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How to Write the Global History of Knowledge-Making

Interaction, Circulation and the Transgression of Cultural Difference

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Chapter 7
Shaping Newtonianism: The Intersection of Knowledge Claims in Eighteenth-Century Greek Intellectual Life

Manolis Patiniotis

7.1 Centers and Peripheries

The center-periphery dichotomy is undoubtedly a difficult and challenging issue. It originates in the writings of the American sociologist Edward Shils (1961), who used it in the study of international relations in the context of colonialism. In Shils' writings, the notions of center and periphery were employed to explain the variation in the cohesiveness of different societies, or of the same society at different periods. The center is the location where the density of institutions, authorities and symbols of unity is greater and, as a result, it exerts centripetal forces on the periphery, which is the broad area where less active individuals and followers are dispersed (Bulmer 1996, 14; Orlans 1996, 25). However, it was only through George Basalla's three-stage model that this distinction gained significant impetus in the history of science. Basalla set out to explain how, by means of Western technology, colonial societies passed from a subaltern status to successful incorporation into the developed world. In his view, the gradual overcoming of various cultural impediments allowed Western science and technology to spread in these societies, resulting in the emergence of a hybrid "colonial science". In the course of time, with the wide acceptance of the methods and values of modern scientific culture, colonial societies managed to build their own scientific and educational institutions, securing their autonomy and self-directed growth (Basalla 1967).

Both Shils' center-periphery dichotomy and Basalla's three-stage model have been largely employed by historians working on science and empire. At a time when modernity theory had reached its high noon, it seemed quite plausible to causally associate Western dominance over the rest of the world with the integrity and efficacy of Western science. Marxist criticism of neo-colonialism particularly focused

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on the role played by science in colonial expansion. Science was increasingly incriminated as one of the main instruments of imperial control over colonized societies. In this context, dependency came to be seen as intrinsic to scientific relations between imperial centers and colonial peripheries. Science did not mark the gradual incorporation of the colonies into a universally valid system of political and economic development; rather, it asserted a distribution of power between the metropolis, which produced and validated knowledge, and the dependent periphery, which was regulated and controlled by that knowledge (Cipolla 1970; Navarro 1976; Brockway 1979; Headrick 1981; Turshen 1984; Adas 1989; Gascoigne 1998).

Historians working on the history of science in the European periphery approached this issue from a different perspective. Instead of adopting a critical attitude, they gladly endorsed the center-periphery dichotomy as a means to ensure the alignment of their respective localities with the winning side of history: Europe was perceived as the unquestionable culmination of modern civilization, and participation in its becoming was considered indicative of the cultural maturity of a society. By asserting the peripheral status of their societies, historians assured their position in a unique course leading to European integration. Being in the periphery was not really a drawback: due to their intrinsic qualities and powers, peripheral societies were in a position to follow and eventually incorporate the civilizational patterns that represented Europe. Thus, for a number of social formations that did not enrich European culture with distinctive scientific attainments (particularly those that did not belong to the core of the Scientific Revolution), dependency became a way to establish themselves in the vicinity of Europe (Kılınç 2008; Nieto-Galan 2008; Patiniotis 2008; Simões et al. 2008).

In this context, historical inquiry into the emergence of modern science naturally focuses on the places and events that gave birth to what is now considered "original" science. The rest of the story is confined to a more or less straightforward process of distribution of the new ideas and practices to the European periphery, which, by means of science, aimed to get on board the train of modernity. Scholars on the periphery, however, were for various reasons unable fully to assimilate the new methodological developments. Many of them contented themselves with simply copying and mechanically reproducing the findings of their contemporaries. Others were at pains to align their religious and scholastic convictions with the new spirit that began to spread in their local contexts. They picked up and combined ideas and practices they considered important to upgrading their intellectual profile, but their persistent adherence to outdated patterns of natural philosophy bears witness to their inability to embrace the full dynamics of modern science. This situation perpetuated the center-periphery dichotomy, and had long lasting effects on the way the various societies of the European periphery eventually accommodated modernity.

The case study presented in this chapter aims to provide an alternative to this narrative by showing that the use of the center-periphery dichotomy in historiography of science actually obscures the complex processes that marked the making of modern science. These processes transcend the currently established cultural hierarchies and involve a variety of localities that participated in the shaping of science by mutually appropriating and transforming one another's intellectual traditions (Patiniotis 2013a).

The subject matter of this study is eighteenth-century Greek-speaking scholars and how they got involved with the Newtonianism of their period. It is now widely accepted that the history of eighteenth-century Newtonianism is not about the spread of the "original" Newtonian ideas across Europe, but rather about the intersection of a locally produced set of natural philosophical ideas with knowledge traditions immanent in a variety of intellectual environments across the continent and beyond. Accordingly, what later came to be known as Newtonian physics is the outcome of this long and multifarious process, rather than a straightforward implementation of Newton's *Principia*. Taking this perspective, the article endeavors to place Greek intellectual life on the map of the intellectual exchanges that shaped eighteenth-century Newtonianism. Contrary to the claims of received historiography, the Greek-speaking scholars of the time did not perceive Newton's ideas as a powerful achievement contributing to the unquestionable progress of natural knowledge, but as a *challenge* to the character of their contemporary philosophy. Like many other European scholars, they tried to answer the question: How could Newtonian natural philosophy be integrated into the philosophical discourse without breaking with metaphysics? To this end, they involved a number of intellectual traditions and knowledge claims to produce a local synthesis, which reflected their ambition to perpetuate philosophical inquiry into Nature through a metaphysically grounded version of Newtonian philosophy.

