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VEGETAL AGENCY: THE SAP CONTROVERSY IN EARLY EIGHTEENTH-CENTURY FRANCE TREATISES ON PLANTS AND GARDENING

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This article examines how the apologetics of the abbé Noël-Antoine Pluche (1688–1761) impacted his presentation of botanical knowledge in the ten dialogues published in the first and second volumes of his natural history book *Le Spectacle de la nature* (1732–1750). Pluche popularized a conception of the physical world where plants are reducible to inert mechanisms, devoid of life and agency. First, I examine the various intertwinements of science and theology in his depiction of plant anatomy, by investigating his use of mechanical analogies, his adoption of the sap circulation hypothesis, and his application of the pre-existence theory to account for both generation and vegetative multiplication. I then compare Pluche's understanding of plant growth with those offered by contemporaneous gardening treatises, demonstrating that part of Pluche's project included opposing the materialist and animist undertones found in these gardening treatises that emphasized vegetal life, self-organization, and sap agency.

Keywords: sap circulation hypothesis; plant growth; natural theology; early Enlightenment France; gardening treatises

With *Le Spectacle de la nature, ou Entretiens sur les particularités de l'histoire naturelle qui ont paru les plus propres à rendre les jeunes gens curieux, et à leur former l'esprit* (9 vols, 1732–1750), the abbé Noël-Antoine Pluche (1688–1761) became the most well-known proponent of physico-theology and a major popularizer of natural history in eighteenth-century France.[1] This 'popular Christian encyclopedia', in Gipper's apt words, focused on man in relation to the divine, and gave animals pride of place in its depiction of nature as a perfect work of art.[2] In the chapters concerning plants, Pluche's primary intention was, as in other chapters, to show God's hand in the anatomy of plants, in the diversity of the

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1 Noël-Antoine Pluche, *Le Spectacle de la nature* (Paris, 1732), vol. 1, was translated into English as *Spectacle de la nature, or Nature Display'd. Being Discourses On Such Particulars of Natural History, as Were Thought Most Proper to Excite the Curiosity, and Form the Minds of Youth* (transl. S. Humphreys), 7th edn (London, 1750). All references to the *Spectacle* are to this translation, unless noted.

2 Andreas Gipper, 'Vulgarisation scientifique et physico-théologie en France. *Le Spectacle de la nature* de l'abbé Pluche', in Lise Andries (dir.), *Le Partage des savoirs* (Presses Universitaires de Lyon, Lyon, 2003), pp. 21–34, at p. 27.

vegetable kingdom, and in the beauty of flowers. Accordingly, many studies have focused on Pluche's apologetics, his mechanistic explanatory system, and his providentialism, inspired by Bernard Nieuwentijt (1654–1718), William Derham (1657–1735), and Noël Regnault (1683–1762).[3] Few, however, have examined the ideological inflection that Pluche gave to his restitution of botanical knowledge. This study hopes to fill this gap by asking how his natural theology is perceptible in his presentation of plant science (a vague term deliberately chosen to include systematics, anatomy, physiology, agronomy, gardening, and the care of fruit trees), framed as ten dialogues on plants in the first and second volumes of *Le Spectacle de la nature*. My focus will lead us to examine how Pluche based his understanding of plants' physiology and anatomy on Cartesian mechanism and the pre-existence theory, which he deemed well suited to underpinning his *botanico-theology*.[4]

However, as such an investigation would far exceed the scope of this study, we will narrow our focus on sap. In the early eighteenth century, sap agency was a matter of controversy. Whereas sap circulation was debated by plant anatomists, another point of contention, briefly evoked by Pluche and correlated to the sap circulation hypothesis, has so far received little critical attention. Let us call it the growth-by-sap problem: sap would be directly involved in growth by exuding and freezing upon contact with the air, thus creating new plant parts. Such a view would dispute (1) the sap circulation conjecture, since it assumes that vegetal bodies are open systems, (2) the pre-existence theory, according to which plants are completely predetermined in the seed. In Pluche's *Spectacle de la nature*, the problem of sap-induced growth is raised in the immediate context of vegetative propagation, a vegetal faculty of great interest to gardeners, since they propagated fruit trees by suckers, cuttings, and grafts. In the years 1650–1750, gardening treatises were extremely popular, most notably the various works on fruit trees by the gardener Jean de La Quintinie (1626–1688), and the *Curiositez de la Nature* by Pierre Le Lorrain de Vallemont (1649–1721).[5] Many of these treatises were compilations of conjectures, theories, experiments, and observations. They were regularly updated, as evidenced by the large number of re-editions. However, since past versions were never entirely expurgated from these re-editions, potentially conflicting explanations and distinct epistemological models could coexist in the same text. Consequently, the vestiges of the cosmology and the understanding of nature elaborated in the first editions persisted into the eighteenth century. In this context, we will examine how plant knowledge in gardening treatises differed from Pluche's presentation of plant growth in *Le Spectacle*. In the first part of this study, we will sketch out Pluche's depictions of sap functions and trajectories

3 B. Nieuwentyt, *Existence de Dieu démontrée par les Merveilles de la Nature* (1725); G. Derham, *Théologie physique* (1725); N. Regnault, *Entretiens physiques d'Ariste et d'Eudoxe* (1729); see especially the studies directed by Françoise Gevrey, Julie Boch and Jean-Louis Haquette in *Écrire la nature au XVIII^e siècle. Autour de l'abbé Pluche* (Presses de l'Université Paris–Sorbonne, Paris, 2006). See also Nicolas Brucker, 'What Abbé Pluche owed to early modern physico-theologians', in A. Blair and K. von Greyerz (eds), *Physico-theology: religion and science in Europe, 1650–1750* (Johns Hopkins University Press, Baltimore, 2020), pp. 183–193; Benoît de Baere, *Trois introductions à l'abbé Pluche: sa vie, son monde, ses livres* (Droz, Genève, 2001); D. Trinkle, 'Noël-Antoine Pluche's *Le Spectacle de la Nature*: an encyclopaedic best seller', *Stud. Voltaire Eighteenth Cent.* **358**, 93–134 (1997).

