



Project
MUSE[®]

Today's Research. Tomorrow's Inspiration.

The Health of the Body-Machine? or Seventeenth Century Mechanism and the Concept of Health

Shapiro, Lisa.

Perspectives on Science, Volume 11, Number 4, Winter 2003,
pp. 421-442 (Article)

Published by The MIT Press



For additional information about this article

<http://muse.jhu.edu/journals/posc/summary/v011/11.4shapiro.html>

The Health of the Body-Machine? or Seventeenth Century Mechanism and the Concept of Health

Lisa Shapiro

Simon Fraser University

The concept of bodily health is problematic for mechanists like Descartes, as it seems that they need to appeal to something extrinsic to a machine, i.e., its purpose, to determine whether the machine is working well or badly, and so healthy or unhealthy. I take issue with this claim. By drawing on the history of medicine, I suggest that in the seventeenth century there was space for a non-teleological account of health. I further argue that mechanists can and did appeal to structural integrity, as a non-teleological notion of form, to ground the norms required for ascriptions of health.

In this essay I want to do two things. First, I want to draw out some of the problems a thorough-going mechanistic concept of health faces. And second, I want to begin a story about how seventeenth century mechanists come to develop a concept of health consistent with their understanding of the natural world.

The story focuses on a familiar figure: Descartes. For his position motivates the need for such a story. Descartes claims to the Marquess of Newcastle in a letter of October 1645 that “the preservation of health has always been the principal end of my studies” (4:329; 3:275).¹ Though here he might be exaggerating for effect, remarks throughout his writings—especially the correspondence with Elisabeth of 1644 and 1645—support this general sentiment.² But despite his overt interest in both his own

This paper has benefited greatly from the comments of Saul Fisher and Robert Pasnau as well as from discussions at the 2002 HOPOS meeting in Montreal, the University of British Columbia and the University of Victoria. I would also like to thank Saul for asking me to participate on the HOPOS panel and so for the opportunity to work through these thoughts.

1. The citation format is as follows: (volume of Adam and Tannery [Descartes (1996)]: page number; volume of Cottingham, et al. [Descartes (1984–89)]: page number).

2. See for example the letters to Elisabeth of 8 July 1644 (5:64f, 3:237f), 18 May 1645 (4:200ff) and May or June 1645 (4:218f, 3:249f). The *Treatise of Man* and the *Discourse*

health and that of others, Descartes says very little about the philosophical foundation of ascriptions of health. That is, he offers us very little of the conceptual basis for the norms that serve to distinguish the normal, or healthy, from the pathological, or unhealthy. This lacuna might be more than mere oversight, for it is not clear how Descartes' mechanism allows for such a distinction. However, that the course a mechanist can take is obscure does not entail there is no course he might take. Indeed, I argue here that mechanists, including Descartes, have a concept of health available to them.

To elucidate this mechanist concept of health I take a closer look at Descartes' position and situate it in its historical context. I first lay out what the problem of a notion of health appears to be for him, and sketch the standard way of solving it. In my view, however, this standard solution oversimplifies matters. To bring this out, I take a short historical detour through the writings of Nicholas Abraham de la Framboisière, whose views on therapeutics are interestingly positioned between the Aristotelian and mechanist accounts of the workings of the human body. I then propose a different way of solving the problem, one that most readers of Descartes rule out *tout court*. Standard solutions presuppose that there is no way of getting norms out of a mechanistic natural world. I argue that an early-modern mechanist can appeal to an *intrinsic stable structure* to ground the norms of health and illness. We might think of this structure as a formal cause, though one different from the substantial forms which Descartes and others reject as occult. Though the seeds of such a position are in Descartes' writings, in the end, I do not think that it is his considered view. But it is not his *mechanism* that prevents him from adopting the position wholesale. Indeed, as I will show, it seems that later mechanists such as Spinoza and Locke adopt a similar notion of form in their accounts of individuals. We thus might well ask why Descartes was unwilling to go that far, or perhaps, how he might be read as a transitional figure in the story to be told. In addressing these questions we can see somewhat more clearly the tensions in a mechanistic concept of health.

Descartes' problem of health

Let me begin by sketching the problem a notion of health has been taken to present for Descartes. On Descartes' official position, living bodies are simply machines whose workings can be explained by appeal to the laws of physics. However, these laws do not in and of themselves allow us to

both demonstrate a concern with the implications of the new physioanatomy they present. The *Meditations* famously includes the medical examples of a phantom limb and a dropsical patient, and in the Preface to the *Principles*, Descartes clearly indicates that medicine, as a branch of the tree of philosophy, should follow from his metaphysics and physics.

distinguish when a machine is working well or badly. As Descartes writes in the Sixth Meditation in discussing a man with dropsy:

A clock constructed with wheels and weights observes all the laws of its nature just as closely when it is badly made and tells the wrong time as when it completely fulfills the wishes of the clockmaker. In the same way, I might consider the body of a man as a kind of machine equipped with and made up of bones, nerves, muscles, veins, blood and skin in such a way that, even if there were no mind in it, it would still perform all the same movements as it now does in those cases where the movement is not under the control of the will or, consequently, of the mind (7:84; 2:58).

There seems to be nothing in the nature of either a clock or an animal-machine, taken on its own, which can tell us whether the machine is in good working order, or an animal is healthy. So long as each obeys the laws of physics, which it cannot but do, it remains in accord with its nature as an extended thing. The human body seems to be no exception here. And so, there seems to be no good way to ground ascriptions of health to a human body by appeal to the body alone.³

However, Descartes observes that we can make an assessment about whether a machine works, or whether a body is healthy, if we know the purpose of the machine. He writes: “Admittedly, when I consider the purpose of the clock, I may say that it is departing from its nature when it does not tell the right time” (7:85, 2:58). If we know a clock was designed to tell time, we can determine whether it is in good working order. And so by analogy, we could determine whether an animal or a human body is healthy if we knew the purposes that body serves—its end.⁴

Now, Descartes quite famously rejects a teleological conception of the physical world. For him, bodies don’t have intrinsic ends. So it seems that

3. Indeed, if we follow this analogy through, it is hard to see how Descartes can ascribe any particular function to parts of a clock other than that of playing a causal role in bringing about a particular physical state. That is, we should not be able to say that a pendulum serves as a device for keeping time, but only that its swings cause a gear to turn. Similarly, it is not clear how we are to ascribe a properly biological function to parts of the body, that is a function proper to a living thing rather than to the causal workings of the universe. Thanks to Saul Fisher for pressing this point. My point in this paper, however, is not so far-reaching as to examine the possibility of a mechanistic biology, or notion of life. Rather my discussion will focus on the mechanist’s ability to distinguish between the normal and the pathological through a concept of health.

