

FROM THE MORE GEOMETRICO TO THE MORE ALGEBRAICO: D'ALEMBERT AND THE ENLIGHTENMENT'S TRANSFORMATION OF SYSTEMATIC ORDER

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1 Introduction

Bartholo: Siècle Barbare!...

Rosine: Vous injuriez toujours notre pauvre siècle!

Bartholo: Pardon de la liberté: qu'a-t-il produit pour qu'on le loue? Sottises de toute espèce: la liberté de penser, l'attraction, l'électricité, le tolérantisme, l'inoculation, le quinquina, l'Encyclopédie et les drames...

(Beaumarchais (1965: 48)

When Beaumarchais let the major antagonist of his play *The Barber of Seville* voice his contempt of the *siècle des lumières*, he was not just introducing the character as an insufferable bigot, but also ironically characterizing the movement that he himself championed: the

Enlightenment. For many European intellectuals, the Enlightenment heralded the loss of the stability and structure that were regained only a century earlier over the chaos of the reformation.¹ This loss of structure not only became apparent in the realm of the political, where republicanism soon ran rampant through various social strata and classes, but also in the hallowed halls of epistemology and metaphysics. If the Enlightenment was the *Age of Reason*, it was so only in a very peculiar sense²: all that the seventeenth century had recognized as rational – systematic structure, deductive order, unshakable foundation and certainty – was now disdained and scorned as oppression and hierarchy, barren tautology, superstition and a headstrong insensitivity to the one truly productive force in human reasoning: doubt. It was, then, the age of Reason's self-deprecation and self-castigation. In praising the humility of Locke's powers of the mind, the elusiveness of Newton's metaphysical commitment and the erudite ignorance of

¹ Paul Hazard (1961: 15) does not shy away from characterizing the early modern period – *l'âge classique* – as a period of consolidation after the shock of the renaissance: “L'esprit classique, en sa force, aime la stabilité: il voudrait être la stabilité même. Après la Renaissance et la Réforme, grandes aventures, est venue l'époque de recueillement. On a soustrait la politique, la religion, la société, l'art, aux discussions interminables, à la critique insatisfaite; le pauvre navire humain a trouvé le port: puisse-t-il y rester longtemps, y rester toujours! L'ordre règne dans la vie: pourquoi tenter, en dehors du système clos qu'on a reconnu pour excellent, des expériences qui remettraient tout en cause?” Not unsurprisingly, given his respect for Hazard, Israel (2006: 17) equally regards the (early) seventeenth century as a period in which the confessional strife following the reformation was relatively stabilized.

² For this reason, Peter Gay (1966: 141) goes so far as to deny that the Enlightenment was an Age of Reason: “The philosophes' glorification of criticism and their qualified repudiation of metaphysics make it obvious that the Enlightenment was not an Age of Reason but a Revolt against Rationalism”. The tendency to regard Enlightenment as a project of rationality is mainly due to the role reason took up in deciding religious and political questions, *i.e.* reason's becoming the new rule of faith (cf. Beiser 1996: 5).

Bayle's Encyclopedism, the *philosophes* saw shadows where until only recently the natural light of human understanding had shone bright, shadows they believed were cast by the flickering of this light itself.³

The project of the Enlightenment, however, was not just one of destruction, devaluation and defamation, not even – and maybe even especially – in its radical form. It constituted a reorganization of a constellation of concepts that were, of course, thoroughly prepared by the earlier phases of modernity, but that were now endowed with new and unexpected properties. In this constellation, the meaning of concepts such as reason, right and knowledge underwent a major transformation, shifting from an association with discipline and discreteness to one with spontaneity and continuity. These qualities were those associated with the one true object of inquiry: nature, in all its complexity, its multiple facets and its vicissitudes. If anyone then believed that the proper study of mankind is indeed man, then he believed it was man's shortcomings, his limitations, his ungainly rigidity in the face of the dynamic cornucopia of form and matter that was the natural world that deserved our attention⁴.

³ This is clearly recognizable in Voltaire's *philosophe ignorant*, whose humility Blumenberg (1966: 475) said "könnte – nach einer kleinen, aber entscheidenden Änderung, die nicht 'Säkularisierung' ist – einem mittelalterlichen Traktat zur Erinnerung an den Vorrang des Heils vor der Erkenntnis entnommen sein".

⁴ Two texts that clearly testify to this are Diderot's *Pensées sur l'interprétation de la nature* (Diderot 2005: 64-65): "Quand on vient à comparer la multitude infinie des phénomènes de la Nature, avec les bornes de notre entendement et la faiblesse de nos organes, peut-on jamais attendre autre chose de la lenteur de nos travaux, de leurs longues et fréquentes interruptions, et de la rareté des génies créateurs, que quelques pièces rompues et séparées de la grande chaîne qui lie toutes choses?" and Buffon's *Premier Discours: De la manière d'étudier et de traiter l'Histoire Naturelle* (Buffon 1749: 5): "lorsqu'on est parvenu à assembler des échantillons de tout ce qui peuple l'Univers, lorsqu'après bien des peines on a mis dans un même lieu des modèles de tout ce qui se trouve répandu avec profusion sur la terre, et qu'on jette pour la première fois les yeux

In this paper, I would like to bring to the fore some of the major contrasts between the early modern and the high Enlightenment conceptions of knowledge. The major difference is not that the former is systematical and the latter un- or antisystematical; indeed, Ernst Cassirer (2007: 7) has rightly remarked that “[d]er ‘esprit systématique’ wird keineswegs geringschätzt oder beiseite geschoben, aber er wird aufs schärfste vom blossen ‘esprit de systèmes’ geschieden”, but he may have lacked sensitivity for the fact that this separation would only allow the new concept of system to structure reality in the background. Indeed, Cassirer’s view has been criticized time and time again for its awkward teleology, which read in every pre-Kantian figure the preparation of the critical system and the modern conception of science he took it to be grounding. Yet, the greatest flaw of Cassirer’s enormously compelling and charming account of the Enlightenment is the unity, the harmony and the intentionality he ascribed to it. This was, undoubtedly the artifact not only of his own gaze, but equally of his choice of sources: for it was D’Alembert whom he granted the honor of posing as the spokesman of the *philosophes*’ philosophical self-consciousness.

