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Indexing Nature: Carl Linnaeus (1707-1778) and his Fact-Gathering Strategies

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Indexing Nature: Carl Linnaeus (1707-1778) and His Fact-Gathering Strategies[1]

Staffan Müller-Wille[2] & Sara Scharf[3]

Abstract

Early modern naturalists were faced with what has been termed the 'first bio-information crisis'. A key figure in resolving this crisis was the Swedish naturalist Carl Linnaeus (1707-1788). This paper will focus on Linnaeus's day-to-day working routines on the basis of manuscript material held at the Linnean Society (London). What this material shows is that Linnaeus had to manage a conflict between the need to bring factual information into a fixed order for purposes of retrieval, and the need to integrate new information into that order. A way out of this dilemma was to keep information on particular subjects on separate sheets, which could be reshuffled and complemented by additional sheets. It is only very late in his life, however, that Linnaeus realized the full potential of this technique, by inventing what look like index cards. What we thus hope to show in this paper is that one of the main cognitive advantages commonly assigned to writing – the possibility to abstract words and statements from their context and rearrange them freely in lists, tables and filing systems – had to prevail over considerable practical and psychological obstacles. What seems an obvious thing to do in hindsight, e.g. to work with something like index cards, had to be learned through an incessant, painstaking process of experimentation, fact-gathering, and reorganization.

(**Note:** all figures included at end of text, pp. 25-39)

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[1] Preparation of this paper has greatly profited from presentation at two workshops, one on "Making Small Facts Travel: Labels, Packages and Vehicles," which took place at the London School of Economics, March 27-28, 2008, and another on "Seriality and Scientific Objects in an Age of Revolution, 1780-1848," which took place at the University of Cambridge, 16–17 June, 2008. We would also like to thank Gina Douglas, Lynda Brooks, and Ben Sherwood from the Library of the Linnean Society for invaluable support and help. A two week research stay at the library for Sara Scharf was funded by British Society for the History of Science. Staffan Müller-Wille's research was generously supported by the Arts and Humanities Research Council.

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Introduction

How well do "facts" travel? According to the Polish immunologist, epistemologist, and philosopher of science Ludwik Fleck, not well at all. Employing an economic trope, Fleck insisted that, "the circulation of thought is always related, in principle, to its transformation."[4] Yet Fleck acknowledged that there also is a distinct way of communicating, in which thoughts undergo minimal transformation. This he called "information," where statements are "exchanged among specialists who are equivalent in a given field" and communication approaches the "exchange of conventional signals."[5] For Fleck, the paradigm case of such a form of communication was communication through the medium of numbers and algorithms. An even more ubiquitous and pervasive medium, however, is the alphabet. The most obvious way of "making facts travel" is to write them down and communicate them to others in this form. Writing is the most fundamental, and oldest, "technology of distance," to use Ted Porter's phrase.[6]

Curiously, the power of writing to transcend place and moment, and traverse space and time, seems to depend on its non-representational nature. A written description may convey information about how a particular plant or animal looks, but usually the text itself does not bear any resemblance whatsoever to the object it describes. Writing, as the anthropologist Jack Goody has argued, is not primarily representational but "provides ... a locational sorting device." It creates a space of its own, a space whose boundaries and internal dimensions

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[4] Ludvik Fleck, "The Problem of Epistemology," in R. S. Cohen and T. Schnelle, eds., *Cognition and fact. Materials on Ludwik* Fleck (Dordrecht: Reidel, 1986), pp. 79–112, here: p. 85; emphasis in the original.
[5] *Ibid.*, pp. 86–87.
[6] Theodore M. Porter, *Trust in Numbers. The Pursuit of Objectivity in Science and Public Life* (Princeton, N.J.: Princeton University Press, 1995), ix; for a call to attend to writing technologies more closely, and review of more recent literature in the history of science, see Lorraine Daston, "Taking note(s)," *Isis* 95 (2004), pp. 443–448.

have no immediate counterpart in the world, and which, precisely for that reason, may accommodate and align objects in ways that abstract from the contexts that usually convey meaning to them. Lists, therefore, and not narrative or discursive texts, dominate the earliest forms of writing. “The list,” Goody explains, “

> depends on physical placement, on location; it can be read in different directions, both sideways and downwards, up and down, as well as left and right; it has a clear cut beginning and a precise end, that is, a boundary, an edge, like a piece of cloth. Most importantly it encourages the ordering of the items, by number, by initial sound, by category, etc. And the existence of boundaries, external and internal, brings greater visibility to categories, at the same time as making them more abstract.[7]

Many of the conceptual effects of writing are strongly counter-intuitive. This is evident from the fact that certain seemingly mundane and trivial writing technologies took centuries to be invented and developed. One such invention is index cards, i.e. labelled paper slips of a standard size stacked in order to create a repository of pieces of information that can be readily retrieved, collated and reordered. What is counter-intuitive about this writing technology is that factual information is apparently stored more reliably and effectively if it is arranged not in a fixed, topical order, but contained in a flexible system, which, in principle at least, allows for the free circulation of its elements. The prerogatives of such systems for information storage may seem pretty obvious in a world dominated by the internet. So obvious, indeed, that it is easy to miss the fact that they had to be invented, and that their

[7] Jack Goody, *The Domestication of the Savage Mind* (Cambridge: Cambridge University Press, 2007), p. 81.

invention was the result of trial-and-error processes which were not guided right from the start by a clear picture of what one was going to achieve. It was indeed only in the late eighteenth century that administrators, librarians, and scientists began to use filing systems that resemble index cards.[8]

One of the first naturalists, as far as we can see, to use index cards was the Swede Carl Linnaeus (1707-1778), who is otherwise known for the introduction of binominal nomenclature, a universal system of labelling plant and animal species. He did so in the mid-1760s, that is, towards the end of his career. In the following, we will try to survey the long and tortuous route that led Linnaeus to conceive of this innovation. Before we do so, however, a couple of words on Linnaeus's place in the eighteenth-century botany seem in order.

Linnaeus and the Order of Nature

Cultural historians of natural history seem to love the Renaissance, the Dutch Golden Age and, to a lesser extent, the nineteenth century.[9] If it comes to studying the relationship between practices of collecting, writing, and reading in natural history, and the world-pictures that emerged from these practices, the eighteenth

[8] For a succinct analysis of this shift see Élizabeth Découltot, "L'art de l'extrait: definition, evolution, enjeux," in E. Découltot, ed., *Lire, copier, écrire: Les bibliothèques manuscrites det leurs usages au XVIIIe siècle* (Paris: CNRS editions, 2003); on the early modern history of filing technologies see Ann Blair, "Note taking as an art of transmission," *Critical Inquiry* 31 (2004), pp. 85–107; on their development in the modern period see Markus Krajewski,. 2002. *Zettelwirtschaft: Die Geburt der Kartei aus dem Geiste der Bibliothek* (Berlin: Kulturverlag Kadmos, 2002) and Delphine Gardey, *Écrire, calculer, classer (1800-1940)* (Paris: La Découverte, 2008).

[9] Two magnificent recent publications illustrate the bias towards pre-eighteenth-century natural history: Brian W. Ogilvie, *The Science of Describing: Natural History in Renaissance Europe* (Chicago: University of Chicago Press, 2006), and Harold J. Cook, *Matters of Exchange: Commerce, Medicine, and Science in the Dutch Golden Age* (New Haven: Yale University Press, 2007).

century largely remains uncharted territory.[10] In part, this is certainly due to the fact that this century has so much to offer for a more philosophically minded history of ideas. The late eighteenth century, after all, saw the temporalization of Arthur O. Lovejoy's *Great Chain of Being*, the re-conceptualization of generation as reproduction, and the emergence of a new science of life focussed on the organism and the principles of its organisation rather than living beings in their particularity.[11] Who, faced with these watersheds in intellectual history, would want to study the rather mundane (by then) practices and quite unsophisticated writings of a Carl Linnaeus, when more colourful figures like Georges Louis Leclerc de Buffon or Charles Bonnet, conversing freely with the *savants* and putting forth bold speculations, abound?

Yet, Linnaeus's impact on how natural history was done and thought about in the eighteenth century is not to be underrated. He redefined the objects, methods and aims of natural history as those of a fact-gathering, collective, and cumulative science.[12] Personally, he managed a huge network of correspondents and travelling students that spanned the globe and through which new discoveries would reach his desk on an almost daily basis. In part, this enterprise was supported by the great care with which Linnaeus had laid down a code of practice for naturalists in his *Fundamenta botanica*, already published by 1736, and re-edited and expanded in 1751 as *Philosophia botanica*. The descriptions of new species that reached him would therefore follow a standardized format, terminology, and nomenclature. Yet all this new

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[10] For a notable exception see Emma C. Spary, *Utopias Garden: French Natural History from Old Regime to Revolution* (Chicago: University of Chicago Press, 2000).
[11] For a still inspiring survey of these intellectual trends, see François Jacob, *La logique du vivant. Une histoire de l'hérédité* (Paris: Gallimard, 1970).
[12] Staffan Müller-Wille, "Collection and Collation: Theory and Practice of Linnaean Botany," *Studies in History and Philosophy of the Biological and Biomedical Sciences* 38 (2007), pp. 541–562.

information had also to be integrated with what was known already, not the least in order to assure that a species hailed as a new discovery had not actually already been described elsewhere. The communication of facts through large-scale networks of correspondents had to be channelled into a small-scale practice of checking new facts against each other and against established facts in order to distil updated and more accurate accounts that could then be communicated to the outside world again through the printing press.[13]

In order to tackle the flow of information that went over his desk, Linnaeus exploited the possibility of publishing sequences of editions of his works. Linnaeus's *Genera plantarum*, for example, published for the first time in 1737 and then listing 935 plant genera, ran up to seven authorized editions, the last one listing 1343 genera.[14] This is in striking contrast to previous writers in natural history, who rarely saw their works to several editions, often because they had waited until middle or even old age to publish. Significant parts of the output of two of the biggest names in Renaissance natural history, Ulisse Aldrovandi (1522-1605) and Conrad Gessner (1516-1565), for example, never appeared in print

[13] Staffan Müller-Wille, "Joining Lapland and the Topinambes in flourishing Holland: Center and periphery in Linnaean botany," *Science in Context*, 16 (2003), pp. 461–488.
[14] The editions of the *Genera plantarum* are: Leiden 1737, Leiden 1742 ("editio secunda aucta & emendata"), Paris 1743 ("editio secunda nominibus Plantarum Gallicis locupletata"), Halle 1752 ("quae novis 70 celeb. auctoris generibus sparsim editis locupletata, in usi auditorii recudenda curavit Christoph. Carolus Strumpff"), Stockholm 1754 ("editio quinta ab auctore reformata et aucta"), Stockholm 1764 ("editio sexta ab auctore reformata et aucta"), and Frankfurt 1778 ("editio novissima novis generibus ac emendationibus ab ipso perillustri auctore sparsim evulgatis adaucta curante D. Joanne Jacobo Reichard"). The *Species plantarum* went through two editions in Linnaeus's lifetime (Stockholm 1753 and 1762), and the *Systema naturae* through twelve (1735 to 1768), growing from an eleven-page folio volume to three octavo volumes of around 2,500 pages. For more detailed bibliographic information, see 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)* (London: British Museum, 1933), no. 284–321. Linnaeus is a bibliographer's nightmare.

or were published posthumously only.[15] Linnaeus, in contrast to that, was just 29 years when he published the first edition of *Genera plantarum*. And he was quite aware that this was unusual. “You will know that these really should not be the work of someone my age,” he addressed his readers in the preface, “but of elders a hundred years old,” adding by way of a rather weak excuse: “[I] knew this too and therefore intended them for those later years. But exhausted by the labour, persuaded by the advice of friends, and instructed by the often unexpected fates of long efforts, [I] finally seized the opportunity to publish.”[16]

Certainly, as always, Linnaeus knew precisely what he was doing when seizing this opportunity. As some contemporaries already noted, he was undoubtedly more concerned about getting his books out quickly than about their accuracy or completeness. After all, having a first edition out and receiving criticisms and suggestions from correspondents offered the best platform from which to produce a second edition, one that could then be advertised as superior to the previous ones, and would in turn provide the stepping stone for the next edition, as well as a good deal of additional income.[17] This strategy also

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[15] Aldrovandi, who had planned to publish a comprehensive encyclopaedia of natural history, only managed to prepare the volumes on insects and birds for the press during the very last years of his life. The two last volumes of Gessner’s *Historia animalium*, dealing with serpents and insects, were published posthumously only (1587 and 1634 respectively), just like the bulk of his botanical work, including magnificent illustrations, which saw the light of day only in the eighteenth century (*Opera botanica*, 2 vols., 1754 and 1771). John Ray (1627-1705), who published an “amended” edition of his *Methodus plantarum nova* (London 1682) in 1703, is the only pre-Linnean exception we can think of. Of course, works in natural history often went into several reprint editions and translations even before the time of Linnaeus; the point here is that Linnaeus systematically used re-editions as an opportunity to correct and complement his earlier work.

[16] Staffan Müller-Wille and Karen Reeds, “A translation of Carl Linnaeus’s introduction to *Genera plantarum* (1737),” *Studies in History and Philosophy of the Biological and Biomedical Sciences* 38 (2007), pp. 563–572, here: p. 570.

[17] On Linnaeus’s strategies of self-promotion, see Gunnar Eriksson, “The Botanical Success of Linnaeus. The Aspect of Organization and Publicity,” *Svenska Linné-Sällskapets Årsskrift* 1978 (1979), pp. 57–66. As Tomas Broman suggested to us, re-editions may also have been

entailed, however, that Linnaeus had to find ways by which he could process large quantities of facts rapidly and reliably.

