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Systems and How Linnaeus Looked at Them in Retrospect

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Summary

A famous debate between John Ray, Joseph Pitton de Tournefort and Augustus Quirinus Rivinus at the end of the seventeenth century has often been referred to as signalling the beginning of a rift between classificatory methods relying on logical division and classificatory methods relying on empirical grouping. Interestingly, a couple of decades later, Linnaeus showed very little excitement in reviewing this debate, and this although he was the first to introduce the terminological distinction of artificial vs. natural methods. In this paper, I will explain Linnaeus's indifference by the fact that earlier debates were revolving around problems of plant diagnosis rather than classification. From Linnaeus's perspective, they were therefore concerned with what he called artificial methods alone – diagnostic tools, that is, which were artificial no matter which characters were taken into account. The natural method Linnaeus proposed, on the other hand, was not about diagnosis, but about relations of equivalence which played a vital, although largely implicit role in the practices of specimen exchange on which naturalists relied to acquire knowledge of the natural world.

Contents

1. Introduction

In 1972, Philip R. Sloan published a paper on 'John Locke, John Ray, and the Problem of the Natural System' that is rightfully considered a classic in the history and philosophy of the life sciences. The subject of the paper was a controversy about the proper choice of criteria for classifying plants that played out at the very end of the seventeenth century between three naturalists: the English naturalist and theologian John Ray (1627–1705), Joseph Pitton de Tournefort (1656–1708), demonstrator at the *Jardin du Roi* in Paris, and the Leipzig physician, astronomer and botanist August Bachmann (1652–1723; also known as Augustus Quirirnus Rivinus). According to Sloan, this debate opened cracks in a well-established scientific tradition for philosophical influences to take hold – most importantly, Robert Boyle's (1627–1692) distinction of primary and secondary qualities, and John Locke's (1632–1704) critique of the idea that classification could be based on a

knowledge of the essence of things classified. Ray in particular, Sloan supposes, mobilized this critique against his two 'continental' opponents. Rivinus and Tournefort stuck to a tradition going back to the Italian natural philosopher Andrea Caesalpino (1519–1603), who had demanded that botanical classifications should proceed by logical division paying heed to structural features of the flower and fruit only, that is, organ systems that served reproductive functions and hence constituted 'essential parts' of plants. Ray, in contrast, favoured a 'multi-criterial classification' that considered all sorts of characters, including natural habitats and medical virtues. Because knowledge of essences is not attainable, Ray argued according to Sloan's interpretation, classification needs to proceed by 'empirical collection of a large number of "accidents", "secondary qualities", or "simple ideas"'.[1] With this, two opposing positions were established that have ever since dominated debates within taxonomy.[2]

Alongside David Hull's more general, philosophical critique of essentialism and its role in history,[3] and two important historical papers on Linnaeus's taxonomic methods by evolutionary ecologist Arthur J. Cain and intellectual historian James L. Larson,[4] Sloan's paper of 1972 contributed to consolidating a master-narrative of the history of taxonomy that has had enormous influence on the philosophical critique of 'essentialist' thinking, especially since the early 1980s after Ernst Mayr popularized this critique in his magisterial *The Growth of Biological Thought*.[5] Despite this influence, however, the debate Sloan looked at has rarely been revisited by historians and philosphers of the life sciences to scrutinize it in more detail. The fact that the sources are in Latin, and that there is little secondary literature available on the three main protagonists, may have been a contibuting factor, but the main reason is probably that Sloan's account is so concise, nuanced and carefully argued, that it is difficult to find an entry point for complicating the story he has told us.[6]

And yet it is high time to revisit Sloan's claims. For one thing, there has been a lone voice that, based on a re-reading of Sloan's sources, has offered a substantial critique of his view that Rivinus and Tournefort represented the conservative side of the debate, relying on Aristotelian *divisio per genus et differentiam specificam*. In his book *Cognitive Foundations of Natural History*, Scott Atran shows that Caesalpino's system already was not generated by logical division *a priori*, that Ray did not share Locke's scepticism about the reality of natural kinds, and that Tournefort explicitly

[1] Phillip R. Sloan, 'John Locke, John Ray, and the Problem of the Natural System', *Journal of the History of Biology*, 5 (1972), 1–55 (38, 44).

[2] P. R. Sloan (note 1), 51–52.

[3] David L. Hull, 'The Effect of Essentialism on Taxonomy - Two Thousand Years of Stasis (I)', *The British Journal for the Philosophy of Science*, 15 (1965), 314–26.

[4] Arthur J. Cain, 'Logic and Memory in Linnaeus' System of Taxonomy', *Proceedings of the Linnean Society London*, 169 (1958), 144–63; James L. Larson, 'Linnaeus and the Natural Method', *Isis*, 58 (1967), 304–20.

[5] Staffan Müller-Wille, 'Making Sense of Essentialism', *Critical Quarterly*, 53 (2011), 61–77.

