Teleomechanism redux?
The conceptual hybridity of living machines in early modern natural philosophy

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We have been accustomed at least since Kant and mainstream history of philosophy to distinguish between the 'mechanical' and the 'teleological'; between a fully mechanistic, quantitative science of Nature exemplified by Newton (or Galileo, or Descartes) and a teleological, qualitative approach to living beings ultimately expressed in the concept of 'organism' – a purposive entity, or at least an entity possessed of functions. The beauty of this distinction is that it seems to make intuitive sense *and* to map onto historical and conceptual constellations in medicine, physiology and the related natural-philosophical discussions on the status of the body versus that of the machine. In this presentation I argue that the distinction between mechanism and teleology is imprecise and flawed, on the basis of a series of examples: the presence of 'functional' or 'purposive' features even in Cartesian physiology; work such as that of Richard Lower's on animal respiration; the fact that the model of the 'body-machine' is not at all a mechanistic reduction of organismic properties to basic physical properties but on the contrary a way of *emphasizing* the uniqueness of organic life; and the concept of 'animal economy' in vitalist medical theory, which I present as a kind of 'teleo-mechanistic' concept of organism (borrowing a term of Timothy Lenoir's which he used to discuss 19th-century embryology) – neither mechanical nor teleological.

1.

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physiology and the related natural-philosophical discussions on the status of the body versus that of the machine. For instance, it has been suggested that there are two main traditions in the history of ideas, differing as to the conditions an explanation has to satisfy in order to be acknowledged as scientific: the Aristotelian tradition and the Galilean tradition (von Wright 1971, 2); the former is considered to be a teleological explanation, the later a causal/mechanistic explanation. The distinction is preserved in exactly the same form when thinkers such as Polanyi argue, contra Nagel, that the scientific understanding of living is necessarily "finalistic" (Polanyi 1969, 157).

In this paper I argue that the distinction between mechanism and teleology is imprecise and flawed, on the basis of a series of examples: the presence of 'functional' or 'purposive' features even in Cartesian physiology; the presence both therein and in the 'Oxford physiologists' of notions such as the 'office' (*officium*) of particular organs, along with the extension of Harvey's discovery of the circulation of the blood in a teleological direction by figures such as Richard Lower; the fact that the model of the 'body-machine', as in La Mettrie, is not at all a mechanistic reduction of organismic properties to basic physical properties but on the contrary a way of *emphasizing* the uniqueness of organic life; and the concept of 'animal economy' in vitalist medical theory, which I present as a kind of 'teleo-mechanistic' concept of organism (borrowing a term of Timothy Lenoir's which he used to discuss 19th-century embryology) – neither mechanical nor teleological.

So: we are faced with a familiar and apparently historically robust distinction between, on the one hand, teleological models and explanations of living beings, and causal and mechanistic models and explanations. But scholars have often maintained that the distinction is of little use in making sense of historical texts – except that the point is never particularly made about early modern natural philosophy, which, in various forms – from Dijksterhuis to Floris Cohen – tends to be presented as the heyday of mechanism (even if, *pace* Alan Gabbey, some writers have drawn attention to the plurivocity of mechanism).

In an elegant article on mechanism and teleology in Aristotelian biology and Hellenistic medicine, Heinrich von Staden is critical of the reliance on this distinction (von Staden 1997). He notes that historians of ancient science and philosophy tend to distinguish teleologists – like Plato and Aristotle – from mechanists – like Democritus and Epicurus. But von Staden further observes, quite consonant with the analysis I shall suggest here, that there is a great variety of teleological commitments even in those we can presume to be teleologists. Notably, Aristotle, even though he does use "the language of agency" to describe Nature, often tries to avoid using the language of design, and specifically mentions cases in which the function of an organ or process cannot be specified teleologically (von Staden 1997, 183). Von

Staden promotes the figure of Erasistratus as a kind of 'mechanist' (200-201) who may have seen the need for a compatibility between teleology and mechanism. (Erasistratus has a mechanistic vision of matter, and applies principles to the body that are consistent with Alexandrian mechanism more broadly: pneumatics, hydraulics and hydrostatics). Physiological processes are explainable mechanistically. Yet at the same time he insists on interpreting all of this within a teleological framework.)

Similarly with respect to early modern natural philosophy, scholars such as Gaukroger, Osler, and Lennox have noted either an 'irreducible' presence of teleological analyses in representative early modern natural philosophers (e.g. Boyle, Gassendi) or a more discreet presence of functional concepts in self-proclaimed mechanists such as Descartes. A different way of challenging the clarity or exactness of the traditional distinction emerges when we consider that early modern automata were indeed *models of Life* – that is, not attempts to deny the specificity of Life but rather to model it! Referring to eighteenth-century automata such as Vaucanson's duck, Jessica Riskin notes that such constructions were not intended so much to 'demystify' or 'reduce' living entities to a set of neutral, inert mechanisms, as to assert the irreducibility of both of these: "The defecating Duck and its companions commanded such attention, at such a moment, because they dramatized two contradictory claims at once: that living creatures were essentially machines and that living creatures were the antithesis of machines."[1]

And, moving onto to early 19th century German biology, Timothy Lenoir proposed the influential category of 'teleomechanism' to explain attempts by embryologists like Blumenbach to overcome what Kant had posited as an insurmountable disjunct or distinction, between mechanical and teleological principles (some of this met with approval from Kant, leading to a separate problem of the extent to which *Naturphilosophie* can be said to be Kantian or not). The general Kantian idea which Lenoir calls teleomechanism is that, unlike in the rest of natural science where mechanical explanations must be pursued as far as possible, in the organic realm, purposive organization has to be assumed as given (Lenoir 1982, 30, 113[2]). In addition to Blumenbach, a teleomechanist research program was explicitly present

[1] Riskin 2003, 610, 612; for further discussion of mechanisms and automata as responses to the challenge to explain Life see Wolfe (forthcoming 2011).