The Linnaean collection at the Linnean Society of London offers unique manuscript material to understand how Linnaeus organized and processed written information on a day-by-day basis while producing his taxonomic publications. The material includes annotations in books published by others, annotated herbarium sheets, loose-leaf as well as bound manuscript material, annotations in Linnaeus's personal copies of his own publications, often interleafed with blank sheets to accommodate annotations, and, finally, several thousand letters. All in all, this material covers the whole span of Linnaeus's working life, and it would lend itself to an analysis of "investigative pathways" in the style of the late Larry Holmes.[18] We plan to carry out such an analysis, but so far we have only completed a first, very rough survey of the material. This, we hope, has already yielded enough interesting results with respect to Linnaeus's inductive procedures to merit their presentation in this working paper series. In particular, Linnaeus's paper-based information management techniques show a curious dialectic between bringing representations – names, references, descriptions, and drawings – into a fixed order, and setting them loose again for purposes of comparison and rearrangement. Linear and tabular arrangements, that is, were only temporary stages in an ongoing process of wrapping up and unpacking factual information. We will present this process by focussing on four groups of manuscript material: excerpts from natural history books that Linnaeus produced during his student years in

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a way for Linnaeus to protect himself against piracy and reclaim intellectual property over his work; and it proved to be a nice way of making money, of course.

[18] Frederic L. Holmes, *Investigative Pathways Patterns and Stages in the Careers of Experimental Scientists* (New Haven, CT: Yale University Press, 2004).

Uppsala 1727 to 1731; the manuscript for the *Fundamenta botanica*, published during his stay in Holland in 1736, but which he had already compiled between 1731 and 1733; manuscripts from the preparation of his *magnum opus*, the *Species plantarum* of 1735; and finally, the already-mentioned index cards from the mid-1760s.

Manuscripta Medica, 1727-1730

During his years at Uppsala university, Linnaeus made excerpts from a number of natural history books, probably while lodging with Olof Celsius (1670-1756), professor for theology at Uppsala University and provost of Uppsala cathedral, who possessed a well-equipped library.[19] At first sight, the resulting manuscript, entitled “Manuscripta medica” (Figure 1), looks like any other commonplace book. However, a sideways look reveals that it was put together from a number of paper fascicules of slightly differing paper sizes (Figure 2). Each of these fascicules (Figure 3) contains excerpts of one publication, and each of these excerpts is neatly organized in the following way: first, a title page; then a dichotomous diagram illustrating the system that was used to structure the content of the respective book; and, third, a tabular list of the genera treated in the book, sometimes followed by a few notes (Figure 4). A particularly beautiful example is provided by the fascicule that Linnaeus produced from Johan Jonston’s *History of Insects* (1653) (Figure 5). The title page is made to look like a real frontispiece, including a small spider web occupying the upper right-hand corner, and the descriptions of insects are neatly laid out in paragraphs, with the names underlined, and little drawings in the margins (Figure 6).

[19] Thomas Magnus Fries, *Linné. Lefnadsteckning*, 2 vols. (Stockholm: Fahlcrantz, 1903), vol. 1, p. 55.

The extreme care with which these excerpts were made reveals that they were more than fleeting notes. Linnaeus, with no funds for real books, was in fact putting together a do-it-yourself pocket-library, and it is not unlikely that it accompanied him during his trip through Lapland in the summer of 1732.[20] However, paper was expensive, too, and what we see in these excerpts, therefore, is utmost condensation. A loose, uncompleted fascicule half the size of the others shows how Linnaeus literally "packaged" information on a subject – here, on caterpillars, drawn from a source we have not yet identified (Figure 7). This packaging of information often resulted in linear lists of names and references, the minimum of information that can serve as an *aide mémoire* (Figure 8). But the *Manuscripta medica* show that Linnaeus went beyond the mere list in attempts to use the paper-space as expediently as possible. What he generated was a *two-dimensional* arrangement of lists and blocks of running text, which occasionally were quite independent of each other. At one point, for example, Linnaeus combined the end of a tabular representation of Augustus Quirinus Rivinus's (1652-1723) plant system with notes on drinks (tea, coffee, chocolate, beer) and a two-columned list of "bad" and "correct" plant names (Figure 9).

Fundamenta botanica, 1731-1733

In the summer of 1729, Linnaeus's financial situation improved: he received a royal stipend and was able to teach botany and mineral assaying in private classes.[21] The cost of paper was no longer such an issue. A number of manuscripts have survived from this period, certainly

[20] On Linnaeus's financial situation as a student, see Fries, *Linné* (note 17), vol. 1, p. 50. His travel journal from Lapland mentions "my Ornithology, Flora Uplandica and generic Characters" as part of his equipment, see *ibid*., p. 85.
[21] Fries, *Linné* (note 17), vol. 1, p. 54.

the most interesting ones being three notebooks (Figure 10) entitled *Fundamenta botanica*. Their numbering – Vol. IV, Vol. VII, Vol. VIII – reveals that there must have been a larger set of such notebooks, of which only these three survive (Figure 11). They contain manuscript material that relates to part of the deluge of publications that poured out of Linnaeus once he had arrived in Holland in 1735, more specifically, material pertaining to the *Fundamenta botanica* (1736), a booklet containing 365 aphorisms on the science of botany, and two taxonomic works, the *Genera plantarum* and *Hortus cliffortianus* (both 1737. Before he came to Holland, Linnaeus made sure to have his arrival announced in a learned journal published in Hamburg, the *Hamburgische Berichte von Neuen Gelehrten Sachen*. Above all, this announcement spoke highly about several manuscripts that he carried with him and which he wanted "to bring, not to his own disadvantage, to the press in Holland." The three volumes probably represent what survived from these manuscripts. "All that this skilful man thinks and writes," the announcement went on,

> is methodical and he does not rest until he has brought the science or the project, in which he engages, into an order corresponding to nature. As can be concluded from this, he possesses an exquisite power of judgment, while not lacking a natural ability for invention. His diligence, patience and industriousness are extraordinary.[22]

The author of these laudatory statements was in all likelihood Linnaeus himself.

Vol. IV of the *Fundamenta botanica* manuscript contains drafts of aphorisms 127 to 153 of the published version. Of more interest with respect to the ways in which Linnaeus compiled factual information in

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[22] Felix Bryk, ed., *Linnaeus im Auslande: Linnés gesammelte Jugendschriften autobiographischen Inhaltes aus den Jahren 1732-1738* (Stockholm: In eigenem Verlage, 1919), pp. 102–103.

handwritten form are volumes VII and VIII. According to their subtitle, both deal with “specific differences,” and thus show that Linnaeus already in the early 1730s embarked on a project, which he was only able to complete twenty years later, in 1753, with the publication of *Species plantarum*: the compilation of a universal catalogue of plant species.[23] And such a project was indeed a matter of “diligence, patience and industriousness,” as the manuscript amply demonstrates. Unlike *Manuscripta medica*, the two volumes are not sewn together from a number of handmade little fascicules, but were probably ordered from a book-binder as ready-made notebooks. In order to compile species definitions, Linnaeus divided the empty pages into unevenly distributed spaces by horizontal double lines, each of these spaces headed by the name of a genus. The remaining space was then subsequently filled with species definitions complemented by references to the works from which these definitions were drawn (Figure 12). Variations in ink colour and handwriting show that Linnaeus did not write the text from beginning to end, but worked at different times on different genera, probably excerpting while reading natural history books from cover to cover.

This way of organizing a notebook reveals a couple of interesting points. First of all, it is a rather costly strategy in terms of paper space. Each genus was treated as an independent “slot” or “box,” into which species and references could be “dropped” once Linnaeus came across them. If there happened to be few species only – or if Linnaeus was unable, or simply did not care, for whatever reasons, to collect

[23] *Hortus cliffortianus* (1737) comes close to realizing that goal, but is in effect a catalogue of species growing in a particular garden only, the private botanical garden of the merchant-banker George Clifford, for whom Linnaeus worked as a curator from 1736 to 1738; see Carl Linnaeus, *Musa Cliffortiana*, with an introduction by Staffan Müller-Wille, translated by Stephen Freer (Königstein: International Association for Plant Taxonomy, 2007).

information on them – the “boxes” remained empty. Second, the unequal spaces that Linnaeus allocated for different genera indicate that he had some kind of preconception about the “size” of genera; some were small and others were large, that is, had to accommodate many entries for species. Finally, these estimates could be wrong, of course, thus creating space problems. A “box” might overflow, its contents threatening to spill into the adjacent one. Linnaeus occasionally dealt with such eventualities in a curious manner. Rather than continuing the list of species at some later point in the manuscript, he flipped the page, turned the book upside-down, and continued the list writing from bottom to top (Figures 13 and 14). The series of species in a sense “folded” onto itself, in order to save the integrity of genera; the flat paper-space gains virtual depth, making the “boxes” formed by each genus almost palpable.

Species plantarum, 1746-1753

It is only in 1746 – after his return to Sweden in 1738, a three year practice as physician in Stockholm, and “patriotic” endeavours, carried out during his first years as professor of medicine and botany at Uppsala University (like the compilation of a *Fauna suecica*), and travels through various Swedish provinces[24] – that Linnaeus returned to the project of compiling a universal catalogue of known plant species. Two sets of manuscripts have survived, one consisting of loose sheets, the other showing remains of binding. Their chronological relationship is not yet established with certainty, but Swedish scholars, who catalogued the Linnaean manuscripts in the 1950s, reckon that the loose sheet manuscript is the earlier one, while the bound one represents the “final”

[24] Lisbet Koerner, *Linnaeus: Nature and Nation* (Cambridge, MA: Harvard University Press, 1999).

manuscript version of the *Species plantarum*, as it is closer to the published text.[25]

The loose sheet manuscript is organized in a curious manner (Figure 15). Linnaeus used paper sheets of standard size, folded them once, and stuck one sideways into the other. The manuscript, that is, again consists of fascicules, but unlike the *Manuscripta medica*, fascicules which could be expanded by inserting additional pages. Each fascicule carries the name of a genus on the title page, followed by a list of species names. In a similar manner as with the *Fundamenta botanica* manuscript volumes on "specific differences," each of these species is allocated a certain space on the manuscript pages, which is then filled with references to descriptions and drawings of the species in the extant literature. The result is again an uneven succession of empty and crammed paper spaces, but now *within* each genus (Figures 16–19). In contrast to that, the genera themselves are each allocated their "own" fascicule, occupying a paper space that is infinitely expandable. Moreover, as each fascicule contains information on one genus only, genera can be shuffled around. There are again instances, where the content of one "box" spills over into another, but now these instances are restricted to species, not genera (Figure 20). The manuscript, it turns out, is actually a filing system. As such, it shows strong resemblances with the way in which Linnaeus organized his herbarium. Rather than transferring specimen into bound volumes, as was still usual at his time, Linnaeus kept them on loose sheets, which were then stored in a purpose built cupboard. Looking at the herbarium and the loose sheet manuscript of *Species plantarum,* one can get a vivid sense

[25] Cf. J. M. Hulth, "Linnés första utkast till Species Plantarum," *Svensk botanisk Tidskrift* 6 (1912), pp. 627–631.

of why Linnaeus felt, as he himself once described it, like a “hen laying an egg per day” while working on *Species plantarum*.[26]

If the loose-sheet manuscript is actually the predecessor of the bound one, then it seems likely that Linnaeus at some point felt the need to copy the information from his files into a consecutive manuscript to be handed over to the type-setter. The manuscript shows traces of having been sewn into one volume by hand, and one page could contain species lists for more than one genus. The result of this decision, however, was catastrophic: the manuscript abounds with insertions, deletions and lines indicating rearrangements (Figure 21). If this is what the type-setter actually saw as the “final version” of the *Species plantarum*, his job must have been pretty difficult.

The prime reason why the bound manuscript ended up in such disarray was likely very simple: while Linnaeus worked on the manuscript, he would constantly receive new material from correspondents and recent publications, material that needed to be integrated with what had been written down already. Bringing the manuscript into a fixed, rather than flexible order, inevitably created problems as each genus was now allocated a strictly limited space. Another, less obvious, reason is that Linnaeus continuously experimented with the arrangement of the species and genera. Evidence for this is provided by occasional lists of species on loose sheets of smaller size that were intercalated with the bound manuscript. These lists represent alternative linear arrangements of species within a genus. On one such page, for example, Linnaeus moved the species *Convulvulus Balatus* from one position in the linear sequence of species to another, and then back again in a second list that he copied down

[26] Staffan Müller-Wille, “Linnaeus' herbarium cabinet: a piece of furniture and its function,” *Endeavour* 30 (2006), pp. 60–64.

next to the first (Figure 22). Such experiments with linear species arrangements had significant consequences, because Linnaeus identified species within a genus by a serial number in the *Species plantarum* (1753), which he would use for referencing purposes in other contexts (Figure 23). Any addition or rearrangement would upset these numbers, so it was important to work out the "right" series, presumably one that was continuous such that "new" species in an intermediate position were unlikely to come up. This would inevitably happen every now and then, nevertheless, as is evinced by annotations in Linnaeus hand in his personal copy of *Species plantarum*. In the botanical volume of the tenth edition of the *Systema naturae* (1758-59), Linnaeus would integrate such species with the original list of species from the first edition of *Species plantarum*. But rather than changing the numbering adopted in the latter work, he marked the new species by capital letters. In terms of referencing, this created a hopeless mess, of course.[27]

Annotated books, 1752–1778

The annotations in Linnaeus's personal copy of *Species plantarum* illustrate another system of collecting and keeping track of information that Linnaeus seems to have used throughout his lifetime with much more constancy and efficiency than loose-sheet or bound manuscripts. All the personal copies that Linnaeus possessed of his numerous publications were interleafed with empty pages by the book-binder, so that each printed page was faced by an empty one that could accommodate annotations. These annotations not only included corrections for later editions, but, more importantly, additions as well. In

[27] Charlie Jarvis, "A concise history of the Linnean Society's Linnaean Herbarium, with some notes on the dating of the specimens it contains," in B. Gardiner and M. Morris (eds.): *The Linnean Collections* (London: The Linnean Society, 2007).

the case of taxonomic publications, like his *Genera plantarum*, he used this opportunity systematically. One of his personal copies of the first edition of the *Genera plantarum*, for example, uses the regular layout of the genus descriptions on the printed pages to compile lists of species of that genus in manuscript on the interleafed page facing the printed description. One can see Linnaeus “dropping” species one by one into the “boxes” provided by the strictly regular layout of the printed text (Figure 24). The result is another handwritten precursor to the *Species plantarum*, which Linnaeus equipped with a manuscript title page of its own, dated Nov 15 1752 (i.e. shortly before publication of the printed version) and dedicated to his son Carl (1741–1783), then twelve years old (Figure 25).