7.2 Ambiguous Modernity

It is a widespread assumption that, since Galileo's time, the mathematization of Nature and the establishment of the epistemological authority of the experiment brought about a new kind of physics, which culminated in the so-called "Newtonian synthesis". The new natural philosophy has ever since been characterized by a happy and productive symbiosis of mathematics and experiment. Eighteenth-century Greek-speaking scholars were well-versed in natural philosophy and mathematics. They had published a great number of treatises dealing with the most recent developments in both fields and, in some of them, they deployed a sophisticated philosophical discourse seeking to clarify the metaphysical foundations of Newtonian physics. However, one issue that often puzzles historians is the attitude of Greek-speaking scholars towards experimental philosophy. Their books contain a great deal of references either to specific experiments or to the value of experimental study of Nature at large (for example: Voulgaris 1805a, 6; Theotokis 1766–1767, vol. 1, 7–10; Koumas 1807: vol. 4, 230–31). Beyond the written level, however, there is no evidence that they conducted actual experiments. They mention experiments made by others, comment on remarkable observations made in European laboratories and observatories, argue for the acquisition of experimental devices for schools, and declare their adherence to the new empirical method of investigation as opposed to infertile scholastic explanations; but, as far as we know, they never conducted actual experiments. At most (and according to scarce evidence), they organized some experimental demonstrations for the illumination of their students or perhaps of a wider learned public. The heuristic role of the experiment, and its instrumental use in the quantitative investigation of Nature, was beyond their remit (Xenakis 2003, 518–20, 535–36 (esp. footnote 713), and 552–55). Besides, as Veniamin of Lesbos[1] noted in the context of a debate about the weight of phlogiston[2]:

> Of course, as Europeans prove the weight of phlogiston by means of experiments, we should also reject this idea [of the negative weight of phlogiston] through experiments. But since we lack two conductive thermometers, we will currently postpone the experimental proof and content ourselves with a proof through *logos* [by means of logical arguments]; because, I believe, a proof through *logos* is not inferior to a proof through experiment (Veniamin of Lesbos 1813, 22; my translation).

Similar things hold concerning mathematics. Newtonian mechanics—itself originally part of mathematics—symbolized the convergence of natural philosophy with mathematics. Inasmuch as one of Newton's major aims was to study the generation of celestial trajectories, mechanics was prompted to cross the border of pure quantification and enter the realm of dynamics. Geometry could not accompany natural philosophy in this venture; the redefinition of space, time, and motion went hand-in-hand with the introduction of calculus as the backbone of rational mechanics (Cohen and Whitman 1999, 382; Patiniotis 2005, 1634–35). This approach was totally absent from Greek natural philosophy, however. Greek-speaking scholars had produced a significant number of elaborate treatises on Euclidean geometry, conic sections, and modern developments in algebra (Veniamin of Lesbos 1818, 1820a; Voulgaris 1767; Govdelas 1806, 1818; Dougas 1816; Theotokis 1798–1799; Kavras 1800; Koumas 1807; Sparmiotis 1793; Christaris 1804). However, at no point did they connect developments in mathematics to rational mechanics. On the contrary, their treatment of the fundamental notions of the new natural philosophy retained a high degree of metaphysical sophistication. Several scholars ventured to provide novel syntheses and employed a highly technical vocabulary, but they persistently abstained from applying mathematics to the study of Nature. Instances of purely mathematical elaborations were scarce, and even those were chiefly confined to trivial problems of Archimedean or Galilean mechanics. On the other hand, the

[1] Veniamin of Lesbos (1762–1824) studied mathematics and physics in Pisa and Paris. In Paris, he made the acquaintance of Adamantios Korais (1748–1833), the patriarch of the Greek Enlightenment, and was influenced by his political views. He directed the school of Kydonies (Ayvalık) from 1802 to 1812. During his service, the school acquired a reputation as the best school for the sciences. He promoted the teaching of the heliocentric system, and introduced the concept of Πανταχηκίνητον (Pantachikiniton: The All-Mover), an ethereal agent that accounts for all celestial and natural kinetic phenomena (Dialetis et al. 1999, 62–64).

[2] A self-repellent substance that was considered the bearer of heat in the context of the widespread imponderable fluids theories of the eighteenth century.

emphasis placed on empirical examples drawn from everyday life indicates the authors' desire to deal with the new natural philosophy in a primarily qualitative way.

