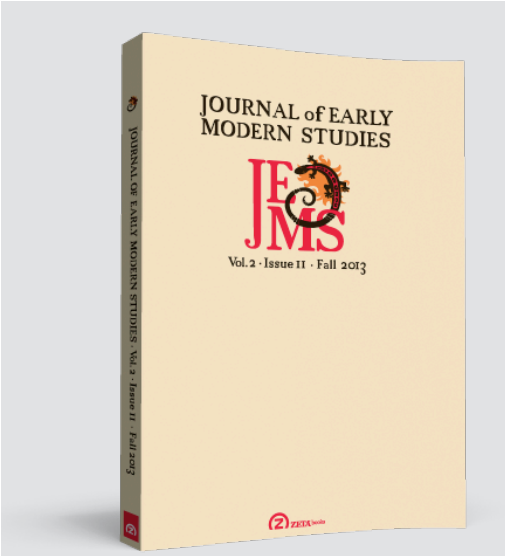

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The Preservation of the Whole and the Teleology of Nature in Late Medieval, Renaissance and Early Modern Debates on the Void*

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Abstract: This study shows that an important number of late medieval, Renaissance and early modern authors postulated the same teleological principle in order to argue both for and against the existence of the vacuum. That postulate, which I call the "principle of subordination," holds that in order to preserve the good of nature, the particular and specific natures must be subordinated to the common and universal nature. In other words, in order to preserve nature as a whole, the individual tendencies of bodies must be subordinated to the general tendency of nature. Throughout the wide range of cases addressed in this study, a continuity is observed in the rationales underlying the discussions about the existence of the vacuum. All of them, tacitly or not, ascribed to nature the teleological principle of subordination, mostly by interpreting traditional experimental instances. Although this continuity is clearly recognizable, variations in nuances and details are also present, owing to the various contexts within which each response to the question of the existence of a vacuum emerged.
Keywords: void and self-preservation of the whole, particular nature and universal nature, experiments on the void, late medieval natural philosophy, late scholasticism, Renaissance natural philosophy, early modern natural philosophy.

* This paper is a version with significant alterations of my essay "La naturaleza y sus fines en la discusión sobre el vacío desde el siglo XIII hasta el siglo XVII," *Patristica et Mediaevalia* 24 (2003), pp. 65-89. I wish to thank Claudia Dumitru for translating the original paper from Spanish into English and Daniel Di Liscia for his valuable suggestions and comments on previous versions of this text. All translations of the primary sources are mine, unless otherwise indicated.

1. Introduction

A review of the long history of vacuist and anti-vacuist positions held from Antiquity to the Modern Age shows that these were based on arguments of an empirical, a theological and a metaphysical nature.[1] This article will draw on several examples of various perspectives on the vacuum held during the period extending from the thirteenth to the seventeenth century in order to examine how they all employed a particular kind of teleological argument. It will show that a significant number of medieval, Renaissance and early modern authors adopted a teleological postulate that, although present in various formulations and across different contexts, can be summarized as follows: to preserve the whole of nature, the specific and the particular must be subordinated to the common and the universal.[2] Many authors used this postulate as a ground to support their anti-vacuist positions, and at times to explain empirical phenomena. On the other hand, this postulate was also accepted by some vacuist authors, who did not see it as a sufficient reason to reject the possibility of the existence of the void. Furthermore, the postulate had applications in various fields, beyond the discussions about the existence of the vacuum, such as biology, ethics and politics.

2. The Principle of Subordination in Medieval Sources

The sources that set the agenda for the medieval discussions on the vacuum were chiefly the central chapters of Book IV of Aristotle's *Physics* and, to a lesser extent, Book I, Chapter 9 of his *De Caelo*. To these were added ancient Greek and Arabic texts, recovered late in the Middle Ages, which introduced a new series of experiments, on the basis of which one could argue both for and against the existence of a vacuum.[3] Starting from these sources, the medieval commentaries on the *Physics* and *De Caelo* combined Aristotelian theory with empirical observation (while primarily relying on thought experiments). The usual medieval practice was to adopt Aristotle's position on the void, which barely took into account the empirical data. From there, commentators would

[1] The essential reference work for a study on vacuum theories from the Middle Ages to the seventeenth century, one which informs my own work, is Edward Grant, *Much Ado about Nothing. Theories of Space and Vacuum from the Middle Ages to the Scientific Revolution*, Cambridge: Cambridge University Press, 1981. See also Charles Schmitt, "Experimental Evidence for and against the Void: The Sixteenth-Century Arguments," *Isis* 58 (1967), pp. 355-357; Cornelius De Waard, *L'expérience barométrique. Ses antécédents et ses explications*, Thouars: Gamon, 1936.