[2] Lenoir then suggests further subdistinctions, notably, between Kant and Blumenbach on the one hand and Kielmeyer, von Baer et al on the other hand: the latter group allows for teleological principles to play a causal role in mechanistic science; see Lenoir 1982,126. The extent to which Kant could actually have accepted Blumenbach's vision of teleological principles as *real* causes of order in organisms, and not merely as *regulative* (or as we might say, heuristic) principles has been noted by Richards 2000 and Zammito (forthcoming 2011), who have thus has challenged Lenoir's account. This does not affect the concept of teleomechanism as I am borrowing it from Lenoir. See also Huneman 2006.

in early 19th c German life science in fields such as physiology, systematic zoology and later embryology (with the idea of the *Bauplan*).

Here I take Lenoir's term 'teleomechanism' more generally as a 'marker' for a distinctive conceptual trait in early modern natural philosophy's attempts to respond to the challenge of explaining living, organic entities. However diverse or irreducible to one set definition the different actors in the story prove to be, it appears that all the forms of teleology discussed here fall under 'natural teleology', not a 'divine' or 'rational' form of teleology, according to a distinction suggested by Alison Simmons (Simmons 2001, Distelzweig 2011). Natural teleology means the attribution of ends to natural, non-rational bodies and their parts (or at least bodies that are treated with any particular reference to their possessing higher-level intentional features).

Of course, not all teleomechanists are equal; they do not all articulate one and the same claim, doctrine or even set of intuitions. To defend a role for final causes in natural philosophy is not the same as to speak of the 'office' of the liver or the functional properties of systems. Indeed, work in early twentieth-century philosophy and more recently in the philosophy of biology has distinguished between different kinds of teleology: explanatory and ontological, systematic and etiological, intrinsic and extrinsic (Gayon and Riclès, eds., 2010 and Goldberg 2011) or, referring back to ancient examples, notably the difference between Aristotelian and Platonic-Galenic teleology, 'heuristic' versus 'genuine' teleology (von Staden 1997, 197).

In a very different sense, it is also possible to be suspicious about the concept of teleomechanism *ab ovo*, because mechanism has to refer to an ontologically complete view of the material world as mechanistically specifiable, which renders even weakly teleological explanations at best superfluous, and at worst otiose (Berryman 2003 makes a version of this point with regard to antiquity, where she finds that the distinction between mechanism and teleology makes almost no sense). One might say that, in contrast to Berryman's view, the interesting cases are the hybrid ones – where mechanism and teleology are compatible, either because of the myriad subtle definitions of each of these two opposites (some forms of mechanism have a strongly stated functional component, some forms of teleology are either strictly explanatory or 'teleomechanist'). This view is closer to von Staden's, discussed above. With regard to early modern natural philosophy, it would doubtless be enough to present a detailed enough portrait of a figure such as Harvey (or Willis, or Glisson, or Haller, or La Mettrie, or Bordeu) to challenge the clear-cut *frères ennemis* concepts of mechanism and teleology. In addition to providing an overview in support of this point, I aim further to reconstruct a concept of 'teleomechanism' as a constitutive feature of early modern natural philosophy faced with organic life.

I will proceed as follows: first I discuss the cases of mechanism and rudimentary forms of teleomechanism (from Descartes to Boyle and Willis), moving towards more explicitly articulated teleomechanistic schemes (Fontenelle and Leibniz) and concluding with an examination of what I variously describe as structural-functional and organizational concepts of living systems, as they appear in some representative vitalist and materialist figures.

2.

The idea of iatromechanism has been familiar to several generations of scholars, entering in the past 10-20 years into a mini-culture war of its own , thinking on the one hand of Alan Chalmers' nice demonstration that, e.g. Boyle's mechanical philosophy is irrelevant to his empirical enquiries (Chalmers 1993), and on the other hand of Richard Westfall's rather frontal denunciation of the concept:

> Iatromechanism did not arise from the demands of biological studies; it was far more the puppet regime set up by the mechanical philosophy's invasion. . . . For the most part, iatromechanism was simply irrelevant to biology. It did not prevent the vital work of detailed observations; it contributed almost nothing to understanding what was seen. Besides the subtlety of biological processes, the 17th century's mechanical philosophy was crudity itself. Above all, it lacked a sophisticated chemistry which has turned out to be a prerequisite for a rapprochement of the physical and biological sciences. One can only wonder in amazement that the mechanical explanations were considered adequate to the biological facts, and in fact iatromechanics made no significant discovery whatsoever (Westfall 1971, 104).

If we were studying trends and ideologies in the historiography of medical mechanism (not just iatromechanism as the restrictively defined episode involving some combination of Descartes, Borelli and Boerhaave, but more generally the forms of mechanistic models in the history of medicine, physiology and biology from 1650 to the 1800s), the obvious counterpart to Westfall's judgment would be that of Joseph Schiller, in a little-known book on the notion of organization in the history of biology (Schiller 1978).

Schiller is explicit about the history of science requiring *commitments*. Thus he polemicizes against Roger, Canguilhem, Foucault and their 'anti-Cartesianism', saying that instead, if we listen to the scientists, it is clear that all major breakthroughs in organizational models/concepts in physiology and the related sciences including embryology, have been mechanistic. (Schiller 1978, 12). He thinks that Descartes' expression " disposition des organes" in the final section of the *Treatise on Man* means the same as "organization," which itself means the same thing as, e.g. "machine organique" (until the nineteenth century, with the emergence of organicism, *ibid*., 19). A machine is simply an organized entity, the parts of which act

together towards a definite goal. Schiller also argues that vitalism cannot do without mechanistic analyses, however much it protests against the latter (96); an easy example is Barthez's second book, on muscular motion. And he points to the frequent presence of the term 'organisation' in vitalist medical writing. I have argued elsewhere that this concept is neither fully 'organismic' nor, of course, fully mechanistic, exactly in line with its quasi-synonym, 'animal economy' (Wolfe and Terada 2008, Wolfe 2009).