Jean le Rond D’Alembert (1717-1783) did, of course, play a major role, albeit one he himself tended to downplay, in both the formulation and the proselytizing of Enlightenment *philosophie*, by co-editing the (in)famous *Encyclopédie*, and by introducing this vastly influential project with a preliminary discourse that is one of the frankest phrasings of the High Enlightenment’s new mentality. Yet many

sur ce magasin rempli de choses diverses, nouvelles et étrangères, la première sensation qui en résulte, est un étonnement mêlé d’admiration, et la première réflexion qui suit, est un retour humiliant sur nous-mêmes.” Part of the claim of this paper is that Diderot and Buffon are in no way exceptional figures in this respect, but that they make one aspect of Enlightenment epistemology more explicit than many others did.

commentators have stressed that D'Alembert is somewhat atypical a *philosophe* because of his relative moderation in epistemological issues. Indeed, D'Alembert is regarded as the author who tempered Diderot's enthusiastic proliferation of order and disorder with his sobriety and analytically minded *esprit géométrique*.⁵ It is only with respect to this reluctant antisystematist that one could concur with Paul Hazard and state that "l'esprit du XVIII^e siècle, tel qu'il prend ses racines dans le XVII^e, est rationaliste par essence, et empiriste par transaction" (Hazard 1961: 226).

None of this means, however, that one can disregard D'Alembert as a representative of the Enlightened spirit, for his ambiguities and indecisions are not just his own: they are the result of his deep, though perhaps unarticulated, sensitivity to those of his own age. We should be careful in reprehending D'Alembert for his allegiance to what we would consider the vestigial elements of his thought, and praising instead those philosophers who had the dubious courage to fully embrace the new scientific outlook⁶; and we should be equally careful in praising the ambiguity of the moderate Enlightenment as a sign of almost post-modern openness and resistance to "bald naturalism"⁷. I believe D'Alembert's case is especially instructive with regard to this point, because the ambiguities of the Enlightenment rise to the surface in this thinker whose uncontemporaneity was his valuing clarity above partisanship.⁸

⁵ Cf. Anderson (1990: 5)

⁶ Cf. Plekhanov (1956: 12-13), Israel (2006: 704).

⁷ Cf. Saint-Amand (1984), Hayes (1999), Moscovici (2000).

⁸ Grimsley (1963: 267) characterizes D'Alembert as a man who was both too intellectually honest to overlook the objections to his views, and too partisan to fully address these objections. It is this peculiar ambiguity that causes the tensions of Enlightenment discourse to surface so clearly in his texts.

In the first section of this paper, I will discuss D'Alembert's torn attitude towards the role of geometry and mathematics in science. This will allow me to discuss, in section 2, the transformation of logic and analyticity in the Eighteenth Century, and, in section 3, the tension between different conceptions of system that erupted in the first half of the *siècle des lumières*. In the fourth section, I will briefly indicate some of the consequences of this for the epistemology underlying the message of the *philosophes*, and finally formulate some conclusions we can draw from D'Alembert's position.

2 D'Alembert as Reluctant Geometer?

“[I]l contraddire alla geometria è un negare scopertamente la verità,” wrote Galileo in his polemical treatise *Il Saggiatore* (1844: 149), thereby inaugurating the enormous respect for geometry recognizable in 17th Century thought. Geometry was praised not just for the tools it delivered to scientific research, but also for the form in which it was communicated, one that represented clarity, certainty and the potential for universal assent, three marks that determine the early modern ideal of knowledge. For Hobbes, geometrical construction was not just a method that could prove useful to physics, but became the paradigm of the whole of philosophy (which, at that time, still encompassed science)⁹. Many authors also chose to write their works in what was

⁹ In the *Elements of Philosophy Section I: Concerning Body*, Hobbes defines philosophy as follows: “Philosophy is such knowledge of effects or appearances, as we acquire by true ratiocination from the knowledge we have first of their causes and generation: And again, of such causes or generations as may be from knowing first their effects.” (Hobbes 1839: 3) Further on in the same work (Hobbes 1839: 6), he explains this further in the following way: “How the knowledge of any effect may be gotten from the

known as the *geometric method*, the specific structure behind Euclid's *Elements*. The second series of objections to Descartes *Meditationes de Prima Philosophia*, gathered by Marin Mersenne among his academic contacts, closes off with the suggestion that Descartes render his proof of the existence of God clearer by expounding it *more geometrico* (Descartes VII: 128), a request with which Descartes somewhat reluctantly complied. In response, Spinoza would later attempt to cast the *Principia Philosophiae* in this form, and would go on to compose one of the masterpieces of Modern Philosophy after Euclid's fashion¹⁰. Even Newton, the hero of many Enlightenment empiricists, observed

generation thereof, may easily be understood by the example of a circle: for if there be set before us a plain figure, having, as near as may be, the figure of a circle, we cannot possibly perceive by sense whether it be a true circle or no; than which, nevertheless, nothing is more easy to be known to him that knows first the generation of the propounded figure. For let it be known that the figure was made by the circumduction of a body whereof one end remained unmoved, and we may reason thus; a body carried about, retaining always the same length, applies itself first to one *radius*, then to another, a third, a fourth, and successively to all; and, therefore, the same length, from the same point, toucheth the circumference in every part thereof, which is as much as to say, as all *radii* are equal. We know, therefore, that from such generation proceeds a figure, from whose one middle point all the extreme points are reached unto by equal *radii*. And in like manner, by knowing first what figure is set before us, we may come by ratiocination to some generation of the same, though perhaps not that by which it was made, yet that by which it might have been made; for he that knows that a circle has the property above declared, will easily know whether a body carried about, as is said, will generate a circle or no."