[6] To my knowledge, for Ray, the only full biography remains Charles E. Raven, *John Ray, Naturalist. His Life and Works* (Cambridge, 1942). His role in professionalizing English natural history has been studied more recently in Susan McMahon, *Constructing Natural History in England, 1650–1700* (PhD, University of Alberta, 2001). The only volume that extensively treats Tournefort's biography and scientific achievements is *Tournefort*, edited by Roger Heim (Les Grandes Naturalistes Français: Paris, 1957). The chapter dedicated to Tournefort in André Bailly, *Défricheurs d'inconnu: Peiresc, Tournefort, Adanson, Saporta* (Aix-en-Provences, 1992) is largely based on this. Virtually no scholarly attention has been paid to Rivinus since Sloan's article, as far as I can see.

denied that functional importance could serve as a guide in identifying 'essential' characters.[7] Even if Atran's portrayal of the debate is coloured by his overriding ambition to identify universal cognitive structures that run through the history of taxonomy – a feature that has probably stood in the way of a more wide-spread reception of his interesting and highly sophisticated book among historians of science – it shows that some of the textual evidence that Sloan relied on can be interpreted differently.

More impact on Sloan's account can be expected from the general and severe critique of the master narrative he contributed to, which has followed on the heels of the 'practical turn' in the history and philosophy of science. Several historians and philosophers of taxonomy have pointed out more and more vociferously in recent years that terms like 'division', 'essence' or 'accident' may very well have played a role in the history of taxonomy, but that one needs to reconstruct how naturalists actually went about practically in bringing order to nature in order to understand them. Claiming knowledge of essences, and denouncing such knowledge as unattainable, that is, may have played a rhetorical role in debates, but neither essentialism nor its counterpart, radical scepticism of natural kinds, rarely, if ever, furnished the basis of actual taxonomic practices.[8] This criticism somewhat misses the point of Sloan's argument, since the latter overtly focusses on the rhetorical dimensions of the debate between Ray and Tournefort. But it should induce scepticism towards his more speculative claim that the two positions he identified in this seventeenth-century debate have structured taxonomic discussion ever since.

In what follows I will not engage with the essentialism story on its *longue durée* scale. Instead, I want to present some historical evidence that indicates that some of the main premises that had underwritten the Ray-Rivinus-Tournefort debate could appear as hopelessly outmoded already a couple of decades into the eighteenth century. The evidence provided stems largely from what Carl Linnaeus (1707–1778) had to say when looking back on the debate. My point in this is not to claim that this individual naturalist, highly influential and widely read as he was, interpreted this debate in the right way, whereas Sloan got it wrong. Rather, I want to use Linnaeus as an example to argue that the meaning and weight of metaphysical presuppositions, which seem to structure debates in a timeless manner, can radically shift with changing practices. I will do so in three steps: First, by focussing on how Linnaeus looked back on the Ray-Tournefort-Rivinus debate with little excitement, claiming that it had been 'unreasonable'; second, by discussing Linnaeus's explicit distinction

[7] Scott Atran, *Cognitive Foundations of Natural History: Towards an Anthropology of Science* (Cambridge, 1990), 157, 163, 167. The point about Tournefort was already made by Raymond Dughi, 'Tournefort dans l'histoire de la botanique', in *Tournefort*, edited by Roger Heim (Les Grandes Naturalistes Français: Paris, 1957), 131–85. Similar inconsistencies, without attacking Sloan directly, are revealed in John Wilkins, *Species: A History of the Idea* (Berkley, 2009), 65–70.

[8] Direct attacks on the 'essentialism story' can be found in Mary P. Winsor, 'The Creation of the Essentialism Story: An Exercise in Metahistory', *History and Philosophy of the Life Sciences*, 28 (2006), 149–74, and Gordon R. McOuat, 'The Origins of "Natural Kinds": Keeping "Essentialism" at Bay in the Age of Reform', *Intellectual History Review*, 19 (2009), 211–30. Important contributions that undercut the essentialism story for post-Linnaean taxonomy by careful attention to taxonomic practices are Peter F. Stevens, *The Development of Systematics: Antoine-Laurent De Jussieu, Nature and the Natural System* (New York, 1994); Gordon R. McOuat, 'Species, Rules and Meaning: The Politics of Language and the Ends of Definitions in 19th Century Natural History', *Studies in History and Philosophy of Science*, 27 (1996), 473–519; and Gordon R. McOuat, 'From Cutting Nature at Its Joints to Measuring It: New Kinds and New Kinds of People in Biology', *Studies in History and Philosophy of Science*, 32 (2001), 613–45.

of artifical and natural systems by which all previous systems – including Ray's multi-criterial system, but also Linnaeus's own so-called 'sexual system' – turned out to be artificial; and third, by relating the alternative that Linnaeus had in mind with what he called the natural system to practices of specimen exchange and paper-based information processing. In conclusion, I will argue, that the latter practices need to be taken into account carefully when it comes to interpreting past debates in taxonomy.

