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[p. 135]

Chapter 8

Divine Organs? Leibniz’s ‘Hymn to Galen’ and the Best of All Possible Bodies

Raphaële Andrault¹

Abstract My aim is to question the different finalistic approaches to the human body that underlie the theological justifications of anatomy. To do so, I analyze the references that Leibniz made to Galen’s *On the Use of the Parts* that had a strategic purpose in his campaign against materialism. I show that the new mechanistic conception that is endorsed by Leibniz leads him to contradict Galen’s method on two key aspects: 1/ the principle of the best, which, according to Leibniz, is grounded in God’s rationality, casts doubt on the Galenic taxonomy of the human body and precludes the identification of a biological function with the final cause of an organ; 2/ the infinite complexity of Leibniz’s ‘machines of nature’, i.e. living bodies, conflicts with the anthropomorphic representation of their creation as the molding of unformed materials. Accordingly, Leibniz agrees with Galen that a Creator did his best in making our bodies, but he disagrees profoundly on the exact implications of this very general claim.

8. 1 Introduction

Leibniz is well-known as the philosopher who reintroduced final causes into natural philosophy. According to him, Descartes and his *sectators* had gone too far in rejecting final causes and accepting only proximate causes: this Cartesian view might lead to regarding the world as the fortuitous effect of necessary and unpurposive mechanical interactions – a view which would be as disastrous for the intelligibility of the natural world, as it would be dangerous for religion. In the same vein, in the *Tentamen anagogicum, Essay anagogique dans la recherche des causes* (1696), Leibniz argues that we should take into account both the reign of power, according to which everything can be explained *mechanically*, by efficient causes [p. 136], and the reign of wisdom, according to which everything can be explained *architectonically*, by final causes.

[One] can say with Lucretius not only that animals see because they have eyes, but also that eyes have been given [to] them in order to see, though I know that some people, in order the better to pass as free thinkers, admit only the former. Those who enter into the details of natural machines, however, must have need of a strong bias to resist the attractions of their beauty. Even Galen, after learning something about

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the function of the parts of animals, was so stirred with admiration that he held that to explain them was essentially to sing hymns to the honor of divinity. I have often wished that an able physicist would undertake to prepare a special work whose title – or whose aim at least – would be *The Hymn of Galen*.

What is more, our thinking sometimes furnished us with considerations revealing the value of final causes, not merely in increasing our admiration for the supreme Author, but also in making discoveries among his works (Leibniz 1875, Vol. 7, 273; trans. Leibniz 1976, 478–479).

According to this citation, final causes are needed for two different, but complementary, reasons. From an epistemological point of view, one cannot account for the structure of animal bodies, or ‘natural machines’, without assuming that organic structures have been shaped to accomplish their functions. For Leibniz, this teleological point of view is relevant far beyond animal kingdom: it is heuristically useful to know and understand natural things in general. Theologically, the appeal to final causes enables one to acknowledge the role, power, and wisdom of the ‘supreme Author’ who is the source of natural purposiveness. Thus, Galen must be praised not only for having shown that organic structures are not fortuitous, but also for having glorified the beauty and functionality of God’s Creation. However, if it is clear that Leibniz shares with Galen the idea that natural things were purposely and intelligently made by a Creator, the praise of Galen is quite ambiguous in the citation above: Leibniz seems to imply that Galen had, in the end, combined the epistemological and the theological purposes of his undertaking to the detriment of the epistemological part (see Duchesneau 1998, 318).

In this chapter, I analyze Leibniz’s ambiguous and complex references to Galen’s method. My aim is to question the different finalistic approaches to the human body that underlie the theological justification of anatomy. The development of anatomy in the sixteenth and seventeenth centuries, as well as Leibniz’s principle of economy, lead him to adopt notions of organ and function which are very different from Galen’s. The distinction between at least two kinds of finalistic approaches to anatomy is interesting from a perspective greater than that of Leibniz’s philosophy. Indeed, there is a consensus according to which anatomy in itself involves adopting a teleological understanding of the human or animal body (Kant 2000, § 66, 248; Canguilhem 1970, 277; Hankinson 1989, 224). True enough, but such a teleological commitment does not involve regarding organic functions as final causes *per se*. To put it concisely, this general teleological commitment may ground different methods of anatomical investigation, that is to say, different manners of ascribing the ‘uses’, or functions, to organs. Leibniz’s reading of Galen is thus an interesting tool to better understand the complex links between, on the one hand, anatomy [p. 137] as an experimental subject, and, on the other hand, the teleology that usually underlies the notion of divine creation.

8.2 Leibniz’s Reading of Galen

The mention of Galen in the *Tentamen anagogicum* may seem quite general. But there is evidence that Leibniz had first-hand knowledge of Galen’s works from the *Opera omnia* published in Bale by Cornarius in 1549. On several occasions, in reading notes from the 1680’s and well as in the *Analysis didactica* (1696), Leibniz refers to the Latin translations of Galen’s *Methodo medendi*, *De temperamentis libri tres*, *Quod animi mores corporis*

temperamenta sequantur, *De placitis Hippocratis et Platonis*, and *De optima secta ad Thrasybulum liber*. This last reference allows Leibniz to criticize the empirics (Leibniz, 1923, Series 6, Vol. 4, 1232; see also Leibniz, 1923, Series 6, Vol. 5). It is clear that Galen was for Leibniz a reference, both from a medical and a philosophical perspective. Galen was an authority that a seventeenth-century philosopher had to be familiar with, whether he was interested in medicine or not. Leibniz's only negative reference to Galen is not really a reference to his own writings or doctrine, but a reference to some ‘old Galenist’, *vieux galéniste*, who wrongly mocks the moderns (Leibniz 1875, Vol. 6, 200).² Leibniz thus makes a distinction between Galen himself and his caricature, which, during the seventeenth century, depicted the Galenist as a physician who used *ad hoc* faculties.

When dealing with medicine, Leibniz quotes Galen on the importance of the clinical observation of the pulse in an early text entitled *Directiones ad rem medicam pertinentes* (Leibniz 1923, Series 8, Vol. 2, 649).³ But most importantly, he refers several times to Galen's ‘hymn to [p. 138] God’. This is first the case in a letter to the physician Herman Conring in 1678, in which, without explicitly referring to Galen, he explains that there is no hymn to God that is more beautiful than the one which the physician sings when he speaks about the *usus partium*, the use of the parts (Leibniz 1875, Vol. 1, 185). Then, in 1683 (*Initia et Specimina scientiae generalis*), Leibniz criticizes the philosophers who mock Galen for singing a hymn to God. Among other references to Galen, the same year, in a piece entitled *Societas Theophilorum ad Celebrandas Laudes Dei*, Leibniz quotes a whole passage from *On the Use of the Parts*, Book III, Chap. 10 (Leibniz 1923, Series 4, Vol. 3, 850). Lastly, in the *Tentamen anagogicum*, as we have seen, he refers allusively to Galen's ‘hymn to God’. Accordingly, Leibniz's thinking on the use of final causes is explicitly related to his reading of Galen and his understanding of Galen's anatomical method.