Obviously, both of these extreme viewpoints can or should be nuanced. To the *érudit* scholar who denounces the pertinence of mechanism and medicine, we should reply by pointing to the diverse forms of 'micro-mechanism', enhanced mechanism, expanded mechanism (or, in a more individual fashion, we could emphasize the way that, e.g., Boerhaave goes out of his way to distinguish between his usage of mechanical methods in medicine, and the Cartesian way); and to the more positivistically inclined scholar who argues for mechanism as the only way to go, we could point to … the same examples, now understood as weakly 'teleomechanistic' or certainly 'structuro-functional' (a term used in Wolfe and Terada 2008 to describe the combination, indeed integration of anatomical – structural – and physiological – functional – analysis in figures such as Bordeu and Ménuret de Chambaud). Similarly, we would nuance both the 'pro-mechanist' view and the 'anti-mechanist' view by pointing to a kind of inherent or innate otherness within mechanism:

—as Michael Hawkins notes, the new mechanical philosophy did not necessarily eschew all consideration of incorporeal substances; "non-mechanical phenomena remained central concerns in the new mechanical philosophy" (Hawkins 2002, 15). For instance in the notable case of the soul: that all physiological phenomena could be explained mechanically did not mean the soul ceased to have a separate status (à la Descartes, Haller and Bonnet). However, there could be *relocation* of the soul, as Hawkins puts it. Thus, as the body-machines went through various configurations and reconfigurations, the soul – incorporeal? material? substantival or functional? – had to have a new place found for it.

— Additionally one can point conceptually to the internal complexities and indeed hybridity of the genus 'mechanism', and historically, to various cases of actual mechanisms or mechanically designed objects such as early modern automata, which turn out to not be particularly 'mechanistic' in their conceptual ambition (Riskin 2003), e.g. Vaucanson, the inventor of the celebrated flute player as well as the 'defecating duck', was more interested in reproducing key traits of living entities than in reducing such traits to those of inanimate entities.

Much more could be said about (a) the historical complexities of mechanism and (b) how these complexities should lead us on the historiographical level to either nuance attacks on mechanism such as Westfall's, or somewhat ahistorical forms of praise for

mechanism as 'good science' as in Schiller. But my concern here is neither to denounce mechanism nor to praise it; these complexities of mechanism serve instead as a hint or pre-sketch of the form of 'teleomechanism'. If we are to appreciate the presence of this conceptual form, wholly or partially, in the figures under consideration, it will be useful to put together the different kinds of analyses which we tend to be familiar with in partial forms, from the complexities of mechanism 'on the ground' to the many variations on teleology (which are partly the effect of contemporary philosophical distinctions).

Here is a rough map of the early modern natural-philosophical landscape as I see it, for the purposes of this story; it is not exhaustive, and also does not try and catalogue what every major figure said about mechanism (witness the absence of Locke and Hobbes), nor what every such figure said for or against final causes (witness the absence of Bacon or Spinoza), but rather looks at the attempts in the *pensée du vivant* to combine the two.

3.

(a)

Descartes is a typical place to begin. As I've already said, iatromechanism is generally taken to be a kind of Galileanism of life, or, an attempt to inscribe physiological phenomena within a Galilean mechanistic scheme, which is much the same....but in fact, 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 liver (to Elisabeth, May 1646, AT IV, 407). Teleological language is present even in the *Discourse on Method* (part V): "Then, too, we know from this that the true function of respiration is to bring enough fresh air into the lungs to cause the blood entering there from the right-hand cavity of the heart, where it has been rarefied and almost changed into vapors, to thicken into blood again before returning to the left-hand cavity" (AT VI, 53; CSM 1985, 138). More broadly, as Gary Hatfield has noted, "Descartes was committed to a teleology of the mechanical organism, which means that the organism tends towards what is good for it…. In both nonhuman and human animals, the types of physiological processes that cause the passions proper (in humans) are teleologically directed toward the good of the body" (Hatfield 2007, 15; see discussion in Distelzweig 2011).

Thus it makes sense that even Descartes himself is increasingly seen as having a more complex physiology than the classic opposition between 'mechanism' and 'teleology' reveals. The neat conceptual clarity of this opposition does not match up with the historical and experimental context well at all. As Stephen Gaukroger has

observed (Gaukroger 2000), Cartesian mechanistic physiology, far from denying the existence of goal-directed processes, is in fact replete with functional language, e.g. when discussing the circulation of blood and the motion of heart; the Cartesian point is not that bodies actually are machines (an eliminativist view, as Gaukroger puts it) but rather that the structure and behaviour of bodies are to be explained in the same way that we explain the structure and behaviour of machines (a reductionist view).[3] The interplay between mechanistic and teleological notions is more explicit still in the case of Boerhaave (Duchesneau 1997, 301), and ultimately in Haller.

This also makes Descartes seem less far removed from someone like Willis, who frequently uses terms like 'office': "Therefore thenceforward I betook my self wholly to the study of Anatomy and as I did chiefly inquire into the offices and uses of the Brain and its nervous Appendix [i.e. the spinal cord]" (Willis, *Anatomy of the Brain*, "Preface"). The term occurs three times in the Preface:

> I do not think of Empires in Arts, nor do I promise to my self Triumphs by overcoming the World of Letters : But in the mean time, I had wholly frustrated those Illustrious Documents I had long since learned, unless with those Auspices I had laboured in Philosophy, especially the Natural.
>
> For the Province, which I hold in this Academy, requiring that I should Comment on the *Offices of the Senses*, both external and also internal, and of the Faculties and Affections of the Soul, as also of the Organs and various provisions of all these ; I had thought of some rational Arguments for that purpose, and from the appearances raised some not unlikely Hypotheses, which (as uses to be in these kind of businesses) at length accrued into a certain System of Art and frame of Doctrine.
>
> . . .
>
> Therefore thenceforward I betook my self wholly to the study of Anatomy : and as I did chiefly inquire *into the offices and uses of the Brain* and its nervous Appendix, I addicted my self to the opening of Heads especially, and of every kind, and to inspect as much as I was able frequently and seriously the Contents ; that after the figures, sites, processes of the whole and singular parts should be considered with their other bodies, respects, and habits, some truth might at length be drawn forth concerning the exercise, defects, and irregularities of the Animal Government ; and so afirm and stable Basis might be laid, on which not only a more certain Physiologie than I had gained in the Schools, but what I had long thought upon, the Pathologie of the Brain and nervous stock, might be built.
>
> here I made use of the Labours of the most Learned Physician and highly skilful Anatomist, Doctor Richard Lower, for my help and Companion ; the

[3] Osler tends to rely on the older view that if final causes were still present in Descartes despite his stated intention to ban them from physics, this was a sign of "unexpunged Scholastic" elements (Osler 2001, 155-156). Recent work on the 'embodied Descartes' has gone in a different direction.

> edge of whose Knife and Wit I willingly acknowledge to have been an help to me for the better searching out both *the frame and offices of before hidden Bodies*.
>
> (Willis 1681,53f.; Willis 1664, sig. a2r; emphasis mine)

Harvey, too, speaks of the 'office' of an organ:

> Thus far then [I have given an account] of the uterus of the hen and its office, of the generation of the hen's egg, its differences and accidents, in which I have spoken of the things I have myself experienced and proved, and from their example you may form your own judgment concerning all other oviparous creatures. (Harvey 1651/1981, ex. 13 83)

(**here some more examples of Harvey as teleologist**)

We also know that William Harvey is some sort of teleologist, however much Descartes promoted him in the *Discourse* to a key plank in his mechanism[4] – something that is also further extended in the article "Méchaniciens (Médecine)" of the *Encyclopédie* (and in a classic paper by T.H Huxley on the history – and fortune – of mechanistic conceptions in biology, Huxley 1874).

Harvey's analysis of the action of the heart in a wide range of organisms implied that he could identify a range of structurally dissimilar entities – there is no structural similarity in the "heart" of the river shrimp and that of the chicken – which were recognized as "hearts" principally by their performance of a common function.

But the important point to note is that this does not make Harvey some kind of residual Ancient, however much he says Aristotle is his guide; the teleology, whether it is post facto or intrinsic, is also inherently modern. That is, it is important to acknowledge that Harvey is not just a partisan of 'weak teleology' in the sense that some writers have sought to reconstruct Aristotle as a contemporary functionalist in the philosophy of mind (notably Nussbaum and Sorabji); he is someone who thinks that 'ends' matter in a stronger sense.[5] Yet at the same time, final cause in Harvey's eyes plays only a weak role in discovery. It may be suggestive to lines of inquiry but only when, for the most part, it can draw on evidence such as description from observation or experiment to suggest or demonstrate the action of a part or process. This "what is it for?" approach is a legitimate tool of inquiry but so too is analogy or comparative anatomy, neither of

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[4] Descartes devotes a significant chunk of part 5 of the *Discourse on Method* to Harvey, who he refers to as 'an English physician'. He praises him for the discovery of circulation (and says, at least in French, "he was the first to break the ice") but disagrees as to the functioning of the heart. Descartes views it as a more passive organ, receiving a good deal of its 'activity' from the heat of the blood, etc. Some scholarship has focused on who is the more consistent mechanist in this respect. (Descartes also mentions Harvey in *Passions* and *Description du corps humain*.)

[5] He uses Aristotle's language of for the sake of (in Latin) rather than final cause.

which play any necessary or formal role in inquiry for Harvey or others.[6] François Duchesneau has described Harvey's method in *De motu cordis* as an "analytic teleology," i.e., a *post facto* reconstruction of a teleology which is meant to explain the role of each organ (Duchesneau 1998, conclusion) – thus a species of *explanatory teleology*.

This implies we need to make a distinction between a 'teleomechanist' type of complex description or 'systems' description (or 'structuro-functional' explanations as discussed in Wolfe and Terada 2008), and an outright *teleological explanation*. It does seem to be the case that Harvey rejects, or is cautious with respect to the latter. He lets himself be *appropriated* in this direction, which is not the same thing as taking such concepts on board in his own explanatory scheme; the locus classicus of such appropriation is a famous comment of Boyle's.

> And I remember that when I asked our famous Harvey, in the only discourse I had with him, (which was but a while before he died), what were the things that induced him to think of a circulation of the Blood? He answered me, that when he took notice that the valves in the veins of so many several parts of the body, were so placed that they gave free passage to the blood towards the heart, but opposed the passage of the venal blood the contrary way: he was invited to imagine, that so provident a cause as nature had not plac'd so many valves without design: and no design seemed more probable, than that, since the blood could not well, because of the interposing valves, be sent by the veins to the limbs, it should be sent through the arteries, and return through the veins, whose valves did not oppose its course that way (Boyle 1772/1968, V, 427; see discussion in Bylebyl 1982)

Notice that Boyle is not just trumpeting design and summoning Harvey in service of this project; he is emphasizing that the notion of design *actively helped Harvey* in his experimental work.

However, Harvey's caution does not make him, mutatis mutandis, a perfect specimen of teleomechanism which is something 'emergent' here; but it means we need to be discerning when attributing 'teleological' views to these figures. As Alan Salter has noted, forty years after the publication of *De Motu Cordis*, when the physician Richard Lower, a onetime colleague of Harvey's during their Oxford years, sought to extend the Harveyan project on circulation, Lower made very much this sort of distinction. For instance, in Chapter 1 of his *Tractatus de Corde,* we read that

> I must preface my account of (the movement of the blood) by some remarks on the Position and Structure of the heart. When these have been duly considered and collated, it will be easier to grasp how carefully both its Fabric and Position are adapted for movement, and how fittingly everything is

[6] Thanks to Alan Salter for this.

arranged for the distribution of the blood to the organs of the body as a whole (Lower 1669/1932, 2).