¹⁰ It should not come as a surprise that the case of Spinoza's method has been, and still is, the subject of considerable debate. Positions here vary from Joachim's conviction that "the form of Spinoza's exposition is essential to its matter" (1901: 13) to Roth's (1963: 41-43) claim that the choice for the *ordo geometricus* was motivated almost entirely by considerations regarding the exposition of the material. Many authors, however, seem to believe that even if the geometrical method may not be entirely adequate to what Spinoza meant to communicate, it still reflects the latter's predilection for deductive order (e.g. Parkinson 1964: 89; Bennett 1984: 20).

the geometric order in his *Principia Mathematica Philosophiae Naturalis*. The whole of Seventeenth Century Academia with but a shred of faith in the possibility of knowledge seemed possessed by what Pascal called the “esprit géométrique”¹¹.

By the time the High Enlightenment erupted, however, this enthusiasm had dwindled considerably, and the once proud mathematical sciences now met with derision and hostility in scientifically minded circles. Diderot (1994: 561) wondered aloud whether geometry still had a future, now that its foundations had been cast, and Buffon dismissed the geometric method entirely as useless in natural history:

Il y a plusieurs espèces de vérités, et on a coûtume de mettre dans le premier ordre les vérités mathématiques, ce ne sont cependant que des vérités de définitions ; ces définitions portent sur des suppositions simples, mais abstraites, et toutes les vérités en ce genre ne sont que des conséquences composées, mais toujours abstraites, de ces définitions. Nous avons fait les suppositions, nous les avons combinées de toutes les façons, ce corps de combinaisons est la science mathématique ; il n’y a donc rien dans cette science que ce que nous y avons mis, et les vérités qu’on en tire ne peuvent être que des expressions différentes sous lesquelles se présentent les suppositions que nous avons employées ; ainsi les vérités mathématiques ne sont que les répétitions exactes des définitions ou suppositions. La dernière conséquence n’est vraie que parce qu’elle est identique avec celle qui la précède,

¹¹ The esprit géométrique observes a specific order, which “consiste non pas à tout définir ou à tout démontrer, ni aussi à ne rien définir ou à ne rien démontrer, mais à se tenir dans ce milieu, de ne point définir les choses claires et entendues de tous les hommes, et de définir toutes les autres ; et de ne point trouver toutes les choses connues des hommes, et de prouver toutes les autres.” (Pascal 2000: 157-157)

et que celle-ci l'est avec la précédente, et ainsi de suite en remontant jusqu'à la première supposition ; et comme les définitions sont les seuls principes sur lesquels tout est établi, et qu'elles sont arbitraires et relatives, toutes les conséquences qu'on en peut tirer sont également arbitraires et relatives. Ce qu'on appelle vérités mathématiques se réduit donc à des identités d'idées et n'a aucune réalité ; nous supposons, nous raisonnons sur nos suppositions, nous en tirons des conséquences, nous concluons, la conclusion ou dernière conséquence est une proposition vraie relativement à notre supposition, mais cette vérité n'est pas plus réelle que la supposition elle-même. (Buffon 1749: 53-54).

Buffon's complaint that the truths of mathematics were sterile repetitions of arbitrary definitions, would echo through the writings of the *philosophes*, even if many would simply object against the abstract nature of the first principles on which the so-called synthetic method erects its systems (e.g. Condillac 1991: 11). The careless reader might even recognize Buffon and Diderot's extreme view in D'Alembert's writings. But the derogation of geometry would be a peculiar attitude indeed for a professional mathematician, one who took clear pleasure in his academic activities. In fact, in the *Discours Préliminaire*, he hazards a vindication of geometry: "J'en demande pardon à nos beaux esprits détracteurs de la Géométrie: ils ne se croyaient pas sans doute si près d'elle, et il n'y a peut-être que la Métaphysique qui les en sépare. L'imagination dans un géometre qui crée, n'agit pas moins que dans un poète qui invente." (D'Alembert 1821: 47-48) For D'Alembert, then, geometry is not as sterile and stale as many Enlightenment thinkers would suggest, and even requires considerable creative power and imagination. This does not mean, however, that d'Alembert still revels in that worship of the Euclidean method so unbecoming of an Encyclopedist: "J'espère qu'on pardonnera cette digression à un géomètre qui aime son art, mais qu'on n'accusera point d'en être

admirateur outré” (D’Alembert 1821: 48). As he explains in the *Essai sur les Éléments de Philosophie*:

Ce n’est point, comme nous l’avons dit, à l’usage illusoire des axiomes que les Géomètres doivent la sûreté de leurs raisonnements et de leurs principes ; c’est au soin de fixer le sens des termes, et de n’en abuser jamais, à la manière dont ils décomposent leur objet, à l’enchaînement qu’ils savent mettre entre les vérités. [...] Le comble de l’erreur seroit d’imaginer que l’essence des démonstrations consistât dans la forme géométrique, qui n’en est que l’accessoire et l’écorce, dans une liste de définitions, d’axiomes, de propositions et de corollaires. Cette forme est si peu essentielle à la preuve des vérités mathématiques, que plusieurs Géomètres modernes l’ont abandonnée comme inutile. (D’Alembert 1821: 153)

From this passage, it becomes clear that D’Alembert believed the aspect of geometry that was considered throughout the 17th century to be its immense merit, its colossal contribution to all human knowledge, namely the logical, deductive order in which it was cast, its neat division of the process of reasoning into axioms, postulates, definitions, etc. to be its most outdated, inessential aspect. There was a clear reason for this: several mathematicians had become aware of the fact that it was no longer the paradigms of construction or deduction that formed the backbone of eighteenth-century mathematical science, but the paradigms of analysis and integration, together with their concomitant shift towards *algebra* (Cf. Pierobon 2013). Indeed, D’Alembert considered the main reason for the slow progress of British mathematics to be Newton’s insular followers’ erroneous focus on the literary form of the *Principia*: the geometrical order. This order, he suggests, may very well have been chosen in order to hide the new form

of reasoning, Analysis¹², which lies behind Newton's actual discoveries. With this interpretation of Newton's Euclidean style as a form of what Leo Strauss called "esoteric writing", D'Alembert was able to solve the apparent paradox of the great champion in the fight against "hypothesis"—in its pejorative sense of arbitrary, externally imposed principle—espousing the form that expresses the "esprit des systèmes"¹³. For there was no doubt in his mind that algebra deserved the place of honor among the sciences once accorded to the science of choice of the absolutist *ancien régime*, geometry:

La Géométrie qui doit précéder, comme plus simple, doit elle-même être précédée par une autre Science plus universelle, celle qui traite des propriétés de la grandeur en général, et qu'on appelle Algèbre. Deux raisons doivent donner à cette science un rang distingué dans des éléments de Philosophie. La première, c'est que la connoissance de l'Algèbre facilite infiniment l'étude de la Géométrie et de la Mécanique, et qu'elle

¹² D'Alembert probably inferred Newton's predilection for Analysis in science from the following passage from the *Queries* to the *Opticks* (2004: 139): "As in mathematics, so in natural philosophy, the investigation of difficult things by the method of analysis, ought ever to precede the method of composition. This analysis consists in making experiments and observations, and in drawing general conclusions from them by induction, and admitting of no objections against the conclusions, but such as are taken from experiments, or other certain truths. For hypotheses are not to be regarded in experimental philosophy". However, as Guicciardini (2002) has pointed out, Newton by that time considered analysis and algebra to be inferior to synthesis and geometry, and may have chosen to write his *Principia* after the synthetic method because only this style could confer the certainty he deemed worthy of a scientific theory.

¹³ Buchdahl (1961: 11-13) sees this as a result of the two very different styles Newton employed in his two major works: the *Principia* relying on the geometric method to assure its reader of the value of its principles, whilst the *Opticks* are more in line with the antihypothetical manner in which he proposed to proceed. Concordantly, Newton's work would spawn two different tendencies of 18th Century thought.

est même absolument nécessaire à la partie transcendante des deux Sciences, dont la Physique, prise dans toute son étendue, ne sauroit se passer. La seconde, c'est que s'il y a des Sciences qui doivent avoir place par préférence dans des éléments de Philosophie, ce sont sans doute celles qui renferment les connoissances les plus certaines accordées à nos lumieres naturelles. Or l'Algèbre tient le premier rang parmi ces Sciences, puisqu'elle est l'instrument des découvertes que nous pouvons faire sur la grandeur. (D'Alembert 1821: 261)

If any science deserves to be considered of the highest rank, it is surely algebra. D'Alembert is not just making a statement about the way in which one should conduct research in the physical sciences, but is also suggesting that the structure of reasoning, i.e. logic itself should be fashioned after this new Queen of the Sciences. In this, he shows himself to be extremely sensitive to Locke's great intervention in the 17th Century concept of Knowledge.

3 The Chain of Thought

Throughout the Renaissance and the 17th Century, Philosophers targeted the philosophy of the schools by criticizing the traditional logic based on Aristotle's Organon. The aspect of this doctrine that met with the most resistance was the so-called syllogistics. Francis Bacon, one of those figures who, in the *philosophes'* eyes, provided the great inspiration and instauration of modern science and its accompanying empirical mindset, formulated this criticism in the following way:

in the ordinary logic almost all the work is spent about the syllogism. Of induction the logicians seem hardly to have taken any serious thought, but they pass it by with a slight notice, and hasten on to the formulae of disputation. I on the contrary reject demonstration by syllogism, as acting too confusedly,

and letting nature slip out of its hands. For although no one can doubt that things which agree in a middle term agree with one another (which is a proposition of mathematical certainty), yet it leaves an opening for deception; which is this. The syllogism consists of propositions; the propositions of words; and words are the tokens and signs of notions. Now if the very notions of the mind (which are as the soul of words and the basis of the whole structure) be improperly and overhastily abstracted from facts, vague, not sufficiently definite, faulty in short in many ways, the whole edifice tumbles. I therefore reject the syllogism; and not only as regards principles (for to principles themselves logicians do not apply it) but also as regards middle propositions; which, though obtainable no doubt by the syllogism, are, when so obtained, barren of works, remote from practice and altogether unavailable for the active department of the sciences. (Bacon 1875: 24)

In this passage, Bacon finds fault with the old Organum for its undue stress on the syllogism as the motor of reasoning, and therefore offers to replace it with his own new method, a new Organum. The syllogism has the unerring problem of proceeding from the more general to the particular, thereby presupposing knowledge of the general, the principle. This is unacceptable to Bacon because it precludes any investigation into those principles themselves. In fact, his proposal, an Organum that is based on the method of induction, consists in an inversion of this process, a climbing of the scales of generality towards the most general:

hitherto the proceeding has been to fly at once from the sense and particulars up to the most general propositions, as certain fixed poles for the argument to turn upon, and from these to derive the rest by middle terms: a short way, no doubt, but precipitate; and one which will never lead to nature, though it offers an easy and ready way to disputation. Now my plan is to proceed regularly and gradually from one axiom to another, so

that the most general are not reached till the last: but then when you do come to them you find them to be not empty notions, but well defined, and such as nature would really recognise as her first principles, and such as lie at the heart and marrow of things. (Bacon 1875: 25)

But an inversion of the order proper to Aristotelian logic leaves one thing unharmed: its basic conception of subsumption, of intension and extension. This conception is one which integrates all possible concepts in a single hierarchical order that descends from the most general to the most particular. Even though many concepts involve several more general concepts, its precise location in the hierarchy is defined by its *specific difference* (*differentia specifica*): it is the more general concept (the genus), involving the essential qualities (*propria*) endowed with another specific difference, as opposed to other qualities irrelevant to its precise location (*accidentia*), that makes up the more particular concept (the species). This hierarchical order is best known as the Porphyrian Tree, named after the 3rd-century neoplatonic philosopher whose Introduction to Aristotle's Categories (the *Isagoge*) had been compulsory reading in the Medieval curriculum. That Bacon still adhered to this hierarchical and unitary conception of nature is clear from his exegesis of the myths surrounding the figure Pan in Greek literature in the *Sapientia Veterum*¹⁴. The key with which he tackles these tales, which he interprets as philosophical parables, namely the

¹⁴ McRae (1957: 30-31) equally takes Bacon's interpretation of the Pan-Myth as evidence that he subscribed to the hierarchical conception of nature, whereby the whole of nature is subsumed under one supreme principle. This is largely because, as Anderson (1948: 54) has pointed out, the *Sapientia Veterum* is an indirect attack on the ruling philosophies, via an interpretation of ancient myths as philosophical parables full of the wisdom of the empirically and materially minded way of mind from which Europeans had long since been led astray.

