

Forthcoming in L. Strickland, E. Vynckier & J. Weckend (eds), *Tercentenary Essays on the Philosophy & Science of G.W. Leibniz* (Palgrave Macmillan, 2016)

Philosophy and Science in Leibniz

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This paper explores the question of Leibniz's contribution to the rise of modern "science".¹ To be sure, it is now generally agreed that the modern category of "science" did not exist in the early modern period. At the same time, this period witnessed a very important stage in the process from which modern science eventually emerged. I will argue that Leibniz made a distinctive contribution to the journey from natural philosophy to natural science, and to the modern distinction between science and philosophy, through the development of a conception of physics as an autonomous enterprise.

The terminology here is notoriously slippery, and some preliminary clarifications are therefore in order. When early modern authors use the word *scientia*, the closest translation is normally "knowledge" rather than "science". At the centre of Leibniz's scientific ambitions is a project – the *scientia generalis* – which looks *prima facie* very different from what we would nowadays call "science". If these authors ever drew a distinction between *philosophia* and *scientia*, it would look very different from what is now commonly meant by the distinction between philosophy and science.

Similar considerations apply to the distinction between physics (intended here primarily as the study of the motion of bodies under the action of forces) and metaphysics.

¹ This paper was presented at the Suppes Center for the History and Philosophy of Science in Stanford, at a seminar in the Philosophy department of King's College London, and at the conference in Lampeter from which the present volume originates. I would like to thank participants in the Stanford workshop, the King's seminar, and the Lampeter conference (including Richard Arthur, Martha Bolton, Bill Brewer, Vincenzo De Risi, Stefano Di Bella, Paula Findlen, Michael Friedman, Daniel Garber, Sacha Golob, Eleanor Knox, Paul Lodge, Miguel Palomo, David Papineau, Pauline Phemister, Sherrilyn Roush, Justin Smith, Lloyd Strickland, Tzuchien Tho, and Erik Vynckier) for their questions and comments. Many thanks also to Domenico Bertoloni Meli and Gaston Robert for helpful feedback, to Andrew Janiak for sharing with me a forthcoming paper on Newton's General Scholium, and, especially, to Howard Hotson for his insightful reading of two draft versions. When not otherwise stated, translations are my own.

Physics and metaphysics were two distinct parts of Aristotelian theoretical knowledge but the way in which they were distinguished by Aristotle and his followers is not the way in which we would now see them as two distinct enterprises -- mainly because modern physics is no longer what Aristotle's called "physics", and his Latin followers called *philosophia naturalis*.² Moreover, to complicate matters further, authors who are now widely regarded as among the chief architects of modern science referred to their own endeavour as "natural philosophy" and / or to themselves as "philosophers" or "natural philosophers": it suffices to recall Newton's *Philosophiae Naturalis Principia Mathematica* (1687) or Galileo's request to be named not only "Matematico" (mathematician) but also "Filosofo" (philosopher).³

My discussion will be aimed at uncovering the new enterprise, and the new distinctions which were taking shape in the early modern period under the banner of the old terminology. Although Galileo and Newton still employed Aristotelian language, what they were doing was something significantly new – their *philosophia naturalis* was a new type of "physics" crucially different from Aristotelian physics in its experimental method and mathematical explanation of natural phenomena on the basis of quantifiable features of the natural world.

Likewise, I will argue that Leibniz begins to theorize a distinction between physics and metaphysics that tracks our modern distinction between the autonomous activity of science in its modern meaning, and the undertaking of philosophy. I will try to show that, for Leibniz, physics proper is the study of natural phenomena in mathematical and mechanical terms without recourse for its explanations to metaphysical notions. This autonomy, however, does not imply for Leibniz that physics can say on its own all that there is to be said about the natural world. Quite the opposite. Leibniz inherits from the Aristotelian tradition the view

² Heilbron, *Elements of Early Modern Physics*, esp. pp. 1-11, notes that "at the beginning of the seventeenth century "physics" signified a qualitative, bookish science of natural bodies in general. It was at once wider and narrower than the subject that now has its name: wider in its coverage which included organic and psychological as well as inorganic phenomena; and narrower in its methods, which recommended neither mathematics nor experiment." (p. 1) Any quantified aspects fell under "mixed" or "applied" mathematics rather than physics, including fields such as hydraulics, fortification, navigation and surveying, as well as astronomy and optics.

³ Galileo to Belisario Vinta, 7 May 1610; *Opere*, vol. 10, p. 353: "Finally, as regards the description and motivation of my service, I would wish Your Highness to add the title of Philosopher to the title of Mathematician, since I studied philosophy for more years than the months I studied pure mathematics." Attention to this passage is drawn by Vanni Rovighi, *Storia della Filosofia Moderna*, p. 48, to which my discussion is indebted.

that physics needs metaphysical roots or a metaphysical grounding. For Leibniz, what is ultimately real is reached by metaphysics, not by physics.

This is, however, a metaphysical rather than a physical claim as much in Leibniz's time as it is in our time. Whether physics studies what is ultimately real, or whether a metaphysical level of explanation is needed, is not a question proper to a physics textbook. Students interested in this question will need to turn instead to a philosophy course. This reflects, in my view, Leibniz's chief insight: the new mathematical physics is an autonomous activity which offers its own kind of explanations but does not exhaust what can (and should) be said about the natural world. There is in fact a further level of explanation, based on a different kind of investigation that belongs to a different sphere. This position does not make Leibniz someone who is pursuing a type of inquiry which is nowadays extinct,⁴ since quite a few twenty-first-century metaphysicians continue to think that modern physics does not exhaust all that can be said about reality. On the contrary, I will argue that Leibniz's position marks a milestone toward a modern understanding of the distinction between philosophy and science.

The backdrop: the reform and advancement of all the sciences

Throughout his life, Leibniz pursued the reform and advancement of all the sciences, to be undertaken as a collaborative venture supported by an enlightened ruler.⁵ He conceived of this endeavour as the progressive establishment of a systematic, demonstrative encyclopaedia arising from the development of a *scientia generalis* (general science). His explanation of what the *scientia generalis* was supposed to be, and what it was supposed to accomplish, varies sometimes quite significantly from text to text. Moreover, the explicit mentions of this project decline dramatically after 1688.⁶ Notwithstanding these caveats, it is still possible to

⁴ For a different view, see Garber's *Leibniz: Body, Substance, Monad*, p. 383. Garber suggests that "what Leibniz is doing is a kind of enterprise that we don't do today, either in physics or in philosophy: it is (natural) philosophy as Leibniz and his contemporaries understood the enterprise."

