

Why was there no controversy over Life in the Scientific Revolution? *

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Well prior to the invention of the term ‘biology’ in the early 1800s by Lamarck and Treviranus, and also prior to the appearance of terms such as ‘organism’ under the pen of Leibniz in the early 1700s, the question of ‘Life’, that is, the status of living organisms within the broader physico-mechanical universe, agitated different corners of the European intellectual scene. From modern Epicureanism to medical Newtonianism, from Stahlian animism to the discourse on the ‘animal economy’ in vitalist medicine, models of living being were constructed in opposition to ‘merely anatomical’, structural, mechanical models. It is therefore curious to turn to the ‘passion play’ of the Scientific Revolution – whether in its early, canonical definitions or its more recent, hybridized, reconstructed and expanded versions: from Koyré to Biagioli, from Merton to Shapin – and find there a conspicuous absence of worry over what status to grant living beings in a newly physicalized universe. Neither Harvey, nor Boyle, nor Locke (to name some likely candidates, the latter having studied with Willis and collaborated with Sydenham) ever ask what makes organisms unique, or conversely, what does not. In this paper I seek to establish how ‘Life’ became a source of contention in early modern thought, and how the Scientific Revolution missed the controversy.

“Of all natural forces, vitality is the incommunicable one.”¹
F. Scott Fitzgerald

Introduction

* Thanks to Guido Giglioni, Justin E.H. Smith and Sean Dyde for assistance and suggestions.

¹ Fitzgerald (1945), p. 74.

To ask why there was no controversy over Life – that is, debates specifically focusing on the status of living beings, their mode of functioning, their internal mechanisms and above all their ‘uniqueness’ within the physical universe as a whole – in the Scientific Revolution is to simultaneously run the risk of extreme narrowness of detail and/or of excessive breadth in scope. That is, if we take the question ‘why?’ at face value, a succinct answer can be given right away: the Scientific Revolution was an intellectual construct that we owe chiefly to Alexandre Koyré and Herbert Butterfield, and it was entirely focused on the physico-mechanical sciences; the latter focus was never modified by one iota in the successive historiographic reassessments of this episode which emphasized notably its Puritan, gentlemanly or courtly roots,² and said not a word about the life sciences. Hence our concept of the Scientific Revolution does not include debates over generation, *semina rerum*, species, anatomy, vivisection, animal souls, irritability and so forth.³ Conversely, the title question appears enormous and unmanageable once we realize that it implies many others:

- (i) if Life was *not* a topic of controversy in and for the Scientific Revolution, when did it become one?

This question requires that we decide what counts as a controversy; for surely debates between Harvey and Riolan on the heart, or Whytt and Haller on irritability, do not meet the criteria for a ‘strong’ definition of a controversy in the history of science, as “part of the collective production of knowledge ... the very lifeblood of science, one of the most productive factors in scientific development.”⁴

- (ii) How should we then understand the various activities that existed at the time, from anatomy and physiology (or the study of the ‘animal economy’) to medicine overall, as well as natural history, botany, chemistry?⁵

Notice that even when we discard monolithic concepts of the Scientific Revolution and adopt a much more nuanced approach to the disciplinary status and diversity of natural philosophy,

² A partial exception would be Kuhn (1976) precisely because he introduces a distinction between Baconian-inductive programmes in natural philosophy and more mathematically oriented programmes. As recently as Biagioli (1998) the standard picture which disregards the life sciences is still reiterated, only now with a constructivist flourish that has accents of *épater le bourgeois*: we learn that historians of science still need the concept of the Scientific Revolution to preserve their employment.

³ It is a mark of the extreme provincialism of the history and philosophy of early modern science that it is so preoccupied with endless internal controversies over externalism and internalism, the role of the Church, or the replicability of an *experimentum crucis* that it takes absolutely no notice of recent (and original) work on the specifically ‘biological’ contribution to debates on substance, personal identity, species etc. in early modern thought, in which figures like Gassendi or Walter Charleton loom large (see notably Fisher, ed. [2003] and Smith, ed. [2006]).

⁴ Helga Nowotny, as cited in Mendelsohn (1987), p. 93.

⁵ For an early attempt to answer this sort of question see Roger (1980), esp. p. 258f.

as Domenico Bertoloni Meli does in an exemplary recent article, emphasizing the interplay between the mathematical and medical disciplines, so that “when unraveling the intellectual world in the seventeenth-century, we can no longer separate the history of anatomy from the history of science as if anatomists and physicians inhabited a different world from not only mechanical and experimental philosophers, but also mathematicians,”⁶ this still does not help us answer question (ii) above. We could extend the narrative of the Scientific Revolution to include debates on the circulation of blood, or the usefulness of the microscope (say, Borelli versus Locke), or the epistemological status of the ‘animal economy’ in relation to machine as well as soul⁷; we could be more faithful to the actual contents of the reports presented to the Royal Society or the Académie des Sciences in their first fifty years of existence, which turn out to be much more biologically oriented than the historiography had led us to believe⁸ – but these extensions would miss the dimension of ‘crisis’, that is, the sense that the existence of living beings suddenly again becomes an explanatory challenge or even a scandal (whether it is a scandal from the standpoint of physics⁹ or on the contrary from the standpoint of the autonomy of biology).

In addition, our title question also implies a historiographic claim about the Enlightenment, which follows from (i):

- (iii) Life *is* a controversial topic for the eighteenth century, not the seventeenth (regardless of the varied and significant contributions of Sanctorius, Harvey, Glisson, Malpighi, Baglivi, Descartes, Guillaume Lamy, Swammerdam, Van Helmont ...).

⁶ Bertoloni Meli (2008), p. 709. To my knowledge the first person to raise the issue was Salomon-Bayet (1978), pp. 12, 15, 112, 334 and in the Anglophone literature Cook (1990), pp. 401-404. To mention one more example: out of fifteen essays by prominent scholars in a recent volume on ‘Rethinking the Scientific Revolution’ (Osler, ed. [2000]), not a single one treats even secondarily of the life sciences. Kiernan (1968) argues for a split between physical sciences and life sciences throughout the eighteenth century in France, which is very strange, if we consider figures such as Maupertuis, who sought to extend Newtonian concepts into the realm of generation, or Buffon, who translated Stephen Hales and sought to produce a kind of ‘arithmetic’ of life. Even Diderot declared that his essays on probability were, together with the *Rêve de D’Alembert*, his favourite amongst his writings (Diderot [1961], p. 126).

⁷ The first case is now too frequently discussed for citations to be necessary; on the latter two cases see Salter and Wolfe (2009) and Wolfe and Terada (2008).

⁸ E.g. Hahn (1971)’s classic study of the Académie des Sciences completely omits the life sciences; Kaplan (1993) fails to consider that ‘embodied forms of knowledge’ really were an issue for the Royal Society. Conversely, in a recent attempt to produce a historical survey of the philosophy of biology (Grene and Depew [2004]), the authors bypass our era and thus our controversies entirely, by moving from Aristotle to Descartes and then to Buffon. That the seventeenth and early eighteenth centuries might have expressed something of a ‘crisis’ on topics such as body, species and the minimal constituents of living matter (e.g. Gassendi, Charleton, Lamy) is not an issue for this work.

⁹ Thus Jacques Monod described the discovery that motivated him to go into biology: “the scandal that certain objects exist with the properties of living beings and appearing to violate some physical principles or at least the general notion of the physical world. It seemed scandalous to me. I felt naïvely that one had to confront this scandal” (Monod [1970], p. 50).

