a remarkable metaphor in 1737, defining the role of generic names:

The generic name has the same value on the market of botany, as the coin has in the commonwealth, which is accepted at a certain price—without needing a metallurgical assay—and is received by others on a daily basis, as long as it has become known in the commonwealth.⁴³

What this metaphor clearly expresses is that Linnaean names and ranks did not derive their value from any information they contained in themselves, but by providing others with the material means to access, accumulate, and exchange information.⁴⁴ Linnaeus's taxonomic works were designed to serve as templates for communal annotation, whether this took the form of creating a numbered list of the names of specimens or seeds sent to a correspondent, or whether an interleaved copy of one of these works was used to absorb new data gathered from the latest literature, from a letter received from a correspondent, or during field excursions. Linnaeus himself employed his publications for this purpose, thus being able to churn out one edition after another on the basis of data received from correspondents, and there is growing evidence that other naturalists quickly adopted the same kinds of strategies.⁴⁵ Drawing on an analogy from our digital age, one might claim that the formal structure of Linnaean nomenclature and taxonomy provided naturalists with the rows or "objects" of a crowd-sourced database; the columns, in turn, were constituted by "variables" such as morphological features, economic uses, and habitat or geographic origin of the species in question.⁴⁶

⁴¹ Anke te Heesen, "Accounting for the Natural World: Double-Entry Bookkeeping in the Field," in *Colonial Botany: Science, Commerce, and Politics in the Early Modern World*, ed. Londa Schiebinger and Claudia Swan (Philadelphia, 2005), 237–51; Volker Hess and J. Andrew Mendelsohn, "Case and Series: Medical Knowledge and Paper Technology, 1600–1900," *Hist. Sci.* 48 (2010): 287–314; Isabelle Charmantier and Staffan Müller-Wille, "Worlds on Paper: An Introduction," *Early Sci. & Med.* 19 (2014): 379–97.

⁴² Staffan Müller-Wille and Isabelle Charmantier, "Natural History and Information Overload: The Case of Linnaeus," *Stud. Hist. Phil. Biol. Biomed. Sci.* 43 (2012): 4–15; Müller-Wille and Charmantier, "Lists as Research Technologies," *Isis* 103 (2012): 743–52; Charmantier and Müller-Wille, "Carl Linnaeus's Botanical Paper Slips (1767–1773)," *Intellect. Hist. Rev.* 24 (2014): 215–38.

⁴³ Carl Linnaeus, *Critica Botanica* (Leiden, 1737), 204.

⁴⁴ The metaphor of data as currency is also found in twentieth-century sciences; see Elena Aronova, "Geophysical Datascape of the Cold War: Politics and Practices of the World Data Centers in the 1950s and 1960s," in this volume.

⁴⁵ On the important role of specimen lists in correspondence, see Bettina Dietz, "Contribution and Co-production: The Collaborative Culture of Linnaean Botany," *Ann. Sci.* 69 (2012): 551–69. On Linnaeus annotating interleaved copies of his own taxonomic works, see Staffan Müller-Wille and Sara Scharf, "Indexing Nature: Carl Linnaeus and His Fact Gathering Strategies," *Svenska Linnésällsk. Årssk.* 2011 (2012): 31–60.

⁴⁶ For an analysis of the limitations and potentials of applying this metaphor to predigital media, see David Sepkoski, "The Database before the Computer?," in this volume.

This explains one curious aspect of the many “editions” and “translations” of Linnaeus’s taxonomic work, namely that, strictly speaking, they were not editions or translations at all. As Bettina Dietz has emphasized in a recent article, they rather continued his taxonomic project by incorporating new data.⁴⁷ Many of the editors of these works pointed this out explicitly. The Dutch physician and naturalist Martinus Houltuyn (1720–98), for example, stated in his *Natuurlyke Historie*—issued from his cousin’s printshop between 1761 and 1785—that he had adopted Linnaeus’s “system” [*Samenstel*] and “Latin bynames” [*Latynsche Bynaamen*], but only to add that he had also inserted information from publications by other naturalists such as Buffon in Paris, or Jacob Theodor Klein (1685–1759) in Danzig, whose works rivaled those of Linnaeus in scope and authority.⁴⁸ Philipp Ludwig Stätius Müller (1725–76) made similar remarks in the preface to his German edition of *Systema Naturae*, stating that the reader should “not expect a translation,” either of the twelfth edition of Linnaeus’s *Systema Naturae* or of Houltuyn’s *Natuurlyke Historie*. Instead, Müller’s work also incorporated information gathered from other naturalists, above all from contributions to journals that scientific “academies” [*Sozietäten*] edited in Paris, Stockholm, St. Petersburg, and Vienna.⁴⁹ In the preface to a supplementary volume that appeared in 1776, Müller even asked his readers to report any new discoveries, whether made from reading, in collections, or in the field, directly to him by providing at least a short description and indication of the new species’ taxonomic position.⁵⁰ When Müller died shortly after, his publisher Raspe commissioned Johann Friedrich Gmelin (1748–1804), professor of medicine at the University of Göttingen, and other naturalists to continue the endeavor, adding over the following decades more than seventeen volumes to Müller’s expansion of Linnaeus’s work, including a German translation of Gmelin’s “thirteenth” edition of *Systema Naturae*.⁵¹