4. And, following the point of the previous footnote, if we knew the purpose a body served, be it a clock or a human body, we could also specify the function, and in the case of humans the biological function, of its parts. As I will go on to argue below, it is not clear that a mechanist can make this move without great, and perhaps too great, compromise.

he has a problem. How can he claim that an animal or human body is healthy? The problem stems from the conflict of two principles: first, the natural world is to be conceived non-teleologically; and second, the norms that constitute our concept of health are essentially teleological.

On this diagnosis of Descartes' problem, there are two sets of options. First, one can accept both principles as they stand. On this line, either one can conclude that, in virtue of his rejection of teleology in the physical world, Descartes is not entitled to the notion of bodily health of which he avails himself, or one can argue that Descartes locates the concept of bodily health in an end extrinsic to body. That is, one can argue that he surreptitiously imports teleology into the physical world, and so is able to avail himself of a notion of health. Most commentators who have tackled this problem have him taking the latter option. While there is some variety in this sort of resolution, most take this general shape: Teleology is brought into the physical world in the case of the human being through the union of the human soul with body.⁵ These commentators can be seen as fleshing out Descartes' remark in the Sixth Meditation that "with respect to the composite, that is, the mind united with this body, what is involved [in adverting to a disordered 'nature'] is not a mere label but a true error of nature" (7:85; 2:59). They do so by taking strongly Descartes' claim that the union constituting a human being is a "substantial union," that is, as indicating that a human being is a true substance.⁶ In particular,

5. Gueroult, for instance, takes human medicine to concern "the integrity and preservation of this very substance [the mind-body composite]" (Gueroult 1985, p. 178). For him, the end grounding the norm of health is the preservation of the human being. Canguilhem suggests that he is following Gueroult, but it seems to me his emphasis is slightly different. Canguilhem asserts that "mechanism can explain everything once we assume the existence of machines constructed in a certain way, but it cannot explain why machines are built that way in the first place" (Canguilhem 1994, p. 231). Canguilhem's view is consistent with Gueroult's, insofar as contributing to the preservation of a healthy man is certainly one possible explanation of the construction of the human body-machine. Yet it is not the only explanation available. Indeed, Canguilhem thinks that all Descartes needs is an appeal to God's purposes in creating the world the way it is, and God could have created the body such as it is for a purpose other than joining with a mind to form a human being, though one consistent with that outcome. The relevant portions of Canguilhem (1994) synthesize writings in *La Connaissance de la vie* (Paris: Hachette, 1952) and *Le Formation du concept de réflexe aux XVIIe et XVIIIe siècles* (Paris: PUF, 1955). More recently, Dennis Des Chene (2001) has taken a similar line, which I discuss below.

6. This is a controversial claim. Of recent commentators, only Paul Hoffman (1986) and Des Chene (2001) adopt this view. Schmaltz, who once held it (1992), has indicated that he has changed his position. Descartes refers to the human being as a "substantial union" only in one place, the Fourth Replies (7:228; 2:160), and as Marleen Rozemond has pointed out, Descartes never actually calls the composite a substance, though he has ample occasion to do so. (See Rozemond [1998], p. 165).

they take the human soul to be the form of the human body insofar as it can provide the unifying principle that delimits the body as the particular part of the material world that it is. The human body can then be said to be healthy insofar as its union with the soul is maintained. The end constituting the norm which grounds attributions of health to the human body is just the preservation of the mind-body union.⁷ Thus, teleology enters into the physical world through the human being. All other bodies, including those of animals, are then understood as healthy through comparative physiology.⁸

It is worth highlighting just how much Aristotelianism this sort of resolution requires reading into Descartes. While recent scholarship has succeeded in complicating the intellectual historical narrative by demonstrating that Descartes takes on board a good deal of scholastic machinery,⁹ if Descartes did hold that the soul was the form of the body, it would signal a real compromise of his dualist metaphysics. On this standard solution the health of the body is determined by its relation to the mind. But in accordance with his claim that mind is really distinct from body, Descartes defines the life in purely bodily terms.¹⁰ A dualist framework would define life, then, and a non-dualist standard define health, and that is an odd compromise. Moreover, Descartes himself thinks that medicine should be consistent with his dualism. According to the tree of knowledge he presents in the Preface to the *Principles*, a new medicine is to grow from the trunk of physics, rooted in dualist metaphysics.¹¹

7. More specifically, the soul strives to preserve its union with the body, but this union can only be effected with a properly organized body. Thus, a body is healthy just insofar as it affords the continued union of the mind with that body.

8. Des Chene is the only commentator I know of to address head on the particular problem of animal health and welfare Descartes faces, and he suggests that comparative physiology is the path to veterinary medicine. See Des Chene (2001), pp. 108–111. I am not so sure how this extension of the human case to beings without minds would be justified. The comparative method becomes even more problematic if we consider how we are to think of the health of plants.

9. See for instance Hoffman (1986), Rozemond (1998), and Ariew (1999).

10. Thus in a.5 of the *Passions of the Soul*, Descartes maintains that “it is an error to believe that the soul imparts motion and heat to the body” (11:330). He then follows this point by asserting that “death never occurs through the fault of the soul, but only because one of the principal parts of the body disintegrates” (PS a.6, 11:330). We live just when “there is a continual heat in our heart, which is a species of fire that the venous blood maintains in it, and . . . this fire is the bodily principle of all the movements of our members” (PS a.8, 11:333).

11. See 9B:14; 1:186. The place of medicine in the tree of knowledge also weighs against reading Descartes as having a the statistical account of the norm of health, as well as that which would have him take health be simply a matter of avoiding suffering and prolonging life. Descartes wants his medicine to be rooted in physics and metaphysics.

There is a second line as well, that which involves rejecting the one or the other of the principles. One might, on the one hand, reject mechanism. This option is not interesting for my purposes here, as I want to better understand a mechanist notion of health. One might, on the other hand, reject the claim that a notion of health is essentially teleological. For instance, one might claim that what is healthy is statistically normal, or one might also claim that good health is a matter of avoiding pain and prolonging life, something we just so happen to care about, but for no intrinsic reason. The alternative I will be proposing falls into this last category; it involves denying that ascriptions of health to a body in principle involve a purpose or *telos*. But it is a distinct position. I will argue that mechanist ascriptions of health can rest on a notion of an intrinsic stable structure (I will call this a form), and that this structure (or form) need not be conceived of teleologically. While I will conclude that this position is much more viable as an early modern mechanist's solution to the problem than it has been taken to be, I do not want to claim that this is actually Descartes' solution. I will conclude by speculating why it is not.