The two steps Lower recommends – ascertain position and structure, then 'grasp' fabric, position, and 'fittingness' – match up with the distinction I suggested above. However, I don't want to make a systematic claim here that Harvey stands for a newer kind of teleology – call it explanatory, analytic or heuristic – while, say, Lower stands for something closer to Galenic, 'actual' or 'directed' teleology.[7] For one thing, Harvey often tries to be agnostic here – and does not seem overly keen to be viewed as a 'modern' protagonist of the New Science (rather than proclaiming his 'modernity' like Hobbes, Bacon or Descartes, he calls the neoterics "shitbreeches"[8]). For another, his claim can be appropriated by or integrated into *more* teleological-*cum*-design schemes, as Boyle does, or more classically mechanistic schemes, as happens in Descartes' equally laudatory reference to Harvey.[9] One can also examine his work with a fine comb and determine which sort of causality is chiefly at work, e.g. in his account of generation; some suggest it is actually efficient causality which is paramount there – and that he was taken as such by the Oxford group (who, however, have a very enhanced sense of what counts as 'mechanical').[10]

This 'reintegration' or rather the capacity for such reintegration is what I am calling 'hybrid', one could also call it dialectical, and it is a key feature of teleomechanism. And conversely what seems to be agnosticism about strong teleology in Harvey can quickly be restated as a commitment to such by his friend Boyle, as seen in the above quotation. While my intention is not to simply call for a reevaluation of the importance of teleology in early modern science (see Osler 2001, Lennox 1983 for a historical corrective and Fuchs 2001, Sloan 2007 for more normative statements of the importance of teleology), just as I did not want to centrally focus on the reevaluation of the complexities of mechanism, it seems unavoidable to take a detour through the thought of Robert Boyle, who was undoubtedly the best-known teleologist in early modern science; he would have preferred to be called a friend of final causes.

(b)

[7] Von Staden suggests that Galen subscribes to a "genuine" teleology, not a "merely heuristic teleology" (von Staden 1997, 197); Galen often emphasizes that his predecessors failed to see that any explanation of the function of the parts must be thoroughly teleological. Following Hankinson 1989, one can say that Galen – like Plato and unlike Aristotle – follows a "directed" or "intentional" teleology.

[8] "He [Harvey] bid me to goe to the Fountain-head, and read Aristotle, Cicero, Avicenna, and did call the Neoteriques shitt-breeches" (John Aubrey, *Brief Lives,* cited in French 1994, 220). (Neoterics are like 'nouveaux philosophes'.)

[9] maybe cite ABH

[10] I am grateful for the helpful and interesting discussions on Harvey and teleology I have had with Peter Distelzweig, Benny Goldberg and James Lennox.

In one general sense Boyle is the least interesting for my story, since he overtly presents his analyses in the *Disquisition concerning Final Causes*, the *Free Enquiry into the Vulgarly Received Notion of Nature*, and also the *Christian Virtuoso* as belonging to *design* arguments, whereby mechanism and teleology are both true but united under the banner of design, as here in the Preface to the *Free Enquiry*:

> And because many atheists ascribe so much to nature that they think it needless to have recourse to a deity for the giving an account of the phenomena of the universe : and on the other side, very many theists seem to think the commonly received notion of nature little less than necessary to the proof of the existence and providence of God, I […] thought myself, for its sake, obliged to consider this matter, both with the more attention and with regard to religion (*Works*, V, 158 ; cited and discussed in Simonutti 2000, 309).

Boyle stresses the 'utility' of final causes in natural-philosophical explanations — i.e., it is possible for someone to say all of this beautiful handiwork – vertebrate eyes, finches' beaks, lungs and teeth and so on – is the sign of a Designer, but that all scientific explanations must rely on efficient causes. Thus in the *Christian Virtuoso*, he acknowledges that, "To be told that an eye is the organ of sight, and that this is performed by that faculty of the mind which from its function is called visive, will give a man but a sorry account of the instruments and manner of vision itself, or of the knowledge of that Optificer, who, as the Scripture speaks, 'formed the eye'" (*Works*, V, 516; Osler 2001, 163). And in the *Disquisition*: "the naturalist should not suffer the search, or the discovery of a Final Cause of Nature's works, to make him under-value or neglect the studious indagation [investigation] of their efficient causes" (*Works* V, 411). Teleomechanism is something else again.

But in another sense, less concerned with design or rational teleology, and more focused on the mechanics of the body, Boyle is a prominent member of a sub-set of thinkers including Claude Perrault, Fontenelle and Leibniz (possibly also Gassendi), who seek to articulate a model of the human body that combines the best insights of the mechanical theories but also chemical theories (Azouvi 1982). In *Disquisitions* Boyle refers to the human body as a "compound engine, such as mechanicians would call hydraulic-pneumatical" – and elaborates on this by pointing to the "spirits, vital and animal" and "little springy particles", and "things analogous to local ferments", all of which "are not to be discerned in a dead body" (Boyle in Works 1772/1966, V, 422; Lennox 1983, 52).

(c)

We encounter a first full-blown form of teleomechanism with Fontenelle and Leibniz. Earlier I recalled how mechanism – Cartesian and other – is more complex than the old straw man of iatromechanism (whether as portrayed by Westfall in the

1970s or by Bordeu et al. in the 1750s). This is the case both in its 'canonical forms' (from Descartes to Boyle to Boerhaave) and, less surprisingly, in its later more complex forms such as Haller's physiology (which has been described as micro-mechanism or expanded-mechanism by Monti and Duchesneau respectively). Similarly – in a kind of parallel – iatrochemical explanations such as those found in 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. The teleomechanism proper comes in when all these models are deliberately blended.