One can see from this short sketch that translations and editions of Linnaeus’s *Systema Naturae* were products of intense and complex paper work. They often built on one another, rather than directly on Linnaeus’s own publications, and they relied on a wide array of additional written sources—other general works in natural history, local floras and faunas, journal articles, and letters from correspondents—to integrate the latest discoveries. Müller coined a revealing expression for the unflagging compilatory activity that lay behind such works. In advertising his supplementary volume, he emphasized that “all *Addenda*, *Appendices* and *Mantissae* of the Knight von Linné have been properly slotted in [*gehörig eingeschaltet*],” and that the same had happened to new species reported by other naturalists.⁵² *Einschalten* is a verb with over-

⁴⁷ Bettina Dietz, “Linnaeus’ Restless System: Translation as Textual Engineering in Eighteenth-Century Botany,” *Ann. Sci.* 73 (2016): 143–56.

⁴⁸ Martinus Houltuyn, “Voorreden,” in *Natuurlyke Historie, of Uitvoerige Beschryving der Dieren, Planten, en Mineraalen, Volgens het Samenstel van den Heer Linnæus*, vol. 1, pt. 1 (Amsterdam, 1761), n.p.

⁴⁹ Philipp Ludwig Stätius Müller, “Vorbericht,” in *Des Ritters Carl von Linné vollständiges Natursystem . . . Erster Theil. Von den säugenden Thieren* (Nuremberg, 1773), n.p. For a more detailed account of Müller’s sources and his manner of compilation, see Dietz, “Linnaeus’ Restless System” (cit. n. 47), 148–9.

⁵⁰ Philipp Ludwig Stätius Müller, “Vorbericht,” in *Des Ritters Carl von Linné vollständiges Natursystem . . . Supplements- und Registerband* (Nuremberg, 1776), n.p.

⁵¹ Soulsby, *Catalogue* (cit. n. 33), nos. 96–100, 577. The volumes on botany are analyzed by Dietz, “Linnaeus’ Restless System” (cit. n. 47), 150–2.

⁵² Müller, “Vorbericht” (cit. n. 50), n.p. I thank Sabina Leonelli for coming up with an ingenious English translation for *einschalten*.

tones of mechanical or bureaucratic labor and simply means to insert an object into a preexisting series of other objects.⁵³ It expresses vividly how easy it had become to compile data on plant and animal species after the Linnaean reform. This is not to say that the adoption of Linnaean nomenclature was a smooth and immediate process. It was through a long, protracted, and regionally diverse process, in which social and political relations were at stake, rather than through a mere technological fix, that the full potential of Linnaean nomenclature was realized.⁵⁴ A key element in this process was the fact that Linnaean names and taxa empowered naturalists who were situated in peripheral contexts or subaltern positions to build their own “paper empires” on the basis of purely derivative literary techniques like extraction, compilation, and rearrangement of names and accompanying descriptions. Even Buffon, an ardent lifelong opponent of the Linnaean reform, did not escape the maelstrom of information processing that was set free in this way. From 1801 to 1803, the poet René Castel, once deputy of Calvados for the Assemblée legislative, published a twenty-six-volume “new edition” of Buffon’s *Histoire naturelle* “classified by orders, genera and species according to Linnaeus’s system and with . . . Linnaean nomenclature.”⁵⁵

COUNTING SPECIES

Gmelin compared Linnaeus’s work to an “admirably contrived edifice” constructed in such a manner “as to suffer . . . necessary additions, alterations, and improvements, without injuring its strength, permanency, or symmetry.” Critics of Linnaean natural history, he argued, should consider “that such alterations, additions and improvements, as the *System of Nature* has hitherto required, have been made by the disciples of that great master”—disciples like himself, that is.⁵⁶ This did not keep Lamarck from heavily criticizing Gmelin for having composed his work without “preliminary research,” simply “by attaching to the genera and species already determined by Linnaeus all that he found indicated as new in the works he consulted.”⁵⁷ Similar attitudes shine through when Kant speaks of systems in natural history as mere “depositories” [*Registraturen*], or when Humboldt addressed contemporary naturalists as “sordid registrars” [*elende Registratoren*].⁵⁸ Such invectives became more and more common in the late eighteenth century. They reflect how the Linnaean way of doing natural history

⁵³ Johann Christoph Adelung, *Grammatisch-kritisches Wörterbuch der hochdeutschen Mundart*, 4 vols. (1793–1802), 1:1735. Adelung points out that the word was used primarily in the context of inserting “written sentences.”

⁵⁴ Linnaean nomenclature shares this with other information technologies. On punch card technology, see von Oertzen, “Machineries” (cit. n. 39); on biogeographic maps, see Nils Güttler, *Das Kosmoskop: Karten und ihre Benutzer in der Pflanzengeographie des 19. Jahrhunderts* (Göttingen, 2014).

⁵⁵ René Richard Louis Castel, *Histoire naturelle de Buffon, classée par ordres, genres et espèces, d’après le système de Linné, avec les caractères génériques et la nomenclature Linnéenne*, 26 vols. (Paris, 1801–3).

⁵⁶ Johann Friedrich Gmelin, “Ratio hujus novae editionis,” in *Caroli a Linné: Systema Naturae per Regna Tria Naturae. . . . Editio decima tertia, aucta, reformata* (Leipzig, 1788), n.p.