[2] For the sake of brevity, I will henceforth refer to this postulate as "the principle of subordination."

[3] Among these texts, Heron of Alexandria's *Liber Spiritualium*, the anonymous *Tractatus de inani et vacuo* and Philo of Byzantium's *Liber de ingeniis spiritualibus.* See Grant, *Much Ado about Nothing,* pp. 67-68, 81, 97-98.

search through the experiments known from Arabic and Greek sources for empirical evidence to justify their theoretical stand.

In the medieval period, it was common to speak of three kinds of vacuum known under different names: the interstitial vacuum—located within intra-cosmic bodies; the separate vacuum—located between intra-cosmic bodies; and the extra-cosmic vacuum—located beyond the universe. Concerning the existence of the latter, the medieval views were divided, giving rise to long expositions. Some authors admitted the possible existence of the extra-cosmic vacuum in what used to be called "imaginary space." By contrast, all but one of them denied the existence of the intra-cosmic vacuum, both of the interstitial and of the separate variety.[4] The arguments the medieval authors advanced for rejecting in principle the existence of the interstitial or separate vacuum were inspired by the arguments Aristotle had presented in the *Physics*. Broadly speaking, we can say that Aristotle refuted the intra-cosmic void by three arguments: 1) the existence of the vacuum is absurd because it implies the penetrability of matter; 2) the existence of the vacuum is superfluous because there is no basis on which to differentiate the void from the dimensions occupied by a body; and 3) the existence of the vacuum is impossible because it would prevent motion. Yet not only did the medieval authors extend the Aristotelian arguments—and especially the one dealing with the effects of the vacuum on motion—but they also added new elements to rebut vacuism. Among these was the idea that "nature abhors a vacuum," whose precise origin has yet to be established.[5]

The pioneering studies of Pierre Duhem have revealed that, in the medieval period, the idea that nature abhors a vacuum was frequently supported by the principle of subordination. Duhem presented Roger Bacon (1214/20-1294) as the first exponent of this anti-vacuist argument.[6] In several of his works, R. Bacon develops extensive arguments that serve to deny in various ways the existence of a vacuum.[7] Some of these arguments start from a series of experiments. We will take as our reference the case of the clepsydra, one of the most discussed experiments in the debates about the existence of a vacuum. The term "clepsydra" designated a range of various containers used to hold liquids. What they all had in common was a top opening that could be sealed hermetically—usually so small in diameter that it could be stopped

[4] According to the secondary literature, the one exception is Nicholas of Autrecourt, who accepted the existence of the interstitial vacuum. See Grant, *Much Ado about Nothing*, pp. 74-77.

[5] Edward Grant, "Medieval Explanations and Interpretations of the Dictum *Nature Abhors a Vacuum*," *Traditio* 29 (1973), pp. 327-338.

[6] Pierre Duhem, *Le Système du Monde*, 10 vols., Paris: Hermann, 1913-1959, vol. VIII, pp. 134-148.

[7] See, for example, Roger Bacon, *Liber primus communium naturalium*, *partes tertia et quarta*, in *Opera hactenus inedita Rogeri Baconi*, ed. by Robert Steele, vol. III, Oxford: Clarendon Press, 1911, pars tertia, distinctio secunda, cap. 4-6.

with a finger—and a lower surface perforated with one or more tiny holes.[8] When the vessel had water in it and its upper opening was stopped, the liquid would not flow out through the holes in the bottom. If, however, the upper opening was unstopped, the water would flow down through the holes. To R. Bacon, this experiment was an empirical proof for the impossibility of a vacuum, for, normally, the space from which water had flown out would be filled by air entering through the upper opening, and, contrariwise, when the upper opening was covered and the air prevented from flowing in, the liquid would not flow out.