4 For an in-depth investigation into Descartes' botanical interest, see Fabrizio Baldassarri, 'The mechanical life of plants: Descartes on botany', *Br. J. Hist. Sci.* **52**, 41–63 (2019).

5 Jean de La Quintinie, *Instruction Pour les Jardins Fruitiers et Potagers, avec un Traité des Orangers et des Réflexions sur l'Agriculture. Avec une Instruction sur la Culture des Fleurs*, 2 vols (Paris, 1690) was translated into English as *The Compleat Gard'ner; or Directions for Cultivating and Right Ordering of Fruit-Gardens and Kitchen-Gardens; with Divers Reflections on Several Parts of Husbandry* (transl. John Evelyn) (London, 1693). Le Lorrain de Vallemont, *Curiosities of Nature and Art in Husbandry and Gardening* (London, 1707). All references are to these translations, unless noted.

in plants, and interpret them noting his references to Malebranche and other sources. In the second part, we will further examine what images other popularizers and gardeners, such as Le Lorrain de Vallemont and La Quintinie, gave to sap motion, and to grafting and cutting. What views did they hold that led Pluche to oppose his own theological botany to their plant knowledge?

Vegetal inertia

As evident by the subtitle, *Entretiens sur les particularités de l'histoire naturelle qui ont paru les plus propres à rendre les jeunes gens curieux, et à leur former l'esprit*, Pluche's first aim was to educate youth, and his chosen format, dialogues between gentry members, was borrowed from the conversation model of polite society dominant in the late seventeenth and early eighteenth centuries. To avoid any critique of pedantry, Pluche erased all marks of erudition and occurrences of Latin. References to scholarly works were kept minimal so as not to obstruct the flow of the conversation occurring between a Prior, a young Chevalier, a Count, and a Countess. Finally, Pluche rejected excessive expressions of wonder: his protagonists always show moderation, good taste, and reason, even when they are marvelling at the complex organization of natural beings. Pluche did not encourage in-depth inquiries of the natural world. In the preface, he clarified the notion of the spectacle of nature 'which only implies the Exterior, or what strikes the sense'.[6] Pluche exhorted his readers to remain at the surface of things:

> [W]e think it better becomes us to content ourselves with the exterior Decoration of the World, and the Effect of those Machines which constitute the Prospect. Here, we have Access, and may even see that it was arrayed with so much Splendor, in order to excite our Curiosity. But then, satisfied with a Survey that abundantly fills our Senses and Imagination, it is not necessary that we should require the secret pavilion of the Machines to be unfolded to our View.[7]

In Pluche's natural theatre, all phenomena are produced by mechanisms with the only animation coming from the divine will that intervenes in the most minute affairs. It is no surprise that in Pluche's rendition of the world, plants are, like stage props, inert machines. Pluche's exposé of plants is strictly based on mechanical processes. Trees are complex mechanisms, midway between hydraulic systems and pneumatic machines. Moreover, Pluche is careful not to contradict his thought with his style, as one could note in the French translation of Derham's *Théologie physique*.[8] Contrary to his predecessor, he refrains from personifying nature, and avoids making it the grammatical subject of active verbs. In his description of plant inner functions, the mechanical terminology is no mere rhetorical device when Pluche insists on air elasticity (springs) as the major cause of sap flows. In comments informed by Nehemiah Grew (1641–1712), Marcello Malpighi (1628–1694), and John Ray (1627–1705), one of Pluche's discussants endeavours to trace the sap

6 Pluche, *Spectacle*, *op. cit.* (note 1), p. x.

7 *Ibid.*, pp. x–xi.

8 Guillaume Derham, *Théologie physique ou Démonstration de l'existence et des attributs de Dieu, tirée des œuvres de la Création, accompagnée d'un grand nombre de Remarques et d'Observations curieuses* (transl. Jacques Lufneu) (Chaubert, Paris, 1732).

itineraries using the circulatory model.[9] William Harvey (1578–1657) had demonstrated that blood pumped by the heart moves in a circular fashion in a closed system. Andrea Cesalpino (1524–1603), author of the influential *De Plantis libri XVI* (1583), had led the way by establishing that plants are structurally analogous to animals. He conjectured that tree sap ascends from the roots to the branches and returns to the demarcation between the roots and the shoots, where he precisely located the vegetal heart. In 1667, Claude Perrault (1613–1688) declared his intention to present evidence of sap circulation. He was unable to complete his project, as was Edmé Mariotte (1620?–1684) who failed to provide definitive results in his 1679 essay on plant vegetation.[10] Since then, the expression 'sap circulation' has endured and is used in today's French as a catachresis, i.e. a metaphor so common that it has lost its analogical power, at least as a technical term.[11] In his 1709 review of the latest research, Fontenelle recounted the diverging views about sap circulation among E. Mariotte, Cl. Perrault, Johann Daniel Major (1634–1693), M. Malpighi, Pierre Magnol (1638–1715), and Denis Dodart (1634–1707), noting that everyone agreed on sap dual motion, but the question of circulation remained open.[12] John Ray expressed doubts about sap circulation in 1691. In 1727, the decisive work of Stephen Hales (1677–1761) empirically proved the ascent of raw sap in vessels. Hales demonstrated that the roots sucked water from the ground. Moreover, he showed that the pull exerted on sap by evapotranspiration through the leaves, combined with capillary action, made the sap flow upward. Yet he rejected that sap circulated in plants like blood does in animals.[13] In 1758, Henri-Louis Duhamel du Monceau (1700–1782) reconsidered all opinions and judged the matter not yet settled.[14] In 1765, in the article 'Sève' in the *Encyclopédie,* Louis de Jaucourt (1704–1780), relying on Hales' authority, categorically denied any semblance of truth to the circulatory hypothesis. In supporting the circulation system, Pluche was therefore adopting a position that was still controversial in 1735. What could his motivations have been, given that he generally avoided disseminating science that had not been duly validated by consensus? We contend that sap circulation corroborates the concept of organism as closed system, and supports the Cartesian postulate that matter can be extended but not created. Both pre-existence and conception of growth as expansion of pre-formed germs are the main components of Pluche's explanation of plant anatomy.[15]