⁵⁷ Jean-Baptiste Lamarck, “Sur les ouvrages généraux en histoire naturelle, et particulièrement sur l’édition du Systema Naturae de Linneus [*sic*], que M. J. F. Gmelin vient de publier,” *Act. Soc. Hist. Nat. Paris* 1 (1792): 81–5, on 82. Indeed, Gmelin’s thirteenth edition did build almost entirely on published information; see T. J. Spilman, “Gmelin’s 13th Edition of Systema Naturae: A Case of Neglect,” *Entomol. News* 78 (1967): 169–72.

⁵⁸ Quoted from Güttler, *Das Kosmoskop* (cit. n. 54), 57–8.

increasingly lost its former prestige and was relegated to the netherworld of mere manual labor. Therefore, naturalists began to foreground other concerns besides mere description and cataloging, notably questions relating to the “natural affinities” among organisms and the “laws” governing their global and regional distribution.⁵⁹

But it is worth taking the invectives seriously for a moment. A striking feature of eighteenth-century taxonomic literature, which reflects its compilatory nature well, is the increasing role that numbers began to play in it (see fig. 1). As in any proper register, species and genera were numbered consecutively to create an additional layer of indices that could be used to establish chains of references across field notes, correspondence, collections, annotations, and publications.⁶⁰ Numbering specimens in collections and gardens, or species entries in lists and catalogs, was a long-standing tradition in early modern natural history, to be sure.⁶¹ But with Linnaean nomenclature and taxonomy, such numbers acquired a new level of meaning that is best explained by turning to a revealing example of their day-to-day use in late eighteenth-century natural history.

In 1768, the German naturalist Johann Reinhold Forster (1729–98), then teaching at the Dissenter’s College in Warrington, was asked by Thomas Pennant (1726–98) to assist him in producing a volume on insects for his *British Zoology*. In 1770, Forster published a curious first product from his labors, entitled *A Catalogue of British Insects* (see fig. 2). It consisted of a list of exactly 1,004 Linnaean names of insect species, neatly lined up in two columns and numbered consecutively, both throughout and within each genus. In addition, the list was structured by headings stating the genus name, again numbered consecutively. The purpose of the catalog, as well as the meaning of the abbreviations set against many of the species entries, was succinctly explained by Forster in the preface to his book:

The author of this catalogue . . . presents his most respectful compliments to all ladies and gentlemen who collect insects, and begs them to favour him, if possible, with specimens of such insects, as they can spare, and which he is not possessed of: for this purpose he has made this catalogue, and put no mark to the insects in his possession; those which he has so plentifully as to be enabled to give some of them to other collectors, are marked with a (*d*); those which he has not, are marked either *Berk.* signifying *Dr. Berkenhout’s Outlines of the Natural History of Great Britain*; or *B.* signifying a

⁵⁹ Janet Browne, *The Secular Ark: Studies in the History of Biogeography* (New Haven, Conn., 1983); Philip F. Rehbock, *The Philosophical Naturalists: Themes in Early Nineteenth-Century British Biology* (Madison, Wis., 1983); James L. Larson, *Interpreting Nature: The Science of Living Form from Linnaeus to Kant* (Baltimore, 1994).

⁶⁰ Dietz, “Contribution” (cit. n. 45), 551–69; on Linnaeus’s own use of genera and species numbers, see Charlie Jarvis, “A Concise History of the Linnean Society’s Linnaean Herbarium, with some Notes on the Dating of the Specimens It Contains,” in “The Linnaean Collections,” ed. Brian Gardiner, special issue, *The Linnean* 7 (2007): 5–18; Charmantier and Müller-Wille, “Linnaeus’s Botanical Paper Slips” (cit. n. 42), 224–5. Naturalists collecting for the Jardin des plantes in Paris were commanded to number herbarium specimens and seed sacks; see Marie-Noëlle Bourguet, “La collecte du monde: voyage et histoire naturelle (fin XVIIème–début XIXème siècle),” in *Le muséum au premier siècle de son histoire*, ed. Claude Blanckaert, Claudine Cohen, Pietro Corsi, and Jean-Louis Fischer (Paris, 1997), 163–96, on 174. Humboldt was particularly obsessed with numbering specimens during his excursions in the Amazon region; see H. Walter Lack, “Botanische Feldarbeit: Humboldt und Bonpland im tropischen Amerika (1799–1804),” *Ann. Naturhist. Mus. Wien* 105B (2004): 493–514.

⁶¹ Staffan Müller-Wille, “Reproducing Species,” in *Secrets of Generation: Reproduction in the Long Eighteenth Century*, ed. Raymond Stephanson and Darren N. Wagner (Toronto, 2015), 37–58.