To understand this method, we have to analyze the passage from Galen's *On the Use of the Parts* that is cited by Leibniz (Book III, chap. 10). The general aim of Galen in this passage is to criticize ‘those who through ignorance of Nature's works accuse her of lack of skill’, or, more specifically, ‘those who blame her because she has not arranged to have the superfluities discharged through the feet ... thinking that a man would be better constructed if he could simply extend his foot and discharge the excrement through it’ (Galen 1549, Vol. 1, 495; Galen 1968, 188):

But if I should speak further of such fatted cattle, right-thinking men would justly censure me and say that I was desecrating the sacred discourse which I am composing as a true hymn of praise to our Creator. And I consider that I am really showing him reverence not when I offer him unnumbered hecatombs of bulls and burn incense of cassia worth ten thousand talents, but when I myself first learn to know his wisdom, power, and goodness, and then make them known to others. I regard it as proof of perfect goodness that one should will to order everything in the best possible way, not grudging benefits to any creature, and therefore must praise

² ‘Quelque vieux Galeniste en fera autant par rapport aux facultés de l'école, il en admettra une chylique, une chymifique et une sanguifique, et il en assignera expres à chaque operation; il croira d'avoir fait merveilles, et se moquera de ce qu'il appellera les chimères des modernes, qui prétendent expliquer mecaniquement ce qui se passe dans le corps d'un animal’.

³ ‘Ebenmässig wird das zur ader gelassene blut können examinirt werden. Den Puls zu fühlen ist nicht ohne dass die hände der geringsten Medicorum zu der perfection kommen werden alle differentien zu fühlen, so Galenus bemerket’.

him as good. But to have discovered how everything should best be ordered is the height of wisdom, and to have accomplished his will in all things is proof of his invincible power (Galen 1968, 189).

Galen insists on three attributes of ‘our creator’: his goodness in creating us endowed with the proper positioning and structure of the organs; his wisdom for having ‘found the most perfect disposition’; and, lastly, his power, considering that God did exactly what he wanted to do. These three divine attributes exactly correspond to the attributes on which Leibniz insists. It is thus not surprising that Galen’s *hymnus Dei* retained Leibniz’s attention. As M.T. May puts it, Galen is a ‘contemptuous opponent of the atomists and mechanists. To contemplate the perfection of the animal body and then to attribute to blind chance this marvelous structure, which is so wonderfully adapted to the ends it must serve, seemed to him the depth of stupidity, and he said so with vehemence again and again’ (Galen 1968, 11–12). For this reason, Galen is for Leibniz an interesting polemical tool against the philosophers whom he calls the ‘strong-headed partisans of Epicurus’, that is to say, those who, in the seventeenth century, rejected final causes, and –even worst for Leibniz – who would claim with Lucretius that we see because we have organic parts which happen to be ‘eyes’.⁴ Galen’s and Leibniz’s common enemy are those who explain the conception of the animal body by blind chance, and consequently those who would jeopardize the idea the everything in nature is the effect of the intelligent and benevolent design of God. But what exactly are the consequences of these polemical views with regard to the use of final causes in anatomical explanations? It [p. 139] is one thing to argue, quite generally, that ‘our creator’ has made our organs purposely; it is another thing to adopt the method illustrated by Galen in his book *On the Use of the Parts*. I will now quickly present this method in order to better understand its implications from Leibniz’s perspective.

8.3 Galen’s *On the Use of the Parts*: From Anatomy to Theology

According to the Latin translation that Leibniz read, Galen’s anatomical method consists in ‘referring the use of a small part to the action of the whole organ [*particulae usum ad actione organi totius referrī*]’ (Book III, chap. 13, Galen 1549, Vol. 1, 499; Galen 1907, Vol. 1, 183). *Actions* [ενεργεια] correspond to the general functions of the body, which is itself the proper organ of the soul, and which is thus adapted to the ‘mores’ and ‘faculties’ of the soul. For example, a man is an animal which is very intelligent; so the different functions of the human body, like perception or locomotion, specifically enable the man to be wise. *Usus* or *uses*, or *offices* [χρηια], rather correspond to the contribution that the small parts of the body, the *particulae*, make to the main actions of the body. By definition, ‘uses’ are local and subordinated to actions. There is thus a terminological distinction between uses and actions. The typical example of the difference between *action* and *use* is

⁴ See for example Descartes himself, according to the *Principes de la philosophie* (1, 28, Descartes 1964, Vol. 9b, 37): ‘Qu’il ne faut point examiner pour quelle fin Dieu a fait chaque chose, mais seulement par quel moyen il a voulu qu’elle fût produite. Nous ne nous arrêterons pas aussi à examiner les fins que Dieu ... s’est proposé en créant le monde, et nous rejeterons entièrement de notre Philosophie la recherche des causes finales : car nous ne devons pas tant présumer de nous-mêmes, que de croire que Dieu nous ait voulu faire part de ses conseils’.

provided by the anatomy of eyes – and this is the case in Galen as well as in anatomical handbooks from the seventeenth century. Seeing is the *action* of the eyes, and protecting the eyes is the *use* of the eyelids. Discovering the uses of parts requires entering into anatomical details, and, contrarily to actions, assigning a given use X to a given part Y may be controversial. For example, according to Aristotle, the use of fingernails is to protect fingers; according to Galen, it is rather to facilitate prehension.

Epistemologically speaking, Galen’s method in this work does not have a heuristic function, but a didactic one: the epistemic role of this method is to synthetically present the anatomy of the human body and the description of the parts. Galen’s notion of the use of the parts enables him to present the existence, location, and the exact structure of each part as optimal traits, which perfectly combine with the other traits of the human body. Thanks to this approach, Galen calls attention on undeservedly neglected parts, and insists on the unity and harmony of the whole body in which every single part has its proper use and reason. To put it in a nutshell, Galen’s teleology gives intelligibility and coherence to the different detailed parts of his anatomical descriptions.

Galen’s book also fulfills an apologetic function. As he specifies in *On the Use of the Parts* (Book XVII, Chap. 1), his undertaking goes far beyond anatomy and medicine; it has also a philosophical value, since it is ‘the source of a perfect theology’:

[p. 140] Then a work on the [use] of the parts, which at first seemed to him a thing of scant importance, will be reckoned truly to be the source of a perfect theology, which is a thing far greater and far nobler than all of medicine. Hence such a work is serviceable not only for the physician, but much more so for the philosopher who is eager to gain an understanding of the whole of Nature (Galen 1968, 731).