What makes this system of note keeping particularly interesting is that it could be continued *ad infinitum*, as each new print edition provided a new, fixed platform on the basis of which one could start again to amend existing and collect additional information. This explains the curious fact that, over time, Linnaeus’s annotations in his own books did not get fewer and fewer, as one might expect from a work that aims at the “perfect” edition. On the contrary, later editions show veritable explosions of annotations, as on a page from the tenth edition of the *Systema naturae* (1756), which lists the varieties of the genus *Homo*, i.e. man (Figure 26). What is more, the work of annotating successive print editions of his taxonomic works could even be continued by persons other than Linnaeus himself. An interleafed copy of the twelfth edition of the *Systema naturae*, which was published towards the end of Linnaeus’s working career (in three volumes from 1766 to 1768), contains annotations in his own hand, but also of his son Carl, who would succeed his father in 1778 as Professor of Medicine and Botany at Uppsala University (Figure 27). The practice of interleafing and annotating Linnaeus’s taxonomic works was also taken up by

contemporaries, as copies of these works held by the Herzog August Library in Wolfenbüttel demonstrates.[28] The enormous popularity that Linnaeus's publications enjoyed was probably less due to the fact that they provided a good read, but rather because they provided a perfect template for keeping one's own botanical notes, be it in the field, or in one's own natural history cabinet, and for communicating one's discoveries to others, not the least Linnaeus himself.

Index Cards, mid-1760s

The systems of note-keeping and annotation discussed so far vacillate curiously between bringing things into the fixed, linear sequence of a text and mobilizing them again within a system of virtual "slots", "boxes" or "pigeonholes" that could accommodate new information and rearrangements. In hindsight it seems obvious that the best way to cope with this dialectic would be through a filing system that kept notes on separate, mobile sheets of paper – and at one point at least (as we saw, while preparing the *Species plantarum*), Linnaeus seems to have come close to such a solution. It took him another twenty years, however, to realize it fully in what nowadays would appear as the perfect solution for an age restricted to paper-based information technologies. In the mid 1760's, while preparing the twelfth edition of *Systema naturae* (3 vols., 1766-1768), the last that he himself would see to the press, Linnaeus began to use what looks like index cards: small slips of paper of a standard size of c. 7.5 x 13 cm.[29] The cards carry a genus name at the top followed by notes on that genus,

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[28] Petra Feuerstein-Herz, '*Die große Kette der Wesen.' Ordnungen in der Naturgeschichte der Frühen Neuzeit* (Wolfenbüttel: Herzog August Bibliothek, 2007), figs. 55 and 89.
[29] It seems that Linnaeus used similar cards when preparing *Museum Ludovicae Ulricae* (1764), a catalogue of the queen's natural history collection. They are kept by the Natural History Museum in Stockholm and were on display in a small exhibition on "women in natural history" at the Stockholm observatory in 1995.

sometimes accompanied by small drawings. One genus may be represented by a whole set of such cards, each of these being indexed by the genus name at the top. Today, they are kept in stacks in alphabetical order, but we do not have any independent evidence that this is actually how Linnaeus himself kept them.

As mentioned at the outset of this essay, index cards were far from being a triviality in the eighteenth century. Even libraries only turned from bound catalogues to index cards towards the end of the eighteenth century.[30] Linnaeus seems to have been one of the first scientists to use them. As an information processing system, there is something paradoxical and counter-intuitive about index cards. They can be arranged and stored in a fixed, serial order, but this order remains flexible and can always be dissolved to create alternatives, even two-dimensional arrangements (on a desk, for example).

With this double functionality, index cards probably present most perfectly what Linnaeus was up to when experimenting with different forms of information processing, both in manuscript and in print. Index cards provide “slots” for additional information, while each card individually remains intact no matter how much the system as a whole suffers from additions and re-arrangements. That Linnaeus treated taxonomic units like the genus precisely as such “slots,” rather than beings of a spurious metaphysical nature, can be illustrated for *Cycas* – a plant genus that he found very difficult to describe.

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[30] Helmut Zedelmaier, “Buch, Exzerpt, Zettelschrank, Zettelkasten,” in H. Pompe & L. Scholz, eds., *Archivprozesse: Die Kommunikation der Aufbewahrung* (Köln: Dumont, 2002). “A new method of cataloguing” was introduced in 1825 to the British Museum by John Edward Gray, that is, writing information about species each on a separate loose piece of paper, so that it was easy to reorganize as needed; see Gordon R. McOuat, “Cataloguing Power: Delineating 'Competent Naturalists' and the Meaning of Species in the British Museum,” *British Journal for the History of Science* 34 (2001): 1-28.

In the sixth edition of the *Genera plantarum*, published in 1764, *Cycas* is represented by an entry that only states its name, followed by a sequence of dashes and a note reading: “I have as yet not found anything handed down by authors about the character of this genus.” Seven years later, in 1771, Linnaeus submitted a paper on this genus to the Academy of Science in Paris, which now contained a full description, and which eventually was published in the Academy’s journal in 1775. Two sets of index cards exist with notes on *Cycas*: one, consisting of two paper slips, in rash handwriting and adorned with small drawings of flower parts; and another, consisting of one slip only, in a more neat handwriting and more formally organized according to the scheme in which all genera were described in the *Genera plantarum* (see fig. 28). The latter description is struck through by two vertical lines, a symbol that Linnaeus used to mark text he had copied elsewhere. And indeed, in Linnaeus’s personal copy of his 1764 edition of *Genera plantarum*, he neatly filled in the morphological description by hand in the space provided by the dashes, not forgetting to delete the original disclaimer (Figure 29). The paper on *Cycas* published with the Academy reports how Linnaeus had originally “been forced to omit its description,” as he was unable to “reconcile its fructification [i.e. the morphology of flower and fruit], as given by Rheede and Rumpf, with other palms.” It was only “recently,” by “happy coincidence” that Linnaeus had come across “the flowers of both sexes of this palm, which allows me to describe them here now.”[31]

What this short report evinces is that Linnaeus worked on the genus *Cycas* episodically, as additional material came in, which could help clarify the picture by comparison. The precise sequence of events

[31] Cf. Carl Linnaeus, „Cycas proposita a Carolo Linné,“ *Histoire de l’Academie Royale des Sciences*, *Mémoires de Mathematique & de Physique*, Anné 1775 (1778), pp. 515-519.

remains to be established, but a plausible version is the following. The description of *Cycas* proved difficult, because its morphology differed strongly from other palms. To resolve this difficulty, Linnaeus examined illustrations of the fructification in Hendrik Rheede tot Drakenstein's *Hortus malabaricus* (1678-1703) and Georg Everard Rumpf's *D'Amboinsche Rariteitkamer* (1705), possibly producing the first set of index cards. A full picture, however, only emerged once he gained access to preserved male and female flowers of this plant, resulting in the description noted down on the second set of index cards, copied over into his personal copy of the *Genera plantarum*, and finally published in the Academy's journal.

Conclusions

The main purpose of this paper is rather modest, namely to provide a first survey only of the archival sources that document Linnaeus's day-by-day practice of processing facts. But with respect to this practice we would, however, like to draw a few preliminary conclusions from this survey:

1) The material clearly shows the extent to which Linnaeus relied on inductive, fact-gathering procedures. He was fully aware that empirical material would come in bit-by-bit, day-by-day, gathered as it was by numerous correspondents who were not under his full control, and that he had to accommodate his own working methods to this reality. Experience was not something one possessed. Instead, it came as a temporal series of often unforeseen experiences made by

others. In that sense, Linnaeus can be seen as a proponent of Baconian natural history.[32]

2) The border between manuscript and publication is blurred in the works of Linnaeus. Linnaeus designed the format of his publications to accommodate later annotations (inserted directly on the printed pages or on blank sheets interleafed with his personal copies). And his manuscripts often took the form of published books (bound, and following a set format). Linnean natural history, that is, would never present itself to the world in a complete and perfect "work," but only as a temporary stage in an ongoing series of preliminary publications, manuscript revisions, and amended re-editions.

3) Linnaeus's working methods were characterized by what could be called a "centralizing impetus." Linnaeus liked to keep as much information as possible in one tightly and expediently organized place. Rather than publishing a series of supplements to his main taxonomic works, the *Genera plantarum*, *Species plantarum*, and *Systema naturae*, he reworked the whole body of these works, while retaining the serial order that he had brought into his material from early on. This resulted in an on-going dialectic between mobilizing material (using loose sheets and index cards) for purposes of comparison and bringing it into a fixed, serial order again for purposes of later retrieval and reference. While mobilizing allowed him to treat taxonomic units like genera and species as autonomous units and to explore the multiple "affinities" among these units, "fixing"

[32] Staffan Müller-Wille, "History redoubled. The synthesis of facts in Linnaean natural history," in G. Engel, N. Karafyllis, R. Nanni and C. Zittel (eds.), *Philosophies of Technology. Francis Bacon and his Contemporaries* (Leiden: Brill, 2008), pp. 515–538.

that order occasionally was essential as well, as it created a fresh template on the basis of which additional material could be collected. We therefore see how representations of genera and species in Linnaeus's work vacillate between being points in a linear sequence and being two-dimensional "slots" or "pigeonholes" accommodating such sequences. These poles are reflected in Linnaeus distinction of "artificial" diagnostic systems running through a series of distinctions, and the "natural system," which represented the affinities of plants in a map-like, two-dimensional manner – although it remains to be seen exactly how this distinction relates to Linnaeus's practices.

4) Linnaeus's note-keeping practices, integrated as they were with his publication practices, spread beyond the confines of his cabinet. In fact, it is highly likely that the enormous popularity that his works enjoyed is not the least due to the fact that they provided the grounds for engaging in an enterprise of writing natural history *as a collective*. Each of the re-editions of Linnaeus major taxonomic publications provided a fresh starting point, for himself and for others, to continue the annotation work of natural history in the field, the museum, or the library. They brought previous annotation work to a preliminary closure, and provided a clean slate, so to speak, for further annotations. His printed taxonomic works can therefore be seen as instruments, which organized and accelerated – just like pumps – the stream of facts constantly pouring from networks of correspondents dispersed all over the world onto an individual naturalist's desk, where it was re-arranged and collated to be released out into the learned world again as printed text. For a while, at least, it was one person – Linnaeus himself – who was the central node in this system of circulating facts.

Figures

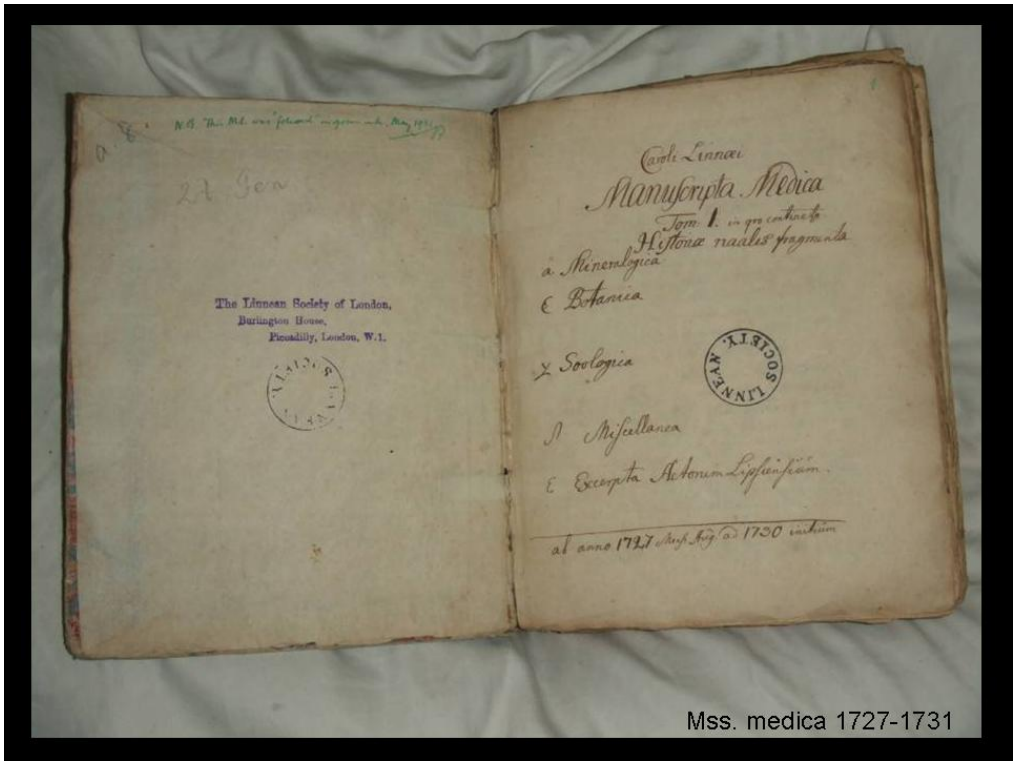

Fig. 1. Carl Linnaeus, “Manuscripta medica” (Ms.), Titlepage. Courtesy of the Linnean Society of London.