2. Taxonomic wars

Sloan's paper is accompanied by a series of diagrams that illustrate the systems that Ray, Rivinus and Tournefort proposed. Each of these diagrams consists of branching, or dichotomous, lines, with differentiating characters specified at the branching points, and the resulting classes of the system at the end points. For Ray and Tournefort, Sloan adds similar diagrams for examplary classes that guide the reader to a breakdown of that class into genera.[9] Such diagrams were not a universal, and far from uniform, feature in early modern taxonomic literature. Caesalpino's *De plantis libri xvi* (1583) lacked them, as Sloan also notes, but the same is true for Tournefort's *Élémens [sic] de Botanique* (1694).[10] In these cases the underlying 'system' has to be culled from chapter and section headings and associated verbal definitions. And where diagrams were employed to illustrate a system, they could take on very different forms. Ray, for example, first provided a list of the classes of his system in *Methodus plantarum nova* (1682), and then employed a complex system of differently styled brackets to the left of the indented text to guide the reader through his further subdivisions in each class, thus producing a hybrid between text and diagram. Rivinus, on the other hand, simply added a separate fold-out table, illustrating 'the basic divisions of plants' (*divisiones Plantarum fundamentales*), to the text of his *Introductio generalis in rem herbariam* (1690) in a way that in its basic features resembles the way Sloan portrays all systems.[11]

The task of extracting 'systems' from taxonomic literature prior to Linnaeus in this way can be significantly facilitated by taking recourse to a publication by Linnaeus himself. In 1738, Linnaeus published a book entitled *Classes plantarum* – a greatly expanded elaboration of the chapter 'Systemata' of his *Fundamenta Botanica* (1736) – that presented the classification systems proposed by his predecessors in a series of dichotomous diagrams of uniform design, each designated as a 'key to the classes' (*clavis classium*) and very much similar to the ones employed by Sloan. Each

[9] For the sake of clarity, I will rely on the Linnaen hierarchy of systematic ranks in describing the systems, with species subordinate to genera, genera to orders, and orders to classes. The terminology was not unified in pre-Linnaean taxonomy. In general, botanists employed the Aristotelian terminology, where genus and species are defined relationally (species being subordinate classes of genera), and higher genera are sometimes referred to as 'supreme' or 'subaltern genera' (*genus summum, genus subalternum*; see the full title of Ray's *Methodus plantarum nova* as cited below). 'Class' (*classis*) and 'order' (*ordo*) where occasionally used as synonyms for the latter however. For an interesting example, see John Ray, *Methodus plantarum nova, brevitatis & perspicuitatis causa synoptice in tabulis exhibita: cum notis generum tum summorum tum subalternorum characteristicis, observationibus nonnullis de feminibus plantarum & indice copioso* (London, 1682), 'Praefatio ad Lectorem' [unpag., 2].

[10] Cfr. Andrea Caesalpino, *De Plantis libri xvi* (Florence, 1583); and Joseph Pitton de Tournefort, *Élémens de botanique: ou Méthode pour connoître les plantes*, 3 vols (Paris, 1694). Dichotomous diagrams are also missing from the the Latin edition of the latter book; see Joseph Pitton de Tournefort, *Institutiones rei herbariae, sive Elementa botanices*, 3 vols (Paris, 1700).

[11] Cfr. J. Ray (note 9); and Augustus Quirinus Rivinus, *Introductio generalis in rem herbariam*, second edition (Leipzig, 1696), 92.

of these diagrams is complemented by a table, covering several pages, that distributes genera under the respective classes and orders of the system. What is curious about this publication is the fact that all of these systems are treated on a par, with short comments on their advantages and disadvantages at the beginning, and that none is given absolute precedence over the others, not even Linnaeus's sexual system, or the alternative system 'according to the kinds of calyx' that he had designed. As Linnaeus explained in the preface, 'There are various systems, some prepared from the fruit, some from the petals, some from the calyx and stamens, yet all aim at the same purpose and target, namely to guide the amateur of botany to genera expediently'.[12]

To understand why Linnaeus was so callous about the plurality of systems that had excited such heated debate among naturalists just slightly more than a generation earlier, it is useful to note that he started from very early on to extract various systems from botanical literature and to put them to use for his own purposes. In a note book entitled 'Manuscripta medica', which Linnaeus compiled during his student years at the universities of Lund and Uppsala, we already find neatly designed dichotomous diagrams and tables representing the systems of Tournefort and Rivinus.[13] What is more, there exists a small manuscript booklet in Linnaeus's hand, entitled '*Spolia botanica*' and containing floral catalogues of three Swedish provinces each of which organized using a different system: the plants of Småland (where Linnaeus grew up) according to Tournefort's system, those of Scania (where he went to school) according to that of Rivinus, and those of Roslagen (a coastal region northeast of Uppsala) according to that of Ray. Apparently, Linnaeus enjoyed playing around with various systems while training himself to become a botanist during local field excursions.[14]

Spolia means war booty, or anything taken from the enemy, and this military metaphor is significant. Not only was the aim of his own manuscript explorative – as its preface specifies, Linnaeus aimed to draw up a 'botanical topography' (*topographia botanica*; another military metaphor) in order to 'draw conclusions with regard to diseases of the inhabitants, the situation and qualities of the country, and many other circumstances'.[15] Linnaeus would also come back to military language later when portraying the earlier debate between Rivinus, Ray and Tournefort. In a systematically arranged bibliography of botanical literature, published in 1736, a separate category of '*Eristici*' – that is, followers of the Greek goddess Eris (Ἔρις), who personifies quarrel and conflict – is reserved for 'theoretical and philosophical botanists who quarrel with each other in writings'. In what follows, Linnaeus provides bibliographical information on three such debates, two from the

[12] Carl Linnaeus, *Classes Plantarum seu Systemata Plantarum omnia a fructificatione desumta, quorum XVI Universalia & XIII Partialia compendiose proposita Secundum classes, ordines et nomina generica cum clave cujusvis methodi et synonymis genericis* (Leiden, 1738), 'Lectori s. Author' [unpag., 2]: 'Systemata in Botanicis varia sunt, alia a fructu, alia a petalis, a calice & staminibus alia confecta, sed omnia in eundem finem & scopum collimant [sic; collineant], ut scilicet Botanophilum ad genus compendio ducant'. Excluded from *Classes plantarum* were systems, however, that did not stick to characters derived from flower and fruit. I will come back to this point in the next section. If not otherwise stated, translations are my own.