This ambiguous relationship of Greek-speaking scholars to experimental philosophy and mathematics has stimulated a historiographical discussion concerning the kind of natural philosophical discourse developed by these scholars. According to many historians, Greek science lacked originality and creativity. It was a vague reflection of the developments that took place in the centers of the Enlightenment, transmitted to the Greek context primarily for ideological purposes (Kondylis 1988). However, due to Ottoman rule over the Greek-speaking populations of the Balkans, even the mere attempt to get Greek intellectual life into contact with Enlightened Europe was a heroic endeavor. For this reason, some historians argue that the apparently low level of philosophical and scientific production reflects the real conditions of Greek society of the time; therefore, questions of originality are anachronistic and irrelevant (Psimmenos 1988, 31). Others consider that, although Greek-speaking scholars might not have been the kind of natural philosophers who could have been found in Western Europe at the time, they did take special care to convey the new knowledge to their intellectual context through a process of careful selection and adaptation, which made this knowledge available for educational purposes (Karas 1991, 89). The fact that, regardless of their degree of sophistication, particular scholars assimilated and spread the new scientific spirit in the Greek intellectual space, countering common ignorance on the one hand and the established authorities on the other, was not only important for the revival of Greek intellectual life, but also determined the subsequent political and ideological developments up to the Greek war of independence (Henderson 1970, introduction). The tacit premise behind such considerations is that Greek scholars were, at best, enlightened teachers: Due to particular historical circumstances, their intellectual activity was confined to education, and this confinement decisively marked the character of their scientific and philosophical production. For reasons that did not depend on their will or capabilities, Greek scholars were unable to partake in the creativity of modern European thought, but one should appreciate the pedagogical and ideological consequences of their work.

To some extent, this approach seems quite reasonable and in accordance with a certain interpretation of historical events. Nevertheless, it fails to take into account the complexities of the intellectual pursuits of the time, and thus properly to assess the fine texture of Greek-speaking scholars' intellectual production. One important thing that should be considered is that, despite the neglect of experiment and mathematics, Greek-speaking scholars developed a high degree of philosophical sophistication aimed at the metaphysical foundation of the new natural philosophy. The examples significantly vary in erudition, span and technical adequacy, but their goal is more or less the same: to accommodate the new natural philosophy in a consistent philosophical framework. This is not the place to review all these enterprises, but let us just mention two examples: Eugenios Voulgaris'[3] attempt to reinvent the concept of *vis inertiae* as a quality of *materia prima* (Patiniotis 2007) and his elaborate enterprise to make modern atomism compatible with Aristotelian hylomorphism (Patiniotis 2013c, 322–33); and Veniamin of Lesbos' attempt to establish an imponderable fluid of his own invention that would secure the material dimension of all actions at a distance (ibid., 333–45). Most of these undertakings led to original syntheses, and displayed the same degree of elaboration as most contemporary works of experimental and mathematical natural philosophy. But they clearly inclined towards philosophy.

In addition to this, almost all major eighteenth-century Greek-speaking scholars who got involved with natural philosophy had also published major works on logic and/or metaphysics (Veniamin of Lesbos 1820b; Voulgaris 1766, 1805b, Koumas 1818, 1818–1820; Konstantas 1804; Moisiodax 1761–1762; Pamplekis 1786; Philippidis 1801; Psalidas 1791). On these grounds, one might argue that the adherence of Greek-speaking scholars to traditional philosophical discourse demonstrates a certain inability to assimilate the methodological and philosophical developments of the Enlightenment. However, the content of their works on logic and metaphysics was *in tandem* with these developments: overt support for empirical research on Nature, denunciation of fruitless scholastic methods, redefinition of the principles of logic on the basis of recent philosophical discussions, and rearrangement of the traditional fields of metaphysics according to the emerging disciplines of modern science. Therefore, the conclusion one could draw from the adherence of Greek-speaking scholars to the traditional form of philosophizing about Nature is not about their *support or rejection* of modern natural philosophy, but about the *way* they chose to practice it.

7.3 New Painting on Old Canvas

7.3.1 Experiment and Mathematics

One important thing historians tend to overlook is that, in the eighteenth century, the new natural philosophy was still an unstable synthesis. The much-appreciated convergence of experimental philosophy with mathematics was not an established fact, neither for philosophers, nor for mathematicians and natural philosophers. When

[3] Eugenios Voulgaris (1716–1806) was a Corfu-born Greek-speaking Orthodox clergyman and scholar. He decisively contributed to the revival of Greek philosophy as teacher and director of some of the most influential Greek schools of the time. His intellectual itinerancy took him to places such as Venice, Constantinople, Bucharest, Leipzig and finally Saint Petersburg, where he became Catherine II's courtier and archbishop of Slavensk and Kherson. He authored books on metaphysics, logic, literature, theology, history and politics as well as some of the most influential scientific treatises of his time, in which he attempted to merge neo-Aristotelian philosophy with the attainments of modern European thought (Patiniotis 2013b).

d'Alembert wrote his article on experimental natural philosophy in *Encyclopédie*, he felt compelled to make a clear distinction between experimental philosophy and the "mathematical sciences" (d'Alembert 1756). The article defended the empirical method of natural inquiry against those adhering to the Aristotelian and Cartesian perceptions of natural philosophy. But what was the particular character of this method? As described by d'Alembert, the empirical study of Nature wavered between two patterns: observation and experiment. Observation was confined to a superficial perception of reality, while experiment was a systematic and penetrating questioning of Nature. The aim of experiment was to produce new phenomena in order to force Nature to disclose its hidden principles. In this respect, the physics of observation could be called "vulgar" and "palpable", whereas experimental physics could be called "occult", on the condition that "occult" was deprived of its apocryphal connotations. Of course, the man who shaped modern experimental philosophy was Newton. "Newton appeared, and showed first what his predecessors had only glimpsed: the art of introducing Geometry into Physics, and by bringing together experience [= experiment] with calculus formed an exact, deep, bright and new science" (d'Alembert 1756, 299; my translation).