An historical detour: Nicholas Abraham de la Framboisière

To help motivate the non-teleological position I will put forward, I offer a story that shows that the standard solution does not quite fit historically. This account thus suggests we look for an alternative solution. As of now, the beginning of the story has one key figure, Nicholas Abraham, sieur de La Framboisière. More historical work needs to be done, and I hope this paper will provide good reason for doing it. For I believe that the character of La Framboisière provides grounds for thinking that Aristotelianism was on the way out in early modern medicine, just as it was in the physical sciences of the period.¹² That is, I take him to be representative of a certain turn in Aristotelian and Galenic medicine at the beginning of the seventeenth century.

Since most historians of science, let alone philosophers, have never heard of La Framboisière, a biographical sketch is in order. La Framboisière was born in 1560, the son of a surgeon, Hector Abraham, in Reims. After working with his father during an outbreak of the plague, he went to Paris, where he was educated in the Collège Royale and in the Faculté de Médecine with Jean Riolan. In 1597 he inaugurated the first French ambulance service in the retaking of Amiens, and in 1600 became *médecin ordinaire de roi*, as well as the chief army physician, under

12. It is perhaps uncontroversial that Aristotelianism was on the way out in early modern physiology, but little work has been done on the way in which these developments in physiology were transferred to the theory and practice of medicine.

Henri IV—a position he held also under Louis XIII, until he was stripped of his title and responsibilities as result of a dispute with Cardinal Richelieu.¹³ In the early seventeenth century he published his *Oeuvres*, which begin with a natural history, entitled *La principauté de l'homme*, arguing—as its title would suggest—that human beings are the most perfect of God's natural creations. This work is then followed by his medical writings, including his *Le Gouvernement nécessaire a chacun pour vivre longuement en santé*, his *Loix de médecine*, as well as works on surgical methods and pharmaceutical remedies. The medical works are followed by a treatise on grace. This last work includes logic, rhetoric and ethics, and so affords one the ability to understand well, to speak well, and to live well, respectively. The *Oeuvres* was first published in 1613, and it was reprinted up through 1669. The first edition of the *Gouvernement* on its own appeared in 1600, and that of the *Loix* in 1608. His works were also translated into English.¹⁴ La Framboisière died in 1636.

It is worth noting that there are affinities between the prescriptions of La Framboisière and Descartes—both concerning medicaments and the techniques of regulating the passions. There is some similarity between La Framboisière's remedies and Descartes' prescriptions to Elisabeth (though both accord with common sense, and so any similarity might be accidental).¹⁵ Further, their accounts of the regulation of the passions seem to operate on similar principles. La Framboisière states the basic principle of prescribing remedies in his *Loix*: "It must be that all remedies be contrary in quality, since contraries are remedies of contraries. Because if all that which is immoderate is contrary to nature and that which is moderate in accord with nature, it must be by necessity that what is immoderate is reduced to mediocrity by an immoderate contrary."¹⁶ The basic principle is

13. I have not been able to ascertain what the dispute was about, but it would be interesting to find out given that Richelieu was an enforcer of Aristotelianism for political ends.

14. A translation of a part of La Framboisière's course on medicine by John Phillips titled *The art of physick made plain and easie* was published in London in 1684. An earlier translation of a part of that work, *De Causis Morbificus*, was published under the title *An easy Method to know the Causes and Signs of the Humour most ruleth in the Body, and to avoid thereby things hurtful, etc* in London, possibly in 1640.

15. See Descartes' letter of 8 July 1644 to Elisabeth (5:65; 3:237). He prescribes diet and exercise to cure an indisposition of the stomach. Compare the discussion of exercise with La Framboisière, *Gouvernement*, ch. XIX, and the many chapters on diet.

16. LaFramboisière, *Les Loix de medecine pour procéder methodiquement à la guarison des maladies* in *Oeuvres* (1644), p.357. The French reads: "Il faut que tous les remedes soient contraires en qualité, attendu que les contraires sont remedes des contraires. Car si tout ce qui est immodéré est contraire à nature & ce qui est modéré, selon nature: il faut de nécessité que ce qui est immodéré soit réduit à mediocrité par un contraire immodéré." It is clear from the context that any imbalance results from the flow of bodily fluids.

clear: counter an immoderation with an opposing immoderation in order to neutralize it. In other words, re-establish the equilibrium of the body.¹⁷ Descartes' remedies for the passions, though they seem to be psychological, depend on the physiological effects of our turning our attention to opposing ideas. Opposing representations are associated with an oppositional movement of the pineal gland, and thus with a redirection of the animal spirits. This redirection then restores equilibrium to the body, without which we cannot properly regulate our passions. In this regard it is particularly interesting that generosity, as a general remedy for the passions, is marked by physiological stability: the movement which excites generosity is "even in its continuation, that is, the spirits continue to move in the same way in the brain" and their movements are "firm, constant and always quite similar to one another" (PS a.160, AT XI 452). Hence Descartes' remedy for the passions achieves its effect in just the same way as do La Framboisière's remedies.

I have little interest in demonstrating that La Framboisière's writings exerted a direct influence on Descartes, though the extent to which the former's *Oeuvres* was reprinted suggests that they were generally influential.¹⁸ The similarities between the two works, however, do help to bring out the fact that Descartes, even while he is developing a mechanist physiology, still retains a good deal of Galenic medicine, a medicine founded on balancing the flow of fluids. While he compares the workings of the human body, and indeed of animal bodies, to the workings of a machine like a clock, for him the parts of the bodies are not simply, as they are for Hobbes, springs, strings and wheels, which work through their vibrations.¹⁹ Rather he retains an hydraulic model, wherein the parts of bodies serve as conduits for the animal spirits whose motion makes the body move as it does.²⁰

17. La Framboisière's recommendations for maintaining health and preventing disease in the *Gouvernement* all turn on maintaining the balance within the body. We are to take air which is neither too hot nor too cold, nor too humid nor too dry (ch. II); we are to eat foods which maintain the consistency and temperature of the body (ch. III); drink in proportion to how much we eat (ch. XII); sleep softly and deeply and just long enough to facilitate digestion (ch. XVIII); exercise enough to get the body moving and so keep its natural heat and awaken its spirits, but not so much that it is unpleasant (ch. XIX); and moderate all the passions just by imagining countervailing instances to the causes of excessive passions (ch. XXI).

18. There is no evidence that Descartes read La Framboisière, though given La Framboisière's position as chief army physician and Descartes' writing on medical matters in the 1620s, it is quite possible that Descartes came across his writing.

19. "For what is the Heart, but a Spring; and the Nerves but so many Strings; and the Joynts, but so many Wheeles, giving motion to the whole Body, such as was intended by the Artificer?" *Leviathan*, "Introduction."