[13] C. Linnaeus, 'Manuscripta Medica' (1727–1730), 2 vols, Library of the Linnean Society (London), Linnaean Collections, call no. LMGen, I, ff. 9–26. The volume also contains similar diagrams representing systems underlying Ray's zoological works.

[14] For a more detailed discussion of these early manuscripts, see Staffan Müller-Wille and Isabelle Charmantier, 'Natural History and Information Overload: The Case of Linnaeus', *Studies in Studies in History and Philosophy of the Biological and Biomedical Sciences*, 43, 4–15 (6–7). An edition of the manuscript 'Spolia Botanica', with detailed commentary, can be found in Ewald Ährling (ed.), *Carl von Linnés Ungdomsskrifter* (Stockholm, 1888), 53–105.

[15] E. Ährling (note 14), 57.

Renaissance, and the third involving Ray, Rivinus and Tournefort, alongside a few other, less prominent figures. The general characterisation he offers of these 'followers of Eris' is far from flattering. 'Although these [men] usually befoul their own writings with scoffs and empty words, unworthy of sane and honest men, they often produce observations, rules, and arguments, as it were in the midst of it, so that we have to concede a place for them among philosophers.'[16] In his lectures, as surviving notes from students prove, Linnaeus was even less conciliant, snapping that 'Eristicos have exchanged grandiose, but very unreasonable polemic pamphlets'.[17]

Alongside its general meaning of 'to quarrel, to strive', the Latin verb *litigare* that Linnaeus uses to characterize past debates among botanists also has the more particular meaning 'to litigate' or 'sue in court'. The public aspect of these debates is emphasized in later versions of *Bibliotheca botanica*, which explicitly refer to 'public writings' (*scriptis publicis*).[18] The disdain with which Linnaeus looked back on the debate between Rivinus, Ray and Tournefort may therefore have to do with his well-known avoidance of public debate, and I will come back to this point in my conclusions. But there is more to it, as I will show in the following two sections. The four decades that separate the Ray-Tournefort-Rivinus debate from Linnaeus's own publications had seen a thorough revolution in what it meant to do botany, so that the shared methodological assumptions that underwrote earlier discussions about taxonomy did not make much sense anymore to Linnaeus.

3. Artificial systems

In the literature on history and philosophy of taxonomy, the distinction between artificial and natural systems has played a perennial, but equally problematic role. The problem consists in defining a measuring stick by which to assess whether a particular system is natural without buying into anachronistic assumptions. One way to solve this problem is to define as 'natural' those classifications that conform to intuitions about group membership that are based on criteria of overall resemblance. Humans across cultures are able to readily distinguish groups of organisms in their local environments on this basis, with surprising cross cultural parallels in their judgements, especially when it comes to expert judgements.[19] Yet there is a world of difference between recognizing and occasionally naming such groups, and explicit, written accounts of what it is precisely that they share. Cultures without writing obviously have no 'system' in the sense of modern taxonomy.[20] Nor can one suppose that the ambition to create such a system has always accompanied philosophical and

[16] Carl Linnaeus, *Bibliotheca Botanica recensens libros plus mille de plantis huc usque editos, secundum Systema Auctorum Naturale in Classes, Ordines, Genera & Species dispositos* (Amsterdam, 1736), 120: 'Eristicos voco Botanicos Philosophos & Theoreticos, qui scriptis litigarunt. Hi licet propria sua scripta scommaribus & verbis, viris honesti & sanis plane indignis communiter defaecarunt, saepius tamen observationes, Canones & ratiocinia simul in medium produxerunt, ut inter Philosophos eis locum concedere debeamus'.

[17] Caroli Linnaei Arch. et Equ. Praelectiones Publicae in Philosophiam Botanicam habitae Upsaliae 1758 et 1759 [manuscript copy of lecture notes taken by a student and preserved in St Petersburg], Uppsala University Library, Linné saml., D75, 66–7: 'Eristicos som sinsemellan haft stora, men mycket owetiga stridskrifter'.

[18] See e.g. Carl Linnaeus, *Philosophia botanica in qua explicantur Fundamenta Botanica cum Definitionibus Partium, Exemplis Terminorum, Observationibus Rariorum* (Stockholm, 1751), 11.

[19] Brent Berlin, *Ethnobiological Classification: Principles of Categorization of Plants and Animals in Traditional Societies* (Princeton, NJ, 1992).