R. Bacon claims that different situations could arise in the case of the stopped clepsydra: a) that the water flows out and a vacuum occurs; b) that the water flows out and the walls of the clepsydra collapse and meet to prevent a vacuum; c) that the water is suspended and the vacuum avoided. Faced with these options, nature, which always tends towards that which better agrees with it, follows the course that involves less disorder. The most damaging course is a) because it goes against the conservation of material continuity.[9] This option discarded, R. Bacon argues that it is better for nature if c) occurs, and not b). For c) (that is, water being suspended) is only an accident relative to the nature of water, whereas b) (the walls of the clepsydra collapsing in order to meet) is not merely accidental, but contrary to the very essence of the container.[10]

The clepsydra experiment, along with similar others, showed that, in order to avoid a vacuum, nature does not always follow its regular course, since the natural tendency would be for water to move downwards. R. Bacon identifies a series of efficient causes that contribute to avoiding the vacuum—in the case of the clepsydra, the air, which, because of its fluidity, tries to enter the vessel through the bottom holes and holds up the water, the sealed opening, etc.—and adds that they are all governed by a final cause: "the order of the bodies of the universe and the congruence of the machine of the world."[11] This final cause is identified with the universal nature that affects all things and seeks material continuity. The particular nature of water tends only towards

[8] Duhem, *Système du Monde*, vol. VIII, pp. 135-136. Cf. Max Jammer, *Concepts of Space. The History of Theories of Space in Physics*, third enlarged edition, New York: Dover, 1993, pp. 91-92. Albertus Magnus describes the clepsydra and its operation in *Physica*, lib. IV, tract. II, cap. 1, in *Opera Omnia*, curavit Institutum Alberti Magni Coloniensi Wilhelmo Kübel Praeside, Monasterii Westfalorum: Aschendorff, 1987, tomus IV, pars 1, p. 231.

[9] It should be said that this explanation is problematic. One might argue that the negation of the solution of material continuity is precisely equivalent with the negation of the existence of a vacuum, in which case R. Bacon's argument is circular. I owe this observation to D. Di Liscia.

[10] R. Bacon, *Quaestiones supra libros quatuor physicorum Aristotelis*, in *Opera hactenus inedita Rogeri Baconi*, ed. by F.M. Delorme, vol. VIII, Oxford: Clarendon Press, 1927, pp. 199-201; id., *Quaestiones supra libros octo physicorum Aristotelis*, in *Opera hactenus inedita Rogeri Baconi*, ed. F.M. Delorme, vol. XIII, Oxford Clarendon Press, 1935, pp. 229-230.

[11] R. Bacon, *Quaestiones supra libros quatuor physicorum Aristotelis,* p. 201.

that which is the end of water considered on its own, and not as part of the universe. But since water is not only a substance with its own ends, but also part of the universe, its particular nature obeys the universal nature, which is more powerful and rules over it.

R. Bacon defines the universal nature as "the governing force of the universe," which is diffused among the substances of the heavens and throughout all the bodies in the world. All bodies agree in this universal nature and are maintained at a certain general level of perfection and well being. R. Bacon refers to Avicenna[12] in presenting it and applies it not only to the vacuum, but also to other examples from nature pertaining to biology.[13] At least two other contemporary authors used the principle of subordination, again in contexts unrelated to the problem of the vacuum: Albertus Magnus (1200-1280) and Thomas Aquinas (1224-1274). This suggests that the distinction between the universal and the particular natures, understood as a relation of teleological subordination, was part of a philosophical discourse widely shared at the time.[14]

In his commentaries on the *Physics*, Albertus Magnus examines the meaning of this distinction, but he does so outside an anti-vacuist context.[15] The topic is addressed in book 2, when he discusses the meaning of the terms "nature" and "natural" proposed by Aristotle.[16] In a special digression, Albertus distinguishes two senses in which one can understand the difference between

[12] R. Bacon, *Liber primus communium naturalium*, *partes prima et secunda*, in *Opera hactenus inedita Rogeri Baconi*, ed. by Robert Steele, vol. II, Oxford: Clarendon Press, 1909, pars secunda, pp. 92-94. Cf. Avicenna, *Methaphysica siue eius prima philosophia*, Venetiis: Bernardinus Venetus, de Vitalibus, per Hieronymum de Durantibus., 1495, lib. VI, cap. 5, sine numero: "*Intelligo autem per naturam particularem virtutem propriam regis unius individui, et intelligo per naturam universalem virtutem infusam in substantias celorum, quasi unam rem et gubernantem universitatem generationum*."