⁵ In *Leibniz: An Intellectual Biography*, I have tried to show that many of Leibniz's extraordinarily rich but apparently miscellaneous endeavours were aspects of a single master project of reform and advancement of all the sciences.

⁶ In "The *Scientia Generalis* and the Encyclopaedia," Arnaud Pelletier stresses that Leibniz speaks in very different ways of the *scientia generalis*. Moreover, he notes that after 1688 there is only one unfinished draft

identify some broad features of an enterprise which remains constant throughout Leibniz's life as an overarching project he never abandons. This is a project deeply indebted to Renaissance encyclopaedic and pansophic traditions championed by thinkers such as J. H. Alsted (1588–1638), J. H. Bisterfeld (c. 1605-1655), J. A. Comenius (1592-1670), as well as Francis Bacon (1561-1626). In line with the pansophic aspirations of these authors, the *scientia generalis* was intended by Leibniz as the “science” or knowledge embracing the principles, elements, or foundations of all the sciences, out of which the whole encyclopaedia could have been expounded in a systematic way.

Accordingly, in several proposals sketched by Leibniz for a preliminary work containing the “Introduction to the Secret Encyclopaedia” or the “Initia et Specimina” (“Beginnings and Examples”) of the *scientia generalis* proper, the *scientia generalis* is defined in a Baconian manner as pertaining to “the instauration and advancement of the sciences for the common happiness” (“de instauratione et augmentis scientiarum ad publicam felicitatem”).⁷ Once again in line with pansophic and Baconian programmes of reform and development of knowledge, two key features of Leibniz's *scientia generalis* and encyclopaedic project are in evidence: on the one hand, the conviction of the unity of knowledge, grounding in turn a systematic conception of the encyclopaedia; on the other hand, its praxis-oriented aim of advancing the sciences for the promotion of human happiness. As Leibniz writes in a text of 1678-9:

it is in the interest of the happiness of humankind that there be brought together a certain *encyclopaedia* or orderly collection of truths, sufficient (as far as possible) for

explicitly focused on the *scientia generalis* (*Aurora seu Initia Scientiae Generalis*, mid-1690s, LH IV, 7a, f. 11-12; partly published in GP VII, 54-56).

⁷ See especially *Introductio ad Encyclopaediam arcanam; Sive Initia et Specimina Scientiae Generalis, de Instauratione et augmentis scientiarum, deque perficienda mente, et rerum inventionibus, ad publicam felicitatem*, c. summer 1683–beginning of 1685 (A VI, 4, N. 126). Cf. also A VI, 4, N. 85–86, N. 110, N. 115, N. 158–159. Francis Bacon's *Instauratio Magna* envisaged the restoration of man's dominion over nature, lost after the original Fall, through the development of a new empirical and experimental approach to gaining knowledge of nature which could be applied to practical use. His *Novum Organum*, published in 1620 as the second part of this grand plan, was supposed to provide this project with a new, inductive scientific method, intended to supersede the Aristotelian *Organum*. In 1623, Bacon published *De Dignitate et Augmentis Scientiarum*, an expanded Latin version of his earlier *The Proficiency and Advancement of Learning* (1605), which placed this reform of natural philosophy within a comprehensive reorganization of the entire edifice of knowledge.

the deduction of all useful things. And this will be like a public treasury to which could be added all remarkable [subsequent] discoveries and observations. But since [this Encyclopaedia] will be of the most massive bulk, especially regarding matters of civil and natural history, in the meantime a certain *Scientia Generalis* is needed containing the first principles of reason and experience[.]⁸

Leibniz was fully aware that such an all-embracing undertaking ought to be a collaborative enterprise under the patronage of an enlightened ruler. Hence his tireless efforts toward the establishment of Academies of Sciences where collaborative work was to be carried out, and his recurrent search for a patron prepared to finance a scientific programme geared at pooling all systematically developed knowledge into a “public treasury”. In his earliest outline of this overarching plan -- the *Demonstrationum Catholicarum Conspectus* of 1668-9 – Leibniz envisaged first of all the establishment of the “elements of philosophy”, namely the first principles of metaphysics (*de Ente*), of logic (*de Mente*), of mathematics (*de Spatio*), of physics (*de Corpore*), and of ethics and politics or “practical philosophy” (*de Civitate*).⁹ These principles were to constitute the *prolegomena* to further demonstrations including the immortality of the soul and the existence of God.

In a detailed *Memoir for Enlightened Persons*, penned in the mid-1690s and echoing earlier thoughts, he stressed the ultimately practical aim of all these inquiries, namely the promotion of the common good and, thereby, the fostering of human happiness. “To contribute truly to the happiness of men,” Leibniz claimed, “one must enlighten their understanding; one must fortify their will in the exercise of virtues, that is, the habit of acting according to reason; and one must, finally, try to remove the obstacles which prevent them from finding truth and following true goods.”¹⁰ The enlightenment of the understanding was to be achieved, in Leibniz’s view, through the study of logic, that is, “the method of judging and inventing”. “In addition,” he continued, “one must cause to be recorded, as if in a general inventory, the truths of consequence which have already been discovered, and which are to be found not only in books, but also among men of all sorts of professions. And one must, finally, take measures suited to insure the carrying out of research and experimentation in order to advance toward the future as much as possible.” In turn, “to improve men’s will”, it

⁸ *Studia ad Felicitatem Dirigenda*; A VI, 4, 137–8.

⁹ A VI, 1, 494 / LGR 22.

¹⁰ PW 105.

was necessary not only to “put forward good precepts” but also to reform education. Last but not least, the promotion of human beings’ happiness demanded that also “the impediments which ... come from our body” be removed, namely, “one must seek the means of preserving their health, and giving them the conveniences of life”. Thus, Leibniz concluded, “one must inquire into the nature of bodies in the universe, as much as to recognize therein the marvellous traces of divine wisdom, as to notice the respects in which they can be useful to our preservation and even to our greater perfection.”¹¹

In brief, Leibniz’s work in physics and his inquiries into the natural world were integral parts of an encyclopaedic, systematic plan of development of all the sciences grounded in the unity of knowledge and ultimately aimed at human happiness. There is no better way to celebrate the Glory of God in His creation, Leibniz thought, than by advancing all the sciences and thereby improve the human condition.¹²

Metaphysics and physics -- from natural philosophy to natural science

Against this backdrop of Leibniz’s encyclopaedic scientific ambitions, and their indebtedness to pansophic traditions which may seem far removed from modern scientific approaches, we can now tackle the question of how Leibniz contributed to the rise of modern “science”, broadly understood. Leibniz is, of course, traditionally numbered among the architects of the seventeenth-century “scientific revolution” from which modern science eventually emerged. His contributions are diverse and could be considered from a variety of angles, not least his invention of the calculus. I will focus, however, on what seems to me his distinctive contribution to the development of the concept of modern science itself as an undertaking distinct from philosophy. In doing so, I will revisit some aspects of one of the most hotly debated issues in recent literature: namely, the relationship between metaphysics and physics in his thought.