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, Serpentines, etc. . . . The greatest Chemistry apparatus of all in the human Body, the most wonderful Laboratory is 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 (Fontenelle 1707/1730: 16, my translation).

If we take teleomechanism in this more specific sense, not just of the presence of disparate elements – mechanistic and purposive – in a given text, but to mean a deliberate grafting together of these elements with a synthetic intent, an even more overt case would be Leibniz. Where Boyle had defined the body as a hydraulico-pneumatic machine, Leibniz goes one step further, presenting the body as a hydraulic-pneumatico-pyrotechnic machine (Fichant 2003, Smith 2007). The question then becomes what kind of account the physiologists ought to provide in order to explain these properties of the body-machine. Leibniz's account emphasizes teleology. In order to explain the functions of the body, Leibniz appeals to an idea of final causation, and justifies this use of teleology by claiming that an account of final causes is essential to the description of any machine:

> The human body, like the body of any animal, is a sort of machine. Any machine moreover is best defined in terms of its final cause, so that in the description of the parts it is therefore apparent in what way each of them is coordinated with the others for the intended use. (Leibniz, *Corpus hominis et uniuscujusque animalis Machina est quaedam*, 1680-1683, trans. J. Smith, in Smith 2007, 151)

Thus, like Boyle and unlike the received view of Descartes (but as we have seen, Descartes, like Boerhaave, is evidence of a 'hybridity' even within mechanism),

Leibniz embraces teleological explanations of the functions of the extended body of animals and humans. This stems from his pessimism regarding the possibility of fully explaining bodily functions mechanistically. Leibniz also holds that physiological systems can be explained, in principle, in terms of mechanistic causation, but not at root; that is, on the one hand, such a reduction to mechanical causes will not always be fully possible at the present state of knowledge, but on the other hand, there is a categorial difference between organisms and mechanisms for him.[11] As he writes in the fifth letter to Clarke:

> As for the motions of the celestial bodies and even the formation of plants and animals, there is nothing in them that looks like a miracle except their beginning. The organism of animals is a mechanism which supposes a divine preformation. What follows upon it is purely natural and entirely mechanical.[12]

In the *Discourse on Metaphysics*, Leibniz proposes a synthesis of the mechanical explanation of living beings and an explanation in terms of final causes, which is not unlike Boyle's in the *Disquisition*, but clearly places much stronger weight on the value of the mechanical explanations. Yet at the same time Leibniz has an expansive concept of the body-machine, as, in typically conciliatory form, he wants "to reconcile those who hope to explain mechanically the formation of the first tissue of an animal and all the interrelation of the parts, with those who account for the same structure by referring to final causes" (§ 22). Both types of explanation, he says, "are good; both are useful not only for the admiring of the work of a great artificer, but also for the discovery of useful facts in physics and medicine" (*ibid.*). In a way that is quite different from Boyle's argument for putting together design and mechanism, Leibniz recommends that we "join the two ways of thinking" (*ibid.*):

> For I see that those who attempt to explain beauty by the divine anatomy ridicule those who imagine that the apparently fortuitous flow of certain liquids has been able to produce such a beautiful variety and that they regard them as overbold and irreverent. These others on the contrary treat the former as simple and superstitious, and compare them to those ancients who regarded the physicists as impious when they maintained that not Jupiter thundered but some material which is found in the clouds. . . . To use a practical comparison, we recognize and praise the ability of a workman not only when we show what designs he had in making the parts of his machine, but also when we explain the instruments which he employed in making each

[11] As Andrault puts it: "Machines are subordinate to physical causes that are not yet completely reducible to their mechanical reason, which means that one cannot straightaway geometrize the machine, nor the circulation of blood.... One may invoke for instance some pre-existing elements of the living machine or some "physical cause", which are not yet mechanically explicable. A living body is *essentially* a machine, even if no one is yet capable of explaining the former exactly as they would the latter" (Andrault 2010, 16)

[12] Leibniz, Fifth Letter to Clarke, § 115, in Clarke 1738/1978, vol. 4, 667.

> part, above all if these instruments are simple and ingeniously contrived (*ibid*.)

Closer to Boyle is Leibniz's way of putting together efficient causes and final causes: the former are a deeper mode of explanation yet sometimes this proves too difficult; the latter is easier and "can be frequently employed to find out important and useful truths which we should have to seek for a long time, if we were confined to that other more physical method of which anatomy is able to furnish many examples" (*ibid*.). A feature which distinguishes Leibniz from the main features of the teleomechanist concept I am seeking to reconstruct here is his 'foundationalism'. The concept in his case is clearly metaphysically founded, in contrast to the other cases we have encountered here.

My final case of Teleomechanism is the interplay between materialism and vitalism in the 18th century.

4.

The term 'vitalism' is frequently used, in both the history of the life sciences and contemporary philosophy of science, philosophy of biology, etc. as both (i) something which lies outside the boundaries of respectable science, and more specifically, (ii) a quasi-synonym of 'teleology'.[13] Conversely, materialism is frequently defined as a direct opposite of vitalism; it is treated as a quasi-synonym of 'mechanism' (despite Descartes or Boyle's anti-materialism, and Diderot's anti-mechanism, to name some obvious cases). This is still the case in a recent entry in a major reference source, the *Oxford Companion to the History of Modern Science*: we are told that "materialists explain everything in terms of matter and motion; vitalists, in terms of the soul or vital force" (Wellmann 2003). The various ways, historical and conceptual, medical and biological and other, in which this is a false opposition, make for an interesting story but not one that belongs here. Rather, I wish to show how both materialism and vitalism, considered now in some representative cases of the mid-eighteenth century, are moments of teleomechanism. I shall discuss each of these in turn.