Figure 1. Frontispiece of the first volume of Carolus Linnaei . . . *Systema Naturae*, edited by Johann Joachim Lang (Halle, 1760). This edition was a pirated reprint of Linnaeus's tenth edition and may be the one Linnaeus himself referred to as the eleventh. The frontispiece shows a statue of Diana, taken from the frontispiece of Linnaeus's *Fauna suecica* (Leiden, 1746), and adds a human figure taking notes and pointing at the monkey in the top of the tree to the right. The heading refers to "names and numbers" [numeros et nomina] as essential elements of Linnaean natural history. The accusative is odd but may simply convey the idea that naturalists should work "toward names and numbers."

manuscript catalogue of *British Insects* communicated to the author; or *B. B.* which signifies *Berkenhout*, together with the manuscript catalogue. *N. S.* is put to such insects as have not yet been described by Dr. *Linnaeus*, and are *new species* with new specific names.⁶²

At a glance, then, Forster's catalog informed its readers of species he possessed in abundance, including species that were "new" to natural history, as well as species he knew existed and hoped to acquire through exchange to complement his own collection. The "d" probably stood for "duplicate;" that duplicates were expendable collection items as advertised by Forster is a notion that notably does not seem to have existed in pre-Linnaean natural history.⁶³ There is evidence that Forster had used the same communication strategy in earlier correspondence, with one similar manuscript list preserved in the Linnaean collections at London.⁶⁴

⁶² John [sic] Reinhold Forster, *A Catalogue of British Insects* (Warrington, 1770), 2; emphasis in the original. The "manuscript catalogue of *British Insects*" probably referred to the insect collection of Anna Blackburne (1726–98); see Arthur MacGregor, "Five Unpublished Manuscripts of Johann Reinhold Forster (1729–1798) in the Archives of the Linnean Society of London," *Arch. Nat. Hist.* 42 (2015): 314–30, on 320.

⁶³ Giuseppe Olmi, "From the Marvellous to the Commonplace: Notes on Natural History Museums (16th–18th Centuries)," in *Non-Verbal Communication in Science prior to 1900*, ed. Renato G. Mazzolini (Florence, 1993), 235–78, on 252–61; Claudia Swan, "From Blowfish to Flower Still Life Paintings," in *Merchants and Marvels: Commerce, Science, and Art in Early Modern Europe*, ed. Pamela Smith and Paula Findlen (London, 2001), 109–36, on 118; Delbourgo, "Collecting" (cit. n. 22), 14.

⁶⁴ MacGregor, "Five Unpublished Manuscripts" (cit. n. 62).

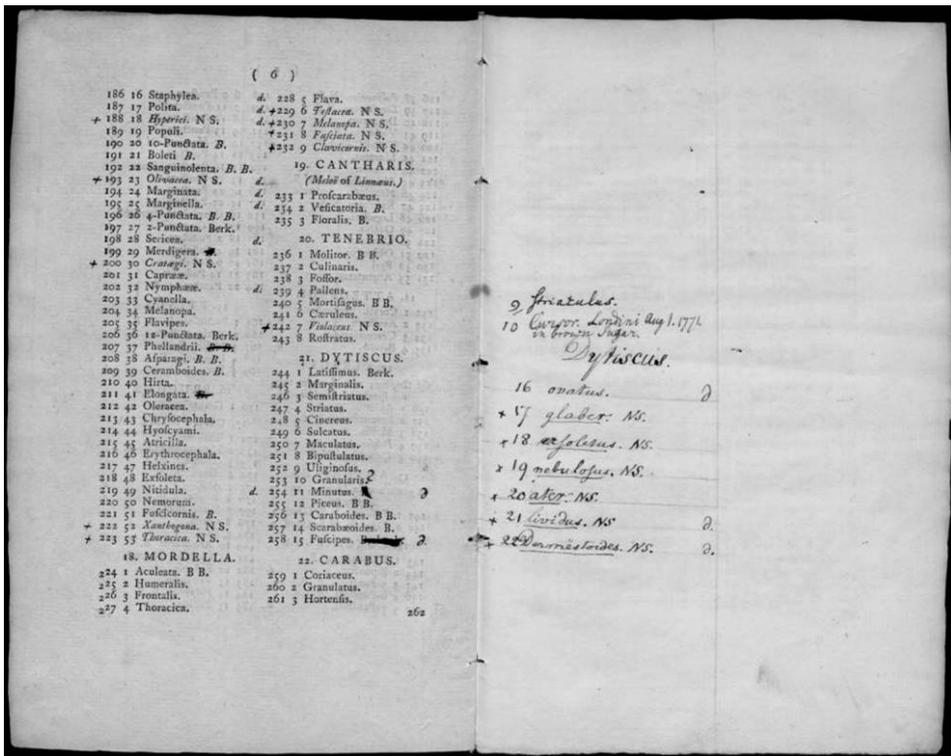


Figure 2. Two pages from Forster, *A Catalogue of British Insects* (cit. n. 62) with annotations by its author. The printed text lists genera and species of insects, employing Linnaean trivial names. The notes document additional species that Forster came across after publication, many of them marked as new species (“NS.”), and in one case reporting when and where a species was found: “10. [Tenebrio] Cursor Londini Aug 1. 1771. in brown sugar.” The latter remark refers to a beetle from Florida that established itself in Europe as a pest of stored foods. Forster, or his informant, may have come across this species in a shipment of sugar. Source: Staatsbibliothek zu Berlin—PK, Abteilung Historische Drucke, Signatur: Lt 12373: R. Courtesy Staatsbibliothek zu Berlin, Preußischer Kulturbesitz.