The distinction between metaphysical and physical explanations

In a very early text, the *Confessio naturae contra Atheistas* of 1668-69, Leibniz writes:

¹¹ WP 106-7.

¹² For a detailed discussion of this point see Antognazza, *Leibniz: An Intellectual Biography*.

through the admirable improvement of mathematics and the approaches which chemistry and anatomy have opened into the nature of things, it has become apparent that mechanical explanations – reasons from the figure and motion of bodies, as it were – can be given for most of the things which the ancients referred only to the Creator or to some kind (I know not what) of incorporeal forms. The result was that truly capable men for the first time began to try to save or to explain natural phenomena, or those which appear in bodies, without assuming God or taking him into their reasoning. Then, after their attempt had met with some little success, though before they arrived at foundations and principles, they proclaimed, as if rejoicing prematurely at their security, that they could find neither God nor the immortality of the soul by natural reason ... It seemed to me unworthy for our mind to be blinded in this matter by its own light, that is, by philosophy. I began therefore myself to undertake an investigation ... Setting aside all prejudices, therefore, and suspending the credit of Scripture and history, I set my mind to the anatomy of bodies, to see whether the sensory appearance of bodies can be explained without assuming an incorporeal cause. At the beginning I readily admitted that we must agree with those contemporary philosophers who have revived Democritus and Epicurus and whom Robert Boyle aptly calls corpuscular philosophers, such as Galileo, Bacon, Gassendi, Descartes, Hobbes, and Digby, that in explaining corporeal phenomena, we must not unnecessarily resort to God or to any other incorporeal thing, form, or quality ... but that so far as can be done, everything should be derived from the nature of body and its primary qualities – magnitude, figure, and motion. But what if I should demonstrate that the origin of these very primary qualities themselves cannot be found in the essence of body? Then indeed, I hope, these naturalists will admit that body is not self-sufficient and cannot subsist without an incorporeal principle.¹³

I regard this as a fundamental text in which we can find one of the first (and indeed the first I am aware of) incipient theorization of a distinction between “science” (taken in a modern sense) and philosophy. The young Leibniz presents here metaphysics and the new quantitative, mechanical physics as two different kinds of explanation. On the one hand, he fully embraces the new mathematically based science, or (as it was still called) “philosophy of nature”, for the explanation of natural phenomena. On the other hand, he maintains that the

¹³ A VI, 1, 489 / PPL 109-110.

new mechanical physics does not answer more fundamental questions about the ultimate principles of reality. A further level of explanation is needed in order to account properly for the features of the physical world of which we have experience. According to him, in physical notions there are implicit principles which cannot be reduced to extension and motion. There must be in bodies a principle of unity and activity. The metaphysical notions expressing such a principle, however, should not enter into the explanations of physics proper, since physics proper is only concerned with the mathematical treatment of natural phenomena which can and should be explained mechanically.

It seems to me that this position about the relationship between physics and metaphysics remains constant throughout Leibniz's ensuing intellectual career. The interpretation that I am proposing differs therefore in some significant respects from the reading of Leibniz's development outlined by Daniel Garber in his milestone monograph *Leibniz: Body, Substance, Monad* (2009).¹⁴ According to Garber, "in the late 1670's, in 1678 or 1679, Leibniz seems to make a decisive break with his past views, and starts what is substantially a new direction. A number of commentators characterize the change as a revival of substantial forms".¹⁵ Garber notes, however, that "matters are more complex than this simple account would suggest. In a way, substantial forms go back at least a decade to the end of the 1660s [that is, I note, the time of the *Confessio Naturae*]; there is a sense in which he never abandon them." "Even so," Garber continues,

there *is* a radical change in Leibniz's thought at just that moment. In 1678 or 1679, *Leibniz seems to extend substantial forms from theology to physics*: substantial forms are important now for body itself, for the concept of body that we need to understand the physical world. He continues to believe, as he had for some time and as he will for the rest of his career, that everything must be explained mechanically, through size, shape and motion. But starting in 1678-1679, Leibniz begins to articulate a new

¹⁴ At the same time, I would like to stress that there is much in Garber's monograph with which I strongly agree, notably the virtues of a developmental approach to Leibniz's philosophical thought, showing (amongst other things) that Leibniz was deeply interested in the world of which we have experience. As Garber argues, far from being a dogmatic thinker unconcerned with the physical world, Leibniz placed the project of explaining this very world of experience at the heart of his philosophical explorations from the very beginning. It is in order to reach a satisfactory explanation of this world of experience that Leibniz thinks and re-thinks his position throughout his life.

¹⁵ Garber, *Leibniz: Body, Substance, Monad*, p. 48.

doctrine: even though everything is explicable mechanically, the foundations of the mechanical philosophy require us to appeal to soul or form.¹⁶

There are indeed very important, and even transformative, developments in Leibniz's metaphysics and physics between the *Confessio Naturae* of 1668-9 and his writings of 1678-1679. In a breakthrough paper of the summer 1676, *De Arcanis Motus et Mechanica ad puram Geometriam reducenda*, Leibniz introduced the fundamental principle of equivalence between full cause and entire effect.¹⁷ In January 1678, in an unpublished paper on the laws of motion and on the collision of bodies (*De corporum concursu*), Leibniz focused on the notion of force, quantifying it for the first time as the product of mass (m) and the square of speed (v^2).¹⁸ In a *Conspectus Libelli Elementorum Physicae*, written between the summer 1678 and the winter 1678/79, he noted that it is not the quantity of motion (mass times speed or mv) which is conserved in the universe, as Descartes maintained, but the quantity of force (mass times the square of speed or mv^2),¹⁹ overturning one of the core principles of Cartesian physics, namely the principle of the conservation of motion.²⁰ Last but not least, in a key programmatic letter of the autumn 1679 to his new patron, the Duke of Hanover, Johann Friedrich, Leibniz boldly endorsed substantial forms in the context of a relaunch of his encyclopaedic plan of the *Demonstrationes Catholicae*.²¹

As Garber acknowledges, however, substantial forms had never been totally rejected by Leibniz, provided they were employed in an appropriate metaphysical context, as opposed to being invoked in physical explanations of natural phenomena. This is one of the key points made in the *Confessio Naturae*. Moreover, around 1668, Leibniz defined “substantial form” in *De Transsubstantiatione* as the principle of action required for a being to qualify as a substance and corresponding to what Aristotle called “nature.”²² In a text composed between 1673 and 1675 he equated the principle of action or *conatus* which is internal to bodies and

¹⁶ Garber, *Body, Substance, Monad*, pp. 48-49; the second emphasis is mine.