To explain something means to give its reason, or finality; and to give its reason, is to refer to the goal-directed intention of an intelligent agent who has created this thing. In the cases where the ends are not evident, one still may be sure that, first, the things under consideration have been created in order to accomplish some ends, and, second, that they could not have been better planned and structured. In other words, when the use of a part is not known, we can still justify the existence and anatomy of this part by arguing that it is in any case the best of all possible structures. As Galen writes in the Book VI, Chap. 12:

The first cause of everything that has been formed is the purpose of its action, as Plato has pointed out somewhere. If, then, anyone asks you why you have come to market, it is hardly admissible to pass over the real reason and give another more elegant ... I grant that there are several kinds of causes: first and most important, that for the sake of which a thing is formed; second, that by which; third, that from which; fourth, that by means of which; and fifth, if you wish, that in accordance with which ... Now, as for me, when anyone asks me for what purpose the vessels of the lung have exchanged natures, that is to say, why the vein has been made arterial and the artery venous, I shall give the true, first cause, namely, that it was better in this viscus alone for the vein to be dense and the artery loose-textured (Galen 1968, 307–308).

The justification of the specific texture of veins and arteries in lungs is the following: in this viscus alone, it is better this way. To appeal to the ‘usefulness’ of a part, instead of appealing to a use, allows Galen avoid seeking the definite end to which this part is

adapted, without casting doubts on the intelligent design to which this part is due. So sometimes, when Galen mentions the exact ‘uses’ of the anatomical parts, he goes from the excellence of the human body to the excellence of its creator. On several occasions, on the contrary, Galen acknowledges his ignorance of the exact reason why such or such a part is structured the way it is, and his reasoning goes the other way around: the idea of the perfection of nature, which is itself due to the excellence of the demiurge who created it, implies that this part is useful. In the first case, the perfect adaptation between a part and its uses is supposed to show the excellence of our creator. In the second case, it is the presupposition that our creator is infinitely wise and powerful that underlies the idea that each part has its own usefulness. For example, in Book III, Chap. 10, Galen acknowledges that he does not know why the length of the internal muscles of the leg differs from the length of the external muscles, but he claims that this difference has its usefulness: ‘for nature, just in everything, has made the size of the muscles to accord with the usefulness of the actions [*utilitate actionis*] they must perform’ (Galen 1549, 494; trans. Galen 1968, 187). In this last case, Galen mentions the general usefulness of the part, which *presupposes* the excellence of its maker, not its use, which *proves* the excellence of its maker.

[p. 141] These different remarks explain why I want to preserve a terminological distinction between *actions* or *functions*, *uses*, and *usefulness* (or *utilitas*, εὐχρηστία in Greek) – and why I do not translate *usus partium* by ‘the usefulness of parts’, as M.T. May does. The distinction between *use* and *usefulness* allows me to distinguish several kinds of teleological relations between parts and functions. Sometimes this teleological relation enables the anatomist to assign a single ‘use’ to a given part – or to the main structural feature of a given part. Sometimes, this simply enables one to claim that every single trait in the human body is the best of all possible traits. Accordingly, the anatomist may be sure that a trait X, of which he does not know the use, that is to say, the reason, is useful. ‘Aristotle is right when he maintains that all animals have been fitly equipped with the best possible bodies, and he attempts to point out the skill employed in the construction of each one’ (Galen 1968, Book I, Chap. 22, 108). However, we should add a condition. According to Galen, the human body is the best possible body, considering the materials from which the demiurge shaped this body. In the passage which immediately follows the mention of the ‘hymn to God’ – a passage which is also cited by Leibniz in his reading notes on Maïmonides (Leibniz 1923, Series 6, Vol. 4, 2492) – Galen specifies the following point:

Then do not wonder so greatly at the beautiful arrangement of the sun, moon, and the whole chorus of stars, and do not be so struck with amazement at the size of them, their beauty, ceaseless motion, and ordered revolutions that things here on earth will seem trivial and disorganized in comparison; for here too you will find displayed the same wisdom, power and foresight. Consider well the material of which a thing is made, and cherish no idle hope that you could put together from the catamenia and semen an animal that would be deathless, exempt from pain, endowed with never-ending motion, and as radiantly beautiful as the sun (Galen 1968, Book III, Chap. 10, 189).

The exercise of the creative power of the demiurge is limited by the nature of the components: in building the human body and its different parts, the demiurge is analogous to the craftsman who does his best to organize the available material. Consequently, the structure of the parts of the human body is not, strictly speaking, the best of all possible

structures. It is simply the best structure that it is possible to form from the two organic fluids ‘catamenia and semen’. This is why the demiurge should not be condemned for having given pain and death to animals and human beings. Those two calamities are just the undesirable and irreducible effects of the raw material used for the creation of the body. Such a view is directly related to the classical Aristotelian distinction between matter and form which are both the two main kinds of causes that explain the genesis of something, and the two ‘components’, or solidary aspects, which individualize a thing (Debru 2008, 266).

[p. 142] 8. 4 Anatomy and Theology in Leibniz: A Panglossian View?

In Leibniz too, we find a close alliance between anatomy and theology (Andrault 2017). In the *Discourse of Metaphysics*, Leibniz, exactly like Galen, cites Plato’s *Phaedo* to promote final causes as intelligible causes. Then, in the article 22, he specifies:

[Those] who apply themselves to explaining the beauty of the divine anatomy laugh at others who imagine that a movement of certain fluids that seems fortuitous could have produced such a beautiful variety of limbs, and call these people rash and profane. And the latter, on the other hand, call the former simple and superstitious, comparing them to the ancients who regarded physicists as impious when they maintained that it is not Jupiter that thunders, but some matter present in the clouds. It would be best to join together both considerations, for if it is permitted to use a humble comparison, I recognize and praise the skill of a worker not only by showing his designs in making the parts of his machine, but also by explaining the instruments he used in making each part, especially when these instruments are simple and cleverly contrived (Leibniz, 1989, 54).

God is thus analogous to a worker who builds a machine. And anatomy, understood as the experimental investigation of the parts of the machine, is a good way to show the skill of the worker. Even when the anatomist does not presuppose that the things he describes obey the will of God, anatomical investigation in itself may be considered as a ‘hymn to God’. Actually, the mechanical analysis of organic parts and the finalistic approach to the human body are perfectly complementary: the first shows the means that are used by the worker, the second sheds light on the adaptation between those means and the ends that the worker had planned.

Because of this connection between anatomy and theology, Hankinson has compared Galen with Leibniz. In the philosophical tale *Candide: Or All for the Best* (1759), Voltaire created a caricature of Leibniz, Pangloss, Candide’s professor of ‘metaphysico-theologo-cosmologology’, who keeps claiming that all is for the best in the best of all possible worlds in face of the worst calamities: wars, venereal diseases, etc.:

Voltaire’s model, as is well known, was Leibniz; but at first sight it might almost as easily have been Galen. For Galen apparently embraced a teleology that was virtually as broad in its scope as that of Candide’s teacher. He explicitly takes his opponents to task for the failing to appreciate the purposiveness in nature, and consequently for failing to see that genuine explanations of things (at least, of the structure and

function of the parts of the human body) must be teleological in form (Hankinson 1989, 206).