The strategy was apparently successful; an interleaved and annotated copy of Forster’s *Catalogue* has been preserved, in which he carefully noted species he had received or come across, either by deleting the abbreviations *Berk.*, *B.*, and *B. B.*, sometimes adding a “*d.*,” or by noting additional species names on the interleaves, often followed by an “*N. S.*” or a “*d.*” A note on the flyleaf of this copy states “Aug. y^c 28. 1771. 42 more insects,” and a calculation at the very end of the catalog registers “43 additional Insects” below the 1,004 already listed and draws up a new sum total of 1,047.⁶⁵ In the same year, 1771, Forster published a book presenting full species descriptions of one hundred “new” insect species. Again, an interleaved and annotated copy has survived from Forster’s library, although in this copy the annotations do

⁶⁵ John [sic] Reinhold Forster, *A Catalogue of British Insects* (Warrington, 1770), Staatsbibliothek Berlin, Abteilung Historische Drucke, call no. Lt 12373R.

not record accessions to his insect collection but instead trace references to his descriptions of new species in entomological literature.⁶⁶

Forster's *Catalogue*, with its extreme reduction of content to species names arranged according to the Linnaean hierarchy, illustrates the degree to which the discourse of classical natural history was dominated by naturalists' concern for their own position within the "market" of natural history. Linnaeus concisely, if slightly disparagingly, defined collectors in his *Philosophia Botanica* as those "who were primarily concerned with the number of species."⁶⁷ How many species of a particular genus were out there "on offer," whether in the hands of other collectors or out in the field? How many species had one already "acquired" in the form of specimens, and how many specimens could one "dispose of" as a kind of collector's capital to acquire specimens of other, preferably "new" or "rare" species? A whole new genre of taxonomic literature—consisting, like Forster's *Catalogue*, of nothing but taxonomic names, arranged in variously numbered and structured lists—emerged to answer these kinds of questions. Often openly advertising their poverty of content by incorporating terms such as "Index," "Nomenclator," or "Catalogue" in their title, these works, but especially their use, still await analysis by historians of science.⁶⁸ The fact that some of them were actually auction catalogs produced to support the sale of a collection clearly indicates that the genre catered to the desires of collectors.⁶⁹

But there is more to Forster's *Catalogue* and its countless cognates. His list of insect genera and species shows striking structural similarities with what is certainly one of the most intriguing visual representations of the "order of nature" in late eighteenth-century natural history, the "genealogical-geographical table of plant affinities" ("Tabula Genealogico-Geographica Affinitatum Plantarum"), which Paul Dietrich Giseke (1741–96) produced on the basis of notes from private lectures that he and the entomologist Johann Christian Fabricius (1745–1808) had received from Linnaeus (see fig. 3). The table represents the plant kingdom in the form of fifty-eight circles of different sizes and slightly irregular shape, distributed over the sheet in an unruly manner, a little bit like an archipelago. The accompanying "explication" of the table does indeed speak of a "map," and of the circles as "provinces" or "islands," each of them standing for a particular "natural order" of plants, their "size" corresponding to the number of genera within each of these orders, and their mutual relative positions expressing relations of "affinity" [*affinitas*].⁷⁰ The orders differ strikingly in "size," that is, the num-

⁶⁶ Johann Reinhold Forster, *Novæ Species Insectorum: Centuria I* (London, 1771), Staatsbibliothek Berlin, Abteilung Historische Drucke, call no. Ls 3924.

⁶⁷ Linnaeus, *Philosophia Botanica* (cit. n. 36), 4.

⁶⁸ For an intriguing study of the catalogs produced of the avian collections in the early history of the British museum, see Jennifer M. Thomas, "The Documentation of the British Museum's Natural History Collections, 1760–1836," *Arch. Nat. Hist.* 39 (2012): 111–25; in the 1830s and 1840s, John Edward Gray (1800–1875) closed a political debate around the British Museum's authority simply by publishing a catalog of its natural history collections; see Gordon R. McOuat, "Cataloguing Power: Delineating 'Competent Naturalists' and the Meaning of Species in the British Museum," *Brit. J. Hist. Sci.* 34 (2001): 1–28.

⁶⁹ On auctions in natural history, see John Michael Chalmers-Hunt, ed., *Natural History Auctions 1700–1792: A Register of Sales in the British Isles* (London, 1976); Samuel J. M. M. Alberti, "Objects and the Museum," *Isis* 96 (2005): 559–71, on 564. On the history of economic, and even commercial, dimensions of natural history, see Ina Heumann and Nils Güttler, eds., *Sammlungsökonomien* (Berlin, 2016).

⁷⁰ Paul Dietrich Giseke, ed., *Caroli a Linne . . . Praelectiones in Ordines Naturales Plantarum* (Hamburg, 1792), 625. Giseke's "Tabula Genealogico-Geographica" became the model for many