20. The *Treatise of Man* provides clear examples of this thinking, and there he compares

Although Descartes' prescriptions owe a debt to Galenic medicine, he does not offer a typically Galenic justification for them. A comparison with La Framboisière is helpful here. While La Framboisière's explanations for why a particular remedy is in order are usually pragmatic—grounded in how the proposed remedy can restore the balance of humors—it seems from what he writes in the *Principauté des Hommes* that their ultimate justification lies in an Aristotelian metaphysic, in keeping with the Galenic tradition. There he quickly runs through the bare basics—that all natural things result from the union of matter with form, and that all the principles and movements of natural things are the result first of God, and then of the forms which make things as they are.²¹ Unsurprisingly, Descartes makes no such explicit appeal to Aristotelianism. That he does not seem to want to justify his remedies in this way runs counter to the standard way of approaching Descartes' problem of health, one that would have Descartes importing Aristotelian metaphysics in the case of the human being. Descartes has an opportunity here to ground his prescriptions by appeal to the union of the soul with the body, and he does not. And rightly so, for his doing so, as I have just noted, would compromise his dualism.

In connection with the obscurity of the justification for Descartes' prescriptions, it is worth remarking just how cursory the appeal to Aristotelian metaphysics is in La Framboisière's justification. While Aristotelian metaphysics is invoked in La Framboisière's *Oeuvres*, it does not play any active explanatory role. The four lines of mention it gets in the first paragraph of *Principauté* is the last we see of it. While we might explain this by claiming that La Framboisière was concerned principally with the *art* of medicine and not medical *theory*,²² I suggest that there is more to it than that: La Framboisière marks a turn in medical thinking. Brockliss and Jones, in *The Medical World of Early Modern France*, note that both the *Gouvernement* and the *Loix* were published in French rather than in Latin in an effort to educate a broad-based audience in medical matters, and that La Framboisière, in part because of his experience with the plague, was

the workings of the human body with that of a fountain (11:131; 1:100f). We can find such thinking throughout Descartes' writings, for example, in Part V of the *Discourse* and in the *Passions*.

Descartes' brand of mechanist physiology differs from the Galenic model in at least two obvious places. First, and most obviously, they do not agree on what the fluids at issue are. Second, Descartes and the Galenists will have different explanations of the motions of fluids. Nonetheless, Descartes' medicine is not as discontinuous with Galenism as that of Hobbes, say, would be.

21. La Framboisière, *Oeuvres* (1644), p. 44. The exposition extends all of four lines.

22. Indeed, the entry in the *Biographie Nationale de France* dismisses La Framboisière as having contributed little original to medical theory.

concerned to shift the focus of medicine from the curing of diseases which present themselves to the prevention of medical illnesses.²³ My thought here is that this shift in focus came along with a de-emphasis on the traditional theoretical underpinnings of medicine. The institutions of medicine became newly focused on the practical task of keeping people healthy. Following this train of thought, through such a shift in focus, exemplified by someone like La Framboisière, it becomes possible to consider a Galenic model of therapeutics *apart* from an Aristotelian underpinning. In turn, it would not be surprising if this de-emphasis opened a conceptual space for theoretical change, such as a mechanistic foundation for medical practice, in the first half of the seventeenth century. I put this forward only as a suggestion. Substantiating it would require more historical research than I have done, or indeed than, to my knowledge, has been done to date.²⁴ If my hunch is right, then there are some historical reasons to doubt that Descartes would have resorted to drawing on Aristotelian metaphysics to ground his conception of health. For if prior to Descartes there was already a turn away from Aristotelianism in medical theory, why would he want to go backwards? In physics he clearly wanted to go forward, and there is no reason to think he saw medicine any differently.

Now it might well be that Descartes does not *want* to go backwards, but is just caught in a bind. He doesn't want to import teleology into the natural world, but he thinks he has to appeal to the purpose or design of a machine if he wants to make claims about how well that machine is working, or whether a body is healthy. That is the suggestion of the Sixth Meditation. Before settling on this resolution to Descartes' problem of health, however, I want to consider whether there really is no hope for the mechanist to find a norm for health in the physical world.

An alternative solution: form as structure

I begin with some cues within Descartes' own writings, for there are several passages that suggest that Descartes thinks that bodies have their proper good, independently both of any purpose they might serve and of their participation in a union which gives them purpose. For instance, in PS a.107, Descartes adverts to a time *prior* to the union, when there was nutriment in the body more suitable to maintaining it.²⁵ The body's

23. See Brockliss and Jones (1997), p. 99.

24. Much has been written about medical theory—the history of anatomy and the development of Harvey's model of the circulation of the blood. Brockliss and Jones (1997) provide the most comprehensive work on the practice of medicine, though their focus is mostly on medical institutions. Most work is thus either on medical theory or medical practice, but there is little work on the relation between the two.

25. "For it seems to me that our soul's first passions, when it began to be joined with

ability to maintain its life seems to be a good independent of its union with the soul and intrinsic to its mechanism. And this is not the only place Descartes speaks of the body in this way. In both the *Passions* and the correspondence with Elisabeth, he also adverts to a perfection proper to the body itself.²⁶ These passages identify a perfection proper to the body independent of its union with the soul—a perfection which the soul, in virtue of the union and the passions and feelings of pleasure and pain it affords, can then be made aware of and appreciate. The perfection of the body does not seem to be constituted by this awareness.²⁷ The question then is whether we can understand this perfection or good of the body in wholly mechanistic terms. If so, we can then understand the body as being more or less healthy in proportion to how closely it achieves this perfection.

We might begin by considering Descartes' remark to Elisabeth: why should a demonstration of strength, whereby the body manages to sustain itself even though it undertakes an arduous activity, demonstrate bodily perfection, and thereby afford the soul pleasure? In the account of pleasure and pain in the *Treatise of Man*, Descartes suggests that the soul's sense of the body's *completeness*—of the body's forming an integrated whole which, because of the “good constitution” of its parts, withstands breakage and the separation of those parts from the whole—leads to a feeling of pleasure. Similarly, we feel pain when the completeness of the body's construction is undermined by an external force.²⁸ If we apply these observations

our body, must have been due to the blood, or other juice entering the heart, sometimes being a more suitable nourishment than the usual for maintaining the heat in it which is the principle of life” (11:407).

26. Later in the *Passions*, Descartes claims that the “natural use [of the passions] is to incite the soul to consent and contribute to actions which can serve to *preserve the body or render it more perfect in some way*”(PS a.137; 11:430; emphasis added). And to Elisabeth, while explaining the correlation of “the pleasure of the soul which constitutes its happiness” with our bodily state, he writes that we feel cheerful in “bodily exercises like hunting and tennis which are pleasurable in spite of being arduous” because “in the process it [the soul] is made aware of the strength, or skill, or some other *perfection* of the body to which it is joined”(To Elisabeth, 6 October 1645; 4:309; 3:270; emphasis added).