Regarding anatomy, the commitment to this teleological program has been called ‘Panglossism’ by Gould and Lewontin (1979). In reality, Gould and Lewontin targeted the ‘adaptionists’, who, in twentieth-century biology, deemed that every trait of an organism has been naturally selected because it was optimal in its environment (see also Radner, 1998)⁵. The two authors criticized the confusion [p. 143] between the current function of an organ and the reason (or the genetic cause) why the organ has evolved this way. But this epistemological context is of little consequence here. Whether within the framework of the adaptionist program targeted by Gould and Lewontin, or within that of the theological-anatomy promoted by Galen, Panglossism presupposes that *explaining* the structure of an organ means *justifying* its presence in the organism, that is, with giving its ‘final cause’ or ‘reason’. When an organic trait seems unreasonably complex, fragile or impractical, Panglossism consists in claiming that it is the best *relative* to other circumstances – that is to say, that this trait could not have been better or different without being detrimental for other organs or other functions in its environment. From an epistemic perspective, Panglossism plays on two levels: 1/ the notion that knowing the anatomy of an organ amounts to understanding why it is the best; 2/ the notion that in the cases where organs are not obviously the best of all possible organs, they are at least the best considering the constraints that limit the range of possibilities. And indeed, with the two notions of *use* and *usefulness*, it seems that Galen endorses these two different strategies. To be fair, these two strategies obey more a didactic purpose than a heuristic one, as I have already mentioned. Consequently, one should not think that Galen’s Panglossian claims in *On the Use of the Parts* summarizes his anatomical thought and experimental practice.⁶ However, my aim in this chapter is not to do justice to Galen in evaluating all the different aspects of his method; it is rather to better understand Leibniz’s own teleology in the light of the passages from Galen to which the seventeenth-century philosopher explicitly refers.

Is Leibniz’s so-called Panglossism analogous to Galen’s teleology in *On the Use of the Parts*? And does Leibniz claim that every trait of the human body is the best of all possible traits, at least relative to the material available to the Creator? To be sure, Leibniz famously claims that we live in the best of all possible worlds. But does this thesis imply adopting the same justification for the organization of the human body as Galen does in *On the Use of the Parts*? Actually, this is not the case. For one thing, Leibniz never considered that our body is the best of all possible bodies, since according to him, it is only the world, i.e. the whole series of the things that belong to the world, that is the best – not such or such component of the world. For another thing, the best is selected by God on the basis of the comparison between several worlds, which are themselves defined as an infinite number of compossible things. The best choice is thus not limited by the skillfulness of God (which is absolutely unlimited), nor by the raw material he employed to create the world. The choice of the best is based on a comparison between an infinite number of worlds which human beings cannot intellectually grasp and compare.

For these two reasons – the conception of God’s power, which is incomparable with the ability of a craftsman, and the notion of infinity that is essential in Leibniz’s claim that our

⁵ However, we do not agree with Radner’s conclusion concerning Leibniz’s Panglossism.

⁶ Most notably, to be fairer and more specific on Galen’s method, it would be required to compare *On the Use of the Parts* with his *Anatomical Procedures*. See Rocca 2008.

world is the best of all possible worlds – Leibniz does not hold the Panglossian view that is explicit in the third and seventeenth books of Galen’s *On the [p. 144] Use of the Parts*. More precisely, Leibniz’s teleological understanding of anatomy differs in three key aspects from Galen’s ‘hymn to God’: 1/ it implies that there are possible organic bodies that are better than the human body; 2/ it is based on the possibility to anatomize the human body all the way down to the infinitely small; 3/ the choice of the best world supposes for Leibniz that God respects the principle of economy and, consequently, that a single organ always has several functions. These three aspects are conceptually closely connected, but I will examine them successively, for further clarity.

8.5 The best of all possible bodies?

In the third chapter of the third book of *The Use of the Parts*, which Leibniz cited, Galen explains that the feeling of pain is an undesirable natural effect of God’s creation, due to the material – ‘catamenia and semen’ – from which God creates the human body (see van der Eijk 2017):

Consider well the material of which a thing is made, and cherish no idle hope that you could put together from the catamenia and semen an animal that would be deathless, exempt from pain, endowed with never-ending motion, and as radiantly beautiful as the sun (Galen 1968, 189).

According to this view, pain, among other limits that define the human condition, is not an organic function that is regarded by Galen as something good. And yet, God cannot be considered responsible for this ‘flaw’, because he did his best, given the nature of the available material. Strikingly enough, pain is not justified in itself, as an optimal or a useful trait. The fact that animal bodies feel pain is only justified relative to the conditions of their creation. Leibniz does not regard pain as an optimal trait either, but not for the same reason. First, Leibniz claims that there probably exist bodies which are not endowed with pain. One can well conceive of bodies which are better than human bodies in this respect. Consequently, our body, the human body, is not the best of all possible bodies. Thus, it is not an accident if Leibniz did never claim, as Galen did, that ‘all animals have been fitly equipped with the best possible bodies’ (Galen 1968, Book I, Chap. 22, 108). Second, for Leibniz, human features that are apparently negative, like pain, are not due to the material used by God. Such a justification would lead to equating God with a craftsman, and thus, to badly underestimate his power. Leibniz rather justifies apparent negative traits like pain by taking into account the whole world of which human bodies are just components.

If Leibniz argues that pain is not optimal *per se* in the human body, and, accordingly, if he does not regard the human body as the best of all possible bodies, it is first because he wants to fight against the necessitarianism that he perceives in the justification of the feeling of pain that some of his contemporaries proposed (Andrault 2018, 35). Indeed, according to William King’s *On the Origin of Evil*, which Leibniz discusses in the *Theodicy* (1710), human beings ‘must’ suffer from pain in order to be informed in a quick and easy way about what is harmful to the [p. 145] body, and, thus, about what to avoid (King 1702, 62). As for Regis, he deems that ‘God could not have saved the man from pain without depriving him from a means which he needed in order to preserve himself’ (Regis 1691, Book II, Part. 2, Chap. 29, 261). In contrast, Leibniz is very clear on the fact that he

‘doubts ... whether pain be necessary in order to warn men of peril’ (Leibniz *Theodicy*, §342, Leibniz 1875, Vol. 6, 317; trans. Leibniz 1985, 330).⁷ In other words, Leibniz deems doubtful and inconclusive the typical teleological explanation of pain, which regards it as a necessary warning for the self-preservation of human beings.