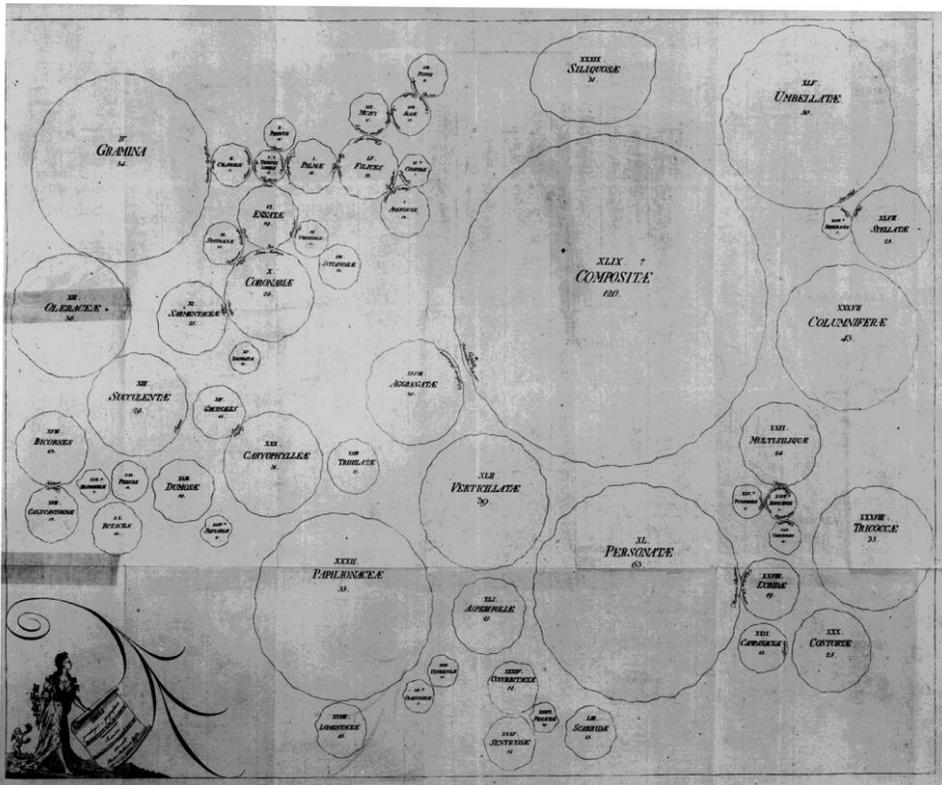


Figure 3. “*Tabula Genealogico-Geographica Affinitatum Plantarum*,” in Giseke, Caroli a Linnaei *Prælectiones* (cit. n. 70). The circles represent “natural orders” or plant families, and their size represents the number of genera they include. This number is also noted in the center of each circle, along with the family name and a roman numeral. The relative position of each circle indicates its taxonomic relationship with other families, sometimes highlighted by inscribing the names of closely related genera on the inside of two circles that face and almost touch each other.

ber of genera they include (from eight to 120), just as the numbers of species per insect genus differ conspicuously in Forster’s *Catalogue*. Both documents thus create an impression of a landscape of abundance and scarcity, of remoteness and propinquity, knowledge of which the old Linnaeus apparently imparted to his disciples with the unmistakable air of a sage privy to the mysteries of nature.⁷¹ The objective of Linnaeus’s speculations about a “natural” plant system may have been loftier than that of Forster’s *Catalogue*, but his manuscript explorations of plant affinities took exactly the same form

map- or network-like representations of the “natural system” that were published in the first half of the nineteenth century; see Giulio Barsanti, *La Scala, la mappa, l’albero: Immagini e classificazioni della natura fra sei e ottocento* (Florence, 1992); Theodore W. Pietsch, *Trees of Life: A Visual History of Evolution* (Baltimore, 2013), 26–65. For a scrutiny of a particularly impressive “map” of bird affinities produced by Hugh Strickland in 1840, see Mary P. Winsor, “Considering Affinity: An Ethereal Conversation,” *Endeavour* 39 (2015): 69–79 (issue 1), 116–26 (issue 2), 179–87 (issues 3–4).

⁷¹ See especially the dialogue on plant affinities and their recognition that Giseke reports having had with Linnaeus in the summer of 1771 (*Prælectiones* [cit. n. 70], xv–xx). Linnaeus, Giseke claims, was constantly “chuckling” at the naïveté of his student’s answers.

of numbered lists structured by headings and were certainly of equal strategic importance in his dealings with other plant collectors.⁷²

There is a further way in which Forster's *Catalogue* connects with the higher aspirations of late eighteenth- and early nineteenth-century naturalists. The catalog he produced was one of British insects and thus patently displayed a distribution of genera and species that was peculiar to the British Isles. The shares that certain plant families held in the overall number of genera and species of a certain climate or region played a fundamental role in the attempts of Augustin de Candolle, Alexander von Humboldt, and Robert Brown to establish "laws" that governed the geographic distribution of plants in the second and third decades of the nineteenth century.⁷³ And again, the relationship of these endeavors to the practice of numbering species and genera in taxonomic works, especially local and regional floras and faunas, was not accidental. All three naturalists had themselves been involved in large-scale floral projects—de Candolle assisted Lamarck in the third edition of his *Flore française* (5 vols., 1805), Browne prepared a survey of the Australian flora (*Prodromus Florae Novae Hollandiae*, 1810), and Humboldt and his travel companion Aimé Bonpland issued seven volumes on South American plants (*Nova Genera et Species Plantarum*, 1815–25) as part of their landmark travel account—and all three naturalists relied on floral catalogs for their calculations. A palpable example of the kind of labor that was involved in this endeavor can be found in a footnote that Humboldt added to his preface to the first volume of *Nova Genera et Species Plantarum* when presenting a table comparing the absolute and relative number of species per "natural family" for France, Germany and Lapland:

Since our floras are for the most part arranged according to the artificial system of Linnaeus, [Karl Sigismund] Kunth, to whom I am much obliged for being in my service, transcribed the plants growing spontaneously under diverse [climatic] zones into natural orders; a labor which is truly cumbersome and protracted and if it had not been carried out in the most accurate manner, I could in no way have set out the arithmetic ratios of the geography of plants here.⁷⁴

Karl Sigismund Kunth (1788–1850) also appears on the title page of *Nova Genera et Species*, but in a subaltern position, as the one who "put [the volume] into order from the handwritten paper slips of Aimé Bonpland." Humboldt's remarks not only illustrate the longevity of Linnaeus's sexual system as a handy diagnostic tool but also show how its limitations could be overcome by simple, if tedious, reallocation of species to their "natural families" or "orders."⁷⁵ One of the sources that Humboldt cites on the German flora, Heinrich Adolf Schrader's (1767–1836) *Flora Germanica*, pro-

⁷² Müller-Wille and Charmantier, "Lists" (cit. n. 42), 750–2.

⁷³ Browne, *The Secular Ark* (cit. n. 59); James L. Larson, "Not without a Plan: Geography and Natural History in the Late Eighteenth Century," *J. Hist. Biol.* 19 (1986): 447–88; Güttler, *Das Kosmoskop* (cit. n. 54), chaps. 1–3, esp. 181–5.

⁷⁴ Alexander von Humboldt, "De Instituto Operis et de Distributione Geographica Plantarum Secundum Coeli Temperiem et Altitudinem Montium Prolegomena," in *Nova Genera et Species Plantarum*, 7 vols. (Paris, 1815–25), 1:iii–lviii, n. 6 on xiii.

⁷⁵ While I focus in this essay on data-driven change in classical natural history, it is worth noting that Linnaeus's sexual system provides an excellent example of the kind of "data drag" that natural history was experiencing as well. The sexual system remained in use in natural history for almost a century, although most naturalists, including Linnaeus, readily admitted that it was thoroughly "artificial." On data drag, see Kaplan, "Lexicostatistics" (cit. n. 9).

vides a glimpse of how this task was sometimes made easier for Kunth. Schrader included a list that numbered species and genera in exactly the same way, as explained above for Forster's catalog.⁷⁶ Kunth could thus easily extract species numbers for each genus and only needed to add these numbers for each of the natural families. Humboldt planned to publish a stand-alone, second edition of their biogeographic treatise once Kunth had returned from Paris to Berlin to become professor of botany and vice director of the botanical garden, and throughout the rest of his life Kunth provided Humboldt with species numbers, partly drawn from what was to become his own magnum opus, a multivolume "Enumeration of all plants hitherto known arranged according to their natural families."⁷⁷ The second edition never materialized, but the surviving letters and manuscripts show that Kunth and Humboldt's speculations about relative and absolute species numbers involved the keen observation of how many species were known, above all, to naturalists at other important centers of botany, especially Paris.⁷⁸

Kunth clearly exemplifies one of the "sordid registrars" that a younger Humboldt had despised, but on whose activities he, like other naturalists with higher aspirations, had to rely. "Registering" species with the help of Linnaean nomenclature and taxonomy was an activity that created the very condition for treating species and higher taxa as objects that could be meaningfully counted. As long as names and taxa had diagnostic functions, the number of species per genus was only a trivial consequence of the diagnostic criteria adopted. Once names and taxa were reduced to labels and containers in order to enhance the exchange of information—once the system they formed became a system of relations of equivalence, rather than difference—species numbers began to take on new, empirical meanings. The Linnaean reform, that is, was a pragmatic affair, serving the needs of an emerging landscape of central institutions and increasing levels of division of labor in natural history, but its widespread adoption also changed the ontological status of species from logical category to countable object.

CONCLUSION: DATA IN NATURAL HISTORY AND THE HISTORY OF NATURE

It is well known that the irregular patterns that emerged from late eighteenth- and early nineteenth-century attempts to document the geographic and taxonomic distribution of species formed the chief explanandum of Darwin's theory of evolution by natural selection.⁷⁹ Paleontology, with its observations on the stratigraphic distribution of species, followed a similar trajectory; as David Sepkoski has argued, it grew into a "substantially 'data-driven'" discipline in the early nineteenth century that contrib-

⁷⁶ Heinrich Adolf Schrader, *Flora Germanica* (Göttingen, 1806), 83–100.

⁷⁷ Karl Sigismund Kunth, *Enumeratio Plantarum Omnium Hucusque Cognitarum Secundum Familias Naturales Disposita*, 5 vols. (Stuttgart, 1833–50).

⁷⁸ See the various letters and manuscripts by Kunth preserved in Alexander von Humboldt's papers (Staatsbibliothek Berlin, Nachl. Alexander von Humboldt, gr. Kasten 6, 8, and 13). They have recently been made available online at <http://humboldt.staatsbibliothek-berlin.de/werk/> (accessed 22 April 2017). On "counting" data in contexts of international competition, see Aronova, "Geophysical Datascape" (cit. n. 44).