This directly reverses Foucault's claim in *The Order of Things* that 'Life' did not exist before the emergence of biology as a science bearing that name, in the nineteenth century,¹⁰ as well as the much more common claim, found typically in histories of physiology and related textbooks, that the 'modern', functionally specified concept of man as machine successfully banished concepts such as 'Life' from science, especially once the 'machine' is augmented with Darwinian evolution and the modern synthesis.¹¹

The irony here is that it is precisely *after* Cartesian or LaMettrian concepts of *bêtes-machines* or *homes-machines* that Life becomes a locus of a kind of ontological crisis, either because natural philosophers worry about what it is, what its minimal conditions and components are, or because they worry about the boundaries between dead matter and living matter – such as when Buffon, in his comparison of the animal and vegetable kingdoms, ponders the exact nature of “le vivant et l'animé”: whether Life is a metaphysical property of certain entities (“un degré métaphysique des êtres”) or a “physical property of matter”; he ultimately opts for a kind of ‘panspermist’ hypothesis in which life is always potentially present in matter, notably in the form of organic molecules, so that “raw matter” merely means “dead matter.”¹² Similarly, Gabriel-François Venel, in his long entry “Chymie” for the *Encyclopédie*, states that organic molecules and organized bodies are subject to laws that are different from (“essentiellement diverses de”) the laws of matter in motion; as sources, he refers both to Buffon and to the errors of iatromechanist physicians with respect to the functioning of the “animal economy.”¹³

Lastly, in addition to this revision of the ‘Enlightenment’ concept, our question also raises a specific disciplinary issue standing in close relation to point (ii) above:

(iv) Does this emerging ontological concern about Life reflect the constitution of a science?

Is it a precondition for a science? The concern and its various verbal expressions

¹⁰ Foucault (1966), including the additional claim that “l'histoire naturelle, à l'époque classique, ne peut pas se constituer comme biologie” (p. 173). For an excellent, less tendentious discussion of the shifting meanings of 'biology' and its predecessors, 'physiology' and 'natural history', and an analysis of the relation between 'philosophy' and these terms, see Gayon (1998). For the newer view that the eighteenth century *was* significantly concerned with 'vital' matters, see Reill (2005), which is full of in-depth analyses of figures such as Buffon, Barthez and then Herder and the Humboldts, but is confusing taken as a whole.

¹¹ The classic, and influential statement of this view is Loeb (1912); see also Smith (1976) for suggestive, but inconclusive discussion.

¹² Buffon (1749), II, *Histoire générale des animaux*, ch. 1, “Comparaison des animaux et des végétaux,” in Buffon (1954), pp. 238a-b; *ibid.*, ch. 2, “De la reproduction en général,” in Buffon (1954), p. 245b.

¹³ Venel (1753), p. 410.

clearly predate the coinage of the word ‘biology’ in German and French (and its establishment as a science) by roughly a century.¹⁴

As I will try to show in closing, the emergence of a ‘field of controversy’ concerning the status of Life is hardly synonymous with the constitution of the science called ‘biology’. That does not mean it is not productive of forms of knowledge, such as ‘medicine’ or ‘natural history’ or in a very different kind of categorization, ‘knowledge of the body’. But by the time the name ‘biology’ (or its close competitor, ‘zoonomy’) comes to the fore as a “synthetic, unitary science of life,”¹⁵ its concerns are quite different. Similarly, the question of the ‘scientificity’ of medicine and anatomy in the late seventeenth century, or their disputed ‘revolutionary’ status are again not to be confused with the existence of controversies over Life.

1. Was Life a controversial topic in early modern natural philosophy?

If we can speak of early modern life science, from physiology to theories of generation, from the chemical investigation of blood, aether and spirits to treatises on fermentation and fevers, then we can inquire into its relation to the constitution and stabilization of other parts of natural philosophy, such as mechanics and atomistic physics. Figures such as Harvey, Descartes and Borelli, or Boyle, Pitcairne and Malpighi, or Charleton and Boerhaave then loom large on the map and if our goal were to revise accounts of the Scientific Revolution so that they took account of such figures, it would seem reasonably easy to achieve – although if we hoped to find scientific discoveries which contribute to a unified notion of physiological function, we shall not; if we take, e.g., one century of analyses of digestion, from Francesco Redi and Giovanni Borelli in the 1650s-1660s to René de Réaumur and Théophile de Bordeu in the 1750s, none of the experiments on gizzards and their grinding power, discussed by many naturalists, produce any unified result, until Lazzaro Spallanzani conducts experiments on digestion in the 1780s.¹⁶

But, as I have suggested in the Introduction, another problem arises, which is less easy to resolve. It was stated bluntly in the early 1700s by Georg-Ernest Stahl, a court physician to Duke Johann Ernst of Saxon-Weimar and subsequently, as of 1694, a Professor of Medicine at the University of Halle: in all these competing theories of the human body, notably the very successful mechanistic theories, “*Life* was never mentioned nor defined, and I could find no

¹⁴ See Salomon-Bayet (1981); Caron (1988).

¹⁵ Singer (1929/1958), p. 917.

¹⁶ Salomon-Bayet (1978), pp. 336f., 342-343, 355f., 348.

logical definition provided.”¹⁷ To follow Stahl’s suggestion, we could say that Life is either discussed but immediately dissipated into the entities and processes which subserve it, or promoted to the extent that vital spirits, vital heat, animation are so co-extensive to the field of investigation that Life again dissipates into the analysis as a whole. There is discussion, but no controversy, in the sense that there is no polarization between Life and non-Life (with the notable exception of Stahl in his polemic with Leibniz, which I shall turn to in section 2). Let us consider some representative examples.

Boyle’s corpuscularianism, despite its experimental attention to living bodies, the ‘history of human blood’, respiration and so forth, holds that living and nonliving things alike are arrangements of a single universal matter, which is corpuscular. Vital processes may be considered as separations and recombinations of material corpuscles. Boyle does not want to trace vitality back to a faculty or a power, but rather to a certain arrangement of particles. Blood does not possess an innate faculty which makes it ‘alive’ but, like sweat or snow, possesses its specific chemical properties “by virtue of the motion, size, figure and contrivance of [its]own parts,” and new qualities are produced by “changing the texture or motion” of bodies’ constituent corpuscles.”¹⁸ Now, in an interesting passage in his *Disquisition About the Final Causes of Natural Things* – a work in which Boyle describes the human body as a ‘hydraulico-pneumatic’ machine – Boyle appears to grant that there is a kind of category difference between “Living Animals” and “Dead ones,” in which the latter are more like stones, possessed simply of a static structure. But then he quickly returns to his ‘micro-mechanical’ view (even if, *qua* corpuscularian his mechanism is an enhanced mechanism possessed of chemical properties) and explains that the difference lies in the innumerable “Liquors, Spirits, Digestions, Secretions, Coagulations” but also “Motions” of the body and its limbs, which are present in living bodies but not in dead ones; in other words, a purely structural difference.¹⁹

If we turn to mechanism, including its medical variant, iatromechanism (leaving aside here the irreducible variety of forms of mechanism, the incommensurability of their types of explanation, including the possibility that iatromechanism may have been “simply irrelevant to

¹⁷ Stahl (1706b), in Stahl (1859), vol. 2, p. 224.

¹⁸ Boyle, *Origin of Forms and Qualities* (1666), in Boyle (1772), vol. 3, p. 13; see also *Some Considerations Touching the Usefulness of Experimental Natural Philosophy*, Second Tome (1671), in *ibid.*, vol. 3, p. 427; Hall (1969), vol. 1, p. 294.