The theory of pre-existing germs, which partly derived from the observations of Antonie van Leeuwenhoek (1632–1723), Nicolaas Hartsoeker (1656–1725), and Jan Swammerdam (1637–1680), was given its most authoritative formulation in France by Nicolas Malebranche

9 See F. Baldassarri, 'Plants and laboratories: the ascent of sap between physics and vegetal physiology' (this issue).

10 Mariotte, 'Premier Essay: De la Vegetation des Plantes', in *Essays de Phisique, ou Memoires pour servir à la sciences des choses naturelles* (Estienne Michallet, Paris, 1679), pp. 1–179. René Heller, 'Mariotte et la physiologie végétale', *Mariotte, Savant et philosophe (†1684), Analyse d'une renommée* (Vrin, Paris, 1986), pp. 185–203.

11 The use of 'sap circulation' as a catachresis has been rarely noticed until now. The English usage favours the locutions sap ascent, sap flow, or sap motion. For more information about the history of the theory of sap motion, consult N. Hopwood, S. Müller-Wille, J. Browne *et al.*, 'Cycles and circulation: a theme in the history of biology and medicine', *Hist. Phil. Life Sci.* **43**, 89 (2021). For a study of cultural and symbolic investment in sap, consult Giulia Pacini, 'Une Sève Nouvelle et pure': tree sap and the regeneration of the nation in French revolutionary discourse and practice', *Eighteenth-Cent. Stud.* **53**, 409–427 (2020).

12 'Sur la circulation de la sève dans les plantes', *Histoire de l'Académie royale des sciences* **1709**, 44–49 (1733).

13 His conclusions were disseminated in France with the translation of the *Vegetable Staticks* by Buffon in 1735. For a recent discussion of Hales' work on sap ascent, see H. R. Brown, 'The theory of sap in trees; some historical and conceptual remarks', *Phys. Perspect.* **15**, 320–358 (2013), at pp. 14–17.

14 Henri-Louis Duhamel du Monceau, 'Discussion sur la sève des arbres', *La Physique des arbres* (Paris, 1758), pp. 312–326.

15 Jacques Roger, *Les Sciences de la vie dans la pensée française au XVIIIe siècle. La génération des animaux de Descartes à l'Encyclopédie* (Albin Michel, Paris, 1993), pp. 334ff.

(1638–1715).[16] After examining a bulb and seeing a minute tulip already dotted with leaves and buds, he deduced that seeds contain the plant in miniature and he applied it to all future plants to come. Accordingly, Pluche argues that an all-powerful God could have engaged in creation 'whenever it should be necessary to substitute a new one in the Room of another, that Age had decayed' but preferred to create everything 'at once' 'for all Successions of Ages' by inserting new generations inside the seed of the first tree.[17] In this cosmogonic tale, which echoes the Augustinian motto *Deus creavit omnia simul*, all seeds only needed the earth liquors to swell and grow in size. External factors such as temperature and humidity put the dormant pre-formed seed in motion and prompt its growth.[18] In short, 'God alone formed all germs from the beginning and it is earth sap that develops and nourishes them by circulating within them, and it is air that impels the circulation.'[19]

The problem of plant cuttings

For plant cuttings, however, the growth of a whole plant from a fragment could be evidence of an agent or living principle. If this were the case, one would be forced to admit that sap does not only swell already existing parts, but it also creates them. When plant cuttings grow into whole plants, where and how do they find the missing parts if not in the soil and the sap? One of the protagonists wondered about this possibility: 'Nevertheless I find myself embarrassed by layers and cuttings. … If sap can give roots to a tree, what prevents us from saying that it can also provide a stem and a top, leaves and fruits?'[20] If sap were to produce trees out of cuttings, these new plants would not be included in God's creation. An identical issue regarding monsters arose during the same period, prompting heated debates among the members of the Royal Academy of Sciences.[21] As is true with monsters, vegetative multiplication would be an accident and thus would elude the programmatic nature of seed-based cosmology.[22]

Pluche had several answers for what was, presumably, a strong objection. He extended Malebranche's theory of pre-existing germs and used it to comprehend all buds, and argued that cuttings were born out of invisible germs covering the entire surface of plants. Pluche relied on the authority of Dodart who extrapolated on the pre-existence of seeds in plant buds.[23] When removing a bud or a branch to grow a fruit tree, the gardener was effectively planting the equivalent of a seed. Pluche did not distinguish between embryos, seeds, or meristems, and his metaphorical use of 'seed' added confusion to the

16 Nicolas Malebranche, *Recherche de la vérité Où l'on traite de la nature de l'esprit de l'homme et de l'usage qu'il en doit faire pour éviter l'erreur dans les sciences* (ed. J.-C. Bardout), book I, chap. VI (Vrin, Paris, 2006; first published 1674–1675). See K. Detlefsen, 'Supernaturalism, occasionalism, and preformation in Malebranche', *Perspect. Sci.* **11**, 443–483 (2003).