Leibniz notably criticizes the ‘optimalist’ perspective on pain by appealing to the fictional ‘animals of the sun’ depicted by Cyrano de Bergerac, the French seventeenth-century author of the *États et Empires du Soleil*. Those creatures do not feel pain because they are made up of a many small obedient animals. Exactly as if their body was perfectly fluid, they cannot suffer from a lesion in a nerve or membrane (in Leibnizian words, ‘a solution of continuity’), that causes (or rather corresponds to) the feeling of pain.

There is also nothing to preclude the existence in the universe of animals resembling that one which Cyrano de Bergerac encountered in the sun. The body of this animal being is a sort of fluid composed of innumerable small animals, that were capable of ranging themselves in accordance with the desires of the great animal, by this means it transformed itself in a moment, just as it pleased; and the dissolution of continuity caused it no more hurt than the stroke of an oar can cause to the sea (*Theodicy*, §343, Leibniz 1875, Vol. 6, 318 ; trans. Leibniz 1985, 331)

Accordingly, the bodies of these animals are better than ours, and the structure of our body is not the best conceivable structure. Why, then, has God not given better bodies to human beings? Why should we experience pain or other natural evils, such as diseases or accidents, if God could create the same kind of creatures as Cyrano’s animals of the sun? How can we justify God on this point? Contrary to Galen, Leibniz’s argument does not appeal to the constraints of the available material. God is not subject to anything, and his power and wisdom are not limited by anything. In the case of pain, Leibniz’s justification is simply based on the fact that it is not the human body which is the best, but the world of which the human body is a part. It is thus not possible to isolate this body from the infinite series of things that constitute the world. The world as a whole is the best, but not our body considered separately.

Quite often, Leibniz insists on the fact that we should not limit Nature and its possibilities to the things we are already familiar with. If we, human beings, are endowed with a body that can suffer from pain, it is not because God had no other choice, or because the material from which our body is made is blood and sperm. It is because God’s goodness implies that, in the best possible world, there are some ‘rational animals clothed in flesh and bones, whose structure involves susceptibility [p. 146] to pain’. Harmony is not to be sought inside the human body, nor between the human body and its own environment. Harmony is rather to be found in the co-existence of all the natural species that constitute the universe, whether on our ‘globe’, where we cannot find a creature similar to Cyrano’s animals of the sun, or on other planets, where there may well be some animals which never experience pain (Andrault 2019).

[These] animals [described by Cyrano] are not men, they are not in our globe or in our present century; and God’s plan ensured that there should not be lacking here on

⁷ This does not mean that Leibniz does not think either that the feeling of pain is absolutely contingent –he clearly opposes Pierre Bayle, who deemed that the feeling of pleasure could have the same protective effect as pain. But this precision does not change the fact that Leibniz does not justify the feeling of pain itself by saying that it is needed for our self-preservation. On these details, see Andrault 2018.

earth a rational animal clothed in flesh and bones, whose structure involves susceptibility to pain (*Theodicy*, §343, Leibniz 1875, Vol. 6, 318; trans. Leibniz 1985, 331).

Cyrano’s fictional animals allow Leibniz to show that we should not reduce the range of biological possibilities to the organic conditions that are observed and described here and now. There is no good reason to identify any given organic feature of the animal body with the best possible way to accomplish such or such a function. Although Leibniz does not detail his views on this biological question, he is very attentive, in the *Theodicy* as well as in the *New Essays on Human Understanding*, not to reduce the organic possibilities to the organic traits we believe we know very well. In those two books, this view falls within the context of the Leibnizian critique of anthropocentrism and anthropomorphism. On this matter, he agrees with Cyrano’s perspective. It is not completely impossible that Galen, when he claims that animal bodies have been ‘fitly equipped with the best possible bodies’, comes under Leibniz’s criticism here. As Leibniz indicates in the *Discourse on Metaphysics*, ‘God is a skillful enough artisan to produce a machine which is a thousand times more ingenious than that of our body, while using only some very simple fluids’ (§22, Leibniz 1989, 54). It is thus not a legitimate strategy to base our reasoning on God’s abilities on a simple extension of what we observe here, among human creations. The precision on the ‘simple fluids’ could be interpreted as a direct criticism of Galen. At the very least, it is important to retain that Leibniz did never maintain the Panglossian idea according to which ‘everything is for the best’. The Leibnizian ‘best’ is only to be interpreted from the perspective of a comparison between different possible worlds, i.e. in a perspective which is neither necessitarian nor anthropocentric.

8.6 Change of Scale in the Late Seventeenth Century: The Infinitely Small

There is another reason to compare Galen’s hymn to God with Leibniz’s views on anatomy, as Hankinson does: it is very clear that Leibniz also supports a theological use of anatomy. However, anatomy cannot have exactly the same meaning as in Galen’s texts. For Leibniz, anatomy means the analysis of the complexity of living bodies, a complexity which extends all the way to infinity. This notion of anatomy, which is supported both by metaphysical theses and by experimental reasons [p. 147], completely changes the manner of conceiving the teleological links between organs and functions. In addition, it changes the meaning of the comparison between God and the most skillful of craftsmen.

There is no chaos in the inward nature of things, and there is organism everywhere in a matter whose disposition proceeds from God. More and more of it would come to light if we pressed closer our examination of the anatomy of bodies; and we should continue to observe it even if we could go on to infinity, like Nature (*Theodicy*, preface, Leibniz 1875, 64; trans. Leibniz 1985, 65).

From the very beginning of the eighteenth century, Leibniz uses the word ‘organism’ to mean the order and ‘artifice’ – or functionality – of matter all the way down to infinity (Fichant 1993; Pasini 2011; Smith 2011, 106; Andrault 2011; Duchesneau 2010 and 2012). This property of living bodies to be endlessly organized in their smallest parts is also

expressed by the notion of ‘machine of nature’, which differs from artificial machines made by men:

For a machine constructed by man’s art is not a machine in each of its parts. For example, the tooth of a brass wheel has parts or fragments which, for us, are no longer artificial things, and no longer have any marks to indicate the machine for whose use the wheel was intended. But natural machines, that is, living bodies, are still machines in their least parts, to infinity. That is the difference between nature and art, that is between divine art and our art (*Monadology*, §54, Leibniz 1875, Vol. 6; 618; trans. Leibniz 1989, 221).

Someone who wants to sing a hymn to God may well analyze, or anatomize, living bodies: at each step of his analysis, he will find an organ, that is, a machine whose structure is adapted to some uses. He will never discover mere matter or unorganized material. For example, if we analyze, or take apart a clock, we ultimately find a bit of metal from which the craftsman can make whatever he wants. If, on the contrary, we analyze the heart, we will find two ventricles, and then, muscular fibers, and then fibrils, and so forth and so on, without ever finding bits of parenchyma which would be unorganized, that is to say, not shaped so as to have specific uses.