¹⁹ Boyle (1688), pp. 74-75.

biology,” and the distinction between a mechanistic *ontology* and a mechanistic *method*²⁰), we might expect to find a straightforward elimination of vital properties in favour of size, shape and motion, including the classic rejection of final causes which is a mark of the Scientific Revolution (thinking of Galileo’s description of the ‘fool’ in his *Dialogues*, Simplicio, as a *cause-finalier*, who thinks that horses are on earth for the sake of man, grass is for horses, clouds and rain are there for the grass²¹, or Bacon’s exclusion from “Physick” of explanations such as “the firmness of the skins and hides of living creatures is to defend them from the extremities of heat and cold : or, . . . the leaves of trees are for protecting the fruit,”²² and of course his ‘barren virgins’; Spinoza’s contempt for the human ignorance which projects concepts of purpose onto the natural world, and so on). Excluding final causes (and thus purposive vital faculties, but also humors and elements²³) in favour of a mechanistic scientific program produced notable drawbacks, such as the difficulty in accounting for ‘epigenetic’ processes. Thus Descartes, who actively promoted the use of mechanical models as heuristics in studying the body, famously admitted his inability to account for the processes of generation in terms that were compatible with the mechanistic program he had set out for himself: “The formation of all the parts of the human body . . . is something so difficult that I dare not attempt (to explain it) yet”²⁴; as Dennis Des Chene comments: “Among the phenomena of life, generation offers, along with the apparently reasoned behavior of higher animals, the greatest challenge to a science based on Cartesian principles.”²⁵ This much is well known; the point I wish to emphasize is that everything ‘vital’ is necessarily excluded from the model, ironically given Descartes’ repeated insistence on health as an ultimate value and his ultimate, post-Cartesian doubt insistence on the survival value of our sensory organs. This exclusion is manifest in most of the celebrated pieces of iatromechanist propaganda, from Baglivi and Boerhaave:

Since Physicians began to examine the Structure and Actions of a living Body, not by Physico-Mechanical and Chymical Experiments, but by Geometrico-Mechanical Principles, they have not only discovered an infinite number of things that were unknown to former Ages; but have made it out, that a Human Body, as to its natural Actions is truly nothing else but a complex of Chymico-Mechanical Motions, depending on such Principles as are purely Mathematical. For whoever takes an

²⁰ For the former possibility see Westfall (1971), p. 104; for the latter distinction see Des Chene (2005), pp. 249-250.

²¹ Galileo (1623/1953), p. 71.

²² Bacon (1605/2000), pp. 86-87.

²³ Anstey (forthcoming 2010).

²⁴ Descartes to Elisabeth, May 1646, AT IV, 407.

²⁵ Des Chene (2003), p. 413. Descartes’ ‘failure’ to explain generation was notorious in the eighteenth century, e.g. Réaumur in the *Art d’éclorre des poulets* saying it is worse than if Descartes had failed to explain the universe (cited in Gasking [1967], p. 68).

attentive view of its Fabrick, he'll really meet with Shears in the Jaw-bones and Teeth, ... Hydraulic Tubes in the Veins, Arteries and other Vessels, a Piston in the Heart, a Sieve or Straining-Holes in the Viscera, a Pair of Bellows in the Lungs, ... Pulleys in the Corners of the Eyes. And tho' the Chymists explain the Phaenomena of natural Things, by the Terms of Fusion, Sublimation, Precipitation &c. And so make a separate sort of Philosophy; yet all these ought to be imputed to the Force of a Wedge, Balance, Leaver, Spring, and such like Mechanical Principles ... the natural Effects of an animated Body can't be accounted for with greater Facility and Clearness any other way... (Baglivi, *De praxi medica*, 1696)

and

The solid parts of the human body are either membranous Pipes, or Vessels including the Fluids, or else *Instruments* made up of these, and more solid Fibres, so formed and connected, that each of them is capable of performing a particular Action by the Structure, whenever they shall be put into Motion ; we find some of them resemble Pillars, Props, ..., some like Axes, Wedges, Leavers and Pullies, others like Cords, Presses or Bellows ; and others again like Sieves, Straines, Pipes ... ; and the Faculty of performing various Motions by these Instruments, is called their *Functions*, which are all performed by *mechanical Laws*, and by them only are intelligible (Boerhaave, *Academical Lectures on the Theory of Physic*, late 1730s).²⁶

One can see why Stahl protested that Life had vanished from the bio-medical purview! Indeed, in a kind of unconscious echo of Stahl's concerns, Boerhaave declared in a much-cited lecture on the "use of mechanical methods in medicine" that "the human body is in its nature the same as the whole of the Universe."²⁷

Of course, these apparently 'pure' statements of iatromechanism mask a more complex (and concrete) reality on the ground, where functional dimensions are never wholly absent from physiological explanations (even Descartes will speak of the "office" of the liver²⁸) and chemical explanations as used in medicine by figures such as Willis and Stahl blend, if not seamlessly, quantitative and qualitative definitions of fermentation, such that one no longer knows what is a strictly particulate explanation versus one on which invokes 'liquors', 'juices', 'heat' and so forth. Consider for instance this elegant statement on the body from Bernard de Fontenelle in 1707, ostensibly in the context of a discussion of the pituitary gland:

The human body considered in relation to an infinite number of voluntary movements it can perform, is a prodigious assemblage of Levers pulled by Ropes. If one considers it in relation to the motion of the liquors it contains, it is another [sort of] assemblage of an infinite number of Tubes and Hydraulic Machines. Finally, if one examines it in relation to the production of these liquors, it is an infinite assemblage of Chymical Instruments or Vessels, Filters, Distillation Vats, Receptacles, Serpentine, etc. . . . The greatest Chemistry apparatus of all in the human Body, the most wonderful

²⁶ Baglivi (1696/1704), pp. 135-136; Boerhaave (1708/1751), p. 81.

²⁷ Boerhaave (1703/1983), p. 96.

²⁸ Descartes to Elisabeth, May 1646, AT IV, 407.

Laboratory is the in the Brain, from whence this Extract of the blood is drawn known as Spirits, the sole material motors of the entire Machine of the Body.²⁹

In addition, there is one notable exception to this narrative of the ‘absence of Life’: Francis Glisson’s *Tractatus de natura substantiae energetica, seu de vita naturae ejusque tribus facultatibus perceptiva, appetitiva, motiva* (1672), usually referred to as *De vita naturae*. After publishing various significant medical works, such as *De rachitide* in 1650 and *De anatomia hepatis* in 1654, Glisson produced this treatise on the ‘life of nature’, describing life as immanent to matter (“life is the intimate and inseparable essence of matter” and “matter contains within itself the root of life”³⁰). Now, it would be easy to dismiss this as a kind of substance metaphysics, as indeed Albrecht von Haller did when he both credited Glisson with the discovery of the property of muscular irritability and excluded him from the history of science proper;³¹ but clearly Glisson reflects on the nature of our organic structure (*organizatio*, § 11), its relation to our sense organs, and how animal spirits are not a sufficient explanation of the features of ‘animation’ and complex perception which our sense organs display. However, it remains a challenge to integrate this aspect of Glisson into a Scientific Revolution narrative (it is rather a species of matter theory) and in addition, this very immanentism means that the nature of Life does not arise as a topic for controversy for Glisson. A converse attempt has been made recently by Guido Giglioni to present the existence of a ‘vitalistic’ strain no longer in a marginal but in a central figure, Bacon, focusing on the theme of the ‘appetites of matter’ and the related fixation on the “prolongation of life.”³² However, on the issue of the demarcation of ‘Life’ as an object (a) that requires a specific science or group of sciences and (b) which existing sciences do not adequately treat, it seems more relevant that when Bacon is outlining the contents of the *Sylva sylvarum* (published posthumously in 1626), he presents thirteen works as “physiological remains,”³³ but out of these, seven concern minerals and six concern attractive force and the transformations of inanimate bodies (even if Bacon discusses these in biological terms); thus Bacon does not attend to, or is not concerned with, a distinction between the living and the non-living.