17 Pluche, *Spectacle*, *op. cit.* (note 1), p. 250. See Malebranche, *op. cit.*, at p. 158.

18 For the theories of preformation and pre-existence, consult Karen Detlefsen, 'Biology and theology in Malebranche's theory of organic generation', in *The life sciences in early modern philosophy* (ed. Ohad Nachtomy and Justin E. H. Smith), pp. 137–156 (Oxford University Press, 2014). Laura Bossi, *Histoire naturelle de l'âme* (Presses Universitaires de France, Paris, 2003); François Duchesneau, *Les Modèles du vivant de Descartes à Leibniz* (Vrin, Paris, 1998).

19 Pluche, *Spectacle* (1733), *op. cit.* (note 1), p. 429 (my translation).

20 *Ibid.*, pp. 433–434 (my translation).

21 The debate on teratogenesis pitted Duverney and Winslow against Lémery between 1724 and 1743.

22 The rich conceptual field of plant cloning has recently spurred new interdisciplinary studies. See, for example, Sophie Gerber, 'An herbiary of plant individuality', *Phil. Theor. Pract. Biol.* **10**, 1–24.

23 D. Dodart, 'Second mémoire sur la fécondité des plantes. Conjectures sur ce sujet', *Histoire de l'Académie royale des sciences* **1701**, 241–257 (1743).

understanding of plant reproduction. Mostly he used the term 'germ' to encapsulate all invisible potential beings, assumed to be minuscule versions of their future developed selves. Consequently, plants were deemed fantastically fertile. Vegetal fecundity had become a recurrent theme in gardening treatises and scientific works, and authors extolled the prudence and management of divine providence in providing mankind with infinite germs and inexhaustible natural resources.

Le Spectacle de la nature taught its readers that germs are miniature forms waiting to be filled and enlarged by sap. As Pluche sums it up, sap 'feeds what it finds all formed, but it forms nothing.'[24] Plants are closed systems, whose lineaments were designed by God at the dawn of time. Therefore, to open up these systems to chance, to movements of matter, would be, in Pluche's perspective, to deny the fundamentals on which his exposition of nature is based. In all these arguments, Pluche does follow a path that his predecessors had already taken. However, he goes further than Regnault, Nieuwentijt, or Derham when he insists on the theological scandal that such a position entails. Sap, if not channelled into fibrous canals, would directly challenge divine authority. This is why Pluche adamantly insists on sap's lack of agency and summons theological reasons to support his denegation:

> In reality if the Juice of the Earth could produce plants, it must be endued with all the Omnipotence of the Creator, in order to give an instantaneous Existence to … all the Parts of a Plant, as the Bark, the Wood, the Pith, the Buds of Branches, Flowers, and Fruits. This juice must be gifted with Intelligence to be capable of such a Variety of Operations, and never by Mistake to cause one Plant to produce the Germs and Fruits of another Species.[25]

All of those who believe that plants can be formed by sap are at risk of confusing God with Nature, as one of the protagonists states: 'I am not able to comprehend how anyone can think the Earth qualified to form the body of a Plant. I would as soon say, it had produced mankind, and even the moon and sun.'[26] The rhetorical device of *adynaton* turns this statement into an absurd proposition. If sap could produce the smallest blade of grass, then it would equal God. Pluche's conclusion is irrevocable: sap or buds are inert matter deprived of movement and life; Creation is the prerogative of the divine. The combativeness of his rhetoric highlights the apologetical aspect of *Le Spectacle de la nature* and Pluche's desire to educate readers. However, an important question remains unanswered: whom was he contradicting? This brief passage is noteworthy for its discordance with the rest of his chapters on plants: the image of the earth creating the sun and the moon borrows from the fantastic register that Pluche is usually keen to avoid. The image does not come from his sources and is nowhere to be found in Derham's fervent extolment of natural wonders, Nieuwentijt's vindicative rhetoric against atheists, or Regnault's measured explanations of vegetal phenomena. Pluche never names his opponents. He probably would have referred to them as 'sceptics', 'Pyrrhonians' or 'Epicureans', to mention the epithets that his predecessors Regnault and Nieuwentijt used. These appellations are, however, extremely general and unrelated to the specific format of Pluche's chapters on plants.

24 Pluche, *Spectacle* (1733), *op. cit.* (note 1), vol. 1, p. 430 (my translation).
25 *Ibid.*, p. 249.
26 *Ibid*.

Pluche's presentation of plants shares many formal affinities with the gardening treatise genre. While the fourteenth and fifteenth dialogues deal with plant growth and reproduction, the first eight dialogues in the second volume include considerations on the beauty and flowering periods of plants, suggestions about the size and orientation of the garden, and lessons on grafting and pruning. In the 1735 edition, Pluche even mentioned consulting with Louis Le Normand (?–1754), director of the vegetable garden at the Chateau de Versailles, and Bernard de Jussieu (1699–1777), botanist at the royal botanical garden in Paris. In fact, the ten chapters that Pluche wrote about the vegetable kingdom are indeed akin to a short handbook on the theory and practice of gardening.[27]