[13] It should be added that R. Bacon maintains that universal nature is prior to individual nature (which in its turn is divisible into particular nature governing the species and particular nature governing the individual) only as concerns "the work and execution of nature." By contrast, as concerns "intent," the particular nature has priority. See R. Bacon, *Liber primus communium naturalium*, *partes prima et secunda*, pars secunda, p. 94. These different types of priority mentioned by Bacon have to do with the medieval discussions of the problem of universals, a topic that is beyond the scope of this paper. For more on this, see Jeremiah Hackett, "Roger Bacon," in Edward N. Zalta (ed.), *The Stanford Encyclopedia of Philosophy* (Winter 2012 Edition), http://plato.stanford.edu/entries/roger-bacon/.

[14] Grant, "Medieval Explanations," p. 330, n. 6, deems it probable that the source of this distinction between universal and particular natures was the anonymous *Liber de Causis* (discovered and translated from Arabic into Latin in the twelfth century). Cf. Grant, *Much Ado about Nothing*, pp. 69-70.

[15] Duhem, *Système du Monde*, vol. VIII, p. 146, mentions Albertus Magnus' anti-vacuist position and sets it in contrast with that of R. Bacon, in that it does not use the principle of subordination. What Duhem does not tell us is that Albertus does apply this principle in biology, as we shall see.

[16] Cf. Aristotle, *Physica*, II, 1, 192b8-193b21.

the universal and particular natures and on the basis of which the expressions *secundum cursum naturae universalis* and *secundum cursum naturae particularis* are to be interpreted. On the one hand, the universal nature can be understood in a relative sense**,** as that by which the genus differs from the species. Thus, the nature of the animal, as a genus, is the universal nature. On the other hand, there are two ways in which the universal nature can be understood in absolute terms. The first defines the universal nature as the principle of motion and rest on which all things depend, which for this very reason are considered natural. A second absolute reading of "universal nature" states that the universal nature contains and governs all the particular natures.[17]

Albertus gives further details on the dynamics and characteristics of this duality of natures. The universal nature consists in the distribution of the power of the celestial motions to the particular natures, manifesting itself in a unique way in each one of them: "If one were to compare the celestial motions with the things below, then they are like a power that moves and governs the things below. But if we compare the lower natures to the higher ones, then this power is multiplied according to the diversity of the things it governs."[18] This association of the lower and the higher, of the earthly and the heavenly, is part of one of the traditional interpretations of Aristotelianism, primarily based on the exegesis of Aristotle's *Metereology*.[19]

By way of illustration, Albertus offers two examples from Aristotle's biological works,[20] typifying the relation between the universal and particular natures, taken in their absolute sense. One example is that of the corruption of natural beings. The particular nature does not pursue corruption as its end, so death lies outside its course (*praeter cursum naturae particularis*).[21] Nonetheless, things do perish, because of the universal nature, which sets a term to life through successive cycles of generations and corruptions. In the same way, the second example tells us, the generation of the female is not sought by the particular nature, as that nature seeks perfection, which is the male. In fact, females are born due to some deficiency in the efficient causes or in the natural agents involved in the generation. But since the existence of females is necessary to assist the males in procreation and allow for the perpetuation of the species, the universal nature prevails over the particular nature and dictates that on occasion females be born.

[17] Albertus Magnus, *Physica*, lib. II, tract. I, cap. 5, in *Opera Omnia*, tomus IV, pars 1, pp. 83-84.

[18] *Ibid*., p. 83.

[19] *Ibid*., lib. I, tract. I, cap. 6, p. 13. Aristotle, *Meteorologica*, I, 2, 339a.

[20] Aristotle, *De generatione animalium*, II, 3, 737a.