idea that “Pan, as the very word declares, represents the universal frame of things, or nature” (1878: 709), opens his path to the following observation:

That the world is represented with horns, and that such horns are broad at bottom and narrow at top, has relation to the fact that the whole frame of nature rises to a point like a pyramid. For individuals are infinite: these are collected into species, which are themselves also very numerous, the species are gathered into genera, and these again into genera of a higher stage; till nature, contracting as it rises, seems to meet at last in one point. Nor need we wonder that Pan’s horns touch heaven; since the summits, or universal forms, of nature do in a matter reach up to God; the passage from metaphysic to natural theology being ready and short. (1878: 710)

This ascent to the hierarchical conception behind Aristotelian logic does not imply that Bacon is an Aristotelian: it is in fact likely that his major difference of opinion with Aristotle concerned precisely how we should conceive of the status of these “universal forms”, and how we should investigate them. But whatever Bacon may have meant with his concept of a form (and this is very hard to make out indeed¹⁵), he clearly believed that forms are related to each other after the logical manner in which Aristotelian species and genera are subordinated to each other. This is clear from his description of proper inquiry into forms in the second part of the *Novum Organum* by means of the example of heat.

¹⁵ Some authors, such as Whitaker (1970), go as far as suggesting that Bacon’s concept of a form is indefinite, and this because it harks back to a variety of concepts from other philosophies. For an overview of the literature’s indecision with regard to Bacon’s forms, as well as a recent attempt to remedy it, see Fletcher 2005. It seems likely, however, that Bacon’s concept of a form anticipates Boyle’s, which is decidedly non-Aristotelian, but may still allow for a proper classification (cf. Jones 2005).

There, he suggests that heat is a specific kind of motion, distinguished from motion in general by a number of *specific differences* (1875: 151). In discussing the specific kinds of instances which may serve to guide one in proper inductive research, he states that “as Striking Instances lead easily to specific differences, so are Clandestine Instances the best guides to *genera*, that is, to those common natures, whereof the natures proposed are nothing more than particular cases” (1875: 160).

It is not a peculiarity of Bacon’s that his criticism of scholasticism leaves the latter’s conception of logical hierarchy unscathed, an indicator of the ultimately pre-modern mindset some believe to be behind his philosophical project. In fact, we can find the hierarchical notion of subsumption nearly everywhere in early modernity, not just in the writings of the *Port-Royal* rationalists, who merely saw the study of syllogism as rather unenlightening because they believed a great deal more errors of judgment result from relying on false or unclear principles of thought than from the inadequate employment of a rule of inference (Arnauld & Nicole 1992: 167), but also in those writings commonly taken to be precursors of the empirical line of thought that dominated the *philosophes’* theoretical enterprises. Gassendi’s *Institutio Logica* includes an example clarified by means of a schema situating the idea within the porphyrian tree (1727: 84), and Hobbes (1839: 30) equally believes that a proposition consists in stating that one name comprehends another.¹⁶

It is this lingering commitment to the systematic order recognized as proper to the *esprit de systèmes* in the 17th century conception of

¹⁶ Hobbes does, of course, treat the hierarchical relation as a relation between names, and the relation between names as arbitrarily imposed. He does not, therefore, need to regard nature as something that expresses the hierarchical systematic order, like Bacon seems to, but he *is* committed to the fact that man’s knowledge must take the form of a hierarchical system.

inference and tautology that Locke sought to eradicate with his novel description of the inferential process, which did away with levels of generality and particularity altogether. Near the end of his *An Essay Concerning Human Understanding*, he turns to the faculty of reason in order to indicate the contribution this power, distinct as it is from sense, can make to human knowledge. This contribution is twofold: it consists in both the finding and the ordering of ideas so as to complete and organize the *chain of ideas* (1997: 590). It is this conception of the order of thought, not as a hierarchy of levels of generality, but as a continuous chain of ideas, that will lead Locke to reject the usefulness of syllogism altogether (Cf. Ayers 1991: 91). Instead of this form, which relies excessively on the difference in generality between ideas and propositions, something Locke finds far less relevant to their logical status¹⁷, he (1992: 594) suggests regarding inference as a chain of ideas, in which each link agrees with the next. It is hard not to recognize this same conception of logic in D'Alembert's *Discours Préliminaire*:

Qu'on examine une suite de propositions de géométrie déduites les unes des autres, en sorte que deux propositions voisines se touchent immédiatement et sans aucun intervalle, on s'apercevra qu'elles ne sont toutes que la première proposition qui se défigure, pour ainsi dire, successivement et peu à peu dans le passage d'une conséquence à la suivante, mais qui pourtant n'a point été réellement multipliée par cet enchaînement, et n'a fait que recevoir différentes formes. (D'Alembert 1821: 32)

¹⁷ This is clear from his discussion of maxims: the self-evident propositions of the highest generality that rationalists, amongst whom the *Port-Royal* logicians, believed to be the basis of thought, and the origin from which other propositions derive their evidence.

Or in the *Essai sur les éléments de la philosophie*:

Ces notions sont la base de toute la logique. En ne perdant point de vue le sens précis que nous venons d'y attacher, il est facile de réduire tout l'art du raisonnement à une règle fort simple. Nous avons dit que l'art de raisonner consiste à comparer ensemble deux idées par le moyen d'une troisième. Pour juger donc si l'idée A renferme ou exclut l'idée B, prenez une troisième idée C, à laquelle vous les comparerez successivement l'une et l'autre; si l'idée est renfermée dans l'idée C, et l'idée C dans l'idée B, concluez que l'idée A est renfermée dans l'idée B. [...]il faut, d'une part, ne donner à ces spéculations, peu nécessaires en elles-mêmes, que les momens perdus, pour ainsi dire, dans l'étude de la philosophie ; et de l'autre, faire sentir aux jeunes gens que la forme syllogistique, si chère aux scolastiques pour leurs vaines disputes, est bien moins nécessaire dans les véritables sciences, que ces mêmes scolastiques ne le pensent ou ne le disent; que sans cet échaffaudage un esprit juste aperçoit pour l'ordinaire la connexion ou la discordance de deux idées avec l'idée moyenne à laquelle il les compare, et par conséquent la connexion ou la discordance que ces deux idées ont entre elles; que les géomètres, ceux de tous les philosophes qui se sont toujours le moins trompés, ont toujours été ceux qui ont fait le moins de syllogismes; et que la forme syllogistique n'est guère plus nécessaire à un bon raisonnement que le nom de théorème à une véritable démonstration. (D'Alembert 1821: 156)