Fig. 2. Carl Linnaeus, “Manuscripta medica” (Ms.), Front and side view. Courtesy of the Linnean Society of London.

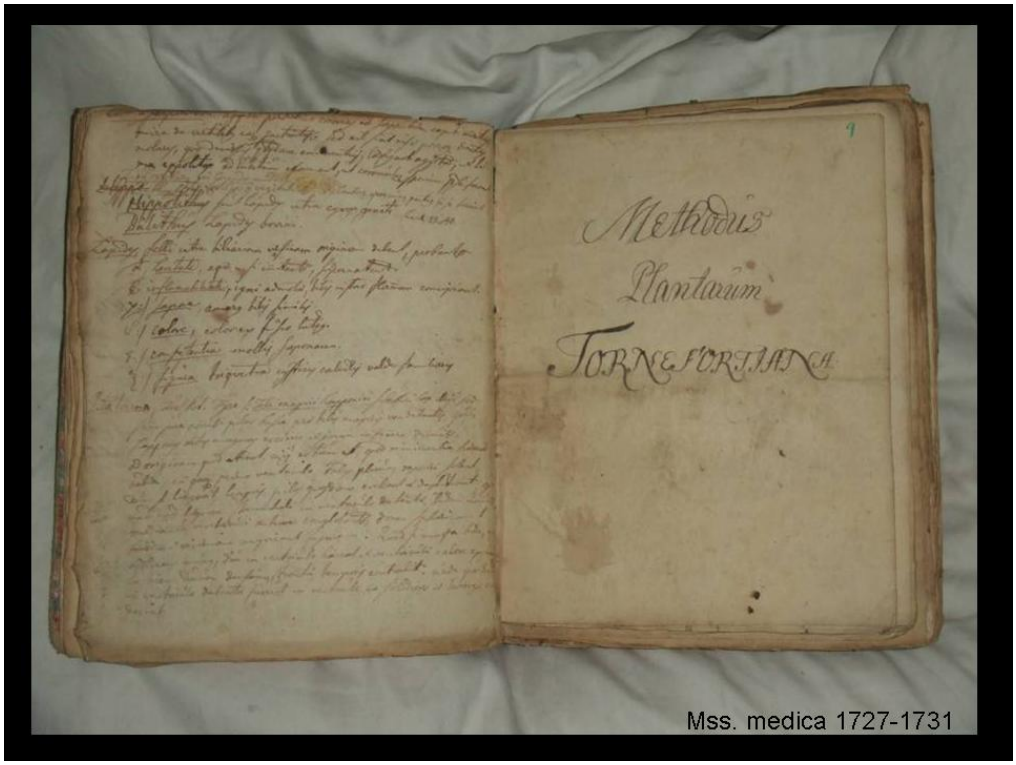

Fig. 3. Carl Linnaeus, “Manuscripta medica” (Ms.), “Methodus Plantarum Tournefortiana.” Courtesy of the Linnean Society of London.

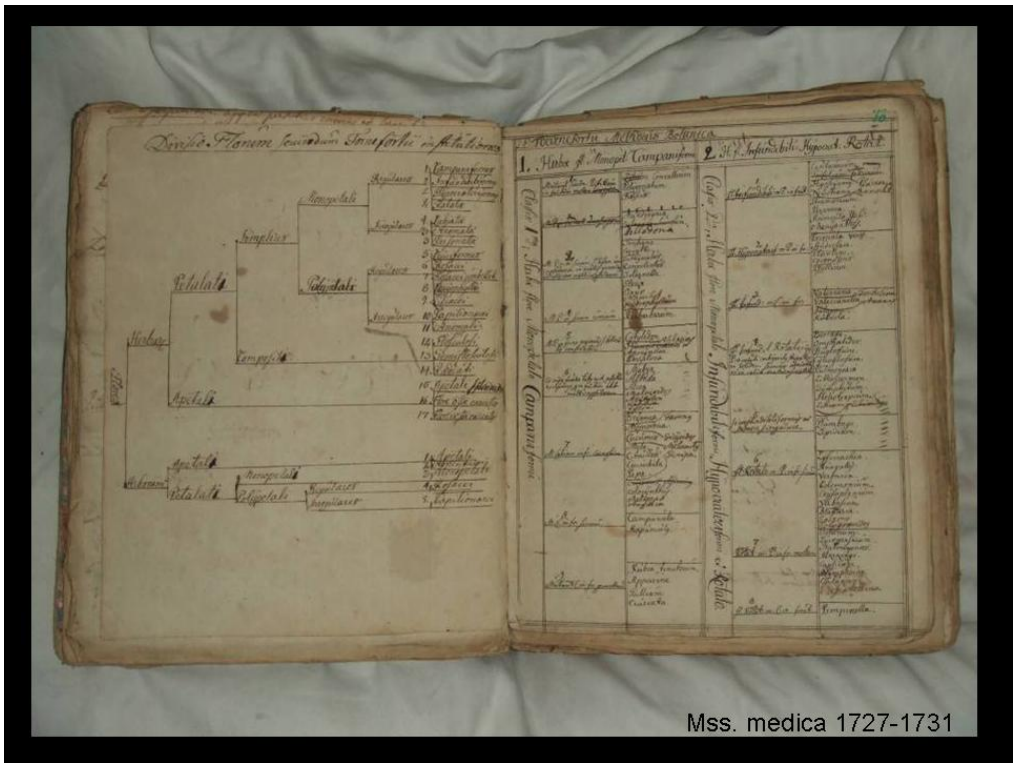

Fig. 4. Carl Linnaeus, “Manuscripta medica” (Ms.), “Methodus Plantarum Tournefortiana.” Courtesy of the Linnean Society of London.

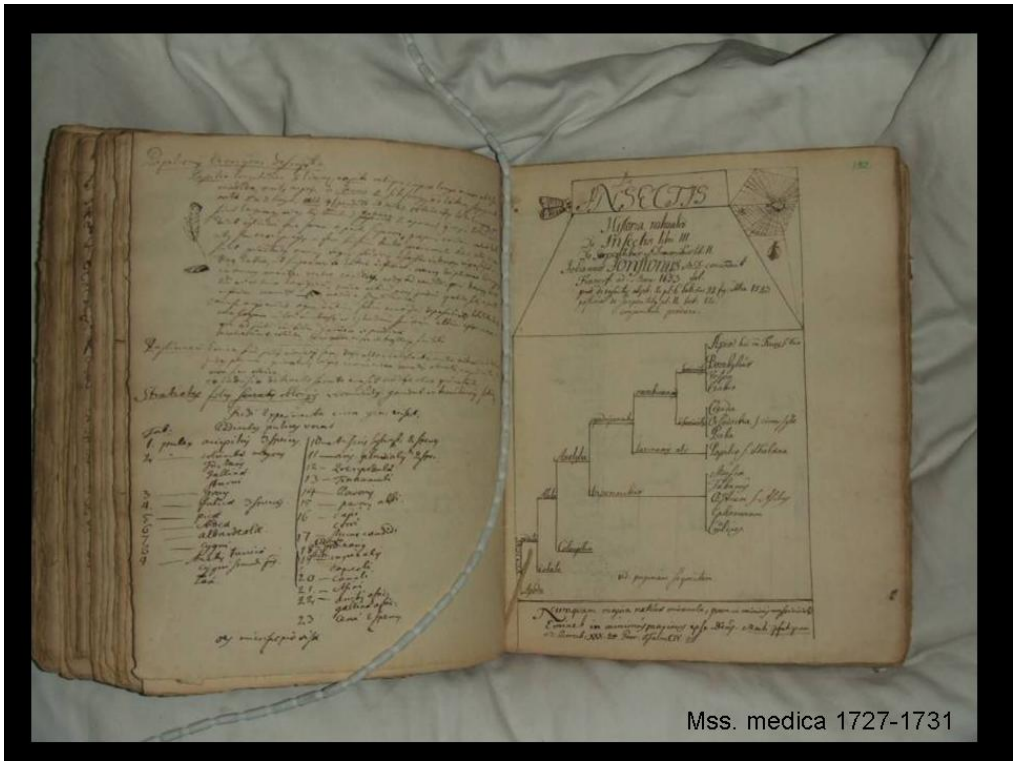

Fig. 5. Carl Linnaeus, “Manuscripta medica” (Ms.), “Insectis.” Courtesy of the Linnean Society of London.

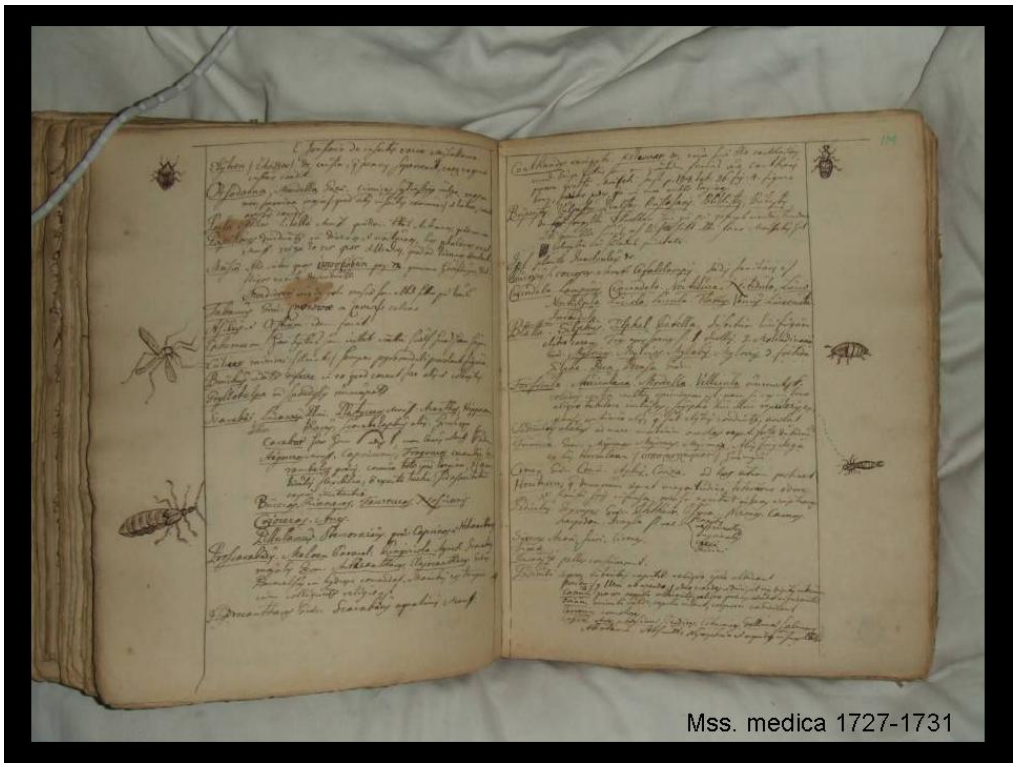

Fig. 6. Carl Linnaeus, “Manuscripta medica” (Ms.), “Insectis.” Courtesy of the Linnean Society of London.

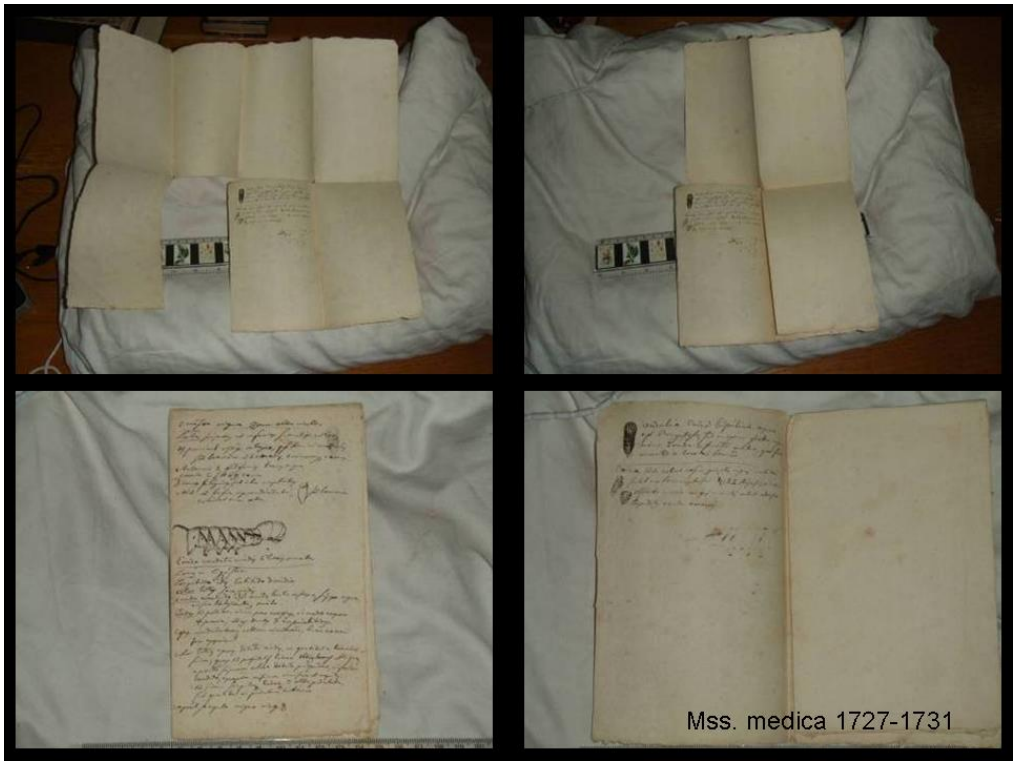

Fig. 7. Carl Linnaeus, “Manuscripta medica” (Ms.), loose sheet on caterpillars. Courtesy of the Linnean Society of London.