27. It might be objected here that Descartes refers to the perfection of the body in the context of discussing the union of mind and body. However, Descartes is not talking about the perfection of the union here, nor is he adverting to the perfection of the body insofar as it is joined to the soul. After all, in the *Treatise of Man*, we are asked to consider a body prior to its being joined with a rational soul. And in the letter to Elisabeth, Descartes claims that sustaining the exertion of sport demonstrate the body's perfection—a perfection it has on its own—to the soul. In the *Discourse*, Part V, Descartes does admit that animals have certain perfections of their own, though they are not as adaptable as human beings.

28. See 11:143–44. See also Pr. IV, p. 191 (8A:318).

to Descartes' later remarks, it then seems that Descartes takes the perfection of the body to consist just in the integrity and stability of the body-machine's construction.

This position resonates with Descartes' account of the human body. For him, the human body is characterized just by the disposition of its organs—that is, by the construction of the body-machine. So for instance, as early as the *Treatise of Man*, he claims that the workings of human bodies “depend only on the disposition of the organs.”²⁹ Descartes espouses this view again and again.³⁰

Descartes' account of basic human bodily functioning in terms of the disposition of body parts follows naturally from his view that the human body just is a machine.³¹ For a machine is just a stable integrated system of moving parts that transfer forces, motion or energy in a pre-determined manner. That is, they have what Des Chene calls “dispositional unity.” Des Chene draws our attention to this aspect of machines, and his historical work on the texts of Salomon Caus and others shows just how important the fitting together of specialized parts was to early modern mechanics.³²

29. See 11:120.

30. Later in the *Treatise of Man*, he accounts for bodily sensation in terms of the arrangement of the nerve fibers in the parts of the machine serving as sense organs (11:141), and more generally he accounts for all of our bodily functions simply by the “arrangement of the machine's organs” (11:202). Descartes also maintains this position—that the functioning of the body depends entirely on the disposition of its organs—in the unfinished *Description of the Human Body*. There he states his position much more strongly, going so far as to claim that “when the body has all its organs disposed to some movement, it has no need of the soul in order to produce that movement” (11:225). The rest of the work is then devoted to defending this claim by describing “the whole of the machine of our body” (11:226), laying out its general structure and its workings in the beating of the heart, nutrition and in gestation. And the idea does not undergo any significant change when Descartes summarizes the central points of these unpublished works in Part Five of the *Discourse* and outlines his account of the beating of the heart (see 6:46; 1:134). Indeed, the idea still pervades Descartes' thoughts about the human body in the *Passions*, where, in his “brief explanation of the parts of the body and some of its functions” in PS a.7, he consistently appeals to “the way in which the machine of our body is composed” (11:331) in order to account for the beating of the heart and the circulation of the blood; in later articles he goes on to explain the production of animal spirits, movement of the muscles, the action of objects on the sense organs, and the way in which these actions affect the animal spirits in a similar fashion (see PS aa.9–16, 11:333–36).

31. In a footnote to his translation of the *Treatise of Man*, Thomas Hall remarks that for Descartes' disciple Louis La Forge a machine is just a “body composed of several organic parts which being united conspire to produce certain movements of which they would be incapable if separate” (Hall [1972], p. 4n6). Thus, La Forge seemed to recognize the facts about machines on which I am about to draw.

32. While there is little new in this sixteenth and seventeenth century conception of a machine, the design of parts becomes much more intricate and specialized in the Renaissance and early modern period. See Drake and Drabkin (1969) and Des Chene (2001).

The concern, however, is whether this dispositional unity is sufficient to generate a norm that might constitute a good proper to the machine alone. Des Chene does not think it is. For, he maintains, this dispositional unity is only a unity at all relative to the purpose of the machine. Without an appeal to purpose, he argues, there is no principled way for a mechanist to distinguish where one machine ends and another begins. And without delimiting the machine in this way, there is no principled way to specify the machine's forming an *integrated* structure, let alone to account for its stability and ability to preserve itself. Des Chene thus presents a sophisticated version of the standard solution to the mechanist's problem of health. Des Chene does allow that machines have a dispositional unity *as machines* that affords us a measure through which to assess how well a machine is working. However, he also maintains that a proper account of that mechanical dispositional unity requires that one machine be properly delimited from another, and the individuation of machines in a natural world described mechanistically requires an appeal to extrinsic purposes. It is through those purposes, according to Des Chene, that we come to differentiate one machine from another, and so put ourselves in a position to avail ourselves of the dispositional unity of a machine in order to make a determination about how well it is functioning.³³

I want to take issue with Des Chene's last move: that we need to appeal to an extrinsic purpose or end to differentiate one machine from another. And I will do so by proposing an alternative position involving what can be called a non-teleological notion of form. On this view, having an intrinsic stable structure³⁴ needs no further explanation, and gives us the basis

33. See Des Chene (2001), Ch. 6. Des Chene writes: "The *one* motion stands out only, it would seem, in relation to the intentions of its builder (or someone else's guesses about them). . . . From nature's standpoint, the choice of a terminus for the concerted motions of the parts is arbitrary. Similarly the choice of the initial activating motion. To isolate the machine from its environs we must, it seems, either look downward toward physical unity or upward toward functional and intentional unity" (*ibid.*, p. 131f). Des Chene seems to be maintaining that ascribing dispositional unity to a machine entails distinguishing the machine from its environment, and that dispositional unity on its own is insufficient to the task. Des Chene's argument, so far as I can tell, is simply one of implausibility. He continues: "the intentional unity of a simulating machine cannot be reduced to dispositional unity . . . it is not clear that the dispositions of the mechanisms comprised in the machine can be conjoined into a single disposition attributable to the whole. The only description of the action of the whole that comes to mind is that of self-preservation. But self-preservation would seem to re-introduce the norms that a reduction to dispositions was supposed to eliminate. Without them it is not clear that we would know under which conditions the machine could be described as intact" (*ibid.*, p. 138).

34. I take it that having an intrinsic stable structure is equivalent to having a disposition to self-preservation, and this position will be implicitly defended in what follows. So it is with this notion that I am taking issue with Des Chene's argument.

for a minimal norm of the good of a body, and so the basis for a notion of health.³⁵ Interestingly, just such a notion of form emerges in the seventeenth century.