The period in question, 1650–1750, was marked by a boom in publications on gardening, and arboriculture, which aimed to satisfy readers' curiosity about trees, vegetables, and flowers.[28] The *Instruction Pour les Jardins Fruitiers et Potagers* by La Quintinie first appeared in 1690, but it remained authoritative for most of the eighteenth century. The *Curiositez de la nature et de l'art sur la végétation: ou l'agriculture et le jardinage dans leur perfection* (1705) by Pierre Le Lorrain de Vallemont (1649–1721) was reprinted 12 times in the first half of the eighteenth century and provided extensive information about plant anatomy and physiology, and on improvements to horticultural and agricultural practices. Antoine-Joseph Dezallier d'Argenville (1680–1765) published *La Théorie et la pratique du jardinage* in 1709, and his work remained extremely influential through his contributions to the *Encyclopédie*. This list of treatises does not pretend to be exhaustive.[29] These well-informed publications are mostly compilations of the available current knowledge, with traditional advice on gardening and plant care, combined with past and recent scientific discoveries. Pluche owned several of these works, as seen in the catalogue of his books.[30] In the following pages, we focus on La Quintinie and Vallemont, because their treatises were not mere collections of practical advice on plant cultivation. They also included conjectures and demonstrations related to plant anatomy and physiology. Both provided eclectic sources of where to find views reflecting animism or materialism.[31] Our juxtaposition of two distinct philosophical trends calls for an explanation. Diverging from Pluche's cosmology with a clear demarcation separating mind from matter, gardening treatises presented plants as embodiments of a vital principle, or enmeshments of matter and spirit. Hence, either the vegetal realm possibly served as evidence of a materialist understanding of nature, with all functions reducible to material properties or, conversely, plant growth and production attested to the existence of a soul diffused in the physical world. These two trends are not always easy to untangle as they are rarely theorized, but perceptible mainly through tropes and formulaic phrases.

27 Pluche, *Spectacle* (1735), *op. cit.* (note 1), vol. 2, p. 47.

28 Florent Quellier, *Des fruits et des hommes. L'arboriculture fruitière en Île-de-France (vers 1600–vers 1800)* (Presses Universitaires de Rennes, Rennes, 2003).

29 For a detailed overview of the major works, consult Chiara Santini, 'L' 'arte' del giardino nell'Europa di età moderna: ipotesi di lavoro e prospettive di ricercar', 2009 Projets de paysage. *Revue scientifique sur la conception et l'aménagement de l'espace*.

30 *Extrait du Catalogue des livres de feu M. l'abbé Pluche, dont la vente se fera en détail, au plus offrant & dernier enchérisseur. Le lundi 24 janvier 1763, & jours suivans, en une salle du Couvent des Grands Augustins* (Frères Estienne, Paris, 1763), in Benoît de Baere, *op. cit.* (note 3), pp. 136–176.

31 Our broad understanding of animism owes much to B. Demarest, J. Regier, and C. Wolfe, who defined it as 'the position that the soul, along with its various faculties and powers, is integral to the functioning of nature as a whole, or to the functioning of some natural entities', Introduction, 'Animism and its discontents. Soul-based natural philosophy and medicine,' *HOPOS* **11**, 494–501 (2021), at p. 494.

Protean sap

When Le Lorrain de Vallemont refers to 'the juices of the earth', it is not certain whether he means that plants each have their own juice, or whether they filter the earth's liquid to obtain the nourishment they specifically require.[32] Van Helmont had concluded through experiments that plants produced their own substance. He had also observed that, during the expansion of plant parts, no weight loss occurred in the soil where a willow grew, and that water alone provided nutrition. As for growth, scholastics had elaborated two models: the *per juxtapositionem* mode, when new layers of matter are added to a core; and the *per intussusceptionem* mode, when nutritive elements travel through canals to a minute portion of the body part, then forming aggregates of matter. The first mode was used to conceptualize the minerals' growth, and the second, the vegetation's.[33] However, this mode of growth was based on the assumption that plant forms remained stable throughout their lives. The practice of pruning and observations of trees in the real world sufficed to conclude that, unlike animals, plants' shapes are not entirely predetermined.

Perhaps this is why Nicolas Dedu (16?–?), a Montpellier physician and the author of a treatise on the soul of plants, developed a variation on intussusception for plants to account for the growth of new branches.[34] The nourishing liquor ascends in the tree and fills in the pores. The superfluous sap flows out after reaching the stem extremity, through any openings; then it freezes, or coagulates, and thereby forms the beginnings of new shoots, fruits, and flowers. Dedu's presentation of vegetal growth had theoretical consequences. He described plants as agents of their own becoming by diminishing the role of pre-formed germs and insisting on the epigenetic model. Growth, far from being predetermined by a seed, as in the pre-existence theory, is left to chance, either by a surplus of nourishing liquor, as Dedu imagined, or by any environmental contingency. In sum, he proposed that plants function as open systems. Little is known about Nicolas Dedu but the fact that his short essay was published with Grew's *Anatomy of plants* in 1685 may be a sign of his affinities with the English naturalist's early form of vitalism.[35] Dedu quotes Lucretius in the very first pages of his treatise: the balance that he manages to establish between the fixed form of plants as well as the possibility of eventual modifications (through the action of sap) bears the imprint of the atomist cosmology of Epicureanism. His suggestion that motion is intrinsic to matter could signal the influence of Gassendi's thought.[36] Moreover, Dedu criticizes naturalists and physicists who constantly summon the divine every time they are unable to account for natural phenomena[37]—a reproach only too well founded, Dodart acknowledges in 1701. The problem with pre-existence, the latter remarks, is that

> '… it directly takes us back to the miracle of Creation; because generation is impossible without semen or equivalent, i.e. without seed or buds, either everything has been

32 Le Lorrain de Vallemont, *op. cit.* (note 5), p. 37 and p. 67.

33 For a recent critical appraisal, consult Cecilia Bognon-Küss and Boris Desmarets, 'Intussusception', in *Encyclopedia of early modern philosophy and the sciences* (ed. Dana Jalobeanu and Charles T. Wolfe) (Springer, Cham, 2022).

34 Nicolas Dedu, *De l'Ame des plantes, de leur naissance, de leur nourriture et de leur progrez. Essai de physique, par Mr. Dedu, docteur en médecine de la faculté de Montpellier* (Paris, 1682), p. 53.