⁷⁹ Janet Browne, "Darwin's Botanical Arithmetic and the 'Principle of Divergence,' 1854–1858," *J. Hist. Biol.* 13 (1980): 53–89; R. Alan Richardson, "Biogeography and the Genesis of Darwin's Ideas on Transmutation," *J. Hist. Biol.* 14 (1981): 1–41; Wolfgang Lefèvre, *Die Entstehung der biologischen Evolutionstheorie* (Frankfurt am Main, 1984); Mary P. Winsor, "Darwin and Taxonomy," in *The Cambridge Encyclopedia of Darwin and Evolutionary Thought*, ed. Michael Ruse (Cambridge, 2013), 72–9.

uted equally to the formation of evolutionary theories.⁸⁰ Are we then to assume after all, in the spirit of Lepénies, that it was increasing “experiential pressure” from ever-heightened levels of accumulated and articulated data that sparked the historicization of nature?

In response to this question, it is worth pointing out two things. First, it was perfectly possible to remain “ahistorical” in face of the strikingly irregular patterns of species distribution; during the first half of the nineteenth century, most naturalists actually did so, and ideas of divine creation and directed evolution have survived the Darwinian revolution to this day. What does it mean to “historicize” nature anyway, if even Darwin and Wallace could not agree on some quite elementary points of their respective evolutionary theories? What meaning was assigned to the data that systematists, biogeographers, and paleontologists accumulated clearly depended on cultural factors other than the mere form that these data took once they were assembled to create new representations of the order of nature.⁸¹ On the other hand, it is equally clear that the ways in which data on the distribution of species were presented with the help of Linnaean nomenclature and taxonomy held an enormous potential for generating surprises. Giseke’s map, or even Forster’s little *Catalogue of British Insects*, was a clear affront to the old idea that nature formed a continuous and unchanging scale of perfection.⁸²

The second point I would like to make concerns the nature of “data” in natural history. Humboldt held on to his early views of induction, writing in 1808 that “the physics of the earth has its numerical elements, just like the world system, and one will only gradually reach knowledge of the true laws that determine the geographic and climatic distribution of plant forms through the collective labor of traveling naturalists.” One such traveling naturalist, Friedrich Sellow (1789–1831), a protégé of Humboldt collecting specimens in Brazil from 1817 to 1831, has been described as having had an “obsession with data.” The journals left from his travels show that these “data” consisted, among other things, of endless numbered lists of the names of species collected, as well as where and when they were collected.⁸³ Just as with Forster’s *Catalogue*, almost nothing can be gleaned from these entries about the properties of the plants and animals encountered, their local environments, or their local uses. So, the data that were recorded in this way were not data that provided information about organisms, but rather what we would call “metadata” today, which in classical natural history consisted of a proper name, allocation of taxonomic position, and information on date and place of provenance.⁸⁴ Humboldt’s early call for “more data” to unravel the unknown “laws” of nature from them essentially did not ask for much more than this. The infrastructure of “labels” and “containers” created by the Linnaean reform began to acquire a life of its own, producing phenomena that could not have been produced without it. This is true in particular for the taxonomic distribution of species, since stating the

⁸⁰ David Sepkoski, “Towards ‘A Natural History of Data’: Evolving Practices and Epistemologies of Data in Paleontology, 1800–2000,” *J. Hist. Biol.* 46 (2013): 401–44.

⁸¹ Wolfgang Lefèvre, “Das ‘Ende der Naturgeschichte’ neu verhandelt: Historisch-genealogische oder epigenetische Neukonzeption der Natur?,” Max Planck Institute for the History of Science Preprint 476 (Berlin, 2016).

⁸² Harriet Ritvo, *The Platypus and the Mermaid and Other Figments of the Classifying Imagination* (Cambridge, Mass., 1998).

⁸³ Hanns Zischler, Sabine Hackethal, and Carsten Eckert, eds., *Die Erkundung Brasiliens: Friedrich Sellows unvollendete Reise* (Berlin, 2013), quotations on 67 and 113.

⁸⁴ On the concept of metadata in library science, see Krajewski, “Tell Data from Meta” (cit. n. 13). There are striking parallels with early modern genealogical practices as well; see Friedrich, “Genealogy” (cit. n. 17).

number of species per genus, or the number of genera per natural family, remains totally within the ontology that this infrastructure created in the first place.

Classical natural history, and its post-Darwinian heir, the discipline of systematics, can thus indeed be considered an information science, that is, a science whose primary aim consists in the storage, organization, and mobilization of knowledge.⁸⁵ But if this is true, it can also be considered inherently “experimental,” in the sense of building on art and artifice to produce new knowledge. Through the accumulation of specimens, containers, labels, and other inscriptions, naturalists bring together objects—on the page of a handwritten or printed text, in a drawing or diagram, within the drawer of a museum depot, or in the showcase of an exhibition gallery—that normally would never have coexisted. It is this peculiarity that endowed classical natural history, despite the occasionally dull appearance of its products, with its very own condition of creativity. The epochal shift from natural history to the history of nature was thus not produced with a kind of teleological necessity through the accumulation of data; rather, the instruments and infrastructures brought into play to manage and enhance flows of data—Linnaean names and taxa, above all—generated unforeseen and, indeed, never-before-seen phenomena that were difficult to reconcile with long-held intuitions.

⁸⁵ Ernst Mayr, “Systems of Ordering Data,” *Biol. & Phil.* 10 (1995): 419–34; Quentin D. Wheeler, ed., *The New Taxonomy*, vol. 76 of Systematics Association Special Volume Series (Boca Raton, Fla., 2008).