[20] Jack Goody, *The Domestication of the Savage Mind* (Cambridge, 1977).

scientific attempts to portray and understand the living world even in literate cultures. It is a well-established fact, for example, that Aristotle never strove to establish a consistent and systematic taxonomy of animals in his zoological writings. There is evidence that he recognized taxa that contemporary taxonomists would consider 'natural' as well. But there is no good evidence that he ever engaged in the modern project of creating an exhaustive, taxonomically consistent, and hierarchically organized catalogue of all life forms on paper.[21]

It is therefore not surprising that the very distinction between natural and artificial systems – or methods; the two terms were handled as synonyms until the latter half of the eighteenth century[22] – has a starting point in history. This starting point, however, does not coincide with the debate between Rivinus, Ray and Tournefort, as one might expect from Sloan's account. While these naturalists spoke of organisms being 'distant' or 'close' by nature, of methods 'conforming to nature', or of methods guiding us to the 'natural places' of organisms, they never mention a 'natural' system or method, let alone 'artificial' ones.[23] The contrast between artificial and natural systems as we know it, was unknown to the seventeenth century.

It was, as a matter of fact, Linnaeus who first introduced the terminological distinction of 'natural' and 'artificial' methods or systems, and that he did so was actually acknowledged as one of his more important achievements by many eighteenth- and nineteenth-century commentators.[24] There are few instances only in which Linnaeus entered into an explicit discussion of this distinction, but they reveal important structural differences between the 'systems' of his predecessors on the one hand, and what since Linnaeus is considered a proper 'natural' system. The most striking feature of Linnaeus's distinction is that he does not use it to draw a line between existing systems. In *Systema naturae*, a book of 11 foliopages displaying the classes and orders of the mineral, plant and animal kingdom that made Linnaeus's name in 1735, he stated:

> No natural system of plants has been constructed up till now, even if one or the other approaches it more closely; nor do I maintain that this system [i.e., the sexual system] is in some way natural (I will perchance exhibit fragments of it at another occasion); nor that a natural system could be constructed before all that pertains to our system is thoroughly known. In the meanwhile, however, artificial systems are entirely necessary as long as we lack a natural one.[25]

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[21] David M. Balme, 'Aristotle's Use of Division and Differentiae', in *Philosophical Issues in Aristotle's Biology*, edited by Allan Gotthelf and James G. Lennox (Cambridge, 1987), 65–89 (88); and Pierre Pellegrin, *Les classification des animaux chez Aristote: Statut de la biologie et unité de l'Aristotélisme* (Paris, 1982), 161. For an interesting discussion of 'natural' taxa in Aristotle's zoology, see Alexander Fürst von Lieven and Marcel Humar, 'A Cladistic Analysis of Aristotle's Animal Groups in the *Historia animalium*', *History and Philosophy of the Life Sciences*, 30 (2008), 227–62.

[22] P. F. Stevens (note 8), 12 and 403, n. 44.

[23] Caesalpino (note 10), 25: 'Cyclamini & Rapi distantissimae est natura in caeteris omnibus'; John Ray, *Stirpium europaearum extra Britannias nascentium sylloge* (London, 1694), Praefatio [unpag., 17]: 'Methodum … Naturae convenientem'; J. P. de Tournefort, *Élémens* (note 10), 20: 'les ranger à leur place naturelle'.

[24] See, e.g., William Whewell, *History of the Inductive Sciences from the Earliest to the Present Time*, 3 vols (London, 1857), III, 268.

[25] Carl Linnaeus, *Systema Naturae, sive Regna Tria Naturae systematice proposita per Classes, Ordines, Genera, & Species* (Leiden, 1735); 'Observationes in Regnum Vegetabile' [unpag.], aph. 12: 'Nullum Systema Naturale, licet unum vel alterum propius accedat, adhucdum constructum est; nec ego heic Systema quoddam Naturale contendo (forte alia vice ejus Fragmenta exhibebo); neque Naturale construi potuit, antequam omnia, ad nostrum Systema pertinentia, notissima sint. Interim tamen Systema artificialia, defectu Naturalis, omnino necessaria sunt'.

This passage contains many ambiguities. It seems clear enough, however, that Linnaeus regards all existing systems, those of his predecessors, as well as his own 'sexual' system, as more or less 'artificial', while the natural system is claimed to be contingent on the growth of knowledge. Linnaeus, that is, used the distinction to mark a break with the past and announce a project for the future. The same contrast underlies the more extended discussion of the difference between artificial and natural systems in the introduction to *Genera plantarum*, a book published two years after *Systema naturae* in which Linnaeus provided what he called 'natural characters' (*characteres naturales*) of more than 900 plant genera.

I have dealt in detail with this text elsewhere.[26] What I want to expand on here are certain logical features of 'artificial' systems that Linnaeus highlights in his discussion. It starts with a broadside attack on all those naturalists who assumed 'various parts of fructification [i.e., parts of the flower or fruit] as a systematic principle' and 'descended according to laws of division from classes to orders all the way down to species'. 'By these hypothetical and arbitrary principles', Linnaeus claims, 'they broke and tore apart the natural, non-arbitrary genera and did violence to nature'.[27] In Linnaeus's opinion, that is, artificial systems do not miss the target of representing nature by accident. Their failure is necessarily implied by the method of logical division, and cannot be avoided by just hitting upon the right set of critieria for division.