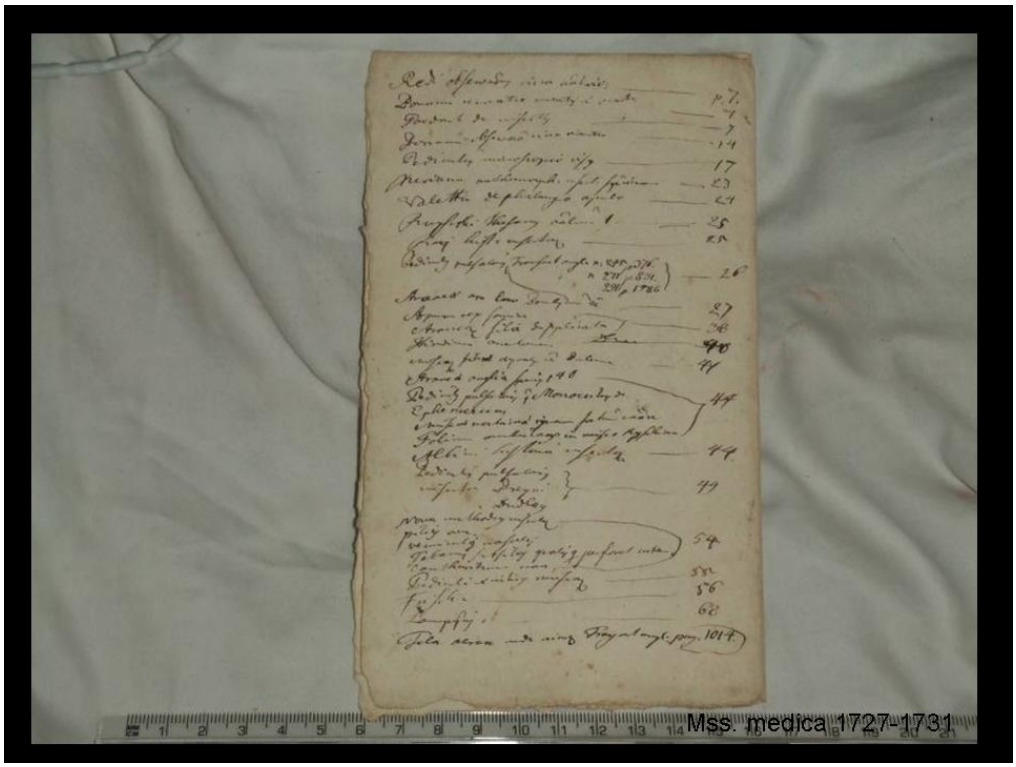

Fig. 8. Carl Linnaeus, “Manuscripta medica” (Ms.), loose sheet on caterpillars. Courtesy of the Linnean Society of London.

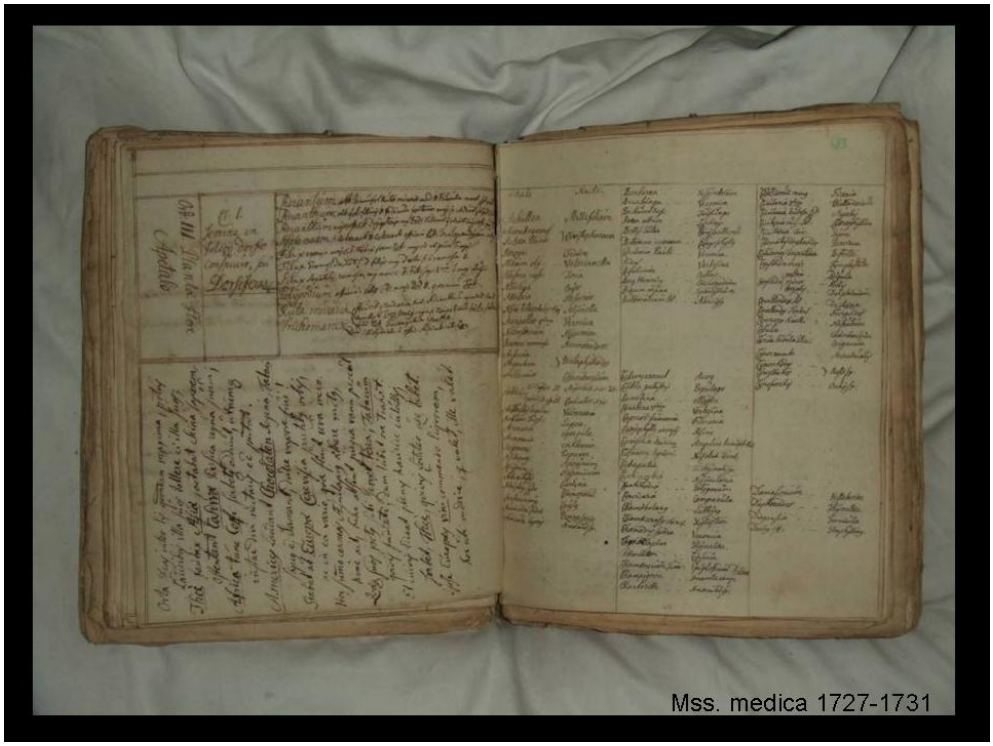

Fig. 9. Carl Linnaeus, “Manuscripta medica” (Ms.). Courtesy of the Linnean Society of London.

Fig. 10. Carl Linnaeus, “Fundamenta Botanica” (Ms.), front covers of all three volumes. Courtesy of the Linnean Society of London.

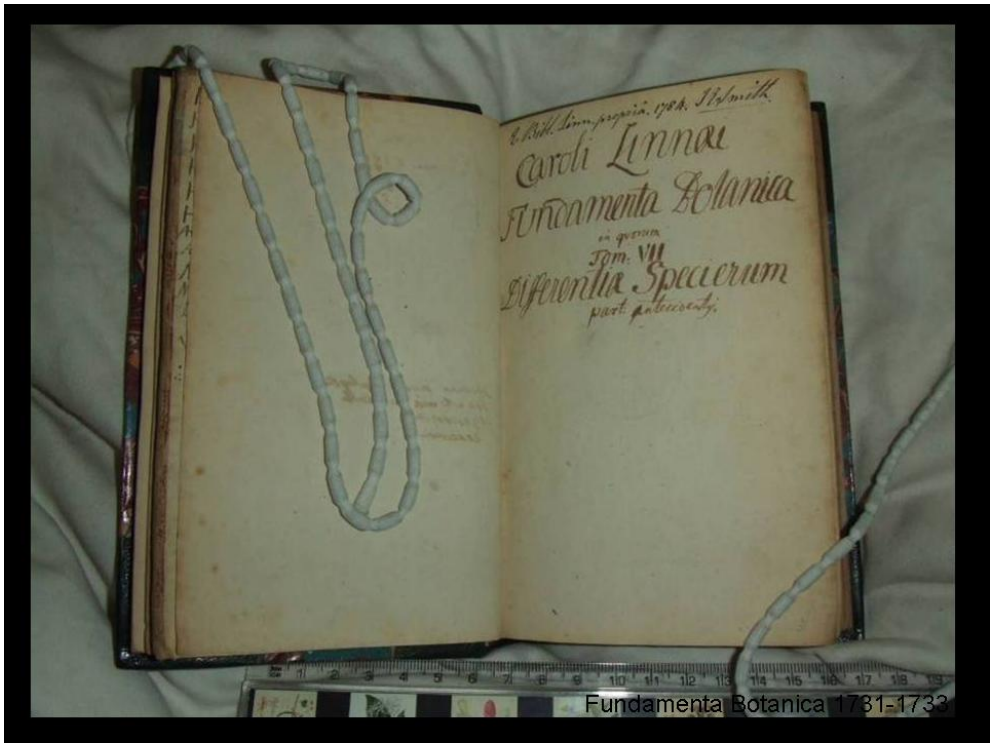

Fig. 11. Carl Linnaeus, “Fundamenta Botanica” (Ms.), title page of volume VII. Courtesy of the Linnean Society of London.

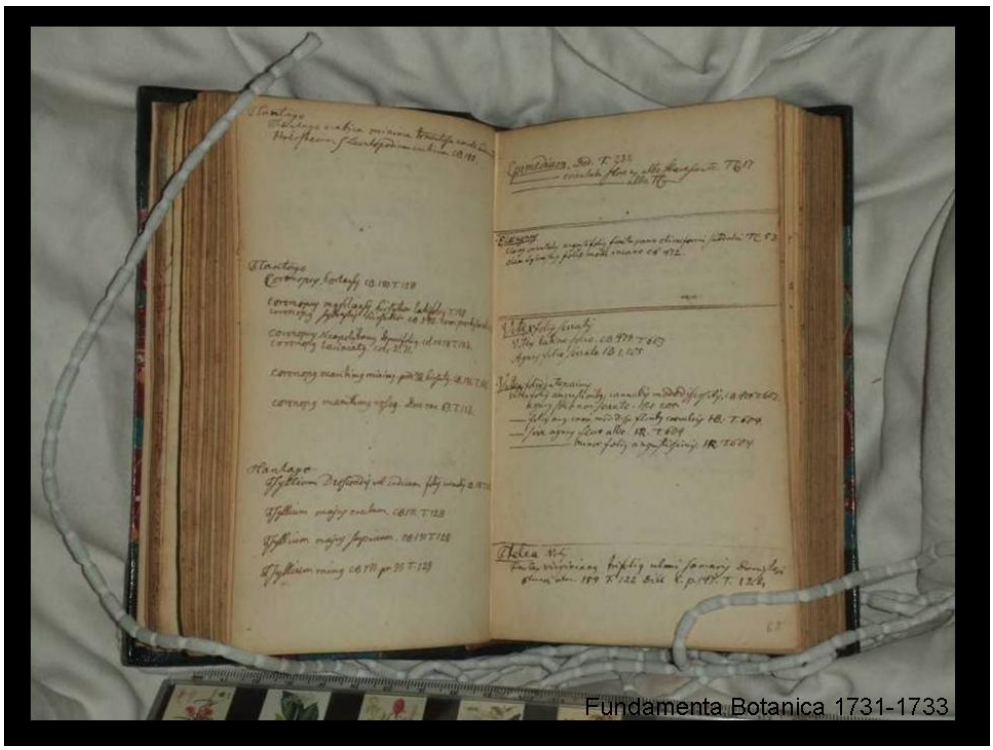

Fig. 12. Carl Linnaeus, “Fundamenta Botanica” (Ms.), Volume VII. Courtesy of the Linnean Society of London.

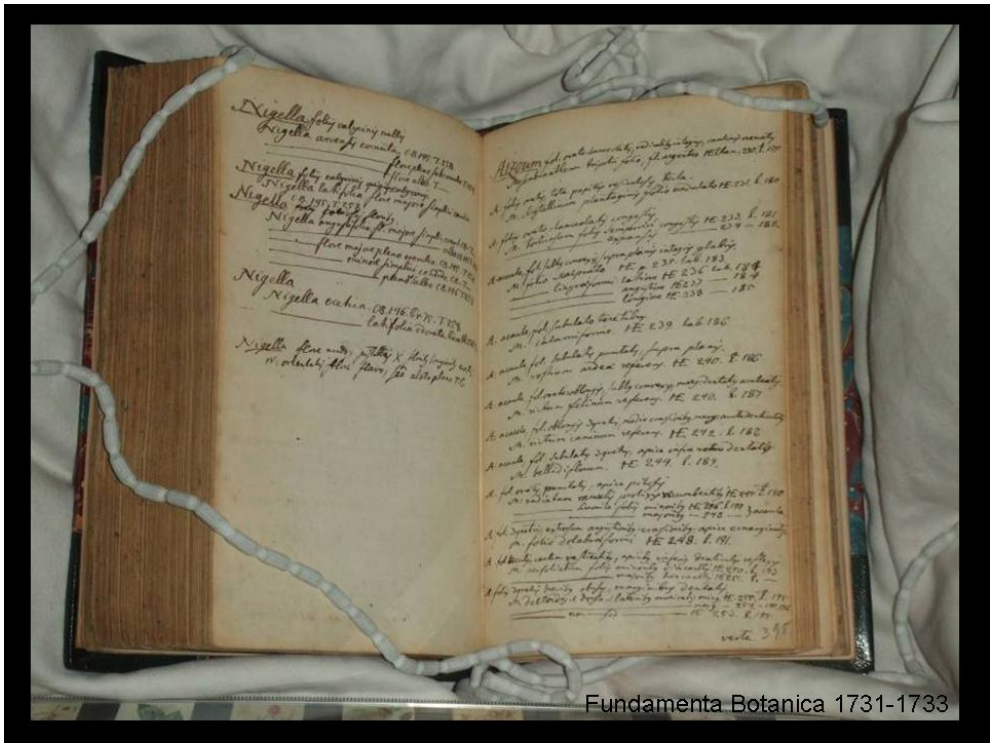

Fig. 13. Carl Linnaeus, “Fundamenta Botanica” (Ms.), Volume VII. Courtesy of the Linnean Society of London.