Eighteenth-century materialism was frequently presented as 'mechanistic' in various kinds of scholarship, often unawares of its debt to the rather normative proclamations of Marx and Engels in this regard (Kaitaro 1987). In fact, hybridity/eclecticism is the norm here, and for our purposes it is noteworthy that materialists such as Julien Offray de La Mettrie (despite the set of associations that

[13] Crick on vitalism, Monod on teleology.

are conjured up by his most famous title, *L'Homme-Machine*) also have a highly 'embodied', not strictly mechanistic conception of the body-machine (Wolfe forthcoming 2012). Whether he is speaking philosophically or medically, La Mettrie combines mechanistic language with properties (chemical, organizational, etc.) that machines do not possess:

> Man is so complex a machine (*une Machine si composée*) that it is impossible to get a clear idea of the machine beforehand, and hence impossible to define it. For this reason, all the investigations which the greatest philosophers have conducted *a priori* have been vain, that is to say, in so far as they use the wings of the mind, as it were. Thus it is only *a posteriori* or by trying to disentangle the soul from the organs of the body, so to speak, that one can reach the highest probability concerning man's own nature, even though one cannot discover with certainty what his nature is. (La Mettrie 1751/1987, I, 66-67).

and with reference to the most classic mechanist metaphor – clockwork – which he turns into something else:

> The body is but a clock, whose clockmaker is the new chyle. Nature's first care, when the chyle enters the blood, is to excite in it a kind of fever which the chemists, who dream only of furnaces, had to construe as fermentation. This fever produces a greater filtration of the spirits, which mechanically animate the muscles and the heart, as if they had been sent there by order of the will. (*ibid*. I, 105; see Pépin 2011)

Here it is not so much the birth of functional concepts, as people have studied in the post-'dogmatic mechanist' reading of Descartes (teleology naturalized as it were – giving rise to functional concepts with which to explain, e.g. physiological processes, and these concepts are no longer dependent on any particular overall teleological commitment), as the turning of a mechanistic explanation into something, if not quite teleomechanist, at least in which the machine has an internal principle or dynamism…onwards to *organisation*.

Diderot sometimes uses machine metaphors in writing about the body, but much more rarely than La Mettrie, and in that sense he is barely even a teleomechanist, or if so, in a strong sense. Whereas La Mettrie is indeed interested in the organic, living body as a 'basement level', something ontologically irreducible (not in the sense that he does not accept reductionist, componential explanation but in the sense he is not a genuine *mechanist*); but he is interested in exploring the boundary levels in between body and machine, or machine and organism. As François Pépin has put it, "La Mettrie aime jouer avec les plus et les moins de la machine" (Pépin 2011). Sometimes La Mettrie uses medical knowledge against Descartes – the Descartes of substance dualism – but sometimes he also claims Descartes was more of a materialist (we might say an 'embodied materialist') than he let on. Diderot, in contrast, is fascinated with more complex machine metaphors for organism such as the loom and the

vibrating chords of a harpsichord, to which he adds a variety of chimiatric concepts (Cheung 2010), stressing for instance in the *Éléments de physiologie* that "the human body is a system of actions and reactions" (Diderot 1975-, XVII, 337). And he is both influenced by and somehow in interaction with the conceptual production of vitalist medicine (Kaitaro 1997).

Let's turn now to vitalism – a word which may have been first used to describe the doctrines of the Montpellier medical faculty in the eighteenth century (Wolfe and Terada 2008). It is a well-known feature of Montpellier vitalists that they try and position their 'doctrine' as a neither-nor, or in between, the two strongly opposite positions of mechanism and animism. Bordeu, Ménuret, Fouquet, Barthez in different ways and with different emphases, criticize mechanism – whether Italian iatromechanism, Descartes, Boerhaave or even Haller (who is of course already something of a hybrid or a dialectical figure in terms of 'strict mechanism) for its lack of attention, or explanatory weakness faced with the 'fact' of living, embodied agents, which require specific types of explanations. But symmetrically, they criticize Stahlian animism for its lack of explanatory power, period, since it is a form of 'supernaturalism'. (This is not true of their mentor Sauvages.)

Using perfectly teleomechanical language, Barthez says that "mechanics" is useful for determining exactly what "the advantages of the living body's organs are, in the mechanism of its intended functions" (Barthez 1858, 37). Barthez sounds almost like Stahl here, for whom "the life of the soul consists . . . particularly in action exercised and carried out in a body, by means of a body, on and affecting bodily activities" (Stahl 1859, § LII, 298). Bordeu refers to the 'evident fact' that animal bodies are not like watches because they are self-winding, and comments that unfortunately the Stahlians took this to mean that the higher-level features of vitality (fighting off illness and maintaining stability in the body, whether its temperature, digestive system, etc.) are dependent on the soul (Bordeu 1751, § CXXXI, 1818, vol. 1, 204). Ménuret appeals in good reductionist fashion to a fairly basic, indeed 'base' level of bodily dysfunction – inflammation of the lower intestine – in order to challenge animism:

> Who wouldn't laugh at an animist or Stahlian who would argue that this illness is a gift of Nature or the soul, a kind and farsighted mother who directs all efforts to heal the illness, and even exacerbates them on the pretext of necessity, hoping for benefits that one hopelessly expects from elsewhere ? ("Ténesme," *Enc*. XVI, 137a).

The relevant concept here, as I have discussed elsewhere, is the 'animal economy', which seems to in almost all of its definitions a kind of teleomechanist concept: it is *organismic* (as in the metaphor of the beeswarm, see Wolfe and Terada 2008) but it is also subserved by a variety of mechanistic explanations. The vitalist Louis de La

Caze describes his aim in *L'Idée de l'homme physique et moral* as the explanation of "the mechanism which subserves the functions of the animal economy," a mechanistic level "chiefly founded on anatomical observations" (La Caze 1755, 2); he sounds more clearly vitalistic some pages later when he says that movement and sensation are basic, non-reducible features of the body (*ibid*., 12). Ménuret speaks in rather hybrid terms of "l'organisation animée de notre machine" in the important article "Pouls" (Enc. XIII, 239); after all, what is the medicine of the pulse if not a 'structuro-functional' compromise brokered between mechanism and its opposite? Similarly, Buffon, the theorist of 'organic molecules', comfortably speaks in the same sentence of 'animal economy' and 'machine', or "la mécanique vivante" and "le mécanisme de l'économie animale"[14]; conversely, 'machine' was frequently used to mean 'body'.