Linnaeus presents the reasons for this failure a little later on in a passage that deals with the 'artificial character' (*character factitius*) of genera, that is, definitions of genera generated by the method of logical division, and usually presented in the form of 'dichotomous or synoptic tables'. The key logical feature that Linnaeus highlights is that such definitions distinguish the genus from the 'rest of the genera displayed under the same order' only and 'not from others'.[28] Distinctions in artifical systems, that is, are local distinctions, they divide genera exhaustively and unambiguously within a preestablished context only, the context of genera occupying a certain branch, or division, of the system. Hence the possibility that 'whenever some new genus is discovered, its neighbouring genera become wrong, and as many as emerge from the branch [of the system] to which they have to which it has to be attached'.[29] The new genus may simply display characters that are ambiguous in relation to the distinctions employed by the system, so that one either has to distribute the species of the genus onto different branches of the system, i.e. 'break and tear it apart', or

[26] 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), 541–62.

[27] Carl Linnaeus, *Genera Plantarum eorumque Characteres Naturales secundum Numerum, Figuram, Situm, Proportionem Omnium Fructificationis Partium* (Leiden, 1737); 'Ratio operis' [unpag.], aph. 8: 'Assumserunt enim Varii diversas partes fructificationis pro principio Systematico, & cum eo secundum divisionis leges a Classibus per ordines descenderunt ad Species usque, & hypotheticis ac arbitrariis his principiis fregerunt & dilacerarunt naturalis, nec arbitraria genera'. Here, and in the following, I am following the English translation in 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), 563–72.

[28] Linnaeus (note 27), 'Ratio operis', [unpag.], aph. 16: 'Factitius Character unicam notam generi imponit, qua unum a reliquis sub eodem Ordine exhibitis (non ab aliis) distinguere tenetur. Character ejusmodi est intellectu omnium facillimus, & instituitur per Dichotomias seu Tabulas Synopticas, uti a Rajo (in praecedentibus Synopsis editionibus), Knautio, Kramero dati'.

[29] Linnaeus (note 27), 'Ratio operis', [unpag.], aph. 16: 'cum enim Genus aliquod detegitur novum, fallaces evadunt proximi & quotquot e ramo, cum annecti debet, enati sunt'.

choose new criteria for distinguishing genera. In any case, the system is invalidated by such such new discoveries.

Linnaeus's point about the logical structure of artificial systems would be misplaced, if one could assume, as many commentators have done, that early modern systems generated by logical division were indeed strictly deductive, that is, if each step in the division indeed followed analytically from the previous step. This, however, is clearly not the case. All of these systems, even if restricted to a small number of allegedly 'essential' parts, employed a combination of logically independent criteria. Rivinus's system, for example, first divides flowering plants into those with 'single' and those with 'compound flowers', and then proceeds by dividing both classes according to the form of the corolla (which can be regular, irregular, or a mixture of both in the case of compound flowers). There simply is no deductive relationship between these two criteria, one way or other, and Rivinus was clearly aware of that. In commenting on the dichotomous diagram that illustrated his system he declared that the analytic nature of his distinctions 'will indeed be much clearer once it were demonstrated in the form of a Table how from those divisions of plants all their orders could be deduced'.[30] The subjunctive should be taken seriously. While it is true that the combination of different criteria creates a set of mutually exclusive taxa at the lowest level of the system, the same cannot be said of its intermediate levels. The 'order' *Irregulares* appears twice in the system, both among plants with 'single' and 'compound' flowers. Structurally, this does not differ from a zoological system in which 'viviparous animals' are listed both under 'marine animals' (whales) and under 'terrestrial animals' (all the rest).[31]

Once one realizes that early modern 'systems' were generated by division on the basis of an arbitrary combination of characters, and did not aim to present a neat hierarchy of mutually exclusive taxa of ever higher generality, the debate between Ray, Rivinus and Tournefort reads very differently. It did not turn around the question whether a 'natural' system could be based on a knowledge of essences. Neither Rivinus nor Tournefort, as Sloan notes, based their arguments on this assumption, but rather on the claim that floral traits provided clearer distinctions than others.[32] All three participants, moreover, basically agreed that a system ideally should combine a chosen set of distinctions in such a way that it leads to an unambiguous distinction of genera.[33] What was at stake in the debate, was whether there was reason to restrict oneself to particular plant properties in this choice, and to what degree divisions should respect perceived overall resemblances among plants. What late seventeenth century naturalists engaged in when they constructed their systems was, in a sense, not classification at all, an activity that involves grouping things together. What they engaged in was distinction for the purpose of identifying plants as belonging to one genus or other.

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[30] A. Q. Rivinus (note 11), 92: 'Id vero longe clarissimum erit, si per modum Tabulae demonstretur, quomodo ex illis Plantarum divisionibus omnes earum Ordinibus deduci erant'.

[31] S. Atran (note 7), 156–7, notes that Caesalpino's system already was not deductive, but combinatory in the sense just explained.

[32] P. R. Sloan (note 1), 36–7 (on Rivinus), 47–8 (on Tournefort).

[33] Again, Sloan concedes this for Ray; see P. R. Sloan (note 1), 47. In the Latin edition of his *Élémens*, Tournefort invokes the 'art of combination (*ars combinandi*)' to argue for his system; see, Joseph Pitton de Tournefort, *Institutiones Rei Herbariae, sive Elementa Botanices* (Paris, 1700), 55.