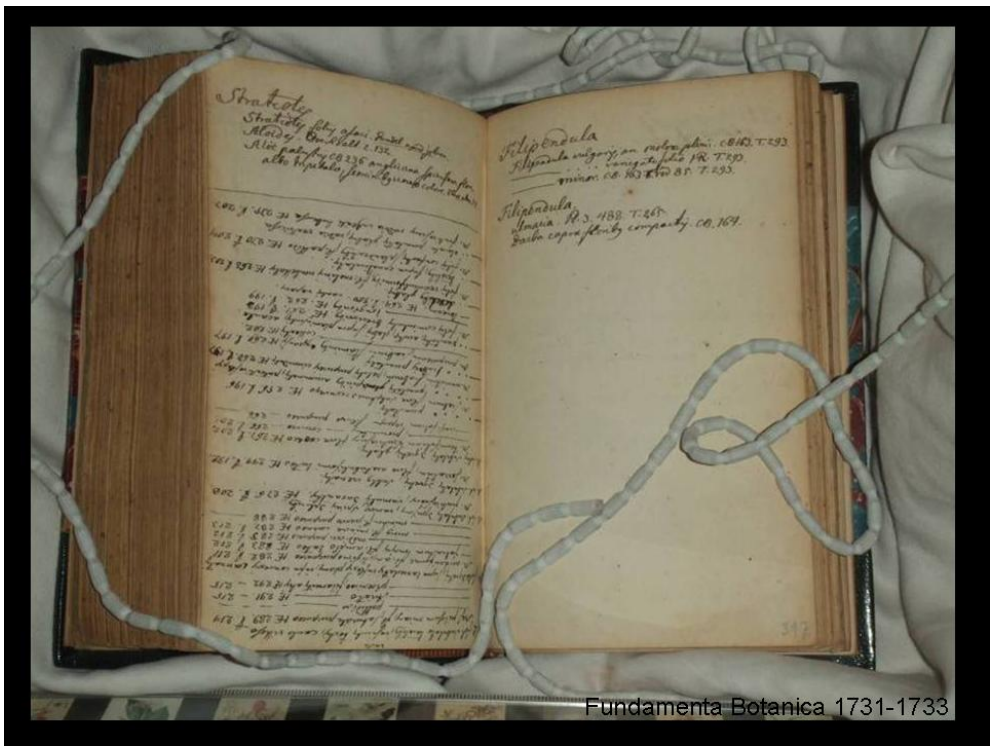

Fig. 14. Carl Linnaeus, “Fundamenta Botanica” (Ms.), Volume VII. Courtesy of the Linnean Society of London.

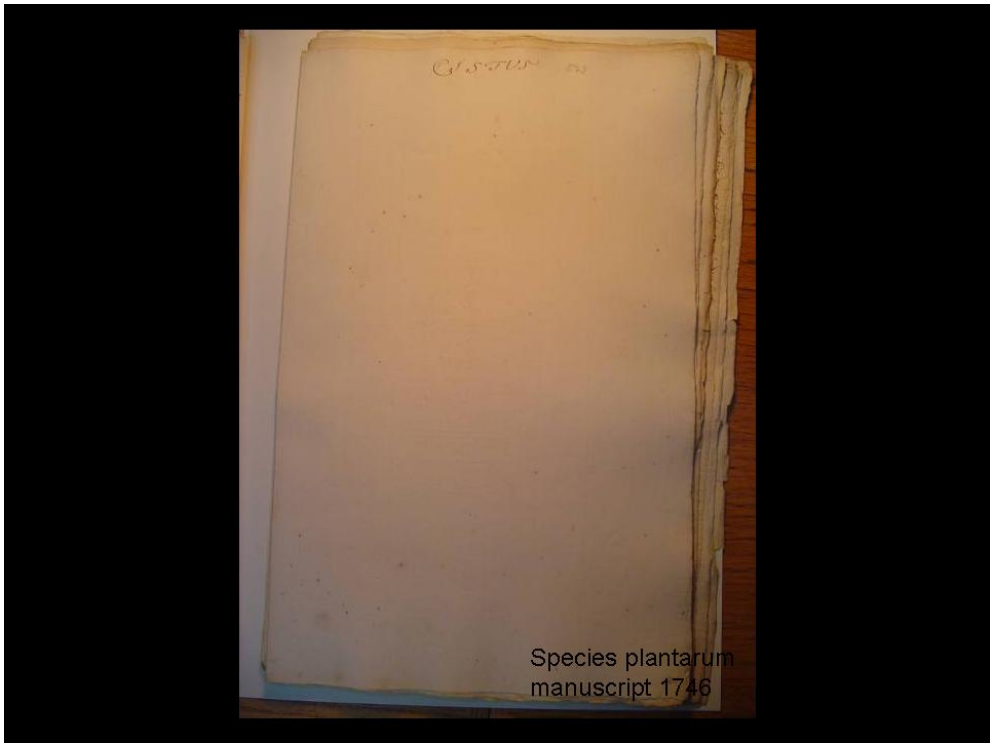

Fig. 15. Carl Linnaeus, “Species plantarum, first draft (1746)” (Ms.), “Cistus”. Courtesy of the Linnean Society of London.

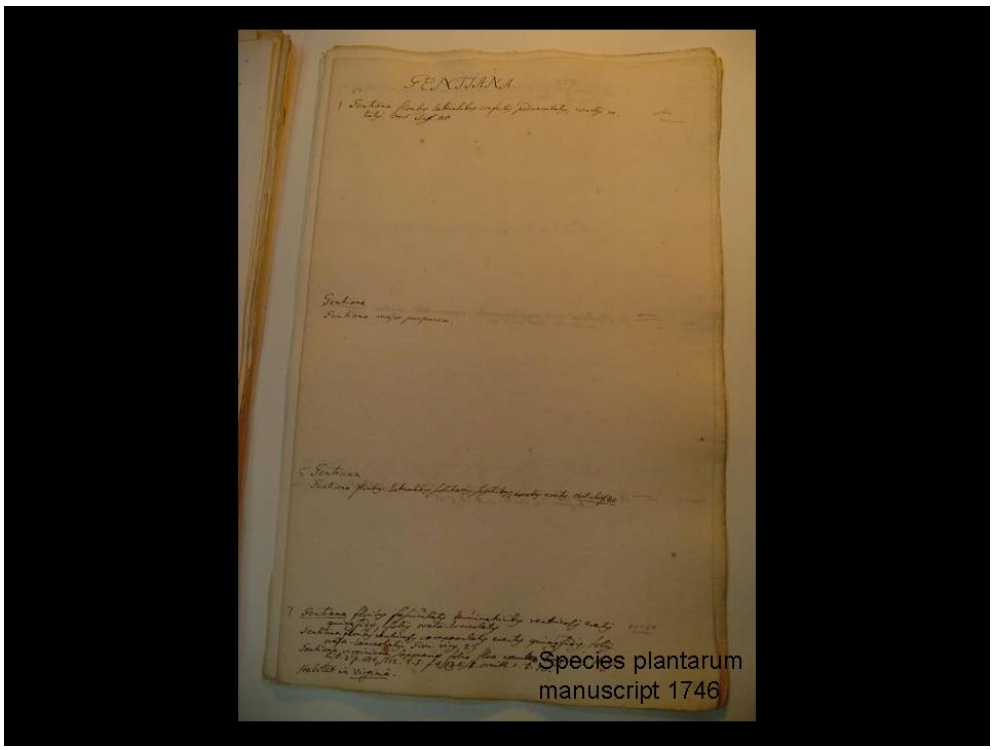

Fig. 16. Carl Linnaeus, “Species plantarum, first draft (1746)” (Ms.), “Gentiana”. Courtesy of the Linnean Society of London.

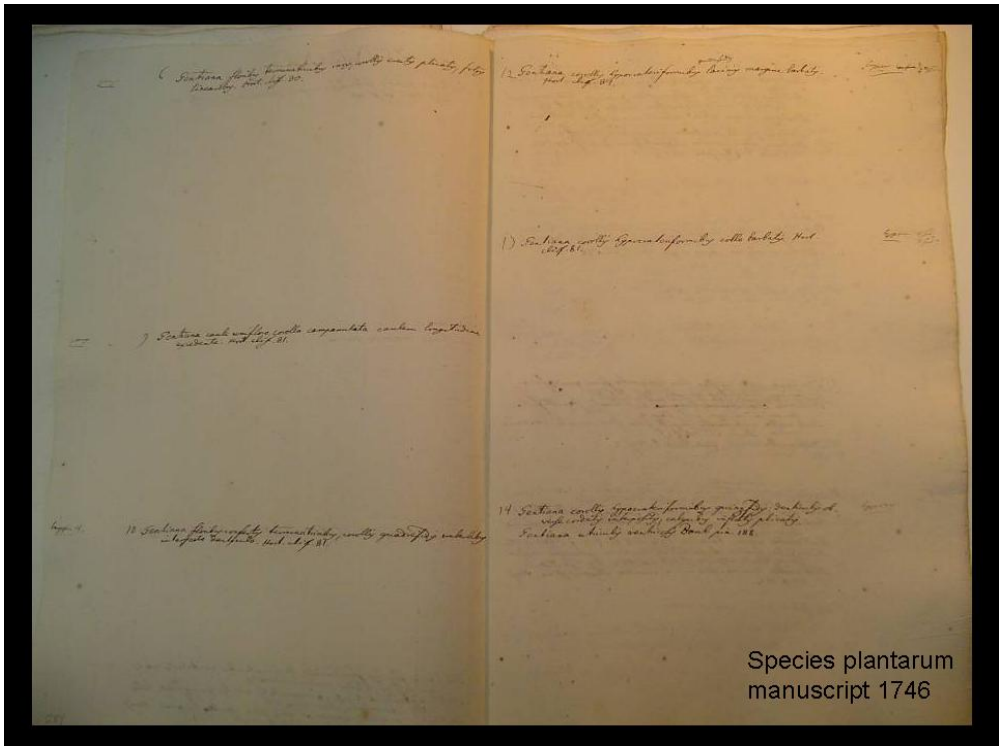

Fig. 17. Carl Linnaeus, “Species plantarum, first draft (1746)” (Ms.), “Gentiana”. Courtesy of the Linnean Society of London.

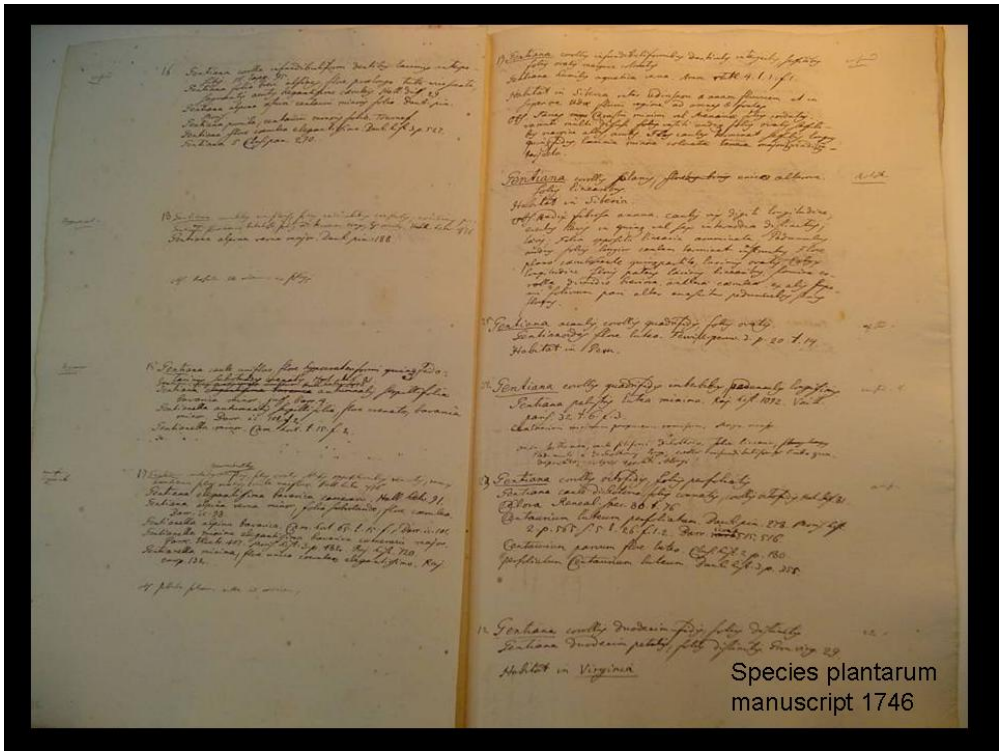

Fig. 18. Carl Linnaeus, “Species plantarum, first draft (1746)” (Ms.), “Gentiana”. Courtesy of the Linnean Society of London.