¹⁷ Edited by Hess in *Leibniz à Paris (1672–1676)*, pp. 202–205 (see p. 203).

¹⁸ Published in Fichant, *G. W. Leibniz. La Réforme de la dynamique*.

¹⁹ A VI, 4, 1989.

²⁰ This result was famously announced in the *Acta Eruditorum* of March 1686 with the publication of Leibniz's *Brevis demonstratio erroris memorabilis Cartesii et aliorum circa legem naturae* (A VI, 4, N. 369).

²¹ See A II, 1, N. 213 and A I, 2, N. 187 (these are two versions of the same letter; a third brief version is published in A I, 2, N. 186). English translations in PPL 259-62 and LGR 47-51.

²² A VI, 1, 511 / LGR 38.

constitutes their principle of “substantiality” with what “the scholastics . . . called substantial form,” using therefore the notion of substantial form not only in a theological context but also in his philosophy of bodies.²³

It should certainly be noted that the philosophy of bodies emerging around 1670-72 is different in at least one crucial respect from the philosophy of bodies underpinning the *Confessio Naturae* and other texts of 1668–9. In these earlier texts, in the case of non-rational beings, Leibniz interpreted the “incorporeal principle” or “principle of activity” needed by bodies in terms of a transcendent Mind (that is, God) rather than as a principle of action immanent in bodies. The move away from the pantheistic dangers of such a view toward a metaphysics fully committed to an intrinsic principle of action in bodies is undoubtedly a momentous one.

However, these shifting metaphysical views do not imply an extension of “substantial forms from theology to physics”. As regards the conception of the relationship between physics and metaphysics, it seems to me that Leibniz remains committed to the same position as the *Confessio Naturae*: metaphysical principles – whether conceived as substantial forms or as some other incorporeal principle – ought not to enter into physical explanations of natural phenomena. Although at the time of the *Confessio Naturae* he had not yet developed the tools for thinking in a satisfactory way about the incorporeal principle required by bodies, he had already matured a view on the relationship between physics and metaphysics which later breakthroughs in both fields did not change.

In sum, Leibniz’s great insight is twofold. First of all, the mathematical and mechanical explanation of natural phenomena is an autonomous enterprise. In such explanations, there is no place for substantial forms. Secondly, our understanding of bodies, or, more precisely, our understanding of their nature, is not exhausted by this kind of inquiry. Quite the opposite. In order to achieve a deeper understanding of the physical world, it is necessary to reach its metaphysical foundations and appeal to metaphysical principles. The crucial point is, however, that these are *meta*-physical principles. They provide the *metaphysical grounding* of physics, the *philosophical foundations* of mechanism, as opposed to being the object of physics proper or being extended to physics itself.

²³ *De vera methodo philosophiae et theologiae ac de natura corporis* (A VI, 3, 158; English translation in LS 64). For a discussion of texts before 1679 in which Leibniz employs the notion of substantial forms, see Fichant, “Mécanisme et métaphysique,” pp. 168, 172-8.

Ascribing the genesis of this important distinction to Leibniz does not depend on the slender thread of an isolated early text. On the contrary: a long strand of similar passages, penned throughout the rest of his life, are quite explicit in drawing this distinction, as well as in agreeing with the outlook on this issue already presented in the *Confessio Naturae*. In paragraph 10 of the *Discourse on Metaphysics* (1686), Leibniz stresses that the consideration of substantial forms “serves no purpose in the details of physics” and that “they ought not to be used to explain particular phenomena”. Nevertheless, “this inadequate understanding and abuse of the forms ought not to make us reject something whose knowledge is so necessary in metaphysics”, although “a physicist can give an explanation of his experiments, making use, now of simpler experiences already past, now of geometric and mechanical demonstrations, without needing the general considerations which belong to another sphere.”²⁴ Writing to Antoine Arnauld on 14 July 1686, Leibniz reiterates that he “subscribe[s] fully to the corpuscular theory in the explanation of particular phenomena; in this sphere it is of no value to speak of forms or qualities. Nature must always be explained mathematically and mechanically, provided it is remembered that the very principles or laws of mechanism or of force do not depend on mathematical extension alone, but on certain metaphysical reasons.”²⁵

The same position can be found in 1695, in the *New System of the Nature and the Communication of Substances*, where Leibniz writes:

I realized that the consideration of mere *extended mass* is insufficient ... So it was necessary to recall and, as it were, to rehabilitate *substantial forms*, which are so much decried these days – but in a way which would make them intelligible, and which would separate the use which should be made of them from their previous misuse. ... just as the soul ought not to be used to explain in detail the workings of an animal’s body, I decided that similarly these forms must not be used to solve particular problems of nature, although they are necessary for grounding true general principles. Aristotle calls them *first entelechies*. I call them, perhaps more intelligibly, *primitive forces*.²⁶

In *On Body and Force and the Laws of Motion* of 1702, Leibniz notes that “although we say that everything in nature is to be explained mechanically,” the principles of mechanism

²⁴ PPL 308-309.

²⁵ PW 63.

²⁶ WF 11-12.

themselves derive “from a metaphysical source, namely, from the equality of cause and effect and from other laws of this kind, which are essential to entelechies.”²⁷ On 10 January 1714, writing to Nicolas Rémond, he recalls that when he looked “for the ultimate reasons of Mechanism,” he was “fully surprised to see that it was impossible to find them in Mathematics, and that it was necessary to return to Metaphysics.”²⁸

It should finally be stressed that, for Leibniz, the forces studied by physics are not primitive forces but the *derivative* forces *grounded* in the former. Primitive forces (identified in the passage above from the *New System* with *substantial forms* or *first entelechies*) are the object of metaphysics, not of physics. Accordingly, Leibniz denounces the misuse of substantial forms in Aristotelian physics, while vindicating them as metaphysical principles of explanation needed to ground the natural phenomena and the physical derivative forces of which we have experience.