Mechanism, corpuscularianism, Baconian natural philosophy (to which one could add Locke’s Helmontian medical reflections but also his philosophical consideration of the ‘life’

²⁹ Fontenelle (1707/1730), p. 16 (translation mine).

³⁰ Glisson (1672), § 8; I quote from a draft translation of *De Vita Naturae* by Guido Giglioni, which he was kind enough to share with me.

³¹ See Giglioni (2008).

³² Giglioni (2009), (2005).

³³ “Table of Contents,” in Bacon (1854).

that is the unity and identity of a plant, animal or a man³⁴) do not address the question of Life; they do not see it as a problem, or *a fortiori* an ontological crisis. If it is historically insensitive to completely leave out the life sciences from all accounts of the Scientific Revolution, as so many do, it is also mistaken to completely gloss over the problem, either in strong terms, such as when Harvey is simply described as a bona fide member of the intellectual construct called ‘Scientific Revolution’ (“Harvey ... tended to stress the importance of observation and experiment, an increased emphasis on which was a vital part of that change in outlook which is sometimes called the Scientific Revolution”³⁵), or in weaker terms, such as Peter Dear’s more recent statement that there is “no reason in principle” to “ignore the sciences of life,” since ‘physics’ in the early modern period is conceived as inquiry into nature in general.³⁶ Something is missing from this picture. Some scholars, particularly in the humanities, would say that what is missing is *the body* – and an entire sub-discipline of cultural history has devoted itself over the past twenty-plus years to studying the historical constitution of the body, with particular attention given to its Renaissance and early modern formations.³⁷ But precisely, what differentiates a living body from a corpse – a leitmotiv in the concern with Life – is heavily determined by the involvement with chemistry. It is to this, via Leibniz, that I now turn.

2. Machines of nature, ferments and chemical metaphysics

Mechanistic approaches to Life should not be caricatured as they sometimes are, e.g. by Richard Westfall, who described medical mechanism as “the puppet regime set up by the mechanical philosophy’s invasion.”³⁸ Whether in its earliest phases or – most evidently – in its late and complexified form such as Albrecht von Haller’s ‘micro-mechanical’ analysis of physiological structure, combining structural and functional explanations, these approaches are not blind to the nature of vital processes, but seek to heuristically model them, e.g. by the

³⁴ See Locke (1701/1975), II.xxvii.4-6 on the Life qua identity of plants, animals and humans in mereological terms. His last word on the question (*ibid.*, III.x.22) does not advance the issue very much: the term ‘life’ is obvious for everyone, but when one turns to the status of a plant in a seed, a chicken in an egg, or a dying man, its sense is harder to grasp.

³⁵ Gasking (1967), p. 40. Rather more *à propos* is that, whatever Harvey’s epistemological approach towards circulation was (mechanistic? Aristotelean? Empiricist? Paduan? Hypothetico-deductive?), “he did not attempt to formulate any general laws of life on a purely mechanical basis” (Ackerknecht [1982], p. 114).

³⁶ Dear (1998), p. 190.

³⁷ Above all, see Brown (1988), Turner (1984) and Sawday (1995), on ancient, modern and Renaissance régimes of the body; and now the section on ‘Bodies’ in Cooter & Pickstone, eds. (2000) and Mandressi (2009).

³⁸ Westfall (1971), p. 104.

usage of automata, which Borelli cleverly described as having “a certain shadowy sameness (*umbratilem similitudinem*) to animals.”³⁹

And yet something has changed by the time of Buffon and Diderot in the late 1740s. ‘Life’, ‘organized bodies’ and gradually ‘organisms’ are everywhere. Where the *Encyclopédie* devotes a long entry to “Life” (“Vie”), its predecessor and inspiration of fifty years earlier, Chambers’ *Cyclopaedia*, has none. Conversely, the *Encyclopédie* has no article on Galileo (whereas Galileo features prominently, e.g. in Brucker’s *Historia critica philosophiae*, which is a major source of the *Encyclopédie*⁴⁰). In 1753, Diderot gave an exhortatory dimension to this state of affairs, and declared that

We are on the verge of a great revolution in the sciences. Given the taste people seem to have for morals, *belles-lettres*, the history of nature and experimental physics, I dare say that before a hundred years, there will not be more than three great geometers remaining in Europe. The science will stop short where the Bernoullis, the Eulers, the Maupertuis, the Clairaut, the Fontaines and the D’Alemberts will have left it. . . . We will not go beyond.⁴¹

Similarly, Buffon asserted that “mathematical truths are merely mental abstractions, which lack anything real.”⁴² Diderot also gave an explicitly ‘vital’ or ‘biologistic’ inflexion to metaphysics, declaring that “It is very hard to think cogently about metaphysics or ethics without being an anatomist, a naturalist, a physiologist, and a physician.”⁴³ What were the roots of this ‘vital’ change? Conceptually, Leibnizianism plays a key role – not necessarily the substance metaphysics of Leibniz as he intended it, but the series of deliberate, materialistically and/or biologically inclined misreadings that were produced notably in France during the early Enlightenment.⁴⁴ In a sense it is ironic for this turn towards ‘Life’ to involve Leibniz so strongly, since he notably described organisms as ‘machines of nature’ which are machines down to their smallest parts and rejected extra-causal, mysterious vital forces. What did he mean by this?

Leibniz, like Aristotle, drew heavily on his observations (and reports from microscopists such as Leeuwenhoek) concerning living beings in the formulation of his

³⁹ Borelli (1680), II, viii.

⁴⁰ As noted by Salomon-Bayet (1978), p. 384.

⁴¹ Diderot, *Pensées sur l’interprétation de la nature*, § 4, in Diderot (1994), p. 561.

⁴² “De la manière d’étudier l’Histoire Naturelle,” in Buffon (1749), p. 53.

⁴³ Wellman (1987), p. 89, n. 43; “il est bien difficile de faire de la bonne métaphysique et de la bonne morale, sans être anatomiste, naturaliste, physiologiste et médecin” (*Réfutation suivie de l’ouvrage d’Helvétius intitulé L’Homme* [1773-1775], in Diderot [1994], p. 813).

⁴⁴ Canguilhem (1980), Wolfe (forthcoming 2010).

metaphysics of substance. It is not that monads possess uniquely vital properties, but that their definition is inspired by the self-maintaining, self-regulating, autonomous features of living beings. In addition, Leibniz seems to have coined the term ‘organism’ in a technical sense to mean a type of entity different from machines, synonymous with ‘organized body’. (I say ‘technical sense’ because the term is used even after Leibniz, e.g. in the *Encyclopédie* – where it does occur, contrary to the claims of earlier scholars – in a yet undefined sense of the word, as synonymous with ‘mechanism’.⁴⁵) But mostly, Leibniz speaks of living beings as “machines of nature,” in various writings. The key feature of machines of nature is that they are machines down to their smallest parts, to infinity: “The organism of a living being (*organismus viventium*) is nothing other than a divine mechanism which is more subtle than an ordinary mechanism in the infinity of its subtlety.”⁴⁶ These aspects of Leibniz’s thought occur, as very often with him, in dialogue or confrontation with other thinkers – here, notably Ralph Cudworth’s ‘plastick natures’ and Georg-Ernest Stahl’s *anima*. Due to the law of the conservation of force among other reasons, Leibniz refuses to allow for any type of extra-causal influence on bodies of a vital principle that would be separate from bodies as a whole. Hence he denies a concept of ‘soul’ as the motive force or controller in the body, which is what Stahl put forth. Leibniz insists that everything that happens in Nature happens according to mechanical laws. Of course, Leibniz also holds that Life stems from a “deeper source” than the ontological level of mechanically specifiable Nature, which remains at the level of passivity.⁴⁷