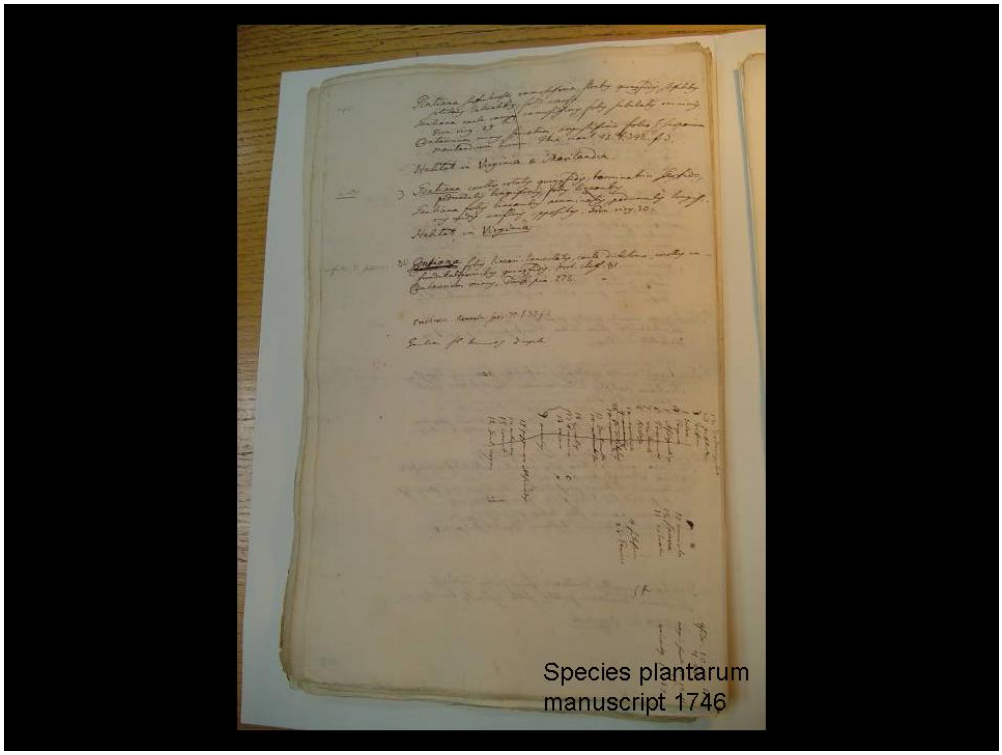

Fig. 19. Carl Linnaeus, “Species plantarum, first draft (1746)” (Ms.), “Gentiana”. Courtesy of the Linnean Society of London.

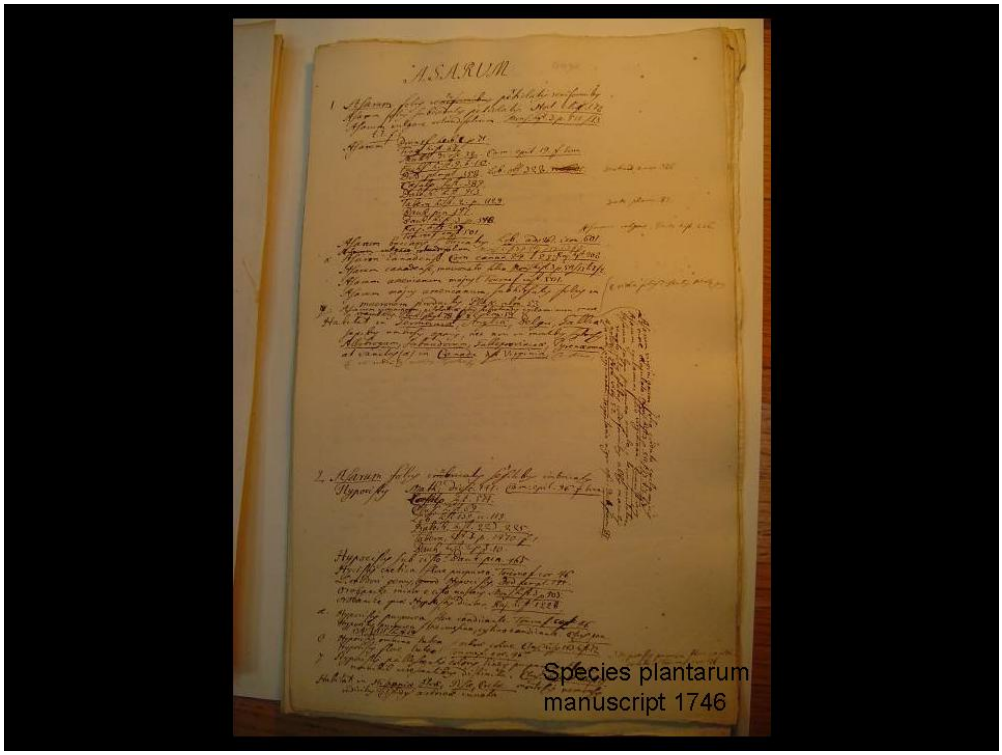

Fig. 20. Carl Linnaeus, “Species plantarum, first draft (1746)” (Ms.), “Asarum”. Courtesy of the Linnean Society of London.

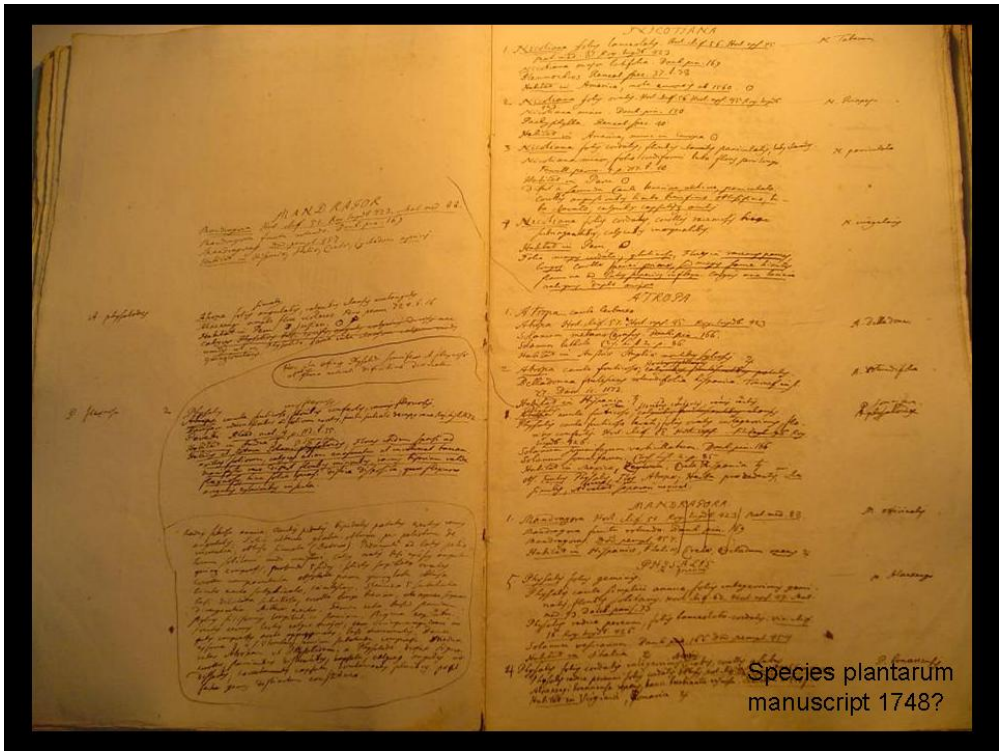

Fig. 21. Carl Linnaeus, “Species plantarum, imperfect manuscript” (Ms.), “Nicotiana, Atropa, Mandragora, Physalis”. Courtesy of the Linnean Society of London.

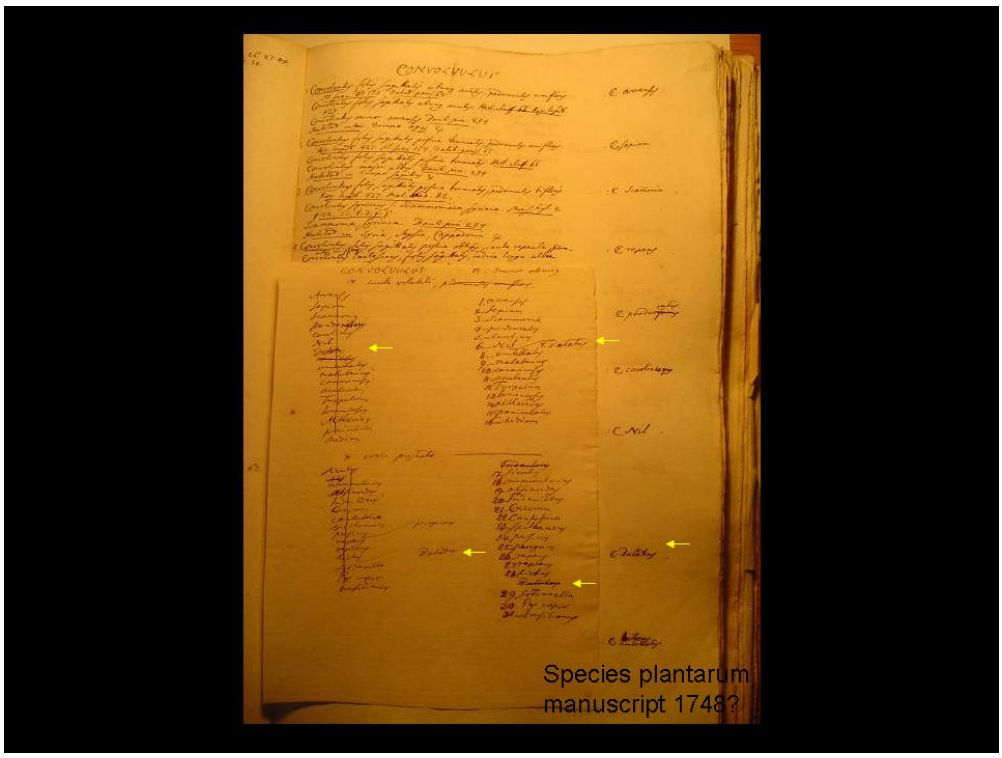

Fig. 22. Carl Linnaeus, “Species plantarum, imperfect manuscript” (Ms.), “Convulvulus”. Courtesy of the Linnean Society of London.

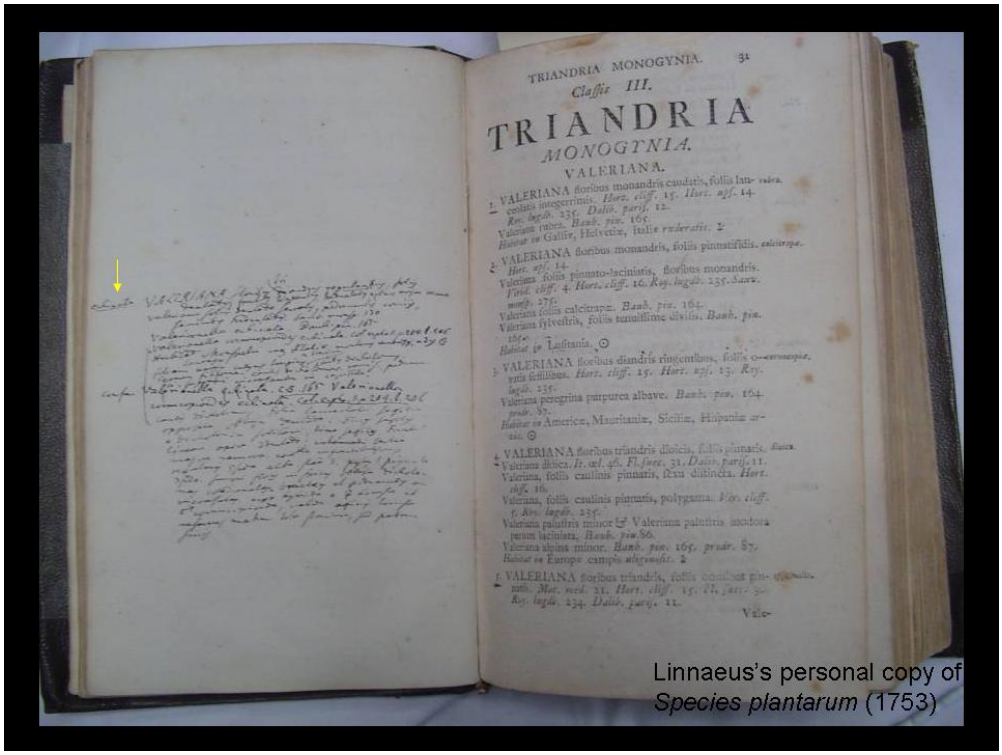

Fig. 23. Carl Linnaeus, *Species plantarum* (Stockholm 1753). Interleafed copy with annotations from Linnaeus own library. Courtesy of the Linnean Society of London.

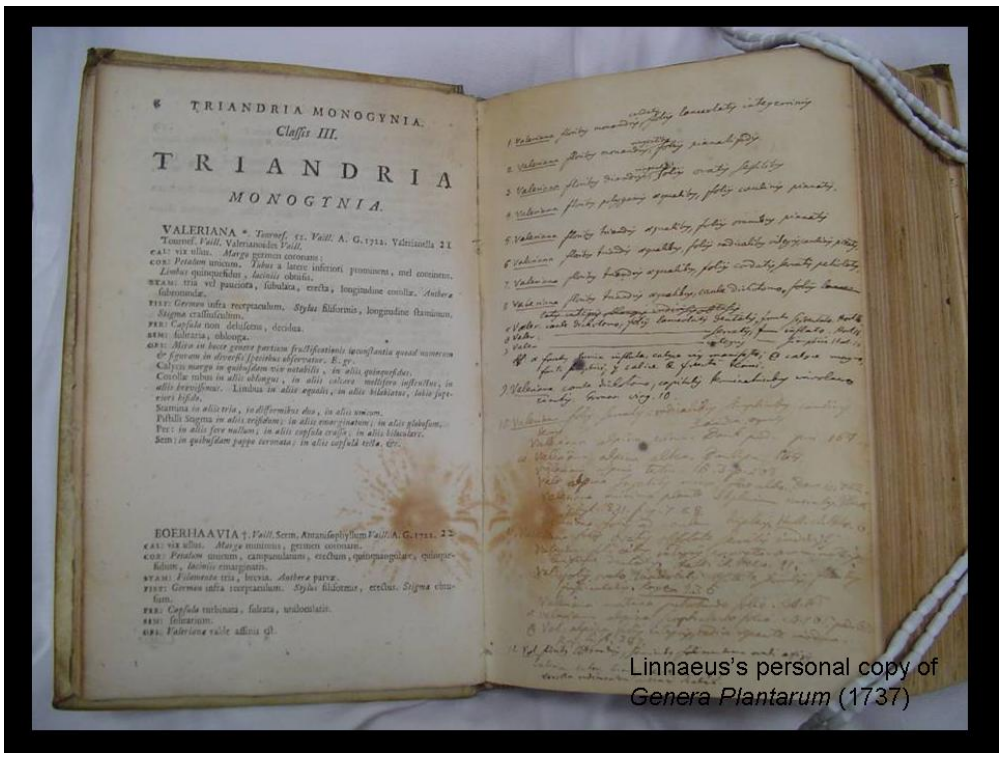

Fig. 24. Carl Linnaeus, *Genera plantarum* (Leiden 1737). Interleafed copy with annotations from Linnaeus own library. Courtesy of the Linnean Society of London.