Objections

There are, however, some fairly obvious objections to the interpretation that I am proposing, namely to the view that, for Leibniz, physics is concerned with the mathematical and mechanical description and explanation of phenomena, without extension of metaphysical entities such as substantial forms to physics proper.

A first objection could appeal to Leibniz’s principle of equivalence between full cause and entire effect. There can be no doubt that, according to Leibniz, this principle (fully recognised, as we have seen, from 1676 onward)²⁹ has fundamental consequences for physics. It follows from the equivalence between full cause and entire effect that force must

²⁷ AG 254-255.

²⁸ “When I looked for the ultimate reasons of Mechanism and of the laws of movement themselves, I was fully surprised to see that it was impossible to find them in Mathematics, and that it was necessary to return to Metaphysics. This is what took me back to Entelechies, and from the material to the formal, and made me finally understand, after many corrections and advancements of my notions, that the Monads, or simple substances, are the only true substances, and material things are nothing more than phenomena, but well founded and well connected. This is that of which Plato, and even the later Academics, and also the Sceptics, have glimpsed something, but these Gentlemen, who came after Plato, did not made use of it as well as him.” (GP III, 606; a translation of this passage can also be found in PPL 655)

²⁹ See Fichant, “Mécanisme et métaphysique,” pp. 179–80.

be estimated from the quantity of the effect that it can produce, leading to Leibniz's fundamental objection to Cartesian physics that it is not the quantity of motion (mass times speed or mv) which is conserved in the universe, but the quantity of force (mass times the square of speed or mv^2).³⁰

Leibniz, however, is quite explicit that the equivalence between full cause and entire effect is a *metaphysical* principle which *grounds* physical principles.³¹ That is, he quite explicitly acknowledges two different levels of explanation. I will come back in a moment to the issue of how these two levels are related. For now I would like to draw attention to the following passages in which this distinction seems to me clear:

there is always a *perfect equation between the full cause and the entire effect*. This law not only says that the effects are proportional to the causes, but also that each entire effect is equivalent to its cause. And despite the fact that this axiom is indeed metaphysical, it is nevertheless among the most useful which can be employed in physics and provides the means to reduce forces to a geometrical calculation.³²

From this fundamental metaphysical principle and its consequence for physics – namely that force must be estimated by the quantity of the effect – Leibniz draws, in turn, an important metaphysical conclusion:

I will add a remark of consequence for metaphysics. I have shown that force should not be estimated by the composition of speed and mass [mv], but by the future effect. Nevertheless it appears that force or power is something real from the present [moment], and [that] the future effect is not. Hence it follows *that it will be necessary to admit in bodies something different from mass and speed, unless one wishes to deny to bodies all power of acting*.³³

³⁰ See *Conspectus Libelli Elementorum Physicae*, c. summer 1678–winter 1678/79 (A VI, 4, 1989), mentioned above. LC 235: “Force or power . . . must be estimated from the quantity of the effect. But the power of the effect and of the cause are equal to each other . . . Here it is worth showing that the same quantity of motion cannot be conserved, but that on the other hand the same quantity of power is conserved.”

³¹ See for instance the passage from *On Body and Force and the Laws of Motion*, cited above.

³² Leibniz to Bayle, 9 January 1687; GP III, 45-6.

³³ Leibniz to Bayle, 9 January 1687; GP III, 48.

With regard to the relationship between physics and metaphysics, it seems to me that what Leibniz is saying here is the following. The metaphysical principle of the equivalence between full cause and entire effect demands that in physical calculations we use the quantity of force estimated by the future effect, with all sorts of fruitful consequences. It is in this sense that this principle is “employed in physics”. This raises, however, a *metaphysical* problem, that is, a problem which does not impact on the mathematical description of phenomena but has crucial import for our conception of the nature of bodies as requiring an intrinsic power of acting which is manifested in the quantifiable features of bodies that enter in our calculation -- mass and (the square of) speed -- but does not reduce to them.

A second objection may point to Leibniz’s defence of the use of final causes in physics. In *Body and Force and the Laws of Motion* Leibniz writes:

Whatever Descartes may have said, not only efficient causes, but also final causes, are to be treated in physics, just as a house would be badly explained if we were to describe only the arrangement of its parts, but not its use.³⁴

In speaking of “arrangement of parts”, Leibniz is clearly referring to a mechanical explanation, as we would explain a watch showing what bit of the mechanism moves what and so on. On the other hand, providing merely an explanation of what bit moves what would not constitute a good explanation of the watch for anyone who has no idea of what such mechanism *is for*, what its purpose, “its use” is.

The passage continues as already cited above:

although we say that everything in nature is to be explained mechanically, we must exempt the explanation of the laws of motion themselves, or the principles of mechanism, which should not be derived from things merely mathematical and subject to the imagination, but from a metaphysical source, namely, from the equality of cause and effect and from other laws of this kind, which are essential to entelechies.³⁵

³⁴ AG 254-255.

³⁵ AG 255.

This position is unpacked in other texts, such as the very interesting *Tentamen anagoricum* of 1696, in which Leibniz declares that

all natural phenomena could be explained mechanically if we understood them well enough, but the principles of mechanics themselves cannot be explained geometrically, since they depend on more sublime principles, which show the wisdom of the Author in the order and perfection of his work.³⁶

The text, however, continues:

in corporeal nature itself, there are, so to speak, two kingdoms which penetrate one another without confusing themselves and hindering one another: the kingdom of power, according to which everything can be explained *mechanically* by efficient causes . . . ; and also the kingdom of wisdom, according to which everything can be explained, so to speak, *architectonically* by final causes[.]³⁷

It seems to me that Leibniz is pointing here again at two orders of explanation of the natural world which should not be “confused”. One is the order of explanation offered by physics proper, that is the mathematical and mechanical explanation of “natural phenomena” through efficient causes; the other is a metaphysical order of explanation through final causes,³⁸ which goes back to what the *Confessio Naturae* of 1668-9 called the “foundations and principles”, and the *Tentamen anagoricum* of 1696 calls “more sublime principles”, that is, metaphysical principles required ultimately to *ground* the “principles of mechanics themselves”. This position seems to me consistent with the distinction between physical and metaphysical explanations which we have encountered in the *Confessio Naturae*, the *Discourse on Metaphysics*, the letter to Arnaud of July 1686, the *New System*, the letter to Rémond of 1714, and, last but not least, *On Body and Force* itself.

³⁶ GP VII, 272; trans. by Garber in *Leibniz*, 234 (an English trans. of this text is also available in PPL 478).

³⁷ GP VII, 273 (an English trans. of this text is also available in PPL 478-479).