For d'Alembert, the value of experimental method was confirmed by the discovery of natural laws, which were counterintuitive and thus could not be found through mere observation. The law of free fall and the calculation of the weight of air by Boyle contained nothing extraordinary, and their discovery did not demand much sophistication. But this was not the case with hydrostatics, for example, and the association of pressure with the balance of fluids. This was a phenomenon that seemed to transcend general laws, although it could no longer be questioned once it was confirmed by experiment. It was at this point, however, that d'Alembert introduced an important distinction between experimental philosophy and the "mathematical sciences":

> … but once this phenomenon becomes known, hydrostatics hardly needs the experience [= experiment]: even more so as hydraulics itself becomes an entirely or almost entirely mathematical science; I say almost entirely because, although the laws of motion of fluids are derived from the laws of their balance, there are cases in which we cannot reduce the former to the latter except through certain hypotheses, and experience is necessary to ensure that these hypotheses are accurate and not arbitrary (d'Alembert 1756, 300–1; my translation).

Thus, once the fundamental natural laws become known through experiment, the various disciplines of physics can become autonomous by turning to mathematics. Although in some cases the "mathematical sciences" may resort to experiment in order to check their hypotheses, in principle they no longer depend on experiments.

In consequence, experimental philosophy exists as an intermediate stage between "vulgar" physics (based on the Aristotelian notion of passive observation) and the "mathematical sciences". It aims to bring to light the fundamental features of natural bodies and the principles that govern natural phenomena. However, although it can be considered an indispensable and fully fledged discipline, its position is right at the entryway to another field: namely, mathematics. From a philosophical point of view, therefore, experimental philosophy appears partial and incomplete, as it is incapable of producing an integrated representation of reality. This can only be achieved by the mathematical sciences, as is the case with Newtonian mechanics, for example, which provided a concise description of the "system of the world". However, it remains incomplete for one further reason: It inherited the Renaissance-era concern about the epistemological validity of induction.

7.3.2 Induction in Renaissance Philosophy

Contrary to received wisdom, Renaissance Aristotelians did not consider Aristotle an infallible authority. Rather, they thought that the corpus of Aristotelian wisdom required methodological refinement and completion by way of new subjects. The perfection attributed to Aristotelian tradition concerned its shape and structure. It was like Euclid's *Elements*, which formed the basis for all possible geometrical knowledge: Aristotle bequeathed to his successors a philosophical system that could form the basis of all natural and metaphysical knowledge. But it did not cover all aspects of reality. It was the task of his successors to supplement philosophy with all the interpretations that Aristotle himself could have articulated but had no chance to do so, just like Euclid, who did not prove all the theorems that could be derived from his *Elements*. In this respect, the problem of method was central to Renaissance Aristotelianism: Philosophers needed to reach an agreement on the extent to which the human intellect was able to comprehend the causes of things, and the most appropriate way to achieve such comprehension (Mikkeli 2009).

The man who most prominently summed up these concerns was Jacopo Zabarella (1532–1589), professor of philosophy at the University of Padua from 1564 to his death. Although his name is mainly associated with the teaching of logic, Zabarella considered logic a mere tool—an *organum*—for the practice of philosophy. Proper science—*scientia*—was only demonstrated knowledge. From this perspective, we truly know something only when we can reconstruct it beginning from its primary causes. Ideally, the human intellect would wish to perceive things *along with* their causes. In this way, knowledge would be *ab initio* deductive: That is, it would be derived from the apparent causes of things, just as theorems are derived from axioms. This is impossible, however, due to the restrictions of human intellect. In order to get to know something, we thus need to execute a double process. By means of *resolution*, we advance from that which is most known to us (the effects) to that which is most known to Nature (the causes). Then, by means of *composition*, we derive the effects from the known causes and thus achieve certain knowledge of the phenomenon under examination and, at the same time, of all phenomena deriving from the same causes. In this context, resolution is a philosophically inferior process—the servant of composition, in a sense—that becomes necessary due to the imperfection of the human mind (Mikkeli 1992, 86–7, 102).

There are two different kinds of resolution, according to Zabarella: "*Demonstratio ab effectu*", which starts from effects and involves reasoning to reach causes lying beyond sensory experience, like *materia prima* or *primum mobile*; and *inductio*, which also starts from effects, but advances to causes by enumerating singular cases (enumerative induction). The kind of causes that can be discovered through induction are not transcendental substances, but only rules of conduct that govern the phenomena under consideration. In this sense, induction is weaker and less reliable than demonstration through syllogism. Literally speaking, it is not demonstration at all; it just helps the human mind to extract and systematize the regularities that govern a certain variety of phenomena (ibid., 92–5).[4] In order to proceed to real causes, induction must be supported by a mental process some authors call *negotiationem intellectus*, and which Zabarella himself calls *mentalem considerationem*. The opaque perceptions acquired from the phenomena are first analyzed as to their constituents and organized according to their particular features. But it is thanks to *mental consideration* that the human mind becomes able to transcend the empirical level and comprehend real causes from which genuine scientific knowledge can be derived. The entire process leading from effects to causes, and from the knowledge of causes to the *interpretation* of effects, is called *regressus*. Although the invention of *regressus* was previously attributed to Zabarella, it is now documented that Zabarella in fact summarized a discussion that had occupied medieval scholarship for several centuries before his time (ibid., 99–100, 104–5; Jardine 1988, 687–93; Kessler 1998; Mikkeli 2009).