In these passages, D'Alembert echoes the general dismissal of syllogism as useful, and stresses that the notion of logical containment/subsumption is actually one of immediately grasped

identity or difference¹⁸. The relation between ideas is no longer that of a hierarchical system where the most general principle constitutes the top of the pyramid, but that of a series of differentially approximating identities. This is expressed by the new metaphor of the chain replacing the porphyrian tree as the support of the notion of tautology, which is no longer the articulation of the plenitude of the highest principle, but the modulation¹⁹ of the humility and meagerness of a single fact or

¹⁸ This has been clearly remarked by Foucault (1964: 67), who nonetheless seems to situate the shift somewhat too early, namely at the very onset of European Modernity. This is undoubtedly due to his stress on the conception of logic expounded in Descartes *Regulae ad Directionem Ingenii*. Indeed, in this early work, one can already find the metaphor of the chain as a continuous rather than discrete series of identities (Descartes 1996: X: 369). Nonetheless, one has to take into account that Descartes is, in this, as I have shown above, rather unrepresentative of his time, and that this work remained unpublished until 1701, and could therefore not have had a wide influence on the logic of its time. The manuscript was known, of course, to the Port-Royal Logicians, but these seem to have insisted on other aspects of the early work (mostly regarding intuition and the concomitant stress on clarity and distinctness). There are reasons to believe, therefore, that before the main writings of Locke and Leibniz, and perhaps those of Newton, became widely known, the ancient paradigm of logical systematics still prevailed.

¹⁹ My usage of respectively a biological and a musicological metaphor here is far from gratuitous: both of these domains are intimately connected with the ideas of systematics and identity, and their conflict would be productive in Late Enlightenment and Early Romantic philosophy. Additionally, D'Alembert himself had considerable interest in the theory of harmony developed by Jean-Philippe Rameau since the 1730s, where harmonic relations were still read as mathematical proportions expressing identities (the unison and the octave) or gradual differences (starting from fifths, the only admissible interval in Schenker's theory of harmony (1954: 29-44)) (Cf. Rameau 1971: 8-13). Diderot and Rousseau would criticize D'Alembert for this primarily by their respective *mise-en-scène* and encyclopedic indexation of the "querelle des bouffons". Fleshing out the relationship between epistemology and logic on the one hand and harmony theory on the other in the High Enlightenment would, however, go far beyond the scope of this paper.

truth: “L'univers, pour qui saurait l'embrasser d'un seul point de vue, ne serait, s'il est permis de le dire, qu'un fait unique et une grande vérité” (D'Alembert 1821: 33).

4 The Chain of Being(s)

The new supporting metaphor of Enlightenment epistemology, the chain of ideas, soon ran rampant through the discourse of all those associated with the new cultural and social movements in a great variety of complexly related battles. It acquired political and legal applications, revealing itself as an alternative to previous concepts of obligation²⁰. The issue that especially served to move it to the surface and the core of Eighteenth Century debate on systematic order, however, was the controversy surrounding two new and influential approaches to natural history: the hierarchical binomial nomenclature of Linnaeus, and the pragmatic, neo-Plinian style of Buffon. It is in this debate that the new conception of logical continuity would ally itself with the ancient doctrine of the great chain of ideas, the history of which has been famously documented by Arthur Lovejoy (1966). Lovejoy's account, however, may distort the idea by treating it as a locus classicus in Western philosophy. In doing so, it may ignore the different meanings the metaphor acquires in different historical phases

²⁰ “Quand vous aurez ainsi formé la chaîne des idées dans la tête de vos citoyens, vous pourrez alors vous vanter de les conduire et d'être leurs maîtres. Un Despote imbécille peut contraindre des esclaves avec des chaînes de fer; mais un vrai Politique les lie bien plus fortement par la chaîne de leurs propres idées.” (Servan 1667: 34) (cf. also Foucault (1975: 121-122). This new technology of power reveals itself, unsurprisingly, on the very next page, as a *neuropolitics*, with association passing through the “fibres molles” of the brain.

as well as in different theories. In the eighteenth century, the idea of a continuous series of biological forms was indeed immensely popular. This popularity, however, was due to its endorsement by two opposing philosophical strands: Lockean empiricism and Leibnizian rationalism.

It is not a coincidence that Locke's endorsement of the idea of a great chain of being can be found in the 6th Chapter of Book III, in which he expounds his infamous²¹ critique of classification according to the Aristotelian subordination of species and genera. As I have attempted to indicate in the previous section, Locke believed we could do away with this even in logic; how much more detrimental, then, must it be in the study or nature? Indeed, Locke soon dismisses the common classifications as merely pragmatic conventions:

Nature makes many particular things, which do agree with one another, in many sensible qualities, and probably too, in their internal frame and constitution: but 'tis not the real essence that distinguishes them into species; 'tis men, who, taking occasion from the qualities they find united in them, and wherein, they observe often several individuals to agree, range them into sorts, in order to their naming, for the convenience of comprehensive signs. (Locke 1997: 412)

However, it is the reproduction and nutrition of living beings that have always given us reason to believe that there are real species: for it is in these processes that the otherwise abstract logical and

²¹ I venture to call it infamous, because it not only proved seminal for eighteenth-century epistemological thought, but has equally taken up a central place in the late twentieth-century debate on natural kinds since John Mackie (1974) recognized the concept of a natural kind as espoused by Saul Kripke and Hilary Putnam in Locke's "real essence" or "inner constitution". Since then, the interpretation of Locke's position has become inextricable from the debate on realism and nominalism, with many using it "as a foil in framing their own account of natural kinds" (Stuart 1999: 278).