[21] It should be mentioned that Roger Bacon presents a similar argument and attributes it to Avicenna. See *Opus majus*, edited with an introduction and analytical table by J. H. Bridges, vol. II, Oxford: Clarendon Press, 1897, pars I, cap. VI, p. 454.

As mentioned above, another author who adopted the principle of subordination was Thomas Aquinas, in his case in order to discuss "natural love." In an argument designed to defend the thesis that man in his pure state, by the nature God bestowed on him, loves God more than he loves himself, Thomas starts from the premise that, in its natural state, the part cares more for the good of the whole than for its own.[22] Natural love (*dilectio naturalis*) is an inclination imparted to nature by God; hence nothing natural can be perverse. The primacy of the common good over the private good is natural not only in man, but in the whole of creation, yet is called "natural love" in the strict sense only when it comes to creatures endowed with intellect (angels and men). This inclination is seen more clearly in non-rational beings, for their pursuing the common good over their individual good entails that they are made to act this way without any deliberation, by virtue of natural necessity. This hierarchy of goods is at play in many different realms: politics, human nature, brute animals and plants.

> We see that every natural part operates with a certain inclination towards the good of the whole, even to its own danger or detriment. As is clear when someone exposes his hand to a sword to defend his head, on which the health of the entire body depends. Thus it is natural for each part in its way to love the whole more than itself. So, according to this natural inclination and to the political virtue, the good citizen exposes himself to moral danger in the pursuit of the common good. But it is clear that God is the common good of the whole universe and of all of its parts. So every creature loves God more than itself naturally and each in its own way: the insensible things naturally, the brute animals sensitively and the rational creatures through an intellectual love called *dilectio*.[23]

Thomas adds an interesting distinction about the natural inclinations of things. There are two types of natural inclinations: to motion and to action. In the first case, nature curves back on itself. For example, fire moves upwards for its own conservation. By contrast, nature's inclination to action seeks the common good, i.e., the conservation of the species to which the thing belongs. Thus, fire does not act to generate more fire for its own sake as an individual, but for the sake of what is generated, which is its form. And further, it does so for the common good that is the conservation of the species.[24]

The theories of R. Bacon, Albertus Magnus and Thomas Aquinas clearly agree as far as the principle of subordination of the particular to the universal is concerned. All three of them are teleological insofar as they hold that the relation between the universal and the particular, between the whole and its

[22] Thomas Aquinas, *Summa Theologiae*, cura et studio Petri Caramello, cum textu et recensiones leonina, Pars Prima et Secundae, Torino: Marietti, 1952, I, q. 60, art. 5, pp. 293-294.

[23] Thomas Aquinas, *Quodlibet.* I, q. 4, art. 3, p. 9, in *Quaestiones Quodlibetales,* cura et studio Fr. Raymundi Spiazzi, Editio IX, Torno: Marietti, 1956. See the application of this principle in *Summa Theologiae* I, q. 60, art. 5.

[24] Thomas Aquinas, *Quodlibet.* I, q. 4 art. 3, p. 10.

parts, always has the ultimate purpose of preserving the whole. But beyond the shared principle and their teleological character, every theory has its own distinctive features. That of R. Bacon applies directly to the discussions about the vacuum, relying on experiments, although it transcends the field of physics and has applications in biology as well. In the case of Albertus, the idea of a distinction between natures is part of the general metaphysical speculation about nature, clearly applying to biology, while in the case of Thomas, this distinction seems to have its origins in ethics and be extended to other fields. These three basic fields of application (the problem of the vacuum, biology and practical philosophy) reappear in other authors that we will examine next, both in the medieval period and in later centuries.