7.3.3 Induction and Mathematics

Newton published his *Principia* one century after Zabarella's death. We can identify three important methodological developments that marked the transition from Renaissance philosophy to modern natural philosophy. In Newton's time, one important feature that distinguished his philosophy from the dominant Cartesian tradition was the rejection of hypotheses. The "General Scholium" of the second edition of *Principia* (1713) contains the most eloquent statement of this attitude: *hypotheses non fingo*.

> I have not as yet been able to deduce from phenomena the reason for these properties of gravity, and I do not feign hypotheses [*hypotheses non fingo*]. 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 experimental philosophy, propositions are deduced from the phenomena and are made general by induction (Cohen and Whitman 1999, 943).

Both this statement and the four "rules of reasoning in philosophy" in the third book of *Principia* express Newton's intention to take up the old problem of resolu-

[4] In *De Regressu*, Zabarella follows Averroes in a slightly different division. "Demonstrative induction" represents *demonstratio ab effectu*, and handles necessary matters that have an essential relationship to each other. "Dialectical induction" represents *inductio* and handles contingent matters, which can lead to firm knowledge only if all particulars are enumerated. In demonstrative induction, the examination of a limited number of cases provides evidence for the essential connections, and thus our mind can securely infer the universal (Mikkeli 1992, 95).

tion. He also did so in “Query 31” in the third book of *Opticks* (Newton 1979, 404). His opponent was clearly Descartes, and the stake was method: Which was the proper way to proceed from effects to causes? *Demonstratio ab effectu* or systematic induction? Induction, of course, answers Newton, since arbitrary theoretical contrivances and unfounded mechanical conjectures have no place in natural philosophy.

But induction is weak. In a sense, Zabarella was more honest than Bacon, who assumed that arranging data in long comparative tables would lead, through epiphany, to reliable inductive generalizations. Zabarella stressed the need for a particular mental operation that would lead to inductive generalization. And it is actually at this point that we are confronted with the second major methodological development: the connection of experimental induction with geometry. Newton is again the main contributor, but a significant share of fame goes to Galileo as well.

In history of science, the coupling of experiment with mathematics is usually considered a milestone of the Scientific Revolution. But this coupling was not a momentary shift. When Galileo provided the results of his experiments in mathematical form, he had already spent some time at the University of Padua in the aftermath of Zabarella’s philosophical investigations. In this intellectual atmosphere, the combination of geometry with experimental induction was meant to serve as an alternative to *mentalem considerationem*. Early modern natural philosophers gradually came to realize that geometry provided a safe method of generalization that could eliminate imagination, hypotheses and chimerical mechanical interpretations from natural philosophy. Thus, experimental induction could proceed, through the agency of mathematics, from the study of phenomena to the formulation of *natural laws*. As mentioned above, according to d’Alembert, the man who brought this method to perfection was Isaac Newton, who created “an exact, deep, bright and new science” (d’Alembert 1756, 299).

However, as already stated, the overtones of Renaissance philosophy’s low esteem for induction become evident from a close reading of d’Alembert’s article. This actually holds true for many texts of the eighteenth century. The ideal that still inspires philosophers is that of synthetic knowledge: the deductive comprehension of Nature. Induction represents the weak side of philosophy that becomes necessary due to the human intellect’s limited abilities. This idea resonates in d’Alembert’s implication that experimental philosophy lies at the entryway of the mathematical sciences. The experiment furnishes fundamental knowledge of natural phenomena (which unfortunately, d’Alembert notes, cannot be obtained through immediate observation), only to put it at the service of the mathematical sciences, which are exclusively responsible for producing a comprehensive reconstruction of reality. Thus, the mathematical sciences are invited to take the place of composition in the scheme of *regressus*. Real science, i.e. the certain and justified knowledge of reality, is a product of the mathematical intellect, which is able to organize reality in such a way that all phenomena will be derived from natural laws. And this is the third methodological development sealed by the Newtonian synthesis. As Newton himself noted, the content of the three books of *Principia* is nothing more than the *synthesis* of whatever he had previously discovered by means of *analysis*. Although, according to I. B. Cohen, there is not the slightest evidence that the propositions of *Principia* had been discovered by means of experimental or (even) mathematical analysis (Cohen and Whitman 1999, 123–24), Newton's statement confirms his allegiance to the traditional ideal of science by simply substituting composition with calculus (ibid., 49–51 and 122–23).

New drawing on old canvas. The index of values is more or less the same. Real *scientia* is deductive knowledge, the kind of knowledge that enables us to comprehend the variety of natural phenomena beginning from solid and unaltered first principles. Experimental induction is perceived as an unreliable method, which is part of scientific method only inasmuch as the human intellect is incapable of perceiving phenomena along with their causes. But historians of the Scientific Revolution are right in stressing that the introduction of mathematics into natural philosophy was a major development. Of course, the meaning of mathematics itself changed considerably in the seventeenth century, but that discussion falls outside the scope of this article. What is important to note is that, as decades went by after the publication of *Principia*, the hitherto self-evident predominance of geometry in natural philosophy gradually gave way to a new distinction. The kind of mathematics required for experimental philosophy was different than that required for the synthetic reconstruction of the "system of the world". Geometry sufficed in the former case, while the latter required the use of sophisticated tools provided by algebra and calculus. Experimental philosophy used mathematics in order to express natural regularities in the form of quantitative analogies, and the geometry "of the ancients" perfectly met this task. The synthetic reconstruction of reality, on the other hand, required mathematical tools suitable for ontological assumptions: The observed orbits of celestial bodies resulted from the *mathematical* form of universal attraction, and the constitution of the "system of the world" was based on absolute, true and *mathematical* space and time.