To begin to see this alternative, consider again the paradigmatic machine for Descartes: a clock. A clock is a peculiar machine to pick as paradigmatic, for it does not do work on anything external to it; it does not (at least by design) transfer motion to anything outside itself. It is thus not a machine in the traditional sense.³⁶ While a clock, like a traditional machine, moves just according to the laws governing the motion of its parts, in its case those movements are geared only towards keeping the machine itself intact and moving.³⁷ That is, a clock's parts are organized not only such that their movement can measure out a period of time but also such that the organizational structure is preserved through that movement. For without that structural stability it could not keep time in any useful way. Indeed, its maintaining its intrinsic structure is a precondition of its being used for anything, let alone as a time-keeping device. And, while oftentimes we design new machines to some end, something's having a given design, or an intrinsic structure, does not determine its possible uses: we can use a spring to keep time, to absorb the force of impact, or even to send a signal through the waves it can propagate. Its possible uses are constrained by the conditions under which it loses its characteristic structure.³⁸ And what is true of artificial machines is also true of "natural machines": if we had a body which intrinsically kept to a periodic motion, we could use it as a clock, even though that use has not played a causal role in the body's having the properties it does. This idea is what lies behind atomic clocks, or even a sundial. These cases show that mechanical integrity is a necessary *precondition* of something mechanical working *as* a ma-

35. I will implicitly agree with Des Chene here that self-preservation can serve as the disposition that can unify the machine, and that in doing so it introduces a norm into the machine. I will, however, disagree with him that the disposition to self-preservation reintroduces the norm dispositional unity was supposed to eliminate, namely that provided by an Aristotelian formal cause.

36. A machine in the traditional sense is designed to assist in doing work, either in moving unwieldy objects over a distance (think of simple machines like an inclined plane, a pulley or a lever, used in construction), or in streamlining complex tasks (think of a loom or a printing press).

37. Of course, a clock is not a perpetual motion machine, but in designing a clock one wants it to keep ticking and to keep time for as long as possible. Indeed, Descartes in Rule 13 alludes to a concern with devising just such a perpetual motion machine (10:436–37; 1:55). Thus, the perfect machine is one that is self-contained in this way.

38. Of course, its uses are also constrained by how well that something might achieve some end compared to other things, but its retaining its structure under a set of conditions is assumed in evaluating that something's relative utility.

chine—doing work toward some purpose or end. In order to be considered useful at all, a thing must have a stable structure of its moving parts. This structural integrity, as much as the motion of its parts, allows the thing to be put to some kind of work, of whatever kind that might be.³⁹

This stable intrinsic structure provides sufficient grounds to delimit one machine from another. While it might well be the case that the universe as a whole is a machine, it is still a machine of many parts, which are themselves machines, and so on. In individuating them as parts of a larger machine, we need only note that they remain stable structures through the workings of the whole of which they are parts. What makes a machine the machine it is, then, is its particular composition. It will remain that machine just so long as its parts continue to move in coordination with one another. Of course, this arrangement of parts is not necessary; the machine can decompose in a way entirely in accord with the laws of nature. But when it does decompose in this way, it will cease to be the machine it once was. Not only will it be structurally different; in virtue of that structural difference it will also have a different capacity to do work.⁴⁰ In this way, the stable internal structure serves to explain the nature of the machine, and so serves as its form, albeit of a non-teleological character. Though such a view diverges from the Aristotelian conception of form, insofar as that conception is essentially teleological, it still makes sense to call it a form. For the notion of form consists principally in the explanation of a thing's nature, its being the thing it is, without specifying the content of that explanation.⁴¹ Moreover, insofar as a machine's structural integrity constitutes its nature, it provides a measure of its perfection or good.⁴² The perfection of a machine lies just in its having all its parts in order, and in its being organized so that it can maintain that order. Thus, structural integrity contains on its own a norm that can be achieved more or less successfully. A machine is better or worse off inasmuch as it is able to maintain its structural integrity. We need not appeal to any extrinsic purpose to make such an evaluation.⁴³

39. Insofar as the machine is organized in such a way that it maintains its structure, we can understand it to have a disposition to self-preservation.

40. It will not only cease to be able to do the work it once could, but will perhaps be equally suited to perform other sorts of tasks.

41. As Robert Pasnau has meticulously shown, in medieval philosophy the concept of form already deviates from the Aristotelian notion of form as functional explanation and can be understood as "something like an internal efficient cause." See Pasnau "Form, Substance, and Mechanism" (ms).

42. There might well still be problems with this notion of a good proper to body, but these problems are of a piece with the problems Descartes faces regarding the individuation of bodies in general.

43. This is not to say that we cannot. We will certainly want to measure how well a ma-

Under this account, we can see the significance of Descartes' description of the human body. In that description, Descartes emphasizes the arrangement of the body's organs, and this serves two purposes. First, this emphasis serves to point out just how "the machine of the body is composed" determines the motions available within and to the body. Second, it aims to show that this very configuration makes the body the very body it is. Indeed, this is what Descartes claims in the Synopsis of the *Meditations*: "the human body, insofar as it differs from other bodies, is simply made up of a certain configuration of limbs, and other accidents of this sort . . . a human body loses its identity merely as the result in the change in shape of some of its parts" (7:14; 2:10).⁴⁴ The body's organization distinguishes it from other bodies and so makes it the machine it is. Indeed, insofar as the structure of its parts allows the body to preserve itself with that structure under a range of circumstances, that bodily structure allows the body to keep itself alive.⁴⁵ If and only if the body meets these sorts of conditions, is it suitable to be joined with a soul. On this account, it is not its being joined with a soul that gives it the structure it has, or delimits it as the body it is. Rather the structure of the body *itself* allows it to maintain itself. Moreover, such a conception of bodily perfection accords well with what Descartes writes to Elisabeth and in the *Treatise of Man*, and it is equally supported by what he states to be his aim in the *Description of the*

chine performs a particular function, but such an evaluation would be in addition to the evaluation I argue for here.

44. See also the Replies to Second Objections: "But in the case of the human body, the difference between it and other bodies consists merely in the arrangement of the limbs and other accidents of this sort; and the final death of the body depends solely on a division or change of shape" (7:153; 2:109).

45. As noted above, Descartes accounts for death by the disintegration of one of the principal parts of the body. When one of the parts of the body begins to fail, the whole mechanism of the body-machine ceases to be able to function: the machine loses its integrity and so "the bodily principle of the movements for which it is constructed . . . ceases to act" (PS a.6; 11:331). Thus, the human body dies—it ceases to be what it is or to function according to its proper principle—just when it de-composes and the parts of the machine cease to stand in their constitutive relation to one another.

The alternative explanation of Descartes' "death" on which Gabriel Daniel's *Voyage au Monde du Descartes* (1690) seems premised on just such a view. In Daniel's fantastic novel, we are presented with a Descartes who has discovered the nature of the union of soul and body and with this knowledge (and a little snuff) is able to separate the soul from the body at will and then rejoin it (with the help of some restorative hungarian water). In the midst of one of the soul's expeditions away from the body, Descartes' physician visits him, and finds a body uttering in reply to questions the sort of nonsense a machine without a soul would utter. He thus attempts to cure Descartes' illness, but in so doing disorders the body machine so much, that the soul is not able to reunite with it. The suggestion is that Descartes is wandering the world as a disembodied soul.