This aspect of Leibniz – that there is something unique about living beings, and this uniqueness is metaphysically grounded – was strongly brought to the fore by a series of his disciples precisely concerned with ‘biophilosophy’ and, increasingly, with the difference between organic and inorganic entities: Louis Bourguet in the 1720s and, better-known, Charles Bonnet a generation later. Bourguet, in the course of an extensive analysis of crystals, developed an original notion of “organic mechanisms” (*mécanismes organiques*) which functioned in a different way than ordinary mechanisms, and directly influenced Buffon’s idea of “organic molecules.” He suggested that there was a difference between the growth of crystals by juxtaposition or the apposition of new parts, and the organic process of intussusception by which new molecules are integrated into the organic body and form a part

⁴⁵ In the *Encyclopédie* articles “Fibre” and “Nutrition” (VI, p. 670; XI, p. 288) the terms “mécanisme” and “organisme” are used interchangeably, e.g. “the mechanism or organism of nutrition.”

⁴⁶ Leibniz (1961), p. 16, § 13; Leibniz (1978), I, p. 15.

⁴⁷ Leibniz to Hoffmann, 27 September 1699, in Hoffmann (1749), pp. 49a-b, discussed in Duchesneau (1982), p. 82; Leibniz’s reply to Stahl in Stahl (1720/1864), p. 14.

of it – a distinction repeated almost exactly in the second half of the eighteenth century by Linnaeus, Lamarck and others.⁴⁸ Bourguet describes “organic mechanisms” in Leibnizian terms as a combination of various types of molecules – from aether, water, earth, the air, etc. – which are subordinate to a “dominant Monad or Activity.”⁴⁹ As for Bonnet, he explicitly declares that “nutrition, development and the formation of a new organized being are the products of an *unknown force* . . . which has nothing in common with *mechanical forces*,”⁵⁰ and more humorously, that “I have always led my reader back to the Being of beings, and shown his handiwork in all the products which had falsely been traced back to purely mechanical causes, as if an animal had the same origin as a cheese” (Bonnet was Swiss, after all).⁵¹

But let us return to the discussion with Stahl, since it is essentially here that Leibniz develops a concept of organism, because Stahl, in a combination of medico-physiological and chemical reflection, insists repeatedly on *Life*. To put it differently, the recognition of ‘Life’ as a problem (which goes hand in hand with the formulation of ‘organism’ as a concept) is an effect of Leibniz’s debate with Stahl. And, especially on Stahl’s part, the conceptualization of what an organism is and how it differs from a mechanism (or, which is much the same, how a living body differs from a dead body) centrally involves chemistry (or ‘chymistry’); hence Life becomes an object of controversy. I shall briefly discuss this chemical contribution to the emergence of ‘Life’ as an ontologically problematic entity (notably with the concept of fermentation, and the consequent role of analyses of digestion) before turning, in section 3, to the radical materialist appropriation of these inseparably chemical and ‘biophilosophical’ elements, and its relation to the constitution of ‘biology’.

If we recall Bourguet’s distinction between the formation of crystals by juxtaposition of their components, versus organic entities which are formed by the intussusception of their molecules, the issue with chemistry – particularly the notions of fermentation and ‘seeds’ (what Gassendi called, using a Lucretian term, *semina rerum*⁵²) – we can see that the issue is a distinction between beings that are merely ‘formed’ and beings that are ‘generated’. It is only in

⁴⁸ Bourguet (1729), 4th letter, pp. 73, 165-166; see Cheung (2006), § 2; also Duchesneau (2003); Linnaeus, Introduction to the *Systema naturae* (and of course in his celebrated aphorism that ‘Stones grow, plants grow, and live, animals grow, live and feel’, in the *Philosophia botanica*); Lamarck in the *Système des Animaux sans vertèbres*, discussing the formation of the shell in mollusks (Lamarck [1801], p. 55).

⁴⁹ Bourguet, *op. cit.*, pp. 164-165.

⁵⁰ Bonnet (1764), p. 92 (emphasis mine).

⁵¹ Letter to Malesherbes of October 30 1762, quoted in Savioz (1948), p. 214; Bonnet is admittedly protesting against the ban of his *Considérations*.

⁵² The difference is that for Lucretius these ‘seeds’ were simply atoms, whereas for Gassendi they were composites or compounds of atoms; see Bloch (1971), p. 252, n.75.

the late seventeenth century that this distinction becomes crucial – both because the list of candidates for the latter gradually gets defined more narrowly, so it can no longer include metals, crystals and minerals, and because the ‘chemiatric’ Paracelsian-Helmontian-Sylvian-Stahlian tradition of alchemy-chemistry-chemistry strongly focuses on the processes that are unique to organic beings, such as fermentation.⁵³

A major source for this idea of fermentation is Thomas Willis (1622-1675), who taught natural philosophy at Oxford and medicine in London; he was best known perhaps for his discovery of the ‘circle of Willis’ and his great work on the anatomy of the brain (*De cerebri anatome*, 1664, richly illustrated by Christopher Wren). But the work that concerns us is his *De fermentatione* (1659), translated as *A Medical-Philosophical Discourse of Fermentation; or, Of the Intestine Motion of Particles in Every Body*. *De fermentatione* was meant to be the introduction to his theory of fevers, which in fact he explained as the outcome of a vitiated fermentation of blood (Willis also says that he added a treatise on fever to the one on fermentation in order to apply his fermentation theory to fever). “Every disease acts its Tragedies by the strength of some Ferment.”⁵⁴ Is fermentation chemical or mechanical? The chemiatric answer should be straightforwardly the former, since it describes all bodies as being composed of the principles of Spirit, Sulphur, Salt, Water and Earth and the mixture and proportion of these.⁵⁵ But Willis complicates matters by sometimes speaking of fermentation in more purely chemiatric terms, sometimes in more mechanical terms, as a motion of the parts. Ferments helped kindle the particles of spirit and sulphur in the blood into a flame, a combustion that was also called effervescence of the blood, which is how Willis explains body heat and fever. The fermentation in the heart heats the blood like “Water Boyling over a Fire,”⁵⁶ and this heat is distributed to the whole body through blood circulation, constituting the common cause of ordinary body warmth as well as febrile heat. Our body heat is the effect of a chemical cause—

⁵³ I thank Justin E.H. Smith for this suggestion. Joly (2008) observes that Renaissance and early modern chymical treatises frequently describe minerals and metals in terms which we would only use for living beings (“seeds and germination, growth and rot, death and resurrection”); he suggests that this is less because the chemists were intellectually chaotic and more because a doctrine of living being was simply absent.

⁵⁴ Willis, cited in Debus (2001), p. 69.

⁵⁵ According to Clericuzio (ms., 2009), spirits, sulphur and salts are the active principles (with spirits being the most active), while earth and water are passive. Spirits affect various properties of the body, from heat to conservation to preventing putrefaction; e.g., the digestive system is described as a process of fermentation in the stomach. For a discussion of chemical vs. mechanical explanations of fermentation, see Mendelsohn (1964), p. 380; Chang (2002), pp. 56, 59f.