In this respect, there is an important difference between experimental philosophy and the mathematical sciences, but also a fundamental similarity. Their difference concerns the disparate positions they occupy in the value system of natural philosophy, and is reflected in the degree of sophistication of the mathematical tools they employ: Euclidian geometry for the experimenters, algebra and calculus for the mathematicians. But their similarity is even more crucial. The fact that, in both cases, mathematics is employed for the acquisition of natural knowledge subverts the true *philosophical* character of the respective cognitive enterprises, because mathematics is not capable of disclosing the real causes of things. The application of geometry in experimental induction helps formulate the regularities governing various natural phenomena, but cannot reveal their causes: It is an imperfect *mental consideration*. At the same time, the natural laws established through experimental induction do not constitute sufficient ground for the synthetic reconstruction of reality: The *composition* is counterfeit because it does not produce interpretations beginning from the causes of things, but arbitrary mathematical representations beginning from simple quantitative relations.

This is the context of an important philosophical discussion, which is now forgotten. For eighteenth-century natural philosophers, however, the question of the true nature of Newtonianism was crucial. Was it a refined mathematical survey of the mechanical principles of Nature, or a cosmological system? For many decades after the publication of *Principia*, there were natural philosophers who appreciated Newton as a mathematician, but had no respect for him as a philosopher. They believed that the notion of the Newtonian synthesis as an integrated cosmological system should not be attributed to Newton himself, but to his followers, like Henry Pemberton (1694–1771) in England and Voltaire (1694–1778) in France. For this interpretation to be true, however, Newton's ideas would have to contain a metaphysical dimension; and that is highly questionable. Thus, around the mid-eighteenth century, many philosophers, especially from German-speaking environments, admitted that Newton's achievements justly placed him at the pinnacle of the thinkers of his time; but the fact that he replaced the quest for primary causes with mathematical contemplation positioned him outside the premises of metaphysics (Ahnert 2004).

Christian Wolff, the most renowned metaphysician of the time, in the 1741 edition of his *Elementa matheseos universae* warned his readers about the dangers of applying mathematics to philosophy.

> If only those would pay serious attention to this, who from the mathematical principles of natural philosophy and from the optics of the supreme mathematician ISAAC NEWTON try to formulate I do not know what sort of *Newtonian philosophy*; as if imaginary notions, which are sufficient for the mathematical understanding of nature and are seen to be very fertile there, could be usefully introduced into first philosophy and natural philosophy, even, as if from these imaginary notions conclusions could be drawn concerning natural theology and general cosmology (Wolff 1971, 475; cited in Ahnert 2004, 480).

Apparently, many contemporaries had a different opinion; hence Wolff's warning. It is important to note, however, that in the mid-eighteenth century the conviction that mathematics could not provide causal explanations was still widespread. According to Wolff, mathematics consisted in proper *contrivances* that aimed at rendering reality intelligible. But these *mathematical phantasies* under no circumstances represented the *real causes* of things (Ahnert 2004, 481). In this sense, it seems strange that Wolff authored a great number of mathematical treatises (as was actually the case with many eighteenth-century Greek-speaking scholars) and also taught mathematics at the University of Halle, where he was appointed at Leibniz's recommendation. However, neither he nor any Greek-speaking scholar had ever thought that mathematics could serve cosmology, which still remained a branch of metaphysics. The greatest contribution of mathematics to philosophy was that it trained the human mind to reason with rigor and accuracy, a prerequisite for practicing the demanding and often confusing tasks of metaphysics. But that was the limit of its territory. The rest belonged to metaphysics.[5]

[5] A precursor of this attitude can be found in Bacon's statement of 1620: "Natural philosophy is not yet to be found unadulterated, but is impure and corrupted; by logic in the school of Aristotle, by natural theology in that of Plato, by mathematics in the second school of Plato, (that of Proclus and others,) which ought rather to [= which is rather likely to] terminate natural philosophy than to generate or create it. We may, therefore, hope for better results from pure and unmixed natural philosophy" (Bacon 1854 [1620], 362 [aphorism 96]).

7.4 Eclecticism

From the above, it becomes evident that, when Greek-speaking scholars got acquainted with Newtonianism, they found themselves in the middle of a very complex philosophical landscape. The old authorities had faded, but the new ones had not yet been established. And this holds true both for people (Aristotle, Descartes, Leibniz and Newton) and for cognitive enterprises (metaphysics, mechanical philosophy, experimental philosophy, rational mechanics). Greek-speaking scholars felt adequately equipped to measure up to the philosophical challenges of their time. Their contact with the new currents of thought was not limited to adoption, rejection or selection. Rather, it motivated them to participate in the discussions and intellectual fermentation that aimed to shape modern natural philosophy. Their discreet detachment from experiment and mathematics and their determination to refabricate the conceptual and ontological background of the natural philosophy of their time were not evidence of ignorance or conservatism, but expressions of a particular philosophical *attitude*. What was this attitude?