metaphysical categories seem to have causal efficacy. Members of one species but rarely interbreed with members of other species, and if they do, this rarely produces offspring, or at least viable or fertile offspring. Moreover, it is clear that members of one species invariably produce members of the same species. Finally, consumed organic material of members from other species is clearly assimilated to the form and function of the consumer. It is in all likelihood this observation that has inspired the Aristotelian logical framework. Locke, however, does not agree with this picture. Indeed, he cites the phenomenon of teratogeny (1997: 401) as an indicator that offspring does not invariably take after its parents, and goes on to deny the “fact almost as striking as the diversity [of life] itself. This is the discontinuity of the variation among organisms” (Dobzhansky 1951: 4):

in all the visible corporeal world, we see no chasms, or gaps. All quite down from us, the descent is by easy steps, and a continued series of things, that in each remove, differ very little one from the other. There are fishes that have wings, and are not strangers to the airy region: and there are some birds, that are inhabitants of the water; whose blood is cold as fishes, and their flesh so like in taste, that the scrupulous are allowed them on fish-days. There are animals so near of kin both to birds and beasts, that they are in the middle between both: amphibious animals link the terrestrial and aquatic together; seals live at land and at sea, and porpoises have the warm blood and entrails of a hog, not to mention what is confidently reported of mermaids, or sea-men. There are some brutes, that seem to have as much knowledge and reason, as some that are called men: and the animal and vegetable kingdoms, are so nearly joined, that if you will take the lowest of one, and the highest of the other, there will scarce be perceived any great difference between them; and so on till we come to the lowest and most inorganic parts of matter, we shall find everywhere,

that the several species are linked together, and differ but in almost insensible degrees. (Locke 1997: 399-400)

The idea that nature as it is dealt with in natural history undermines rather than supports the concept of species, as well as the differentiation of hierarchical levels accompanying it, would equally find its way in the writings of the *philosophes*. In this light, the following passage from D'Alembert should not come as a surprise:

Deux inconvénients arrêtent ou retardent le progrès des connaissances humaines ; le peu de vérités auxquelles nous pouvons atteindre, et le défaut d'enchaînement entre les vérités connues. Ces deux inconvénients se font sentir plus ou moins, selon la nature des objets sur lesquels roulent ces vérités. [...]

A l'égard des vérités que nous avons appelées isolées et flottantes, et qui ne tiennent ou ne paraissent tenir à aucune autre, ni comme conséquence, ni comme principe, ce n'est guère que dans la physique, et principalement dans l'histoire naturelle, que nous pouvons en trouver des exemples. Elles consistent surtout dans certains faits que l'expérience nous découvre, et qui paraissent, contre notre attente, n'avoir aucune analogie avec les faits qu'on observe constamment dans la même espèce ; par exemple, la qualité sensitive dans certaines plantes, ou du moins les effets apparens de cette qualité sensitive, propriété qui paraît refusée à toutes les autres plantes, et bornée presque uniquement aux seuls êtres animés; la multiplication de certains animaux sans accouplement; la reproduction des jambes des écrevisses lorsqu'elles sont coupées; l'industrie dont certains animaux, certains insectes même, paraissent doués préférablement aux autres ; en un mot, les propriétés particulières que nous observons dans un certain genre d'êtres physiques, et qui semblent contraires à celles des autres êtres du même genre. On peut donc définir les vérités isolées dont il s'agit ici, *des vérités particulières qui font ou*

semblent faire exception à des vérités générales. (D'Alembert 1821: 135-137)

Our attempts at dividing nature into species are thwarted by the variety of peculiar phenomena to which 17th and 18th century studies had attached so much importance, such as regeneration and sensibility. The very idea of a porphyrian tree thereby loses much of its *prima facie* appeal:

Quoi qu'il en soit, celui de tous les arbres encyclopédiques qui offrirait le plus grand nombre de liaisons et de rapports entre les sciences, mériterait sans doute d'être préféré. Mais peut-on se flatter de le saisir? la nature, nous ne saurions trop le répéter, n'est composée que d'individus qui sont l'objet primitif de nos sensations et de nos perceptions directes. Nous remarquons, à la vérité, dans ces individus, des propriétés communes par lesquelles nous les comparons, et des propriétés dissemblables par lesquelles nous les discernons : et ces propriétés désignées par des noms abstraits, nous ont conduits à former différentes classes où ces objets ont placés. Mais souvent tel objet qui, par une ou plusieurs de ses propriétés, a été placé dans une classe, tient à une autre classe par d'autres propriétés, et aurait pu tout aussi bien y avoir place. Il reste donc nécessairement de l'arbitraire dans la division générale. L'arrangement le plus naturel serait celui où les objets se succéderaient par les nuances insensibles qui servent tout à la fois à les séparer et à les unir. Mais le petit nombre d'êtres qui nous sont connus, ne nous permet pas de marquer ces nuances. L'univers n'est qu'un vaste océan , sur la surface duquel nous apercevons quelques îles plus ou moins grandes , dont la liaison avec le continent nous est cachée. (D'Alembert 1821: 45-46)

As D'Alembert makes clear, overcoming this difficulty will require the completion of the chain of ideas and of phenomena linking everything. There is ample reason to believe that the popularity of this anti-Linnaean view of nature reached the *encyclopédistes* through Buffon,

or at least through his pupil Daubenton (cf. Llana 2000). Buffon was, indeed, notorious for his attack on the systematic ordering of species after Linnaeus' fashion that was taking Europe by storm, and equally relied on the idea of a chain of being in order to do so²². The connection with Buffon brings forth an important issue regarding the precise status of this linear order, for some (e.g. Sloan 1976) interpret him as differing from Locke in his ultimate espousal of a form of realism, especially with respect to his notorious species notion. Far from denying that there are no species in reality, Buffon goes on to affirm:

Un individu est un être à part, isolé, détaché, et qui n'a rien de commun avec les autres êtres, sinon qu'il leur ressemble ou bien qu'il en diffère : tous les individus semblables, qui existent sur la surface de la terre, sont regardés comme composant l'espèce de ces individus ; cependant ce n'est ni le nombre ni la collection des individus semblables qui fait l'espèce, c'est la succession constante et le renouvellement non interrompu de ces individus qui la constituent ; car un être qui dureroit toujours ne feroit pas une espèce, non plus qu'un million d'êtres semblables qui dureroient aussi toujours : l'espèce est