Human Body. There he ties knowledge of this disposition of our organs to our maintaining our health, and the idea is that if we can just discover “the nature of our body”—the way our body is put together—we will be able to better maintain its integrity and so be able to live healthier and longer lives.⁴⁶

It is also worth noting that such a notion of mechanical perfection helps make better sense of Descartes’ suggestion that animals work to maintain themselves.⁴⁷ Recall that the standard way of solving Descartes’ problem with health accounts for the health of animals by relying on comparative physiology. Insofar as Descartes does not think that non-human animal bodies are joined with souls, he cannot claim that the survival of the animal is due to its bodily well-being serving the ends of a soul joined with it. Nor is it at all clear what other sort of extrinsic good or purpose the animal’s continued health could serve which does not already presuppose the health of that animal. And of course, Descartes cannot explain the animal’s continued health by appeal to any substantial form or soul that gives the animal its nature. Since the standard view denies that machines contain intrinsic norms, it cannot say that animals, as machines, contain their own standard of health. But this denial seems to run counter both to the fact that animals do work to preserve themselves and the practice of veterinary medicine. The account I am exploring here provides us with a way of understanding how Descartes might consistently claim that animals are machines and are more or less healthy as they are able to preserve themselves. A norm of mechanical stability provides us with a concept of animal health that is not parasitic on that of human health.

Although I do think the account of non-teleological form is tenable and consistent with Descartes’ writings, and so that he *could* have offered it, I do not want to insist that he actually *does* so. Descartes’ writings are equivocal on this matter. In the Sixth Meditation, he does seem to identify human health with the health of the union of soul and body, and moreover, it appears that he does so because he cannot see another way to finding any norm within the physical world. But in the *Passions of the Soul* he is quite clear that life is a function of the body alone, determined by the disposition of its organs, and little in Descartes’ writings suggests that what part of matter constitutes a human body is determined by its being joined to a soul.⁴⁸ Descartes does seem to be of two minds, or else just plain confused. It is instructive to think about why this might be so.

46. See 11:223–24.

47. See *Discourse* Pt. V; Letter to the Marquis of Newcastle, 23 November 1646, (4:574ff, 3:303f); PS aa. 50, 138 (11:370, 431).

48. In the letter to Mesland of 9 February 1645, Descartes does maintain that our body

As I have noted, Descartes' commentators have generally not attributed to him a non-teleological notion of form, nor even entertained this interpretation as a possibility. One explanation for Descartes' not overtly offering the account I have presented is quite simple: Descartes was similarly unable to consider the position I have outlined as a viable alternative. This explanation is a bit puzzling, however, as historically this position *is* one that gains currency in the seventeenth century.⁴⁹

One can see this notion of form clearly in early modern chemical interest in crystal structure. Norma Emerton has drawn attention to Gassendi and Boyle's accounts of regular geometric structure in nature as revealed in crystal figuration,⁵⁰ where each author sought to explain the symmetry of the matter of non-living substances. While regularity in the arrangement of matter could be explained by chance, Gassendi thinks it unlikely that chance could account for crystals being organized in the same way all the way down (so that salt cubes, when broken, break into further cubes, and so on). Instead, he postulates a "seminal molecule" constituted by a group of atoms, organized in a certain way, which serve as the seed from which similar structures grow to build larger and larger crystals with the same intrinsic structure.⁵¹ Contemporary chemists employ the similar notion of "seed crystals." Boyle, too, appeals to an intrinsic structure as a "plastick principle implanted by the most wise Creator in certain parcels of matter"⁵² which explains the regular and symmetric structure of crystals, and in so doing serves as the form of a body without being itself distinct from the matter of that body.⁵³

It is interesting to note that this notion of form-as-structure emerges in the case of crystals. It can be tempting to try to ask *why* a living thing has the organizational structure it does, and to answer that question with an

"remains always numerically the same so long as it is united with the same soul" (4:167, 3:243). Since the notion of health I have been developing is grounded in a non-teleological principle of individuation, one might take Descartes' teleological principle of the individuation of the human body here to ground the teleological notion of health inherent in the standard interpretation. This letter to Mesland provides the sole instance of this claim on Descartes' part. And it is not clear how such a claim is consistent with his mechanist account of the life of the body, an account which does dominate his later works.

49. This is not to say this notion is new in the seventeenth century. See Pasnau (ms).

50. See Norma Emerton (1984), esp. Ch. 5 and 6.

51. See Emerton, pp. 138–9, and *Syntagma philosophicum*, De qualitibus rerum, II, 114–118, 140ff; I, 271, 280 (*Opera Omnia* I and II, 1658).

52. Boyle, *History of Fluidity and Firmness*, Works, I, 275. Quoted in Emerton (1984), p. 144.

53. "the form . . . may be . . . a modification of the matter . . . whose parts, by being so and so disposed . . . constitute such a determinate kind of body" *History of Fluidity and Firmness*, p. 273. Quoted in Emerton (1984).

appeal to some end proper to that living thing. We are not tempted, however, to say crystals have the structure they do because it serves some purpose. This fact shows that it is possible for an explanation in terms of structure to stop there, without appeal to teleology,

Whereas Descartes' writings do not present a univocal endorsement of this non-teleological notion of a self-maintaining internal structure, this notion plays a central role in both Spinoza's and Locke's accounts of living individuals. For Spinoza, what makes a thing, understood under the attribute of extension, the thing it is, is not its being composed of particular matter, nor its being informed by anything apart from that matter. A material thing is delimited from other material things just in virtue of its parts standing in a certain relation to one another, a relation characterized by a *ratio* of motion and rest. When there is a deviation from that *ratio*, the thing is no longer the same thing. And so, as per *Ethics* Part III, Proposition 7, the essence of a thing is just its striving to persevere in its being, or—if we understand a thing under the attribute of extension—its striving to maintain its *ratio*. A thing persists just insofar as its *ratio* allows it to maintain itself, its *ratio*, though all the while being causally affected by other things. Insofar as this *ratio* is a particular proportion of motion and rest, it bears some similarity to the constrained motion proper to a well-structured machine; recall that the structure of a machine fixes the range of possible motions of its parts. Interestingly, in the Lemmas in the middle of Part II of the *Ethics*, where Spinoza introduces this idea, his language draws an explicit connection between this *ratio* and form.⁵⁴

In his discussion of the principle of individuation of living things—that is, things whose material composition changes—Locke also appeals to the organization of a thing to explain its being the thing it is:

We must therefore consider wherein an Oak differs from a Mass of Matter, and that seems to me to be in this; that the one is only the Cohesion of Particles of Matter any how united, the other such a disposition of them as constitutes the parts of an Oak. . . . For this Organization being at any one instant in any one Collection of *Matter*, is in that particular concrete distinguished from all other, and is that individual Life (*Essay Concerning Human Understanding* II.27.4).