4. The natural system

Artificial systems could serve their purpose well, Linnaeus claimed again and again, within contexts in which one was dealing with a given set of already known genera, be it in pedagogic contexts, be it in contexts where already accumulated information about plant genera was to be retrieved.[34] Hence the fact that Linnaeus organized the botanical garden at Uppsala University, his own herbarium, as well as most of his publications according to his sexual system. Where artificial systems fail is in research contexts where the 'nature' of plants is at stake. As Linnaeus succinctly stated in 1764, 'Natural orders have their value with respect to the nature of plants; artifical ones in the diagnosis of plants'.[35] Since the properties of not yet discovered plants cannot be predicted, let alone deduced, inductive and descriptive procedures must take precedence over ratiocinations and definitions. It is for this fundamental reason that the 'natural' system is a project for the future, only to be accomplished by the collective, empirical work of generations.[36]

To approach this fundamental difference between artificial and natural systems, I first want to take a look at some logical features of what Linnaeus called the natural system (and that we take for granted for any proper taxonomic system today). Again, it is the *Classes plantarum* of 1738 that furnish a convenient starting point. It was in this book that Linnaeus first published the 'fragments of a natural system' which he had promised to his readers three years earlier in *Systema naturae*. The presentation of these 'fragments' shows striking structural differences if compared to the preceding twenty-five artificial systems. Instead of occupying 'places' defined within a table of classes and orders generated by a combination of divisions, genera names are arranged into forty-five 'orders' designated by Roman numerals ('Ordo I', 'Ordo II', etc.). Each genus appears once only, hence there is not the kind of overlap between taxa that one so frequently observes in artificial systems. The number of genera brought under each of these orders varies widely, from four to seventy-nine, and the individual lists are arranged in two columns on each page.[37] Later editions of the 'fragments' provided proper names for the 'natural orders', such as 'palms' (*Palmae*) or 'orchids' (*Orchidae*). But the basic structure remained the same.[38]

Just as artificial systems are generated by 'artificial characters', the natural system is produced by 'natural characters' (*charateres naturales*). Strictly speaking, and in contrast to artificial characters, these are not definitions. As Linnaeus explained in the preface to a slim follow-up volume to *Genera plantarum*, they should be regarded as 'descriptions', in analogy to the long, structured texts in which naturalists gave a full account of all known properties of a species.[39] The procedure to arrive at such descriptions was defined by Linnaeus as a straightforward inductive process that involved the careful comparison of individual species. In setting up a natural

[34] See, for example, C. Linnaeus (note 12), 'Lectori s. Author' [unpag., 1–2].

[35] Carl Linnaeus, *Genera Plantarum eorumque Characters Naturales secundum Numerum, Figuram, Situm, Proportionem Omnium Fructificationis Partium*, sixth edition (Stockholm, 1764), 'Ordines naturales', [unpag.], aph. 10.

[36] C. Linnaeus (note 27), 'Ratio operis', aph. 8–9. For a detailed interpretation of this important passage, see S. Müller-Wille (note 26), 546–50.

[37] C. Linnaeus (note 12), 435–514. On the importance of lists in the work of Linnaeus see Staffan Müller-Wille and Isabelle Charmantier, 'Lists as Research technologies', *Isis*, 103 (2012), 743–752.

[38] C. Linnaeus (note 18), 27–36; C. Linnaeus (note 35), 'Ordines naturales', [unpag.].

[39] Carl Linnaeus, *Corollarium Genera Plantarum, exhibens genera plantarum sexaginta* (Leiden, 1737), 'Lectori', [unpag.]: '… *Characteres* hi nil nisi *descriptiones generum* sint …' (emphases in the original). For a full quote and detailed analysis, see S. Müller-Wille (note 26), 552–3.

character, he explained in *Genera plantarum*, 'all species discovered so far have to be considered. [Number, shape, situation, and proportion] have to be described properly for each of the obvious parts of the fructification [i.e. flower and fruit]. Those which do not come together in all species have to be excluded—only those that do come together should be retained'.[40]

What emerges from such an inductive procedure is not a small set of differences that the genus in question exhibits in relation to a particular group of other genera. What emerges is rather something like a general picture of the morphology a group of closely related species shares, 'the simple symmetry of all parts', as Linnaeus called it.[41] Traits, that is, do not enter the natural character of a genus because they can serve to distinguish it from certain other genera, but because they, in conjunction with all other traits that are proper to the genus in question, constitute a unique whole of interrelated parts and properties. This whole, moreover, is related by a web of relations of identity and difference to all other such wholes, in a map- or network-like manner.[42] The logic of the natural system, one could say, is not topical, but relational, and thus strikingly different from artificial systems.[43] That Linnaeus wanted to see 'natural definitions' restricted to the flower and fruit has a simple reason. For him, these were not parts of the plant, but rather the plant itself in its last, developmental stage – '*in actu generationis*' as Linnaeus put it in *Classes plantarum*.[44]