³⁸ See also *Monadology* § 79 (PW 192): “Souls act according to the laws of final causes by appetitions, ends, and means. Bodies act according to the laws of efficient causes by motions. And the two kingdoms, of efficient and of final causes, are in harmony with one another.”

There is, however, a further role played by final causes which is (as Garber notes) “useful in physics itself”. A consideration of final causes -- that is, I take it, a consideration of what certain natural phenomena are for, their uses, their purposes, their functions – “enable[s] us to discover things which are too complex for us to discover if we limit ourselves to the study of efficient causes.”³⁹ For instance, it was indeed very useful to discover that the function of DNA is to encode instructions regulating the development of all living organisms even if we don’t know most or many of the details of how this works (e.g., we don’t know how exactly the extra genetic material present in trisomy causes certain syndromes). To use Leibniz’s own example, discoveries such as that of the magnetic needle would remain of great importance even if we were never to come to an adequate understanding of how the magnetic needle works.⁴⁰ There is therefore a use for final causes in physics proper, but this use does seem consistent with a distinction between physics and metaphysics along the lines I have proposed.

A further objection may come from the fact that early modern natural philosophy was much broader than modern physics.⁴¹ In its largest, etymological sense, “physics” extended to the study of all natural things.⁴² Notably, it included biology. In Leibniz, the notion of living organism is crucial not only for the scientific investigation of the natural world, but also for metaphysics.⁴³ For instance, in an often quoted passage from a letter to De Volder of 20 June 1703, Leibniz presents an ontological scheme according to which corporeal substance is conceived as an “Animal” “made One” by a monad dominating an “organic machine” constituted by an infinite aggregate of monads.⁴⁴ In paragraph 64 of the *Monadology*, Leibniz

³⁹ Garber, *Leibniz*, p. 235.

⁴⁰ Dutens V, 147-148: “in the natural world also the discovery of the magnetic needle is and will be a great thing, even if its workings remain forever unexplained to us.”

⁴¹ On the scope of natural philosophy in the early modern period see Blair, “Natural philosophy.”

⁴² Heilbron, *Elements of Early Modern Physics*, pp. 7-8 identifies the second edition of Hamberger’s *Elementa Physices, Methodo Mathematica ... Conscripta* (Jena 1735) as the first important textbook which explicitly excluded the “whole theory of plants, animals and man” (see Preface).

⁴³ The study of early modern life sciences pioneered by Duchesneau (see *Les modèles du vivant de Descartes à Leibniz*) has been followed by other important contributions which have explored the significance of the notion of living organism for Leibniz. See especially Nunziante, *Organismo come armonia*; Duchesneau, *Leibniz, le vivant et l’organisme*; and Smith, *Divine Machines*.

⁴⁴ “I distinguish therefore (1) the primitive Entelechy or Soul, (2) Matter, i. e. primary matter, or primitive passive power, (3) the Monad completed by these two, (4) the Mass [*Massa*] or secondary matter, or organic

describes living things as divine machines or machines of nature which are “still machines in the least of their parts *ad infinitum*.”⁴⁵ Important studies have stressed the role of the burgeoning early modern microscopy in providing inspiration for distinctive Leibnizian metaphysical theses,⁴⁶ notably his view that “the least particle must be regarded as a world full of an infinity [une infinité] of creatures”;⁴⁷ his claims that there is continuity in nature (“*nature never makes leaps*”),⁴⁸ that “the nature of things is uniform”,⁴⁹ and that the world is a plenum;⁵⁰ and his thesis that apparently inanimate or inorganic bodies reduce to living bodies or organisms (“there is a world of created beings – living things, animals, entelechies, and souls – in the least part of matter”).⁵¹ In brief, one may wonder whether the distinction between metaphysics and science (intended in a modern way as distinct enterprises) breaks down, for Leibniz, in the case of life sciences.

I do not think this is the case. Although microscopy may well have inspired, or perhaps more precisely, *confirmed* some of his metaphysical views, Leibniz remains very clear that monads and the “*World of substances*” belong to an intelligible order, distinct from the *phenomena of the senses* studied by the microscopists.⁵² Monads are not the sort of entities which could be observed if a powerful enough microscope had been devised. Even at microscopic level, the organic bodies studied by life sciences are still extended, sensible entities which are regarded by Leibniz as well-founded phenomena rather than the metaphysical entities which are ultimately real. Assuming the monodological framework of the letter to De Volder or the passages from the *Monadology* quoted above, the relationship between the extended sensible bodies studied by life sciences, and the aggregates of monads from which they result, is analogous to the relationship between the derivative forces studied by physics and the primitive forces which are the object of metaphysics.

machine, for which countless subordinate Monads come together, (5) the Animal or corporeal substance, which is made One by the Monad dominating the Machine.” (LDV 264; trans. by Adams in *Leibniz*, p. 265).

⁴⁵ PW 189.

⁴⁶ See especially Wilson, *The Invisible World* and Becchi, *Arlecchino e il Microscopio*.

⁴⁷ A II 2, 713. An English translation is available at: <http://www.leibniz-translations.com/foucher.htm>

⁴⁸ NE 56.

⁴⁹ LDV 306-7.

⁵⁰ *Monadology* §§ 61-62.

⁵¹ *Monadology* § 190, PW 190.

⁵² Cf. NE 378: “When one considers further what belongs to the nature of these real unities, that is *perception* and its consequences, one is transported, so to speak, into another world, that is to say into the *intelligible World of substances*, whereas previously one was only among the *phenomena of the senses*.”

The hardest objection, however, comes perhaps precisely from Leibniz's theory of derivative forces. How can Leibniz maintain a distinction between metaphysics and physics if he conceives of derivative forces (that is, the forces studied by physics) as *modifications* of primitive forces (that is, intra-monadic forces, which undoubtedly belong to metaphysics)?⁵³ Insofar as derivative forces are *modifications* of primitive forces, one may object that they are, really, the same forces albeit "modified".

Reply: a one-world view

In order to reply to this objection, and more generally, to the points raised above about the principle of the equivalence between full cause and entire effect, final causes, and the relationship between life sciences and metaphysics, the key question to ask is one inherited from Platonism. Put in the broadest terms, we are dealing here with a version of the relationship between appearances and reality inherited from Plato, which is replayed in different ways especially (but not only) in the thought of authors most indebted to Platonism such as Descartes, Leibniz, and Kant. As in the cases of Plato and Kant, we have to ask whether Leibniz held a "one-world" or a "two-world" view.⁵⁴ That is, according to him, are physics and metaphysics about the same objects? Or are they about two different classes of objects with no known or knowable relation? Are phenomena expressions or manifestations of things-in-themselves?