⁵⁶ Willis, *Of Feavers*, in Willis (1659/1681), ch. I, § 1, p. 59 (pagination continuous with *Of Fermentation*); Chang (2004), p. 785.

specifically, of fermentation.⁵⁷ And, most relevantly for us, “The first beginnings of life proceed from the spirit fermenting in the heart.”⁵⁸

Stahl, too, viewed the body as composed of organic matter in a process of fermentation, which in fact meant it was vulnerable to putrefaction – indeed, always in a process of putrefaction in some sense. Some parts of the body are more vulnerable than others, notably the blood; hence Stahl describes circulation as a process which preserves the *mixtio* of the blood and thereby maintains the stability of the whole. This is a good example of how his system renders the chemical and the metaphysical almost indissociable, in his description of the living body as a kind of dynamic equilibrium which constantly has to be maintained. On the one hand this equilibrium is chemically specified, both at the level of the concept of fermentation and with the description of the body as a chemical *mixtio*, not a mere aggregate – aggregates are merely mechanical combinations of portions of matter in motion, whereas mixts imply a notion of qualitative diversity above and beyond the spatial proximity between particles.⁵⁹ Leibniz reiterated this in his own terms: “a mass of matter is not properly what I call a corporeal substance, but rather an aggregate of an infinity of such substances, like a pack of sheep or a pile of worms.”⁶⁰ On the other hand, Stahl famously describes the body and its organs as literally mere instruments of the soul, a position sometimes revised so that “organs are not, as the name might suggest, mere instruments,” but nevertheless, “it is the soul that makes the lungs breathe, the heart beat, the blood circulate, the stomach digest, the liver secrete.”⁶¹ Put these two together and you have the notion of a “highly fermentable organic body [which] has to rely on a vigilant *anima* to discharge the corrupt and harmful materials from the vital economy in a timely manner.”⁶²

These concepts of fermentation are closely linked to concepts of Life, and indeed were actively taken up in the second half of the eighteenth century by vitalists, notably when dealing with the phenomenon of digestion. Whereas mechanists or ‘solidists’, but also Newtonian-inspired physicians (including Boerhaave and Pitcairne) would reduce digestion to a

⁵⁷ Bates (1981) suggests that “for Fernel [and all traditional Galenists], the essence of fever was preternatural heat whereas for Willis it was an inordinate motion of the blood” (p. 49).

⁵⁸ Willis (1659/1681), ch. V, p. 13.

⁵⁹ This distinction, which is crucial for Stahl, will be wholly appropriated by Diderot who uses it to define the relation between matter in general, living, sensing individual molecules and the ‘sensitivity of the whole’.

⁶⁰ Leibniz, “Éclaircissement sur les Natures Plastiques et les Principes de Vie et de Mouvement” (1704), in Leibniz (1978), vol. 6, p. 550.

⁶¹ Stahl (1706a), § xcvi, in Stahl (1859), p. 347.

⁶² Chang (2002), p. 63. It’s not always so clear-cut, though, because chemistry for Stahl is both something foreign to the *theoria medica vera* and nevertheless that which explains life (Roger [1979], p. 45).

quantitative process of ‘trituration’, of spatial relations between masses, or more specifically the expansion and contraction of muscles, chemiatic physicians and post-Stahlian chemists like Gabriel-François Venel, in his articles for the *Encyclopédie* including “Chymie,” “Chaleur,” “Digestion” and “Mixte,” emphasize the chemical transformations of the substances involved in the digestive process. Thus François Boissier de Sauvages, in his *Nosologie méthodique* (originally published 1763), explains that the faculties of the body are equivalent to the properties of matter in general (e.g. gravity, elasticity and attraction), but that *within the organism* these produce processes of fermentation and putrefaction which seem to be restricted to living beings.⁶³

Of course, the mechanical explanations of digestion are augmented with processes such as heat, vibration, the action of the spirits, and continuous compression, recalling our earlier point that it is not always appropriate to fully distinguish the ‘mechanical’ and the ‘purposive’ or the ‘functional’, in seventeenth- or eighteenth-century physiology and natural philosophy. Sauvages believed that the fully self-contained nature of his calculations on the body’s energy proved the existence of an independent soul which was the source of this motion, and – surprisingly, we would think, for an ‘animist’ – praised the discoveries of Baglivi, Pitcairne, Newton and Boerhaave precisely for their calculations as applied to the body.⁶⁴ As Roger French comments, “it is something of an ‘ism’ paradox that the eighteenth-century ‘mechanists’ generally described the body in non-quantitative terms whereas the ‘animists’ used mathematics to demonstrate the need of a soul to power the machine of the body.”⁶⁵ A missing term in this opposition between mechanism and animism is vitalism.

Organisms, ferments and digestive systems all have some more or less obvious, more or less intuitive relation to an idea we might call ‘Life’, and indeed gradually, from the iatrochemists to Stahl, and onwards to his disciples in the mid-eighteenth century and their *Anseinandersetzungen* with the group of physicians who come to be called vitalists by the dawn of the next century,⁶⁶ these kinds of phenomena, together with more broad ‘research programmes’ such as physiology (as opposed to anatomy), are being presented as specifically ‘vital’. Venel, in the article “Chimie” in the *Encyclopédie*, speaks of “changes” which bodies

⁶³ Sauvages (1763/1771), I, §§ 150-154, 261, 266.

⁶⁴ Sauvages (1731), p. 2.

⁶⁵ French (1990), p. 103.

⁶⁶ The word ‘vitalist’ appears at much the same time as does the word ‘biology’, a fact that has not so far been discussed much, if it all. On the history of the former, see Wolfe and Terada (2008); on the latter, see Caron (1988) and Barsanti (2000).

undergo, such that they “move from the non-organic state to the organic state,” and suggests that the “phenomena of organisation [*i.e. organism, organic phenomena, CW*] should be treated by a science separate from all other parts of Physic.”⁶⁷ Where is the crisis, then? What happened to the ontological controversy? Remember that Stahl had spoken in fairly strong terms, if not of scandal then at least of shock: “What shocked me above all was that in this physical theory of the human body, *Life* was never mentioned nor defined, and I could find no logical definition provided.”⁶⁸ And throughout the collection of essays entitled *Theoria medica vera*, he asks about ‘what we call Life’, ‘what purpose does it serve’, within and outside the body?

The problem from an external standpoint is not so much to find a definition – at the present time we still have not agreed on a definition of Life, or what constitutes its exact ‘origin’⁶⁹ – as to understand why it becomes a problem and what the effects of this problem are. One response, a fairly rhetorical one, is Théophile de Bordeu’s (Bordeu was a celebrated Montpellier vitalist, friend of Diderot – who turned him into a character in *D’Alembert’s Dream* – and collaborator of the *Encyclopédie*): “Spare us, once and for all, all these tiny fibres, pressures, globules, thick substances, sharp angles, lymph, hammers and all the rest of the equipment from mechanical workshops with which [earlier doctors] filled the living body – they were the playthings of our fathers.”⁷⁰ Less rhetorically, another possible answer to the ‘why?’ question is suggested by Peter Hans Reill: “if mechanism could, e.g., explain the pumping action of the heart, it was incapable of saying why the heart continually kept pumping without running down.”⁷¹ Obviously, for Stahl a major part of the answer lay in the soul, and specifically its purposive, goal-directed action – a view which earned him the ridicule of many prominent scientists, such as Haller, who suggested that Stahl’s (who rejected interventionist medicine in the face of disease) were to mechanist physicians like a half-naked ancient German warrior was, compared with an armed Roman centurion, in uniform.⁷² One can also try and reconstruct Stahl’s often unnecessarily obscure argumentation in a charitable way, and point out that he never denies the basic laws of physics and chemistry, nor the fact that living bodies, too, obey the laws of motion. As we saw with fermentation, the idea is rather to articulate a

⁶⁷ Venel (1753), p. 410.