Bordeu is often described as having selected the glands as his theoretical object because they are the exemplar of what is non-mechanistic about the animal economy, since all mechanistic physiologies stumble, not on the humours the glands extract from the blood, but on the workings of the secretory organs themselves: for instance, how does a gland differentiate between one fluid and another, given that they are clearly 'intended' to deal with specific fluids and not others?[15] Humours, Bordeu says, cannot be explained according to "the actions of solids and the disposition of the organs" (Bordeu 1751, Preface, in Bordeu 1818, vol. 1, 48). But at the same time he doesn't want to fall back on a chimiatric explanation of humours, just to emphasize that pure mechanism can't account for them. The distinctively Bordevian emphasis here is on the 'sensitivity' of each gland (which works like a force). But to achieve this level of analysis the glands have to be studied according to "position and interconnections, in order to know their action" (*ibid*., 46). There is the structuro-functional analysis encapsulated in a sentence; but it is not superfluous to note that Bordeu continues, "this is indeed part of *Anatomy*" (*ibid*., emphasis in original). Simply, the scope of "anatomical inquiry" must be widened, Bordeu argues, to include "the use of the parts, their interplay, connections and relations" (*ibid*.). This is what he means by 'animating the skeleton of anatomy'. (**Parenthesis on Haller and Bordeu**. Haller, the pupil of Boerhaave who developed ingenious quantitative experiments and experimental protocols, famously spoke of the project of physiology as "anatomia animata"; but the 'vitalist' Bordeu also, less famously, described his goal as being to "animate . . . the skeleton of Anatomy."[16])

Indeed, Bordeu, here as elsewhere, is less 'anti-mechanistic' than he is an 'expanded mechanist', performing experiments by compressing a piece of sponge in the jaws to

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[14] Buffon 1753, 3-4; article "Histoire naturelle," *Enc*. VIII, 226b (the term 'animal economy' occurs several times here).

[15] An interpretive essay on the development and conceptual variety of 'post-mechanistic' gland theories remains to be written, despite the important work of Grmek, Belloni, and Duchesneau.

[16] "Physiologia est animata anatome" (Haller 1747, 5); Bordeu 1751, Preface, in Bordeu 1818, vol. 1, 46.

study how a gland reacts to compression by muscular tissue. Fouquet, in his article "Sécrétion," provides a useful summary of Bordeu's work:

> M. de Bordeu demonstrates, by means of fascinating experiments and dissections, that most of the glands are located such as to prevent their being compressed in any case by the surrounding parts; indeed, one can sense that various misfortunes would result from this compression, among which the hardening and shrinking of the glands would be the least. The parotid gland, which people claim to be the example, the most telling proof of this compression, is actually inaccessible to all the agents which, it is claimed, this gland is exposed to. A short anatomical inspection of the parts says more than any reasoning; we will only note that the space between the angle of the jaw and the mastoid eminence in which a major part of the gland is located, increases with the lowering of the jaw, . . . you can do this on yourself. [17]

Unlike Lower or Willis (*or even Harvey but Harvey is different*), for Bordeu it is not the structure and position of organs which has to be ascertained so that a higher teleology can be ascertained – a higher level of intelligibility and/or a Design as in Boyle. Rather, there is an immanent level of "position . . . interconnections . . . use of the parts . . . their interplay, connections and relations": teleomechanism.

6.

So:

- supposedly pure mechanistic models exhibit sensitivity to functional properties (Descartes, Boyle, Boerhaave etc straight down to Haller's 'micromechanism');

  supposedly anti-mechanistic models ('vitalism' for instance) exhibit a greater recognition of the role of, pertinence of, validity of mechanical explanations of particular phenomena than is generally believed;

- Distinction between different kinds of teleology – explanatory and ontological, etc.

  But all of this is i) within natural teleology, (ii) motivated by challenge of explaining living bodies (thus reasonably close to Lenoir's teleomechanism).

- Comment further on what teleomechanism means here.

[17] *Enc*. XIV, 874a. In case the reader felt this was the work of a Padua anatomist, Fouquet adds that experiments on corpses may not be sufficient evidence of the above points. But it is not an ontological rejection of the pertinence of cadaverous anatomy.

(i) It means something contrary (maybe not an opposite, but a kind of contrary to) a distinction such as Berryman's, where she opposes – the terminology is a bit misleading – the restrictiveness of *mechanistic* accounts (they can say nothing about other parts or levels of the system) to the *inclusiveness* of teleological accounts, which acknowledge that they only apply to certain relevant parts of the world, for which "at least some vital properties or teleological explanations are thought to be required" (Berryman 2003, 346). Teleomechanism has the model-making, reductionist component of mechanism and the pluralism of what Berryman describes in teleology. It accepts the reality of complex organization but also integrates mechanical explanations. However – depending on how strong a teleology it incorporates – it can hold that mechanical explanations have limits, and thereby allow that "within the organic realm the various empirical regularities associated with functional organisms can be investigated" (Lenoir 1981, 305)

(ii) Similarly it is quite contrary to the traditional distinction between mechanistic and organismic accounts of living beings, in which the former is usually present as *excluding* crucial features of living organisms in order to achieve a complete model; the distinction sometimes opposes the reality of homeostatic processes to the 'mere' account of anatomical structures (Gierer 1966). Teleomechanism does not oppose the dynamism of homeostatic processes to the static character of anatomy: it seeks to unite them.

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