Leibniz’s new notion of living bodies as ‘machines of nature’ does not simply reflect his metaphysical notion of infinity; it also results from the experimental changes that anatomy underwent in the second half of the seventeenth century. Indeed, at that time, *anatomien subtiliorem* and microscopic anatomy were developed; and this kind of anatomy *ad minima* was supposed to reveal important functional properties (Duchesneau 1998, 216). In Malpighi’s studies, which promoted *anatomien subtiliorem*, this anatomy shows how tiny fibrils and tiny glands are responsible for the macroscopic phenomenon of glandular secretion, for example. Now, the shift from large-scale to small-scale structures also leads the anatomists to challenge Galen’s taxonomy, as we can see in Steno’s investigation on muscles. After having observed an isolated muscle, and cut it into fibers, and then, the fibers into fibrils, Steno denies that muscles are the ‘true organ of animal movement’. In other words, he says that movement cannot be specifically equated [p. 148] to *the use* of muscles, as the Galenic tradition maintained⁸. Against Galen, he prefers considering motor fiber, i.e. the key functional component of muscles, as ‘the true organ of animal movement’ (Andrault 2016, Chap. 2). Leibniz was well acquainted with Steno, whom he had met in Hanover in the 1680’s. He also knew Malpighi, whom he encountered in Italy in 1690. On several occasions, Leibniz mentions both of them as examples other anatomists should follow (Leibniz 2016, 290). It thus possible that Steno’s and Malpighi’s experimental results also convinced Leibniz of the epistemological limits of the Galenic taxonomy of the human body.

⁸ On the difference between Galen himself and Galenism as a medical tradition in Early Modern Europe, see Mandressi 2013, 29: ‘Il en va du galénisme comme de l’aristotélisme: largement dominant, son empire ne s’exerce pas sans hétérodoxie ni contestations. Constitué dès le Moyen Âge ..., il fournit aux médecins les notions et les systèmes fondamentaux qui leur servent à dire l’homme et sa nature. ... [Cependant] on n’insistera jamais assez sur les écarts, les dissensions et les dissidences qui donnent de la matière au débat et de l’espace à l’interprétation. L’aristotélo-galénisme est un cadre doctrinal fort mais non monolithique, doté d’une grande puissance heuristique qui permet d’inscrire l’homme dans une explication des phénomènes naturels qui se veut complète’.

Beyond these experimental considerations, it is important to retain that Leibniz interprets the change of scale in anatomy as really being an infinite process. This infinite process necessarily implies the endless transformations of means into secondary ends, since the means at a certain scale are the ends of the means at a smaller scale. According to this view, it does not seem possible to determine in advance one level of analysis of the animal body that would be more relevant than the other. The progress of the analysis and its results are deemed to be endlessly provisory. The intrinsic limits of our observations, with or without instrumentation, prevent us from grasping the infinite variety of ends which God has anticipated at every level of anatomical organization. As a consequence, one of the specificities of organic bodies with respect to artisanal machines is the impossibility of dissociating in organic bodies the means, or the material from which the parts are made, from the goal-oriented structure of the parts. Thus, the analysis, or anatomy of living bodies, conflicts with the anthropomorphic representation of the formation of living bodies as the shaping of unformed materials. And it is precisely the distinction between materials (blood and sperm), on the one hand, and the shape and disposition of the parts, on the other hand, that underlies Galen’s *hymn to God*.

The change of scale in Leibniz own physico-theology of the human body has thus important epistemological consequences: it prevents anatomists from identifying a use that they assign to a part, with *the* real reason explaining the existence and the structure of this part (or its exclusive final cause), since there is no connection between the scale of human observation, on the one hand, and the scale of the true organization of the universe, on the other hand. Under Leibniz’s pen, the very notion of *machine*, in comparison with the notion of *organ* or instrument, refers to a hidden complexity, the functioning of which is not yet fully intelligible, whatever the recent anatomical progress.

[p. 149] 8.7 The Most ‘Economical’ Choice: One Part, Several Uses

One could object that Leibniz did claim: ‘not only that animals see because they have eyes, but also that eyes have been given to them in order to see’ (Leibniz 1875, Vol. 7, 273; trans. Leibniz 1976, 479). This seems to be a proof of Leibniz’s endorsement of Galen’s method in *On the Use of the Parts*, or, at the very least, of his conviction that any organic function, like seeing, may well be regarded as the reason, or final cause, of the organ which is involved in this function. Actually, the sole example of the anatomical relevance of Galen’s ‘hymn to God’ that Leibniz ever gives is the action of seeing, that is an *action* – not a ‘use’ – that corresponds to the counter-example of Lucretius’s famous statement on the eyes. After the passage of the *Tentamen anagogicum* in which Leibniz cites Galen’s book, Leibniz illustrates the heuristic use of final causes by the laws of optics. Strikingly enough, Leibniz’s example is not borrowed from anatomy or medicine, but from physics! To be sure, Leibniz agrees with Galen that human beings have a main function: the contemplation of the harmony of the world, to which secondary functions like perception, locomotion, and nutrition are subordinated (see Duchesneau 2010, 75 and 312). But Leibniz never enters into the anatomical details that really correspond to Galen’s method of *de usu partium*, for example by saying that the use of fingernails is to facilitate prehension. In other words, Leibniz just specifies human functions – not the organic ‘uses’ of the organs implicated in the accomplishment of those main functions. I think that there is a very good methodological reason explaining ‘Leibniz’s abiding commitment to [this kind of] empirical inquiry’ (Smith 2011, 14).

In the manuscript *De scribendis novis Medicinae Elementis*, Leibniz writes:

Analysis is the Method for as long as we are investigating the media or organs of any given function and the mode of their operating; and therefore we come to acquaintance with the body through its parts, by which when completed we will come to the Synthesis, and we will describe all of them coordinated into one ..., and altogether the entire economy of the animal, especially when by this very analysis we should discern by inquiring into the organs of a given function, that often the very same organ is devoted to several functions, just as in Machines the wisdom of their maker shines through especially, when many effects are brought about by few things. (Leibniz 1996, 212: trans. Smith 2011, 298–299).

Leibniz does not use Galen’s terminology here, but rather Fernel’s notion of ‘analysis’. According to him, this analysis by means of anatomical investigation will eventually show the various functions of a single part. For example, the analysis will show that the tongue is involved both in sensation, in digestion, in speaking, and in several secondary functions. This is important: the fact that an organ has several uses of equal importance implies that a given use Y of a given part X cannot be regarded as the final cause explaining why this part X is structured the way it is. Since this part X has other organic ends, it would be wrong to teleologically explain the structure of this part on the basis of just one of its functions.

To neglect the different functions of a single organ is not only an epistemic problem for Leibniz; it is also a theological problem. Indeed, according to Leibniz, God acts with parsimony in accordance with the principle of economy: God is [p. 150] analogous to ‘a skilled machinist who produces his work in the least difficult way possible’ (Leibniz 1989, 38; see Duchesneau, 1993, 262–267). Now, this principle of economy is totally opposed to Aristotle’s conceptions of the adaptation of a tool, or a specific part, to one specific use. According to Aristotle, nature is not ‘niggardly, like the smith who fashions the Delphian knife for many uses; she makes each thing for a single use, and every instrument is best made when intended for one and not for many uses’ (Aristotle 1967, 1252b5).