⁶⁸ Stahl (1706), in Stahl (1859), vol. 2, p. 224.

⁶⁹ Deamer and Fleishaker (1994) is a useful collection on the issue.

⁷⁰ Bordeu (1764) in Bordeu (1818), II, p. 670.

⁷¹ Reill (2005), p. 135.

⁷² Haller (1751), p. 956 (a review of Volters’ *Gedancken von Psychologischen sachen*), as quoted in Reill (2005), pp. 123-124.

kind of ‘emergentist’ view in the weak sense that certain arrangements of particles exhibit complex, goal-directed behavior.

However, Stahl is quite adamant that the above be attributed to the soul – which then controls the various mechanically specifiable parts of the body as so many *instruments*. Stahl is a teleologist, who definitely believes that “The question, ‘*What is life?*’ lay behind everything I learned. Life seemed to be characterized by a peculiar reasonableness and purposefulness of instinctive involuntary action” – even if these words belong to another German, in the mid-twentieth century: Wilhelm Reich.⁷³ But all of the new chemical concepts he both appropriates and innovates with allow of both an *anti-reductionist* interpretation (his own), and a *reductionist* interpretation – which is not specifically mechanistic, as we shall see – with materialists such as Buffon and Diderot. And in this reductionist approach, the vital dimension is not discarded.

3. Constitutive materialist ontology of Life or gradual constitution of biology?

Neither biology nor chemistry exist as stable theoretical entities in the early modern or Enlightenment periods, even if chemistry had existed for a long time, but on unstable methodological and conceptual bases, that are only unified with Lavoisier. Yet the constitution of an autonomous ontological region corresponding to ‘the science of living beings’, i.e. biology, is significantly affected by chemistry, as we have seen. One way to describe this is to say that chemistry is, at least at this time, the science which “allows for an understanding of matter as something that – at least provisionally – cannot be reduced to calculation.”⁷⁴ Recall Buffon and Diderot’s anti-mathematical proclamations of a new science of Life (“natural history,” but also the study of the “animal economy” in medicine), or the prominence of the article “Vie” in the *Encyclopédie*.

Chemiatic, Stahlian concepts that merge the chemical and the metaphysical are turned into reductive materialist concepts by Diderot (reductive notably in the sense that they are meant to replace explanations that appeal, e.g. to the soul), *yet* these concepts are not themselves meant to be mechanically or ultimately, mathematically specifiable. This takes several interrelated forms: his ‘enriched atomism’ of vital *minima*, in which the ‘atoms’ or ‘molecules’ of living matter are themselves *alive*; his transformation of Hallerian irritability via

⁷³ Reich (1968), p. 45.

⁷⁴ Starobinski (1999), p. 86.

Bordeu's concept of sensitivity (*sensibilité*) into a concept of organic sensitivity which is itself a property of living matter. The difference between irritability and sensitivity in Haller is that the former is fully mechanically specifiable and is strictly a property of muscle fibres, while the latter has a functional component as it is directed towards the organism's survival, and it presupposes the existence of the 'soul'.

In Diderot, this difference is collapsed into one property of living matter, with some waverings as to whether this property occurs in the elements or only in organized wholes, but he seems to opt ultimately for the latter. Sensitivity and therefore Life require, according to Diderot, the presence of organic "continuity" rather than mere spatial "contiguity" (a distinction directly recalling that between aggregate and mixt, in Stahl).⁷⁵ The difference between the life of an organic being and the life of a wooden automaton, or a watch, is not that the former possesses a soul, or is free, whereas the latter is not. The difference is, one might say, a *structural* one, between two different types of arrangements of parts. This is what Leibniz, a favorite author of Diderot's, meant when he declared that "a feeling or sensing being is not something mechanical like a watch or a windmill"⁷⁶ – or, in Diderot's version (which reflects his annoyance with the prevalent clock metaphor): "What a difference there is, between a sensing, living watch and a golden, iron, silver or copper watch!"⁷⁷ This is why the concept of 'mechanistic materialism' is so problematic, and perhaps downright false⁷⁸: because most materialists, unlike Descartes, do not claim that physical nature is essentially specifiable in mechanistic terms. Diderot's challenge is to be able to do justice to the difference between organic and inorganic beings, without having reference to a concept of 'soul', anima, as the basis of animation (given that the distinction between 'animate' and 'inanimate' initially means possessed-of-soul, and not-possessed-of soul⁷⁹). This will be the concept of active, sensing matter. Hence his materialism is significantly focused on the concept of Life. It is in this sense that his "revolutionary" fervor (of "We are at the dawn of a revolution") is not just a way of participating in the emergence of biology as a science, since it is also a philosophical project – consider the article "Spinozists" of the *Encyclopédie*, by Diderot:

SPINOSIST: follower of the philosophy of Spinoza. One must not confuse the ancient Spinosists with the modern Spinosists. The general principle of the latter is that matter is sensitive; they demonstrate this by the development of the egg, an inert body which

⁷⁵ Diderot (1994), pp. 625-628.

⁷⁶ Leibniz, Preface to the *New Essays*, in Leibniz (1978), vol. 5, p. 59.

⁷⁷ *Elements of Physiology*, in Diderot (1994), p. 1283.

⁷⁸ Kaitaro (1987).

⁷⁹ Cunningham (2003), p. 58.

by the sole means [*instrument*] of graduated heat moves to the state of a sensing, living being, and by the growth of any animal which in its inception [*principe*] is merely a point, and through the nutritive assimilation of plants and – in one word – of all substances that serve the purpose of nutrition, becomes a great sensing and living body in a greater [expanse of] space. From this they conclude that only matter exists, and that it is sufficient to explain everything. For the rest, they follow ancient Spinosism in all of its consequences.⁸⁰

No one has ever produced a satisfactory explanation as to why Diderot chooses to place an affirmation of his biologically motivated metaphysics within an entry on a philosopher (or a derivative of the philosopher, as the article “Spinoza” is a piece of theological boilerplate intended to reassure censorious readers who would logically turn to see what the *Encyclopédie* had to say about this scandalous figure) who did not himself think there was anything metaphysically unique about living beings. In the present context I will content myself with the observation that the difference between ‘ancient Spinosists’ and ‘modern Spinosists’ effectively maps onto the historical narrative I have been suggesting: whereas ancient Spinosists are essentially substance metaphysicians, their modern variants are essentially focused on Life, specifically, the radical implications of the biological theory of epigenesis.

Epigenesis is of course a theory of generation which was opposed to the preformationist theory. We might think that we have finally encountered a proper controversy over Life (or at least generation); but in fact it is not one until Diderot takes hold of it. Or rather, to introduce a distinction, if ‘preformationism versus epigenesis’ is a controversy in the life sciences, beginning fitfully in the early 1700s in the Académie des Sciences and reaching full velocity with Haller, Wolff, and Blumenbach in the late years of the century, what happens with Diderot is that it becomes, precisely in the wake or rather the vein of Stahl, an ontological controversy. This is most explicit if we add to the entry ‘Spinosistes’ a passage from *D’Alembert’s Dream*, the first sentence of which François Jacob in fact used as an epigraph for his *La logique du vivant*:

Do you see this egg? With this you can overthrow all the schools of theology, all the churches of the world. What is this egg? An unsensing mass, prior to the introduction of the seed [*germe*]; and after the seed has been introduced, what is it then? Still an unsensing mass, for the seed itself is merely an inert, crude fluid. How will this mass develop into a different [level of] organisation, to sensitivity and life? By means of heat. And what will produce the heat? Motion.⁸¹

⁸⁰ Diderot, s.v. “Spinosistes,” *Encyclopédie* vol. XV, p. 474 / Diderot (1994), p. 484.