It seems to me that, for Leibniz, the answer is clearly yes, and that, therefore, he holds a one-world (as opposed to a two-world) view. In other words, for Leibniz, the phenomena studied by physics (or, for that matter, the sensible, extended bodies studied by biology) express what is ultimately real. Physics and metaphysics are about what is, *ultimately*, the same reality. They offer, however, two different kinds of explanation of what are -- really -- the same objects. These different kinds of explanation are driven by different sets of issues, serve different purposes and, at least to some significant extent, ask different sets of questions. Physics aims at describing and explaining the "manifest" world -- that is to say, the world of phenomena, the world as it appears to us -- in a mathematical and mechanical way,

⁵³ See for instance Leibniz to De Volder, 20 June 1703 (LDV 262-263; trans. slightly modified): "derivative forces are nothing but modifications and results [modificationes et resultationes] of primitive forces."

⁵⁴ Cf. Adams, "Science, Metaphysics, and Reality," to which I am indebted for this section of the paper.

with the ultimate purpose of predicting and mastering these phenomena for the benefit of humankind.⁵⁵ Metaphysics focuses on explaining the world not as it is manifest in experience but as it really is. Indeed, according to a recognisable Platonic mould,⁵⁶ the primitive and properly “real” entities are non-sensible entities (immaterial, non-extended, “noumenal” entities to borrow a Kantian term) which need to be *postulated* (as opposed to *observed*) in order to account, ultimately, for the phenomena of which we have sense-experience.⁵⁷ It is clear that, for Leibniz, one inquiry is more fundamental than the other, in the sense that metaphysics provides the ultimate grounding of the entities and principles studied by physics. Therefore, metaphysics offers a deeper level of explanation insofar as, for Leibniz, it is metaphysics rather than physics which offers an account of what is ultimately real, and of which physical objects are phenomenal manifestations.

The latter point holds, I think, irrespective of whether Leibniz thought of what is ultimately real in terms of mind-like simple substances or of composite corporeal substances constituted by quasi-Aristotelian matter and form.⁵⁸ Generally put, one could agree with this way of conceiving the relationship between physics and metaphysics without needing to buy into the full package of an idealist metaphysics.

In sum, to use Robert M. Adams’s phrase, in my view, there is for Leibniz a trans-identity between the manifest image of the world, the scientific image of the world, and the metaphysical image of the world:⁵⁹ they are different ways of having a grip on what is,

⁵⁵ I note that the relationship between physics and the “manifest” world has become more complex since the advent of subatomic physics, relativity theory, and quantum theory. These physical theories no longer describe the behaviour etc. of entities roughly similar to the objects of our sense experience the way classic Newtonian physics did.

⁵⁶ See the explicit reference to Plato in the letter to Rémond of January 1714 (GP III, 606) quoted above.

⁵⁷ See *Specimen Demonstrationum Catholicarum*, 1685 (A VI, 4, 2326): “the laws of mechanics themselves do not flow from geometrical but from metaphysical principles, and if all things were not governed by a mind, they would be very different from what we experience.”

⁵⁸ Garber, *Leibniz: Body, Substance, Monad*, defends the view that in his middle years (roughly from the later 1670s to the mid-late 1690s) Leibniz had not yet come upon the monadological metaphysics that will characterize his later years. “Instead, what one finds there is a metaphysics grounded in corporeal substances, extended unities of matter and form.” Moreover, according to Garber, Leibniz’s last (unresolved) problem in his final years is how to put these two metaphysical models together, that is, “how to understand the relations between the bodies that we experience and the monads that are, in some sense, their metaphysical foundation.” (pp. xix, xxi).

⁵⁹ See Adams, “Science, Metaphysics, and Reality.”

ultimately, the same reality of which metaphysics offers the deepest account. They remain, however, *different* images, with different purposes and different uses. The “metaphysical image” may well be the closest to reality for Leibniz, but it is also the most abstract and general, and not nearly as useful as the “scientific image” in mastering nature to the benefit of humankind – the latter (broadly practical) aim being what drives much of Leibniz’s overarching intellectual programme.

A comparison with Galileo, Newton, and Descartes

It may be helpful to compare, at this point, Leibniz’s position with that of other early modern giants, namely Galileo, Newton, and Descartes. Galileo and Newton have a different approach. What they are after is the explanation of certain natural phenomena in mathematical terms. In pursuing this project, they simply decline to do metaphysics, or to worry about providing metaphysical roots.⁶⁰ They recognize that their new science of nature, or (as they still call it) their new “natural philosophy”, should take into account only those aspects (“*affezioni*”) of bodies which are perfectly intelligible insofar as they can be quantified and, therefore, translated in mathematical terms. On the contrary, as Galileo writes in his third letter to Mark Welser on sunspots, it is pointless “*tentar l’essenza*”, that is, speculate about essences of which we have no “intrinsic” knowledge (“*notizia intrinseca*”).⁶¹ Similarly, with his famous *Hypotheses non fingo*, Newton declares that metaphysical

⁶⁰ Descartes even complains about this, pointing at what he regards as the limitation of Galileo’s approach. See letter to Marin Mersenne, 11 October 1638; AT II, p. 380.

⁶¹ In Galileo, *Istoria e Dimostrazioni intorno alle Macchie Solari*. However, it should be noted that, in other works, Galileo seems to make ontological or metaphysical claims about the real existence or non-existence of qualities in bodies beside those which can be treated in mathematical terms, instead of simply declining to take into account in his mathematical explanation of natural phenomena certain features of bodies which are not quantifiable. Regarding the issue of Galileo’s metaphysical commitments, some commentators read him as holding a Platonic mathematical ontology (cf. Burt, *The Metaphysical Foundations of Modern Science*, pp. 74-83; Koyré, *Études Galiléennes*) which would provide a metaphysical justification for the application of mathematics to physics. Other scholars argue for a non-metaphysical reading of Galileo, noting that his “distinctive philosophical contribution to the rise of the new science was to show how one can seek to establish the appropriateness of one type of approach to natural science over its competitors without first establishing a metaphysical framework as foundation and support.” (Hatfield, “Metaphysics and the New Science,” p. 118). See also Vanni Rovighi, *Storia della Filosofia Moderna*, pp. 31-63 and Drake, *Galileo at Work: His Scientific Biography*.

hypotheses “have no place in experimental philosophy” in which “particular propositions are inferred from the phenomena”.⁶²

On the other hand, Descartes and Leibniz are both heirs of the Aristotelian tradition in their looking for a grounding of physics in metaphysics, as graphically represented in Descartes’s beautiful image of the tree of knowledge.⁶³ Leibniz disagrees with Descartes that a mechanical physics cannot grow on Aristotelian metaphysical roots, or at least preserve some key Aristotelian metaphysical intuitions, but he fundamentally agrees with Descartes on the need for metaphysical roots of physics.⁶⁴ In my view, for present purposes, the crucial difference between them is the following.