In the fifth volume of the *Encyclopédie,* Denis Diderot (1713–1784) published a long account of the history of *Éclectisme,* a philosophical trend begun in antiquity by some of the most renowned philosophers (Diderot 1755, 270–93). In this influential article, Diderot follows the consecutive generations of philosophers who represented *l'éclectisme* throughout the centuries, discusses the development of various sets of principles, and expresses his ambiguous feelings about the achievements of particular thinkers. What is important to our discussion, however, is not so much the historical account itself as the programmatic ideas Diderot articulated as a general context for his narrative and, incidentally, for his contemporary philosophy.

His definition of eclecticism stresses the fact that it is a philosophical attitude rather than a specific belief or system of doctrines. It is characterized by impartiality and by the insistence on selecting from other philosophical systems only those ideas that are in agreement with reason and experience. The purpose of this selection is neither building a new system nor rescuing an old one; in fact, this is exactly what *syncretism* does through loans from every available source, which leads to grotesque and incongruous constructions. On the contrary, eclecticism is an active intellectual attitude aiming at philosophical self-realization. Those who practice it borrow from the various existing systems because they believe that one should first get to know existing wisdom and only then try to enrich it with new principles and findings. Thus, they honor the wisdom other people or systems of knowledge have contributed, but are also aware that all philosophical systems without exception have, in the course of time, fallen apart. In search of a new land where philosophy is practiced beyond the limitations of dogmatism and sectarianism, they set reason and experience as the ultimate criteria either for selecting and integrating existing philosophical doctrines, or for suggesting new ones.

According to Diderot, the greatest philosophers in history have always been eclectic. Their followers, however, failing to share the originality and the intellectual independence of their mentors, confined themselves to sectarian systems which did not advance philosophy. In modern times, people like Giordano Bruno (1548–1600), Girolamo Cardano (1501–1576), Francis Bacon (1561–1626), Tommaso Campanella (1568–1639), Thomas Hobbes (1588–1679), René Descartes (1596–1650), Gottfried Wilhelm Leibnitz (1646–1716), Christian Thomasius (1655–1728), Andreas Rudigerus (1673–1731), Johann Jacob Syrbius (1674–1738), Jean Leclerc (1657–1736) and Nicolas Malebranche (1638–1715) gave new impetus to eclecticism. Those representing *systematic eclecticism* tried to build the new edifice of philosophy using stones spread on the ground by the collapse of the old philosophical systems. Soon, however, they realized that many stones were unfit for their purposes, and even more were missing. Thus, they started looking for new material to accomplish their mission. In Diderot's words, "they searched into the depths of the earth, in the waters and in the atmosphere." This quest (along with the respective methodological developments) initiated *l'éclectisme expérimentale,* which aimed at accumulating as much new material as possible for the future building of new philosophy (Diderot 1755, 283–4). It is in this sense that Diderot considers Francis Bacon "le fondateur de l'*Eclectisme* moderne" (ibid., 271). However, in actual fact two kinds of eclecticism remain distinct. Experimental eclecticism keeps investigating Nature, without, for the time being, venturing into major theoretical syntheses. The other kind of eclecticism, *l'éclectisme systématique,* places emphasis on the selection and combination of truths, either those recently unearthed or those originating in the philosophical systems of the past. Logical reasoning and good knowledge of established philosophy are crucial for this kind of eclecticism, as it is mostly dedicated to examining all possible combinations of the available materials. It is a time-consuming and actually inconclusive process, but it is motivated by the conviction that it is possible to start erecting some parts of the edifice of philosophy, even though this may temporarily overstretch resources. Diderot concludes his programmatic reflections with a statement that bears a strong resemblance to one made by Francis Bacon more than a century before:

> Hence we see that there are two kinds of Eclecticism; the experimental, which involves combining known truths & given facts, and increasing their number by the study of nature; the other is the systematic one, which deals with comparing the known truths with each other & with combining the given facts in order to obtain the explanation of a phenomenon, or the idea of an experience. Experimental Eclecticism is the share of laborious men; systematic Eclecticism is the share of men of genius; the man who will bring them together will see his name placed among the names of Democritus, Aristotle & Bacon. (Diderot 1755, 284; my translation).[6]

[6] Cf. Bacon's statement: "Those who have treated of the sciences have been either empirics or dogmatical. The former like ants only heap up and use their store, the latter like spiders spin out their own webs. The bee, a mean between both, extracts matter from the flowers of the garden and the field, but works and fashions it by its own efforts. The true labour of philosophy resembles hers, for it neither relies entirely or principally on the powers of the mind, nor yet lays up in the memory the matter afforded by the experiments of natural history or mechanics in its raw state, but changes and works it in the understanding. We have good reason, therefore, to derive hope from a closer and purer alliance of these faculties, (the experimental and rational) than has yet been attempted" (Bacon 1854 [1620], 362 [aphorism 95]).

It becomes clear, therefore, that Diderot is referring to two different philosophical enterprises, which are *not* identical with the two kinds of eclecticism. Rather, they result from a deeper and more radical distinction. On one side are the two aspects of eclecticism: experimental and systematic. Those who serve them are people of labor and reason respectively. However, both groups of thinkers undertake partial tasks: to collect or retrieve segmented truths for future use in constructing the new edifice of philosophy. Both groups are also subjected to limitations. Those who practice experimental eclecticism place any thought about synthesis in the distant future, and those practicing systematic eclecticism, although positively disposed towards philosophical synthesis, are hounded by the failures of the past. On the other side Diderot places those who aspire to see their names "placed among the names of Democritus, Aristotle & Bacon": These are the people who represent the other philosophical enterprise that should be pursued. The critical discourse and the scientific attainments of the moderns had brought about a situation that was totally new to philosophy. The illusions of the scholastics had been put aside; new findings from the study of the natural world brought an abundant wealth of knowledge, and recent methodological developments opened up new paths for deepening human understanding of Nature. But philosophy was still fragmented, disordered and without clear orientation. Therefore, the primary task of modern eclecticism was to move beyond the laborious work of experimenters and metaphysicians and pursue an overarching *synthesis* that would unite the various dissonant aspects of contemporary philosophy.