⁸¹ Diderot (1994), p. 618.

Aside from its stated radical dimension (overthrowing all schools of theology), there is also clearly something ‘vital’ about the commitment to epigenesis, or even ‘vitalistic’, as Hans Driesch observed: “All believers in epigenesis are Vitalists.”⁸²

The transformative, ‘epigenetic’ dimension of living beings, which fascinates Diderot (“Voyez-vous cet œuf?”) or La Mettrie (who uses Lucretian motifs to describe the living Earth as like a womb (*utérus*) which has now grown barren, so that new species do not arise⁸³), which also fuels the fascination with monsters, is very far removed from the set of possible criteria for the science of ‘biology’ by the early nineteenth century, which include a reductive constraint on explanations of living beings in terms of their physico-chemical nature, a unification criterion which states that all living entities (including plants and animals) possess properties such as development, reproduction, nutrition, respiration, beginning in a basic substance (protoplasm) and ultimately arriving, by the mid-nineteenth century, at the study of development, focusing on structure and function (morphology and anatomy versus physiology); at this point biology also requires cell theory in order to explain cellular division and conjugation, and has to incorporate evolutionary and ecological components.⁸⁴ It is no surprise that Cuvier by 1810 can declare that “the anatomical portion of the general problem of life has been resolved for a long time, at least as concerns the animals which interest us the most.”⁸⁵

To reiterate the point otherwise, the various instances of an emerging ‘life science’ in the eighteenth century (from the renewal of theories of generation to Haller’s work on irritability, to pieces of ‘folk biology’ such as Trembley’s polyp or Bonnet’s aphids) are not themselves identical with an ontological concern with the status of Life. To conflate these two would be to create a monolithic concept of vitalism which would somehow lead inexorably to the constitution of biology as a science. As much as Buffon, Haller, Barthez, Blumenbach, Bordeu, Venel, Diderot and especially Ménéret de Chambaud insist on the separation between life sciences and physical sciences – a separation which formally culminates in Bichat, Cabanis, and Bernard – it is not clear that all these figures, and certainly not Bichat or the ‘founders’ (or at least coiners) of biology Lamarck, Treviranus and Carl Christian Erhard Schmid (the author

⁸² Driesch (1914), cited in Oyama (ms., 2009)

⁸³ La Mettrie (1750/1987), sections 8-11; he thinks the moderns can improve experimentally on this view, but does not reject it wholeheartedly.

⁸⁴ Singer (1929/1958), Caron (1988), Barsanti (2000).

⁸⁵ Cuvier (1810), II, “Histoire naturelle,” p. 207.

of *Physiologie philosophisch bearbeitet*, 1798-1801)⁸⁶ care about ontology. After all, no less a figure than the head of the Montpellier vitalists, Paul-Joseph Barthez, declared “I am as indifferent as could be regarding *Ontology* considered as the science of entities.”⁸⁷ It is true that some of these figures viewed these episodes of the coming-to-be of biology as not conforming to the laws of mechanics (or even violating them), and thus placing “in serious difficulty the traditional paradigm, based on the sovereignty of physics.”⁸⁸ Thus the geologist Jean-Claude Delam  therie (not to be confused with Julien Offray de La Mettrie) declared that the living being was ‘a machine that confounds all our ideas of mechanics’.⁸⁹

4. Conclusion

Why was there no controversy over Life in the Scientific Revolution? This episode (or absence of an episode) completely challenges concepts such as that of ‘paradigms’ or ‘normal science’, for at least two reasons. (a) Since the sciences involved in the constitution of Life as a problem are not unified, discursively, experimentally or by their objects, whether we speak of alchemy, natural history, chemiatic medicine or ‘metaphysical’ reflections on vital *minima* and the relation of body and soul; as Claire Salomon-Bayet pleasantly suggests, it would then have to be a “permanent revolution,”⁹⁰ lasting one hundred and fifty years (in her case the object is the study of life in the Acad  mie des Sciences; we could just as well say ‘from Harvey to Pasteur’⁹¹). (b) By the time it (biology, medicine, etc.) *is* a science and is perhaps on the way to producing normal vs. abnormal patterns of discourse (say, Pasteur versus Pouchet on spontaneous generation) then it has lost its ontological dimension and thus its sense of being a ‘crisis’ or a ‘scandal’ – even if figures such as Hans Driesch at the end of the nineteenth century can effectively replay Stahl versus mechanism, invoking Aristotelian entelechies just like Stahl did.

⁸⁶ Schmid (1798-1801), I, 140, cit. in Risse (1972), pp.153-154. See Schiller (1980), pp. 85-87; Caron (1988), pp. 231-232 for further indications on the early uses of ‘biology’, ‘zoonomy’ and the older ‘physiology’ to designate the same science.

⁸⁷ Barthez (1806), vol. 1, p. 96, n. 17.

⁸⁸ Barsanti (2000), p. 124.

⁸⁹ Delam  therie (1787), II, p. 292, cited by Barsanti (2000), p. 124.

⁹⁰ Salomon-Bayet (1978), p. 15 and (1981), pp. 36, 39.

⁹¹ Cuvier provides his own capsule history of the birth of life science *qua* science (i.e. as a system allowing for causal explanations): we have known the causal processes at work in digestion for centuries; the absorption of substances, since Pecquet, Rudbeck et Ruysch; the process of circulation, since Harvey. “The work of the English and Italian anatomists on the lymphatic system has . . . completed everything that remained to be said in this regard” (Cuvier, *op. cit.*, p. 208).

If Life and the investigation into Life is not then manageable as a Scientific Revolution narrative, we can of course revise the latter to include more discussion of animal spirits, of Newton's queries on sensation and their influence on biomedicine in the next generation, and of course of the shift from a notion of 'soul' to various embodied, cognitive and even neuropsychological concepts. We can also insist on the presence of quantitative experimentation, notably in the Italian anatomists. But we will not be able to reconstruct a controversy over Life within the frame of the development of biology. In the seventeenth century Life is either everywhere, as in Gassendi or Glisson, but it is immediately dissipated into the entities and processes which mechanistically subserve it, or promoted to the extent that vital spirits, vital heat, ferments, seeds and other forms of animation are so co-extensive to the field of investigation that Life again dissipates into the analysis as a whole. There is discussion, but no controversy, in the sense that there is no polarization between Life and non-Life. In the eighteenth century, with Stahl and Diderot, Life becomes a 'crisis' concept – with anti-reductionist and reductionist trajectories, respectively – until by the early nineteenth century it resolves into being a structural concept with no ontological component. This is patently the case in Claude Bernard – a careful reader of Diderot, who left behind an unpublished manuscript on the latter's medical and physiological writings⁹² – for whom vitality is an effect of a particular type of physical organization, and nothing more: "l'élément ultime du phénomène est physique; l'arrangement est vital."⁹³

We could conclude, following a hint of François Duchesneau's, that the concept of 'Life' is an artificial construct, an *être de raison* created when rationality runs up against the speculative limits of a physiological theory that experience cannot wholly circumscribe.⁹⁴ But what about the "revolutionary" force of epigenesis? The sense Diderot had that he and others were "on the verge of a great revolution in the sciences," but not a revolution that was subsumed under an autonomous science of biology? It is this radical, ontologically controversial component of Life that I have discussed here.⁹⁵

⁹² Barral (1900).

⁹³ Bernard (1879), p. 524, cited and discussed in Métraux (2004), pp. 44-46.

⁹⁴ Duchesneau (1982), p. 487.

⁹⁵ This is part of a broader project to examine the relationship between materialism and embodiment in early modern science and the Enlightenment.

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