For Descartes, the bodies studied by physics just *are* the (extended) *substances* of his metaphysics. Hence the lack, in Descartes, of a proper distinction between a physical and a metaphysical enquiry about natural bodies. Physics gets to the bottom of their essence since this essence reduces to the mathematizable and quantifiable property – extension – which is the object of physics. Notwithstanding the fact that Descartes grounds the laws of motion on

⁶² “General Scholium” of Newton, *Philosophiae Naturalis Principia Mathematica*, third edition (trans. by Cohen and Whitman, p. 943): “I have not as yet been able to discover the reason for these properties of gravity from phenomena, and I do not feign hypotheses. For whatever is not deduced from the phenomena must be called a hypothesis; and hypotheses, whether metaphysical or physical, or based on occult qualities, or mechanical, have no place in experimental philosophy. In this philosophy particular propositions are inferred from the phenomena, and afterwards rendered general by induction.”

⁶³ AT IXB, 14 / CSM I, 186.

⁶⁴ Garber, *Body, Substance, Monad*, p. 179 notes that in his project of grounding physics in metaphysics “Descartes is working in a broadly Aristotelian tradition of natural philosophy” while the Galilean project represented a “different strand”: “Galileo’s project was within the domain of mixed mathematics, as it was called, a quantitative account of the world that favoured mathematical description over an account of the ultimate first causes.” Garber concludes with the association of Leibniz with Descartes, and of Newton with Galileo. A comparison of Newton and Descartes’s conceptions of the complex relationship between physics and metaphysics is offered by Janiak, “Metaphysics and Natural Philosophy in Descartes and Newton.” In his forthcoming “Philosophy and Metaphysics in the General Scholium,” Janiak notes that Newton developed his philosophical ideas in an *ad hoc* manner, without articulating any hierarchy of commitments. Perl, “Physics and Metaphysics in Newton, Leibniz and Clarke,” concludes that Leibniz and Newton “were doing different things”: for Leibniz, metaphysics “enables us to account for those features of experience which are not accessible to the restricted methods of science”; for Newton, “such a metaphysical account is superfluous” since “what is not properly accounted for in natural philosophy is readily accounted for by God” (p. 526). For a comparison between Galileo and Descartes, stressing the non-metaphysical approach of Galileo versus Descartes’s concern with the metaphysical grounding of physics, see Dutton, “Physics and Metaphysics in Descartes and Galileo.”

theological considerations such as God's immutability, there is no deeper level of the nature of bodies which physics cannot reach, or which is not its proper object of study. The very claim that the *essence* of bodies is extension, however, is a metaphysical rather than a physical claim. Descartes's physics can, therefore, be aptly characterized as a "metaphysical physics" (to borrow the title of Garber's classic book).⁶⁵ To have a physics which does not include such metaphysical claims about what properties of bodies really exist or don't exist, one has to look at Galileo rather than Descartes. It seems to me that, in Descartes, the only properly and irreducibly *metaphysical* inquiry therefore has spiritual substances or minds as its object. If there is any distinction between physics and metaphysics in Descartes, this is a distinction between a science which studies the corporeal world, adequately grasping its essence or nature, and a science which studies the spiritual world.

For Leibniz, physics proper studies phenomena, that is, the world as it appears to us. Although phenomena are manifestations of substances, substances are not its proper object.⁶⁶ Although only a metaphysical level of explanation gives us a proper understanding of the fundamental principles governing the physical world, these principles belong to a type of inquiry which is distinct from physical investigations. In order to achieve its purposes -- that is, providing mathematical and mechanical descriptions and explanations of phenomena to master nature via our predictions, technical applications, and so on -- physics should not, and need not rely on metaphysical entities such as substantial forms.

Conclusion

Here Leibniz is, once again, heir of the past and herald of the future. He is the heir of the ancient, medieval, and Renaissance tradition endorsing the unity of *scientia* or knowledge and its systematicity. This is a conception which is also a project -- the project of the *scientia generalis* and the demonstrative encyclopaedia. This project finds its expression also in his one-world view about the need for a metaphysical grounding of physics. Consistent with his views on the unity of knowledge and his overarching encyclopaedic vision, Leibniz sees the enterprises of metaphysics, on the one hand, and of the new, mathematical and quantitative

⁶⁵ Garber, *Descartes' Metaphysical Physics*.

⁶⁶ Indeed the claim that phenomena are manifestations of substances and their principles is itself a metaphysical rather than a physical claim; it is an example of how metaphysics provides the grounding of physics but is a different enterprise.

physics, on the other hand, as complementary insofar as they present different accounts of what is, ultimately, the same reality.

Leibniz is, at the same time, herald of the future through one of the first theorized distinctions, in the early modern period, between philosophy and “science” (that is, in this case, the nascent quantitative physics or classical mechanics) as two different, autonomous enterprises. “Autonomy” is to be taken here in its literal sense of having each its own *nómos*. Although linked through a grounding relation, and therefore elements of a systematic vision of the unity of knowledge, metaphysics and physics are two different kinds of explanation. Physics need not and should not rely on metaphysical entities such as substantial forms, and must account for natural phenomena in a rigorously mechanical and mathematical way. On the other hand, although Leibniz is undoubtedly one of the strongest advocates of the new mathematical and quantitative “science”, he is very far from thinking that any real use for philosophy will eventually be restricted to a reflection on the aims and methods of science (in its modern meaning). The ultimate level of explanation will remain for him irreducibly metaphysical and therefore philosophical.

This stance paves the way to the modern conception of natural science in a manner which is different (but, arguably, philosophically richer) than that of other great architects of modern science such as Descartes, Galileo, and Newton. Although there is a sense in which “what Leibniz is doing is a kind of enterprise that we don’t do today, either in physics or in philosophy,”⁶⁷ this is because he was laying the foundations of what did not yet exist in his time, that is, our distinction between science and philosophy, rather than because he was stuck in an obsolete version of natural philosophy.

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⁶⁷ Garber, *Leibniz*, p. 383.

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