35 Brian Garrett, 'Vitalism and teleology in the natural philosophy of Nehemiah Grew (1641–1712)', *Br. J. Hist. Sci.* **36**, 63–81 (2003).

36 John Henry, 'Occult qualities and the experimental philosophy: active principles in pre-Newtonian matter theory', *Hist. Sci.* **24**, 335–381 (1986).

37 Dedu, *op. cit.* (note 34), p. 12.

> created from the very beginning or creations are made every day. Physicists rightly consider that introducing God as a *Deus ex machina* is a flaw in a system. This kind of ending, it may be said, is acceptable in plays, when the topic warrants it, but not in a naturalistic discourse.'[38]

All too happy to get rid of the *Deus ex machina* device in his natural philosophy, Nicolas Dedu adopts an active conception of sap as living principle, which possibly harks back to the Lucretian myth of organized beings emerging from the earth's womb. Pluche will berate these same references to Epicureanism and atomism, by maintaining that when material elements combine, they only end up forming a 'heap of confused masses' without 'organs, life nor soul'.[39] For Pluche, life—be it form, soul, or organization—cannot be an attribute of matter.

When discussing vegetation in his *Curiositez de la nature et de l'art sur la végétation*, Vallemont, like Dedu, describes the plant growth model as intussusception.[40] He extolls sap's faculties, insisting: 'This sap is a Proteus, that takes all sorts of forms. It changes itself into Leaves, Flowers, Fruit, Wood, Pitch, Gum, and Resin; and all these things vary according to the difference of Plants, whose Kinds are innumerable.'[41] Vallemont views sap as the main agent of growth, and the earth as the source of all vegetal matter. His discourse on sap power echoes some sort of vitalist monism, mostly perceptible in the celebratory tone and the evocation of 'Proteus'.[42] He puts the emphasis on life imbued by the vegetative soul. Fruits are produced by sap coagulation. The sap effectively becomes the fruit, as he states: 'this sap, coagulated in the Trunk of an Almond tree, would be an Almond'.[43] While recounting ancient anecdotes of peculiar grafts, Vallemont wonders at the mysteries of this art, attributing them to some *lusus Naturae* with other unexplainable and downright marvelous phenomena, and he is keen to assign sap the major role in all of Nature's operations: 'Let us not forget that sap is the cause of all of these bizarre and incomprehensible metamorphoses: or rather, that it alone masks and transfigures itself in so many different forms. What a pleasant spectacle!'[44] The lure of the peculiar ('bizarre'), the taste for metamorphosis, and the analogy with theatricality pull Vallemont into the orbit of early modern aesthetics and natural philosophy. The metaphor drawn from baroque theatre with its unexpected turns of fortune and multiple disguises contrasts with Pluche's *Spectacle* where nature is rendered as flat, one-dimensional and shadowless as befits a world enlightened by God's will. Whereas Pluche understood production as the mere repetition of pre-existing forms, and conflated providentialism with productivism, Vallemont believes in original invention. He credits the earth and its juice (plant sap), with the power of evolving into multiple forms, albeit under the guise of analogies he found in myth, theatre, and alchemy. In Vallemont's account, sap is accordingly the universal agent of material creation. Traces of this hylozoist conception of nature, which attributed agency and life to vegetal matter, endured into the eighteenth century. The comparison of sap with Proteus was copied, for instance, in the 1721 edition of *La Nouvelle Maison Rustique* and

38 Dodart, 'Second mémoire sur la fécondité des plantes. Conjectures sur ce sujet', *Mémoires de l'Académie royale des sciences* **1701**, 241–257 (1743), at p. 256 (my translation).

39 Pluche, *Spectacle* (1750), *op. cit.* (note 1), p. 249.

40 Le Lorrain de Vallemont, *op. cit.* (note 5), p. 49.

41 *Ibid.*, p. 69 with modifications.

42 See Wolfe's clarification in his overview of the many kinds of vitalism: 'Vitalism', in Jalobeanu and Wolfe (eds), *op. cit*. (note 33), pp. 2129–2148.

43 Le Lorrain de Vallemont, *op. cit.* (note 5), p. 72.

44 *Idem*, *Curiositez* (1709), p. 106 (my translation).

even later in its 1743 reprint.[45] However, by adopting the opinion that the congealing sap produces new plants, Vallemont faces another difficulty. While Pluche demonstrated that sap does not produce anything, i.e. is unable to produce new forms, in Vallemont's view, sap can create forms, but it remains unclear whether it can create organic forms. The problem of form conferring life to matter has still to be addressed.

Plants' lust for life

In contrast with Pluche, who never defines plants as living bodies, Vallemont maintains that plants are bodies endowed with life, as stated in the incipit of his chapter on vegetation.

> A plant is a living Body without Sense, annex'd to a certain Place where it vegetates; that is to say, where it nourishes itself, shoots, increases in size, and produces Leaves, Flowers, and Seeds, or Fruits furnish'd with Seeds.[46]

He then proceeds by defining what he means by 'living body':

> By saying that a Plant is a living Body, I mean, that it contains within itself a Principle of Life, which we may call Soul; from whence proceed the Operations of each Plant, which are Nutrition, Augmentation and Propagation: these three things we shall sometimes express by the single Word Vegetation, which in effect includes them all.[47]

Vallemont is careful to restrict the meaning of vegetative soul: 'this Soul, or this Life consists only in the Order and in the Construction of their essential or organical parts'.[48] He defines the concept of vegetative soul as the overarching organizing principle. It is not entirely clear whether life results from the self-organizing matter or whether life as soul imparts organization to matter. Vallemont also does not extract himself from the following aporia: why are plants living bodies? Because they grow; why are they growing? Because they live. He does not distinguish between life and vegetation, a distinction that the contributor to the *Encyclopédie* will eventually make when differentiating organic matter from living bodies, in the article 'Végétation'. Nevertheless, by emphasizing life, Vallemont clearly shows the influence that an animist conception of matter exerted on his understanding of vegetation.[49] He reconnects with the etymology of *vegetus*, which, instead of meaning inert or unanimated as it eventually would, rather conjured growth and strength.[50] Moreover, his borrowings not only come from alchemy and natural philosophy but also from gardeners and cultivators, including La Quintinie, who wrote extensively on the cultivation, grafting, and care of fruit trees.