According to Leibniz, we suppose rightly that every part of our body has a purpose, but we run the risk of underestimating God’s wisdom if we prematurely assign to a part a single and determinate purpose. On the whole, this method contradicts Galen’s, which, at least in *On the Use of the Parts*, consists in tracing a one-to-one relationship between a part and its main use.⁹ Above all, it consists in identifying this main use with the genetic cause explaining the true origin of the structuration of this part. This strategy implies that the anatomist is able to grasp the reasons the Creator had when he shaped animal bodies.

Let us summarize this last point. Galen’s main strategy, which consists in showing ‘that everything [in animal bodies] is so beautifully ordered that it could not possibly be improved’, is generally useful for theology (Galen 1968, 191). But from a Leibnizian point of view, this method may undermine God’s wisdom. First, it represents God’s wisdom under the features of a craftsman who does his best to organize the available material. And

⁹ Galen does acknowledge that some organs have several functions or actions. For example, the liver ‘has an activity of formation (of veins), production (of blood) and transmission (of the nutritive faculty)’ (Debru 2008, 266). But this concerns the actions of the organs, not the use of smaller parts which contribute to the main actions of the body as a whole. In addition, even if it is not completely clear that one part should have a single use in Galen’s *On the Use of the Pars*, the manner of justifying the organic structures of parts in this book seems to contradict Leibniz’s principle of economy.

in this case, the best seems to be nothing more than what the physician is currently able to see and to understand. Second, in *On the Use of the Parts*, Galen successively justifies one by one each part of the human body. One of the risks of this view is to regard the human body as the sum of separate goal-directed entities.¹⁰ On this matter, one could object that if anatomists want to explain the anatomy of the human body in general surveys and textbooks, they are compelled to describe different organs and parts successively, and to partly sacrifice the notion of the animal body as a whole. The distinction between a heuristic purpose and a didactic one would explain why *On the Use of the Parts* depicts the human body as the sum of several regional entities, which, in their turn, result from the addition of several parts that obey specific local ends. True enough, but Galen’s style in *On the Use of the Parts* differs significantly from the style that was adopted in the late seventeenth-century anatomical works which were praised by Leibniz. As we have seen, Steno and Malpighi challenged the Galenic taxonomy of the body. In [p. 151] addition, their own experimental studies were not presented as ‘hymns to God’ – nor, more generally, as a theologico-anatomy.

They rectified errors on the so-called ‘uses’ of such or such parts, without offering a general and didactic survey of the animal body as a whole. I cannot develop the question of their teleological presuppositions here¹¹, but I can cite Steno himself, when he emphasizes the pitfalls of the idea that nothing is useless in the human body:

Reasonable people should find that peremptory Anatomists are very amusing, when, after having expounded on the use of the parts whose structure they do not know, they justify the uses they give to them by the notion that God and Nature do nothing in vain. But they are mistaken in the application of this general maxim, and what God, according to their reckless judgement, intended for a specific purpose, turns out in the end to be done for quite another purpose (Steno 2009, 123–124, my translation)¹².

Casting doubt on the usual taxonomy of the human body often implies suspending judgement on the so-called uses of its parts. This critical approach to the Galenic legacy in anatomy undoubtedly influenced Leibniz’s views on the topic, particularly from the 1690’s on.

8.8 Conclusion

In the *Discourse on Metaphysics*, Leibniz argues that ‘the way of final causes is easier, and is not infrequently of use in divining important and useful truths which one would be a long time in seeking by the other, more physical way; anatomy can provide significant examples of this’ (Leibniz 1875, Vol. 4, 448; trans. Leibniz 1989, 55). And yet, one cannot

¹⁰ It is worth noting that Galen’s *On the Natural Faculties* offers a very different view of the animal body (see for example Debru 2008, 266: ‘One and the same activity may be parceled out among several organs, and each may have several activities’).

¹¹ I have developed this point in Andraut 2016, Chap. 2 and Chap. 3.

¹² The original is the following: ‘Les personnes raisonnables doivent trouver ces Anatomistes affirmatifs fort plaisants, lorsqu’après avoir discoursu sur l’usage des parties dont ils ne connaissent pas la structure, ils apportent pour raison des usages qu’ils leur attribuent que Dieu et la nature ne font rien en vain. Mais ils se trompent dans l’application qu’ils font ici de cette maxime générale, et ce que Dieu, selon la témérité de leur jugement, a destiné à une fin, se trouve par la suite avoir été fait pour une autre’.

find in Leibniz’ writings any ‘significant example’ of this heuristic use of the final causes in anatomy, an example of which Leibniz claims to have found in Galen’s *On the Use of the Parts*.

In my opinion, Leibniz’s reference to Galen has above all a strategic purpose, but this purpose remains very general. On the one hand, it places Leibniz on the side of the ‘good guys’ (that is the Ancients who fought against the materialist and atomist philosophies which were regarded as incompatible with Christianity). On the other hand, Galen’s idea of a hymn to God allows Leibniz to justify the investigation of bodies as an apologetic tool. Thus placed under the authority of Plato and Galen, Leibniz can promote a conciliation between the natural philosophy of the ‘Moderns’, the fecundity of which Steno’s and Malpighi’s anatomical studies proved, and the teleological explanations of the Ancients. But this dichotomy, as well as this [p. 152] conciliation, may be misleading. Indeed, the then recent advances in the anatomy, or analysis of the human body, led Leibniz to conceive the organs as infinitely complex machines which obey the principle of economy. This new mechanistic conception did not prevent one from adopting teleological principles – quite the contrary, since God is seen as a skilled machinist. And Leibniz is well aware of the fact that anatomical investigation of an organ always presupposed first, that this organ has some usefulness, and, second, that this organ is involved in such or such action or function. But this very general teleological commitment does not imply endorsing Plato’s or Galen’s epistemological principles. For example, with regard to anatomy, the machine analogy prevented anatomists from identifying one use of a part with its ‘reason’, or its exclusive final cause. In this sense, Leibniz cannot be accused of promoting a ‘Panglossian’ view of the human body. To be sure, Leibniz agrees with Galen that God did his best in making our bodies. But on the one hand, neither Galen nor Leibniz regard the human body as ‘the best of all the possible bodies’ from an absolute point of view, i.e. without any limitation nor comparison. On the other hand, they disagree on the reason why this Panglossian statement would be wrong: according to Galen, it is because the Creator was limited by the material from which he shaped the animal bodies; in Leibniz’s philosophy, the choice of the best world requires conceiving an infinity of possibilities, which are in their turn composed of an infinite series of compossible individuals. Thus, the principle of economy and the notion of infinity, which are nodal points in Leibniz’s philosophy, profoundly modify the traditional anatomical perspective concerning the human body that Galen delineated in *On the Use of the Parts*.