Linnaeus was unusually eloquent about the advantages of such 'natural characters'. First of all, they are independent of particular contexts. As the natural character describes a large set of parts and their properties it 'is applicable to all methods proposed or to be proposed'. For the lack of a diagnostic function, moreover, it can remain stable while new genera are being discovered. 'Even if a thousand new genera were discovered, it would not be necessary to add or remove a single feature because of a neighbouring natural genus'. This does not mean that genera, once characterized, cease to change. The discovery of new species of a respective genus will inevitably lead to adjustments of its generic description.[45] This is precisely the use to which Linnaeus put his 'natural' genera. As I have argued elsewhere, Linnaeus employed and developed a wide variety of paper technologies – including bound manuscripts, filing systems, book annotation, and index cards – throughout his career. The central ordering device throughout this wide range of information processing technologies, however, remained to be the genus, which also had a specific ontological status for Linnaeus. The genus served as a kind of 'box' to absorb and process information on species.[46]

The 'natural method' finally differs from artificial systems in a way that leads us to the heart of Linnean natural history. Grouping plants because they agree in their 'nature', rather than distinguishing them for diagnostic purposes, implies that the various members of one and the same natural genus or order can, in a sense, stand in for or replace each other. The natural system was supposed to depict relations of

[40] C. Linnaeus (note 27), 'Ratio operis', [unpag.], aph. 20.
[41] C. Linnaeus (note 12), 487.
[42] C. Linnaeus (note 18), 27.
[43] Müller-Wille and Charmantier (note 37), 750.
[44] C. Linnaeus (note 12), 441.
[45] C. Linnaeus (note 27), 'Ratio operis', [unpag.], aph. 18.
[46] S. Müller-Wille and I. Charmantier (note 14).

equivalence that were of central concern both for the exchange of specimens with other naturalists and for Linnaeus's grand project of creating 'a miniature mercantile empire within a European state'.[47] I have so far emphasized the exploratory nature of Linnaeus's work on the natural system, but it also served a practical purpose. Linnaeus hoped that the characterisation of natural genera and orders would help him to find domestic substitutes for valuable plant species that had to be imported from exotic countries. In this sense, Linnaeus's 'fragments of a natural method' were not another attempt at identifying the features by which plants can be distinguished from each other, but a sophisticated way of charting the terrain for future discovery and improvement.

5. Conclusions

In this article, I have been largely looking through the eyes of one historical figure on taxonomic methods in the late seventeenth and early eighteenth centuries. This is admittedly a slim basis for any kind of historical generalisation. Linnaeus's claim that he was the first to see the artificiality of previous systems generated through logical division, and that he was the first to propose a 'natural' method needs to be taken with a grain of salt, of course. There were clear precedents to what he was up to. The first edition of *Genera plantarum* still acknowledged this, pointing to Tournefort and Herman Boerhaave as those who before Linnaeus had produced something like generic descriptions.[48] Ray as well, in the third edition of his *Synopsis methodica*, tried to characterize classes and orders by drawing together as many common characteristics as possible.[49]

The aim of this article was rather historigraphical than historical, though. What Linnaeus's perception of a break with the past indicates is that the period that preceded him may have experienced massive changes in what it meant to do natural history in general, and how the classification of organisms was supposed to proceed in particular. Division, definition and classification, do not represent timeless conceptual structures, ready to be filled with more or less appropriate empirical content, but are activities carried out in particular contexts for particular purposes. Changes in such practices can therefore not be appreciated by conceptual analysis alone. Careful attention needs to be paid to what naturalists actually did when they introduced order into nature, for what purposes they did it, and in what kind of contexts their work was situated.

Much research remains to be done on the cultures of collection as well as manuscript and print output of late seventeenth century naturalists to gain a more fine-grained understanding of natural history around 1700. Some tentative conclusions can be drawn, however, from the material presented in this essay. Natural history, it has become clear more recently, went through a period of professionalization around 1700, relying increasingly on peer based systems of global exchange

[47] Lisbet Koerner, *Linnaeus: Nature and Nation* (Cambridge, MA, 1999), 144. On the significance of specimen exchange for Linnaeus's taxonomic thinking see Staffan Müller-Wille, 'Nature as a Marketplace: The Political Economy of Linnaean Botany', in *Oeconomies in the Age of Newton*, edited by Neil de Marchi and Margaret Schabas (*History of political Economy*, Suppl. 35: Durham, 2003), 155–73.

[48] C. Linnaeus (note 27), 'Ratio operis', [unpag.], aph. 12. Linnaeus deleted these remarks in the sixth edition.

[49] John Ray, *Synopsis Methodica Stirpium Britannicarum, tum Indigenis, tum in Agris Cultis, Locis suis dispositis*, third edition (London, 1724); cfr. P. R. Sloan (note 1), 45–6.

rather than local relations of patronage.[50] The imagery of war and divisiveness that Linnaeus employed in looking back at the debate between Rivinus, Ray and Tournefort suggests that he associated their contributions to natural history with the religious rifts and imperial ambitions that had tumbled Europe into decades of war in the seventeenth century, the consequences of which he was still feeling in his youth. His vision of the 'natural system' as a project for the future to which anyone could contribute incrementally by engaging in the exchange of letters and specimens, on the other hand, opened prospects of peaceful collaboration and economic improvement. It is a vision that ever since has motivated and unified botanical and zoological systematics, despite the fact that the goal of establishing 'the' natural system is as far away as it was in Linnaeus's time.

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[50] Brian W.Ogilvie, *The Science of Describing: Natural History in Renaissance Europe* (Chicago, 2006); Alix Cooper, *Inventing the Indigenous: Local Knowledge and Natural History in Early Modern Europe* (Cambridge, 2007).