La Quintinie's outlook on plants differed from Pluche's. Gardens were his laboratories where he observed and experimented on and with plants. Notwithstanding the mechanistic

45 *La Nouvelle Maison Rustique* (1721), vol. 2, p. 59; *La Nouvelle Maison Rustique* (1743), vol. 2, p. 61.

46 Le Lorrain de Vallemont, *op. cit.* (note 5), p. 27.

47 *Ibid.*, pp. 27–28.

48 *Ibid.*, p. 28.

49 Broadly understood here as the main component of a non-dualistic cosmology. Whether the soul is substantiated within vegetal bodies or the body is suffused with the world soul, life is immanent in organic matter. For an in-depth study, see Guido Giglioni, 'Francis Glisson's notion of *confœderatio naturæ* in the context of hylozoistic corpuscularianism', *Revue d'Histoire des sciences* **55**, 239–262 (2002).

50 See Dominique Brancher, *Quand l'esprit vient aux plantes Botanique sensible et subversion libertine (XVI–XVIIe siècles)* (Droz, Genève, 2015), at p. 16.

explanation of plants as inert machines, for La Quintinie, plants draw their food from the earth. He envisions roots as actively sucking or attracting water. Nevertheless, his suggestion that plants are their own agents does not come easily, as is most evident in his prudently phrased remarks:

> And yet how difficult soever it may be to explain, or even to conceive a clear idea of what we call *Power*, or *Quality* in sublunary Bodies, I cannot but own my inclination to approve rather of living and attractive powers, than an inanimate and lifeless Row and Order of Parts of Matter. And indeed, it seems to me very Reasonable, to assign Action to that alone which has need of it, namely to *Plants*, to the end that they may Attract, and Suck in such Nourishment, as may be Necessary both to Preserve and Enlarge themselves, and to Multiply their Species. And thence I conclude, that 'tis they that Act.[51]

Despite his awareness that his views might seem unorthodox, La Quintinie grants agency to plant parts. He also adopts the epigenetic growth model with sap congealing and generating new plant parts: stems, shoots, branches, leaves, and fruits.[52] Finally, as Vallemont eventually did, La Quintinie highlights the power of sap metamorphosis:

> For whereas it was at first Liquid, before it enter'd the *Roots*, it becomes in time, and by degrees, in a manner perfectly Hard and as it were Metamorphosed into the Nature either of *Fruits* and *Leaves*, of *Wood* and *Bark*, or *Pith*; and there makes a Body more or less Hard, according as it happens to be disposed of into the several *Fruits, Trees*, or plants.[53]

La Quintinie endows vegetable matter with properties (attraction or affinities) and perceives plants as living entities that have needs, will, and survival instinct. He acknowledges the existence of a material principle of life lodged within plant bodies. However, rather than imagining it on the surface of the entire plant, as Malebranche speculated, he locates it in the lettuce bud, or in the tulip bulb, and all along the stems of vines.[54] On trees, he puts it between the trunk and the roots. Plants depend on it to live, grow, and multiply; hence, he concludes:

> I hold then, that there is in *Plants* a certain Principle of Life, and that is the very same that Philosophers call *The Vegetative Soul*; and that 'tis a necessary Agent which at certain times cannot but act, and that too sometimes after such a manner as Men shall direct.[55]

La Quintinie's concept of the vegetative soul is clearly to be differentiated from sentience. He understood it as an ability specific to living matter, an impulse to act distinct from conscience. As a gardener, he had seen ample evidence of vegetal agency. This trend can be traced back to libertine botany, with plants emerging 'as instantiation of a material universe'.[56] Even deprived of animal abilities, plants show that life could emerge from a uniquely chemical and material world. This dissident materialist trend of thought was most prevalent in Guy de La Brosse (1586–1641) who granted animal faculties to plants.

51 La Quintinie, *op. cit.* (note 5), p. 51.
52 *Ibid.*, p. 36.
53 *Ibid.*, p. 42.
54 *Ibid.*, p. 52.
55 *Ibid.*
56 Guy de la Brosse, *De la nature, vertu et utilité des plantes* (1628). On this, see Georgiana D. Hedesan, 'Plant alchemy, Paracelsianism and internal signature theory in the writings of Guy de La Brosse (1586–1641)'. *Notes Rec.* [2023] (https://doi.org/10.1098/rsnr.2023.0031) (this issue). Natania Meeker and Antónia Szabari, *Radical botany. Plants and speculative fiction* (Fordham University Press, New York, 2020), p. 28.