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References

- Andrault, Raphaële. 2011. Entre anatomie et théologie: l’organisme chez G. W. Leibniz et Nehemiah Grew. In *Natur und Subjekt. IX. Internationaler Leibniz-Kongress*, ed. Herbert Breger, Jürgen Herbst and Sven Erdner, Vol. 1, 18–26. Hannover: Gottfried-Wilhelm-Leibniz-Gesellschaft.
- Andrault, Raphaële. 2016. *La raison des corps. Mécanisme et sciences médicales*. Paris:

- Vrin.
- Andraut, Raphaële. 2017. Leibniz et la connaissance du vivant. In *Leibniz. Lecture et commentaires*, ed. Mogens Lærke, Christien Leduc, David Rabouin, 171–190. Paris: Vrin.
- Andraut, Raphaële. 2018. The mind-body problem and the role of pain: Cross-fire between Leibniz and his Cartesian readers. *British Journal for the History of Philosophy* 26: 25–45.
- Andraut, Raphaële. 2019. Cyrano, Leibniz et le meilleur des corps possibles. *Libertinage et philosophie à l'époque classique (XVII^e–XVIII^e siècle)* 16: 167–188.
- Aristotle. 1967. *Politics*, ed. and trans. Benjamin Jowett. 2 vols. Oxford: Oxford University Press.
- Canguilhem, Georges. 1970 [1963]. La constitution de la physiologie comme science. In *Études d'histoire et de philosophie des sciences*, 226–273. Paris: Vrin.
- Debru, Armelle. 2008. Physiology. In *The Cambridge companion to Galen*, ed. Robert James Hankinson, 263–282. Cambridge: Cambridge University Press.
- [p. 153]
- Descartes, René. 1964–1974 [1896–1909]. *Œuvres de Descartes*, 11 vols., ed. C. Adam, P. Tannery, B. Rochot et P. Costabel. Paris: Vrin/CNRS.
- Duchesneau, François. 1993. *Leibniz et la méthode de la science*. Paris : PUF.
- Duchesneau, François. 1998. *Les modèles du vivant de Descartes à Leibniz*. Paris: Vrin.
- Duchesneau, François. 2010. *Leibniz. Le vivant et l'organisme*. Paris: Vrin.
- Duchesneau, François. 2012. Organisme et mécanisme: de Hoffmann à la controverse entre Leibniz et Stahl. In *Internationaler Leibniz-Kongress. Natur und Subjekt*, ed. Herbert Breger, Jürgen Herbst, and Sven Erdner, 20–38. Hannover: Gottfried-Wilhelm-Leibniz-Gesellschaft.
- Fichant, Michel. 1993. Leibniz et les machines de la nature. *Studia Leibnitiana* 35: 1–28.
- Kant, Immanuel. 2000. *Critique of the power of judgment*, ed. Paul Gruyer, trans. Paul Guyer and Eric Matthews. Cambridge: Cambridge University Press.
- King, William. 1702. *De origine mali*. London: B. Tooke.
- Gould, Stephen Jay, and Richard C. Lewontin. 1979. The sprandels of San Marco and the Panglossian paradigm: A critique of the adaptationist program. *Proceedings of the Royal Society of London* 205/1161: 581–598.
- Galen. 1549. *Opera quae nos extant omnia*, ed. Janus Cornarius, 9 vols. Basel: Froben.
- Galen. 1907. *Galenus de Usu Partium Libri XVII*, ed. Georgius Helmreich, Lipsiae: in aedibus B. R. Teubneri.
- Galen. 1968. *On the usefulness of the parts of the body*, ed. and trans. Margaret Tallmadge May. Ithaca: Cornell University Press.
- Hankinson, R. J. 1989. Galen and the best of all possible worlds. *The Classical Quarterly* 39: 206–227.
- Leibniz, Gottfried Wilhelm. 1875–1890. *Die philosophischen Schriften*, ed. Carl Immanuel Gerhardt, 7 vols. Berlin: Weidmann.
- Leibniz, Gottfried Wilhelm. 1923ff. *Sämtliche Schriften und Briefe*, ed. Deutsche Akademie der Wissenschaften zu Berlin. Berlin: Akademie-Verlag.
- Leibniz, Gottfried Wilhelm. 1976. *Philosophical papers and letters*, ed. and trans. Leroy E. Loemker. 2nd edn. Dordrecht: D. Reidel.
- Leibniz, Gottfried Wilhelm. 1985. *Theodicy: Essays on the goodness of God, the freedom of man and the origin of evil*, ed. A. Farrer and trans. E.M. Huggard. LaSalle: Open Court.

- Leibniz, Gottfried Wilhelm. 1989. *Philosophical essays*, ed. and trans. Roger Ariew and Daniel Garber. Indianapolis: Hackett.
- Leibniz, Gottfried Wilhelm. 1996 [1682–1683]. *De scribendis novis medicinae elementis*. In: Enrico Pasini, *Corpo e funzioni cognitive in Leibniz*, 212. Milano: Franco Angeli.
- Leibniz, Gottfried Wilhelm. 2016. *The Leibniz-Stahl controversy*, ed. and trans. François Duchesneau and Justin Smith. New Haven: Yale University.
- Mandressi, Rafael. 2013. Médecine et discours sur l’homme dans la première modernité. *Revue de synthèse* 134: 511–536.
- Pasini, Enrico. 2011. Both mechanistic and teleological. The genesis of Leibniz’s concept of organism, with special regard to his *Du rapport général de toutes choses*. In *Departure for modern Europa. A handbook of early modern philosophy (1400–1700)*, ed. Hubertus Busche, 1216–1234. Hamburg: Meiner.
- Radner, Daisie, and Michael Radner. 1998. Optimality in biology: Pangloss or Leibniz. *The Monist* 81: 669–686.
- Regis, Pierre-Sylvain. 1691. *Système de philosophie, contenant la logique, métaphysique, physique et morale*. Lyon: Anisson, Posuel & Rigaud.
- Rocca, Julius. 2008. Anatomy. In *The Cambridge companion to Galen*, ed. Robert James Hankinson, 242–262. Cambridge: Cambridge University Press.
- Smith, Justin E. H. 2011. *Divine machines. Leibniz and the sciences of life*. Princeton: Princeton University Press.
- Sténon [Steno], Nicolas, *Discours sur l’anatomie du cerveau* [1669], ed. Raphaële Andrault, Paris, Classiques Garnier, 2009.
- Van der Eijk, Philip. 2017. The Place of Disease in a Teleological World-view. Plato, Aristotle, Galen. In *Teleology in the Ancient World: Philosophical and Medical Approaches*, ed. Julius Rocca, 217-241. Cambridge: Cambridge University Press.