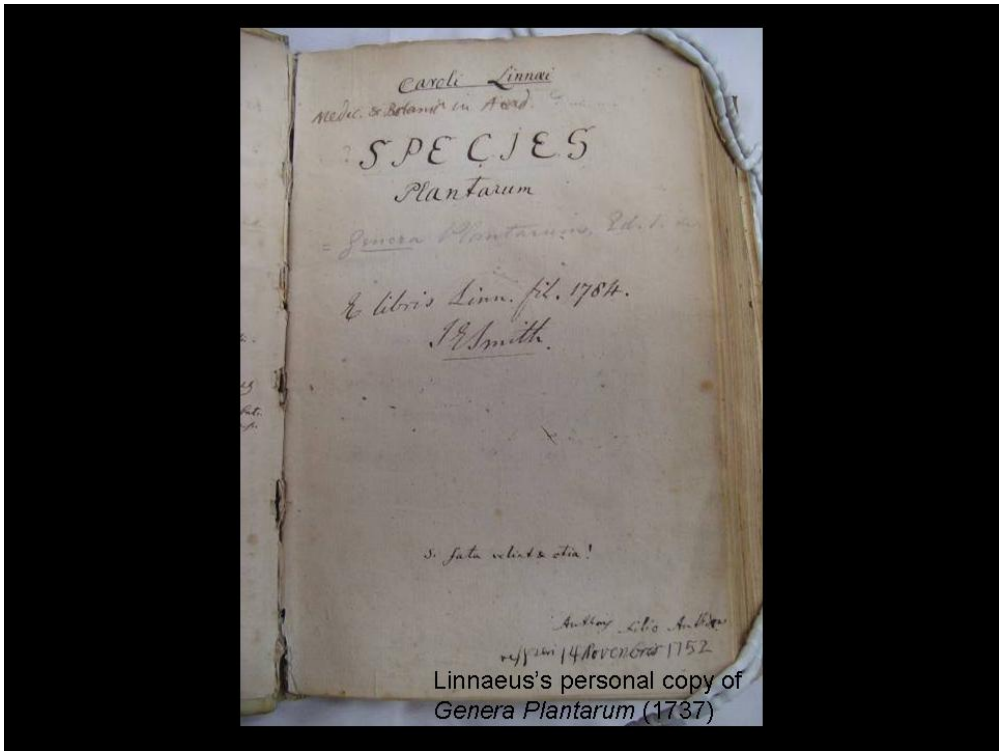

Fig. 25. Carl Linnaeus, *Genera plantarum* (Leiden 1737). Title page of interleafed copy from Linnaeus's own library. Courtesy of the Linnean Society of London.

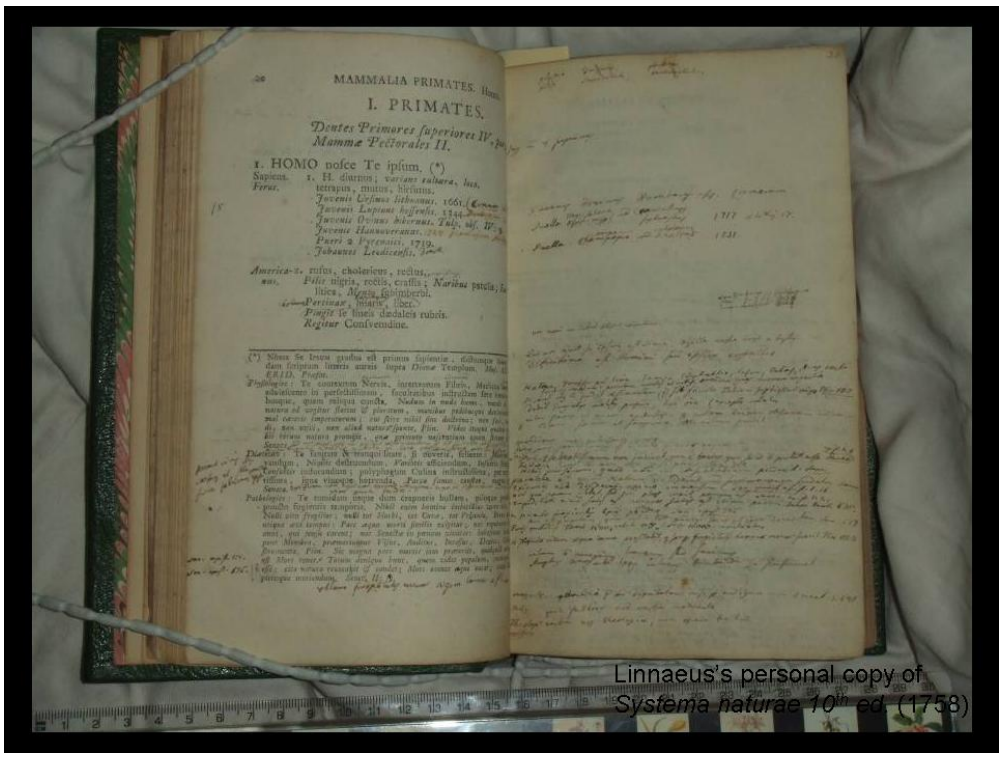

Fig. 26. Carl Linnaeus, *Systema naturae*, 10th edition, Vol. I (Stockholm 1758). From Linnaeus's own library. Courtesy of the Linnean Society of London.

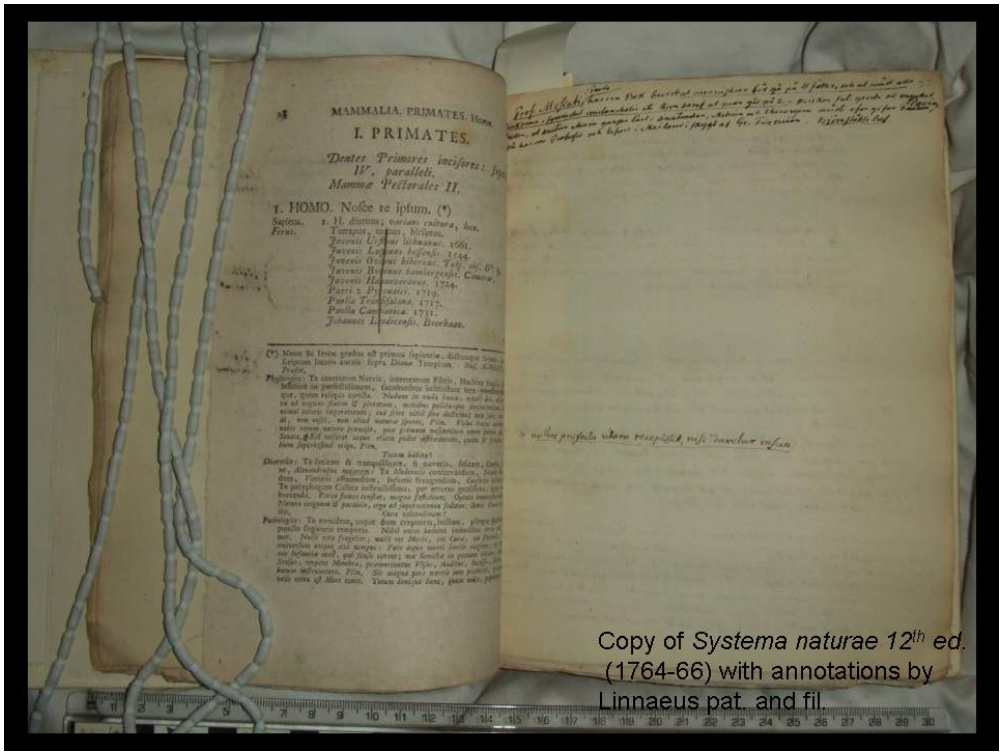

Fig. 27. Carl Linnaeus, *Systema naturae*, 12th edition, Vol. I (Stockholm 1766). Linnaeus's own library. Courtesy of the Linnean Society of London.

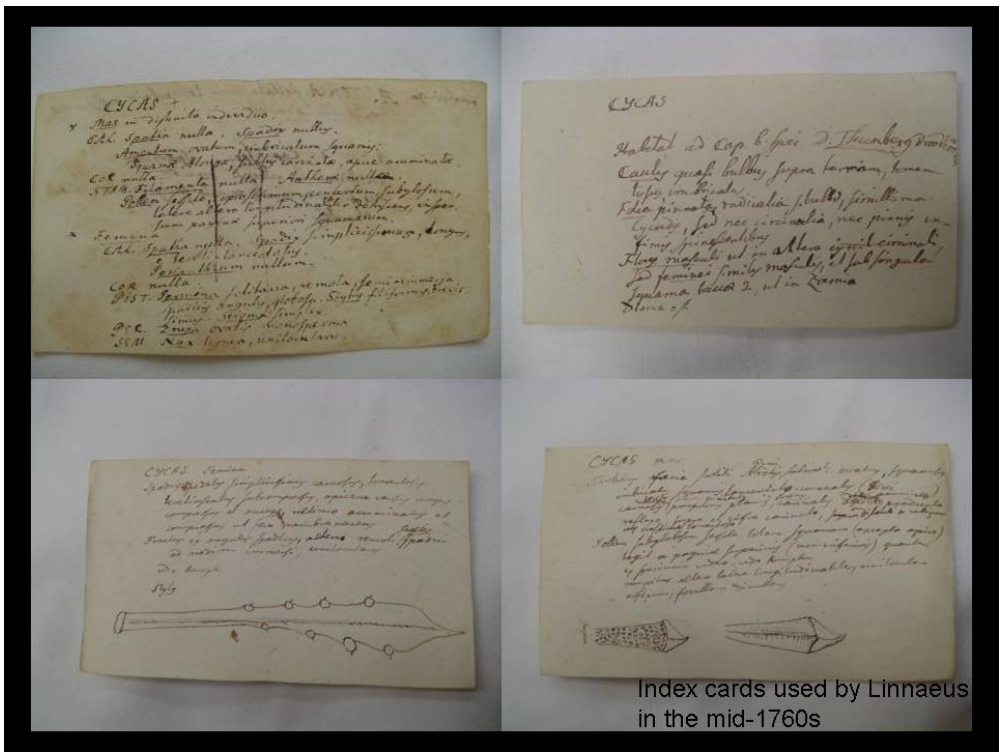

Fig. 28. Carl Linnaeus, paper slips used in preparation of *Systema naturae*, 12th edition (Stockholm 1766-1768). Courtesy of the Linnean Society of London.

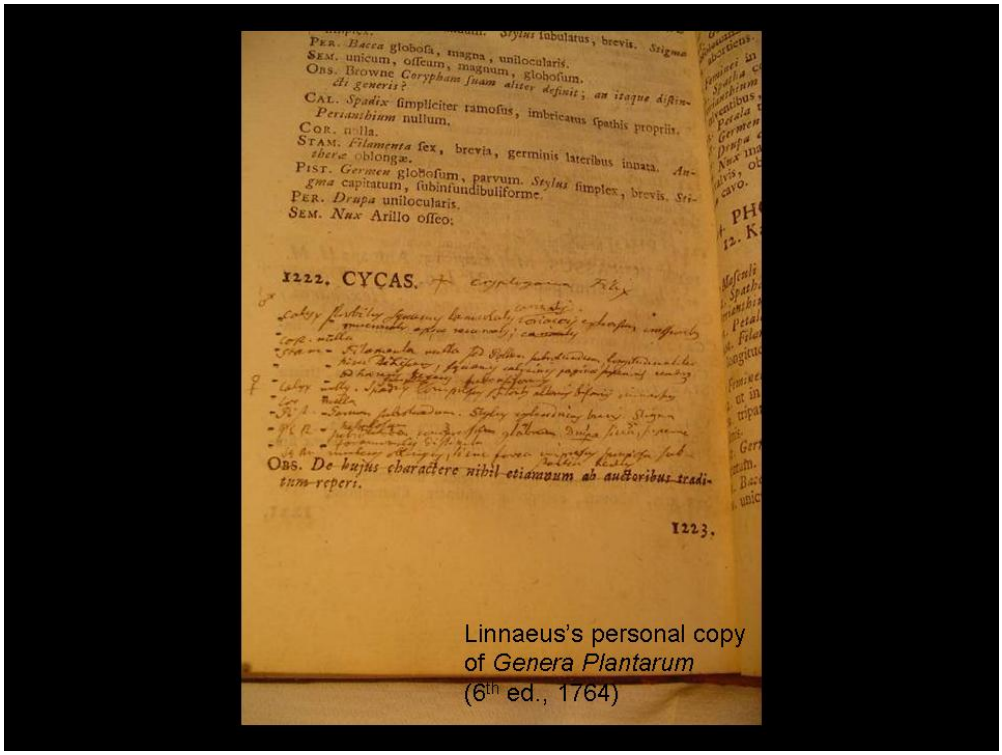

Fig. 29. Carl Linnaeus, *Genera plantarum*, 6th edition (Stockholm 1764), annotated copy from his own library. Courtesy of the Linnean Society of London.

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