Vallemont's *Curiositez* was heavily plagiarized in later editions of the *Nouvelle Maison Rustique* as late as 1743. These late borrowings attest to the persistence of images and metaphors in the first part of the eighteenth century. The animist thread ran through the fabric of the early Enlightenment, as seen in the Paracelsan Francesco Maria Pompeo Colonna's (1646–1726) *Les Principes de la Nature ou de la Génération des Choses* (1731), with its animist and alchemic occultism being a source for vitalism.[57] Inspired by Tommaso Campanella (1568–1639), Colonna reiterated his belief in sap as a material soul participating in the *anima mundi*.[58] As his analogies were drawn from chemistry, and not from the mechanical arts, Colonna equated tree sap with the chemists' 'vegetal mercury' or 'radical humidity'.[59] Plants have an 'essential sperm', he stated, which transforms water into a nourishing liquid.[60] This 'semen'[61] is a material principle enclosed in living bodies. Point by point, Colonna dismissed Pluche's arguments. Instead of assuming an infinity of germs on tree limbs, a speculative expedient postulating an infinite number of imaginary invisible germs to explain the tiniest offshoot, Colonna reasserted the existence of the seminal essence: 'Trees are not composed of an indefinite number of small trees, as the new philosophers assert, but rather there is this multiplicative sperm in every tree canal.'[62] The influence of animist ontology on plant anatomy persisted later into the Enlightenment, and, according to J. Erhard, supplied arguments to Diderot's rejection of the theory of pre-existence.[63]

Conclusion

While sap circulation was being debated in the late seventeenth to early eighteenth centuries, sap agency was a point of contention which opposed Pluche to other authors of gardening treatises. In his presentation of plant functions and parts, the author of the *Spectacle* focused on mechanisms and adopted the pre-existence theory. He relied on the authority of 'Modern' scientists such as Mariotte and Perrault when he assumed that blood circulated in plants. Believing that sap could create new limbs to a tree seemed to him too close to adopting a materialist, atheist viewpoint of Nature. The exaggerated formulation that the earth could create the sun and moon also serves as a cautionary note against the stylistic personification of earth or nature, or the deification of sap as Proteus. Pluche favoured a conception of nature deprived of intrinsic forces such as life, vegetative soul, and growth. He relied on the pre-existence theory to explain the generation process by the power of seeds. All intelligence was contained in seeds, whose programmatic nature, which was

57 Francesco Maria Pompeo Colonna, *Les Principes de la Nature, ou de la Génération des Choses* (1731). Most information on this little-known figure of Paracelsan alchemy in early eighteenth-century France can be found in Gustavo Costa, 'Colonna, Francesco Maria Pompeo', *Dizionario Biografico degli Italiani*, vol. 27 (1982), and G. Costa, 'Un Collaboratore italiano del conte di Boulainviller: Francesco Maria Pompeo Colonna, 1644–1726', *Atti e memorie dell'Accademia toscana di scienze e lettere 'La Colombaria'*, **29**, 207–295 (1964). For his influence on Diderot's thought, consult J. Ehrard, 'Matérialisme et naturalisme: les sources occultistes de la pensée de Diderot', *Cahiers de l'Association internationale des études françaises* **13**, 189–201 (1961); Roger, *op. cit.* (note 15), pp. 436–438.

58 Colonna, *op. cit.* (note 57), p. 12.

59 *Ibid.*, p. 30.

60 Colonna, *Histoire naturelle de l'univers*, vol. 3, p. 168.

61 *Ibid.*, vol. 3, p. 157.

62 Colonna, *op. cit.* (note 57), p. 74 (my translation).

63 Ehrard, *op. cit.* (note 57).

traced back to divine providence, supplied a road map to the unrolling of successive generations. The sap circulatory model posited plants as closed systems. In the contingent physical world, growth was only an expansion of pre-existing forms. Pluche understood the world as inert and denied the existence of animating principles in plants.

Gardeners such as La Quintinie, and authors such as Vallemont, wrote for agronomists, cultivators, and gardeners, who were interested in getting sound advice on practical matters. Grafting and cutting were core activities in the practice of arboriculture. These methods, which exploited the plants' faculty of growing complete beings from fragments, allowed for the multiplication, dissemination, and improvement of fruit trees. Both operations were predicated on the stems and branches' vitality, and bypassed the seed stage. Sap agency, as evidenced by vegetative multiplication, contradicted sap circulation and pre-existence. Hence, La Quintinie localized the vegetative soul in stems, regarding sap as its vehicle and growth as its action. Gardeners empirically knew that plant growth is not restricted to spatial extension; rather, it involves the formation and invention of various forms, such as fruits, leaves, and shoots.

Our distinction between a seed-based cosmology and a shoot-centred explanation of plant physics has helped us to show how plant parts were comprehended through the mediation of contemporaneous cosmologies and expressed by networks of words and images. During this acculturation process, seeds and sap took on the value of models or epistemic nodes, upon which plant ontologies were based and from which plant knowledge was deduced. While Pluche's theological and philosophical references are well known, it remains difficult to know whether Le Lorrain de Vallemont and La Quintinie found the theoretical basis for their explanations of vegetal functions in materialism, in animism, or in vitalism, in the absence of positive statements. What is clear, however, is that when reflecting on their experiments and practices, they could not dispense with an active life principle in plants: this alone put them at odds with Pluche's finalistic mechanism. All followed the metaphor of the spectacle; yet they gave it an entirely different meaning. For Pluche, nature is a re-presentation, a repeated presentation of what God created at the dawn of time. Conversely, Vallemont marvels at the creative powers of the vegetable kingdom and invites readers to observe nature's inventions being performed before their very own eyes. La Quintinie concludes that plants do 'act'. Vegetal growth is a contingent creative process as opposed to that of animals whose final form is predetermined. One might object that Vallemont's animist images could be more a discursive adornment than a fully articulated understanding of plants. This objection may be valid, but these metaphors, even emptied of their substance, persisted and eventually served as footholds for subsequent philosophical heuristic systems, such as eighteenth-century vitalism.[64]

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64 See Wolfe, *op. cit*. (note 33). See also Roselyne Rey, *Naissance et développement du vitalisme en France de la deuxième moitié du 18e siècle à la fin du Premier Empire* (Voltaire Foundation, Oxford, 2000), at p. 99.

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