²² "En approfondissant cette idée, on voit clairement qu'il est impossible de donner un système général, une méthode parfaite, non seulement pour l'Histoire Naturelle entière, mais même pour une seule de ses branches ; car pour faire un système, un arrangement, en un mot une méthode générale, il faut que tout y soit compris ; il faut diviser ce tout en différentes classes, partager ces classes en genres, sous-diviser ces genres en espèces, et tout cela suivant un ordre dans lequel il entre nécessairement de l'arbitraire. Mais la Nature marche par des gradations inconnues, et par conséquent elle ne peut pas se prêter totalement à ces divisions, puisqu'elle passe d'une espèce à une autre espèce, et souvent d'un genre à un autre genre, par des nuances imperceptibles ; de sorte qu'il se trouve un grand nombre d'espèces moyennes et d'objets mi-partis qu'on ne sçait où placer, et qui dérangent nécessairement le projet du système général : cette vérité est trop importante pour que je ne l'appuie pas de tout ce qui peut la rendre claire et évidente." (Buffon 1749a : 13)

donc un mot abstrait et général, dont la chose n'existe qu'en considérant la Nature dans la succession des temps, et dans la destruction constante et le renouvellement tout aussi constant des êtres : c'est en comparant la Nature d'aujourd'hui à celle des autres temps, et les individus actuels aux individus passés, que nous avons pris une idée nette de ce que l'on appelle espèce, et la comparaison du nombre ou de la ressemblance des individus n'est qu'une idée accessoire, et souvent indépendante de la première. (Buffon 1749b: 384-385)

Close inspection of this passage reveals that Buffon applies the idea of a chain of ideas in natural history, and adopts a more Lockean conception of abstract unity as residing in the continuity between various steps in a linear succession²³. In this way, his very interpretation of the concept of a species adopts the new Enlightenment logic, and shows that the linear order was now the major source of truth.

In contrasting two conflicting conceptions of systematic order, namely a hierarchical and discontinuous one and a linear and continuous one, I have seemingly glossed over the many passages in the writings of the Encyclopedists where the invocation of other metaphors challenges both linear and hierarchical structure. In the *Discours Préliminaire*, D'Alembert gives us the images of a labyrinth and of a world map. These images are far from linear, and represent instead the simultaneity of diverging linear sequences (Cf. Moser 1976: 726; Hayes

²³ This position is meant to respond to both the interpretation of Sloan and that of Eddy. Sloan (1987) likens Buffon's notion of species as repetition and reproduction to Harvey's circular conception of a species. I take issue with this because I believe that Buffon's successive modulation is decidedly different from Harvey's circular repetition. Eddy (1994: 650), on the contrary, argues that according to Buffon "[s]pecies, although manifesting themselves in temporal succession, remain single living wholes, that is, reproductions of prototypes and independent of time". I would like to suggest that this assessment is due to a misinterpretation of Buffon's conception of logic and abstraction.

1999: 40). This has given rise to the idea that the model of the encyclopedia is somehow more tolerant, more pluralist, more receptive to contingency, than either the hierarchic or the linear model. I believe, however, that this is largely a misinterpretation: the labyrinthine structure of reality is not essential, but a product of the limitations of human understanding. Here too, the *philosophes* are merely echoing their cherished Bacon, who wrote the following over a century earlier:

The universe to the eye of the human understanding is framed like a labyrinth; presenting as it does on every side so many ambiguities of way, such deceitful resemblances of objects and signs, natures so irregular in their lines, and so knotted and entangled. (Bacon 1878: 18)

To Bacon, the deceitful character is due only to the biases (the idols) of the human mind which keep it from following experience and nature closely, and thereby lead to gross representations. What one desires, then, is an overview of the labyrinth in terms of various itineraries, i.e. linear chains, each of which can later on be integrated in the total chain of ideas. The chaos is only provisional, and subsists in the absence of the relevant links that make the world one harmonious whole. For now, we have but few and disparate links, which gives us little clue as to where they belong. A more complete knowledge, however, will soon resolve the ambiguity and present us with the true system of nature. What we need, above all, is a thread with which to find our way out of the Labyrinth that threatens to devour the children of Athens: a single true itinerary.

5 Conclusion: the Spontaneous Generation of Knowledge

In this paper, I have tried to show how Enlightenment epistemology converged upon a new conception of system that is one-dimensional and continuous, and explicitly dismissed the idea of a discontinuous and hierarchical system. It argues against the latter that it introduces abstruse conceptual distinctions where nature presents only continuity, erects borders where there are only coastlines broadening and narrowing with the tides and distinguishes levels where there is only the immanence of nature and truth. Tempted as we are to celebrate this, we overlook the other implication that, in the Enlightenment, we find no respect for the many layers of complex organization. Instead, we find immanence, equivocation and one-dimensional ordering. Only when unspoiled by human intervention, will the linear continuity spontaneously set itself in the right order and organize itself into the one true picture of the world. Induction, then, requires no logic or functions, but mere amassing of data. This is what Kant (1998: B 167) saw when he likened empiricism to the biological position that endorses a form of spontaneous generation –the position, not coincidentally, that we find in both Buffon and Diderot (Cf. Kant 2002: AA II, 114). The ultimate organization of knowledge into a system is relegated to quasi-mystical analogs of pseudo-Newtonian forces. This is not the progressivist idea that further investigation will fill in the blanks of our worldview, but the idea that further increase of data will lead to a reorganization of the line or sequence into new structures. Ultimately, these labyrinthine ephemera will give way to the one true structure, which will answer all relevant questions. If science is to allow for this, it must be impartial, and therefore indifferent towards individual talent. This is the true face of Baconian science: the institutional entrenchment of the Modern culture of Knowledge as a

collaborative, industrial effort. If we embrace such a view, we should patiently and with resignation continue to produce knowledge, while waiting for the Godot of spontaneous generation that will reveal its meaning. Or we could turn towards the complexity that we, perhaps, mistook for old-fashioned hierarchical metaphysics and idealist equivocation.

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