The organization of matter plays the role of a non-teleological form, insofar as it serves to dispose cohesive matter in a particular way, and so to

54. "If the parts composing an individual become greater or less, but in such proportion that they all keep the same ratio of motion and rest to each other as before, then the individual will likewise retain its nature as before, without any change of form [*absque ulla eius formae mutatione*]" (EIIIL5; cf. also EIIIL4–6).

constitute a living thing, and it does so without introducing any end that might serve to explain that organization further.⁵⁵

Thus it seems that a non-teleological norm gains currency after Descartes. In considering the positions of those who followed Descartes we can gain insight into what might have left him of two minds. If we are to take the mechanical integrity of a thing as a non-teleological norm, it becomes hard to distinguish living from non-living things. What, after all, is the difference between a crystal and an animal, if both have an intrinsic structure which constitutes and serves to maintain them as the things they are? Spinoza, quite famously, sees stones and humans as on a continuum, though many of his readers find this hard to digest.⁵⁶ For Locke, being organized is precisely what distinguishes the living from the non-living. Inanimate bodies are no more than clumps of matter, which change as their matter changes. Crystals, however, seem an obvious counter-example to this distinction.⁵⁷ Perhaps the parts of a living thing are in motion, whereas those of a crystal are at rest. But this distinction will not suffice, as many mechanists presuppose that all matter is in motion. Even appeal to reproductive ability to distinguish the living from the non-living would seem to fail in the case of crystals. For crystals do grow by replicating themselves, and they are even said to do so from a seed.⁵⁸ The need for a principle to distinguish the living from the non-living pulls against a non-teleological notion of form.

And in parallel, the notion of bodily health derived from this position seems an impoverished view relative to human beings. Our state of mind, our conception of ourselves as unions of mind and body, figures importantly in our well-being. And Descartes does recognize this. For him, bodily health is simply a precondition of our achieving the more holistic

55. Locke does introduce an end in his analogy of a living thing with a machine: "what is a watch? 'Tis plain 'tis nothing but a fit Organization, or Construction of Part, to a certain end, which when a sufficient force is added to it, it is capable to attain" (ECHU, II.27.5). But in his fleshing out the analogy, the end in the case of living things turns out to be just "One Common Life," and I take "life" here to be simply the stability of the organization under the motion of the body's parts.

56. Indeed, in his contribution to this issue, "Mechanism and Atomism in Gassendi's Account of Plant and Animal Generation," Saul Fisher shows that Gassendi arrives at a similar conclusion regarding the underlying structures of organic and inorganic matter.

57. One might well think that seventeenth century interest in crystals was in part because they challenge us to think more carefully about the distinction between living and non-living things.

58. Contemporary chemists employ the notion of a seed crystal, as I noted above, but so did Gassendi.

health and well-being that forms a real part of our living a good life.⁵⁹ The problem is how to relate these two conceptions of health to one another, of how to relate our physical lives to our ethical lives.

While related to that of finding norms in a mechanistically described world, these problems are distinctive. I have argued here that the standard problem, of how to find norms of health in a mechanistic world is solvable without importing teleology, or a latent Aristotelianism. First, by considering medical history, I have shown that such a solution is historically plausible. For the writings of Nicholas de la Framboisière suggest that Aristotelianism was on the way out in medicine just as much as it was in physics. Second, I have argued that the stable structure of things constitutes a non-teleological form. Insofar as this form explains the nature of things, it serves as the norm which grounds our ascriptions of health of body-machines. Yet this solution leaves us with other problems—distinguishing the living from the non-living, and understanding how mechanical norms bear on the other things we care about, things which typically do involve ends.

References

- Ariew, Roger. 1999. *Descartes and the Last Scholastics*. Ithaca: Cornell University Press.
- Boyle, Robert. 1914. *History of Fluidity and Firmness*. In *The Works of the Honourable Robert Boyle I*. Ed. Thomas Birch. London.
- Brockliss, Laurence and Colin Jones. 1997. *Medical World of Early Modern France*. Oxford and New York: Clarendon Press.
- Canguilhem, Georges. 1994. *A Vital Rationalist*. Ed. François Delaporte. New York: Zone Books.
- . 1955. *La Formation du concept de réflexe au XVIIe et XVIIIe siècles*. Paris: PUF.
- . 1952. *La connaissance de la vie*. Paris: Hachette.
- Daniel, Gabriel. 1690. *Voyage au Monde du Descartes*. Paris: Vve de S. Bernard.
- Descartes, René. 1996. *Oeuvres*. Ed. Charles Adam and Paul Tannery. Paris: Vrin.
- . 1984–89. *The Philosophical Writings of Descartes*. Three Volumes. Translated by J. Cottingham, R. Stoothof, D. Murdoch and A. Kenny. Cambridge: Cambridge University Press.

59. See for instance the letters to Elisabeth of 1 September 1645 (4:281f; 3:262f) and to Hyperaspistes of August 1641 (3:423f; 3:189f).

- . 1972. *Treatise of Man*. Translated by Thomas Hall. Cambridge, MA: Harvard University Press.
- Des Chene, Dennis. 2001. *Spirits and Clocks*. Ithaca: Cornell University Press.
- Drake, Stillman and I. E. Drabkin. 1969. *Mechanics in Sixteenth Century Italy*. Madison: University of Wisconsin Press.
- Emerton, Norma. 1984. *The Scientific Reinterpretation of Form*. Ithaca: Cornell University Press.
- Gassendi, Pierre. 1658. *Syntagma philosophicum*. In *Opera Omnia*, I and II.
- Gueroult, Martial. 1985. *Descartes' Philosophy Interpreted According to the Order of Reasons II: The Soul and the Body*. Translated by Roger Ariew. Minneapolis: University of Minnesota Press.
- Hobbes, Thomas. 1994. *Leviathan*. Ed. Edwin Curley. Indianapolis: Hackett.
- Hoffman, Paul. 1986. "The Unity of Descartes' Man." *The Philosophical Review*, 95:3.
- La Framboisière, Nicholas. 1644. *Oeuvres*. Lyon: Jean Antoine Huguetan.
- Locke, John. 1975. *Essay Concerning Human Understanding*. Ed. P. H. Nidditch. Oxford: Oxford University Press.
- Pausnau, Robert. MS. "Form, Substance and Mechanism."
- Rozemond, Marleen. 1998. *Descartes's Dualism*. Cambridge, MA: Harvard University Press.
- Schmaltz, Tad. 1992. "Descartes and Malebranche on Mind and Mind-Body Union." *The Philosophical Review*, 101:281–325.
- Spinoza, Baruch. 1994. *Ethics*. In *A Spinoza Reader*. Edited and translated by Edwin Curley. Princeton: Princeton University Press.