Diderot's article is an eloquent testimony to the situation of philosophy, but also an invitation to action. Indeed, the emphasis he places on the study of Nature (the attempts to retrieve "les plans perdus de [l']univers" [Diderot 1755, 283]) testifies to his conviction that natural philosophy occupies a central position in the project of reshaping philosophy. Besides, this is where almost all innovation took place in his time. Therefore, the methodological problems relating to experimental induction and mathematics discussed above should be placed in a broader context: Given the philosophically *imperfect* character of modern natural philosophy and the *inconclusive* character of traditional rationalist interpretations of Nature, but also considering that the two sides involve a significant share of truth, what should be done to secure the integrity of philosophy?

This is the context in which eighteenth-century Greek-speaking scholars undertook their philosophical inquiries. Originating in a seventeenth-century anti-scholastic Aristotelian tradition, which emphasized inquiry into natural causes and even placed physics above metaphysics (Tsourkas 1967; Petsios 2002, 137–76), they were in a position to appreciate the attempts of the moderns to enrich philosophy with new findings and new methods of natural research. At the same time, however, they remained sceptical about the philosophical character of such developments: The way of the moderns did not meet the requirements of genuine *science*. There was no doubt that the findings and methodological developments of contemporary natural philosophy freed it from dogmatism and the epistemological unaptness of the scholastic tradition. But the fragmentary character of experimental philosophy and the ontological ambiguity of mathematics did not make them an appropriate substitute for the traditional way of philosophizing. Proper science—*scientia*—had always been and still was the knowledge of the first principles of things from which the interpretations of all phenomena could be safely derived. Therefore, the major task of the time was the elaboration of a philosophical discourse that could accommodate the attainments of modern natural philosophy without subverting the integrity of philosophy.

This explains why the cautious handling of experiment and mathematics on the part of eighteenth-century Greek-speaking scholars was combined with a more or less explicit attempt to recast the concepts of modern natural philosophy on appropriate metaphysical grounds. Indeed, a close reading of a number of treatises reveals that the common denominator in all such attempts was the metaphysical category of matter: Action at a distance was mediated by a material agent, modern atomism was related to Aristotelian hylomorphism and *vis inertiae* was attributed to *materia prima*. Matter was the solid philosophical background against which Greek-speaking scholars built their philosophical discourse about Nature. Placing the findings of the moderns in this conceptual framework enabled them to bring forth the essential ontological associations of beings, and thus make modern empiricism compatible with the traditional philosophical account of Nature. The kind of philosophical discourse they ultimately produced was their response to Diderot's invitation to establish a *modern eclecticism* by bringing empirical and "systematic" traditions of natural investigation under the same roof.

7.5 Conclusion

Greek historiography of science has regularly emphasized the dependence of modern Greek scientific thought on the achievements of European science. Progressive scholars who functioned as sensitive receivers of the Enlightenment managed (often against the will of conservative secular and religious authorities) to convey the major attainments of their contemporaries to their intellectually idle compatriots. Their own contribution to shaping modern science, however, has been considered insignificant, as new ideas and practices arrived already shaped and confirmed from the enlightened West. As mentioned above, this historiographical perspective establishes a cultural hierarchy between center and periphery. However, for most historians, this is not a problem, inasmuch as it ultimately confirms the inclusion of Greece in the European family—even if in a subordinate position.

In this chapter, we attempted to develop a different perspective in order both to transgress the established center-periphery dichotomy and to unveil the complex interplay among a variety of intellectual traditions that contributed to the making of modern science. The suggested historical reconstruction placed eighteenth-century Greek-speaking scholars in the broader intellectual context of the time. It is true that the philosophical program of Greek-speaking scholars remained fragmentary and incomplete. Moreover, their various attempts towards a philosophical synthesis took an entirely different direction than that which led to the establishment of modern science. But this is exactly why the "view from the periphery" is of particular historiographical importance. The study of eighteenth-century Greek scientific thought enabled us to view some aspects of history of science from a new standpoint. In our attempt to understand the approach of Greek-speaking scholars to modern natural philosophy, we found ourselves in a Europe where Newtonianism was not the indisputable winner in the debates about the appropriate way to study Nature; a Europe where metaphysics maintained its authority in the realm of natural philosophy, and the great philosophical syntheses of the past still inspired scholars; a Europe that remained skeptical about the philosophical validity of experimental induction and the ontological efficiency of mathematics; a Europe that envisioned the future of natural philosophy in many different ways and motivated philosophers to pursue different directions; a Europe, ultimately, that did not much resemble the Europe of the glorious Scientific Revolution.

This perspective helps us transcend the narrow limits of established heroic narratives and internalist reconstructions of the development of science. The questions it investigates are neither only nor mainly concerned with the place of local scholars in a dipolar relationship between centers and peripheries, but with the construction of the universal patterns of science through the intersection and mutual appropriation of different local epistemic traditions.

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