The anonymous author of *Summa Philosophiae*—a work wrongly attributed to Robert Grosseteste[25]—lays out the distinction between natures by emphasizing an element we have already encountered in Albertus Magnus and which will become very common in later developments, namely the idea that the universal nature originates from heaven and spreads to the inferior beings. Besides, it is maintained that the divine blessing concurs with the universal nature in order to govern and improve the world. Precisely therein lies the purpose of the subordination of the particular to the universal:

> Nature, insofar as it is the same with active power and form, [...] is universal or particular. [...] This universality [...] concerns the whole either of the corporeal and mixed universe, or only of the corporeal universe with its own accidents. In the first sense, the uncreated power is a universal nature, in that it universally is the primary cause of all powers and things, and the celestial sphere under it, receiving the influences of its power more abundantly and directly, illuminates and perfects the inferior spheres. In the second and third sense, the universal nature is the force instilled in the celestial substance, namely in the created intelligence that, with the blessing of the Creator, governs and moderates all the corporeal and inferior nature […].[26]

The existence of this universal nature is required by the "order of reason," which refers to an indivisible one throughout the whole series of operations. Since if one alone suffices, it is better to postulate one rather than two. The Neoplatonic tone of this interpretation is confirmed by the author himself, who associates the universal nature with Plato's *anima mundi*. The relation between the whole and the parts is clearly stated: "All things conspire equally in this way with the universal nature, in which they are rooted and from which they

[25] Duhem, *Système du Monde*, vol. VIII, p. 148.

[26] Pseudo-Grosseteste, *Summa Philosophiae*, trac. XVI, cap. 2, p. 590, in Ludwig Baur, *Die philosophischen Werke des Robert Grosseteste, Bischofs von Lincoln*, vol. 9 of *Beiträge zur Geschichte der Philosophie des Mittelalters*, Münster: Aschendorff, 1912, pp. 275-643.

receive their propriety to act, so much so that their similar natures [*connaturae*] and their particular properties sometimes suspend their own effects and actions."[27]

Furthermore, the author notes that the distinction between the universal and the particular is always relative, as is the distinction between genus and species. Thus, we may say that in a sense the particular nature is universal. Likewise, one can say of any species that it is particular relative to its genus but universal relative to its individuals.

> The particular nature is the force and operative property that comes with the species, although its effect is not always found in all individuals. […] So the fire through its particular nature tends to move upwards and to be warm. However, it may sometimes move downwards and lack warmth.[28]

How is this relation of subordination satisfied in practice? The universal nature either belongs to something uniquely determined, or is diffused through all the operations of the particular nature. Motion has the universal nature as its first universal cause, without which the particular nature would not move. But it is also common for it to operate in various ways in opposition to the particular nature. When it comes to giving concrete examples of this relation, the author of the *Summa Philosophiae* does not refer us to the problem of the vacuum,[29] but to the motion of projectiles. He holds, with Aristotle, that between two contrary motions there must be an interval of rest. Thus, when a heavy body is thrown upwards, it moves up until it ends its ascent and then remains an instant at rest, after which it begins its descent. Now, both the ascent and the temporary rest are contrary to the particular nature of the heavy body. The anonymous author claims to be following Aristotle[30] in maintaining that the projectile is carried up to its resting point by the air that has been violently moved and that naturally propels the projectile as long as the impetus imparted to it by the first efficient motor of the violent motion lasts. He thus distinguishes the initial motion (the first motor of which he deems violent) from the motion of the air, which is the effect of this first motor and which, in its turn, sets the projectile on its upward path with a natural motion. This faculty to move cannot belong to the particular nature of the air, but is a "property imparted to the fluid elements by the universal nature."[31] In fact, the particular nature always tends naturally to one of two opposites, while the universal nature takes into account both opposites at once. It therefore constrains the particular nature and makes it act against its natural tendency.[32]

[27] *Ibid*., pp. 590-591.

[28] *Ibid*., p. 591.

[29] The author discusses the vacuum in *Summa Philosophiae*, pp. 417-418.

[30] Cf. Aristotle, *De Caelo*, III, 2, 301b; *Physica*, IV, 8, 215a.

[31] Pseudo-Grosseteste, *Summa Philosophiae*, p. 592.

[32] According to Duhem, *Système du Monde*, vol. VIII, p. 152, John Dumbleton is the only author who later uses a similar line of reasoning to explain the motion of projectiles.

As already noted by Duhem, we also find an occurrence of the principle of subordination in Aegidius Romanus (1247-1316). One of the vacuist doctrines he refutes is the one according to which the existence of a vacuum is necessary to explain why the earth rests at the center of the universe. Proponents of this view argue that, since every part of the void is identical to every other part, the earth is not attracted more in one direction than in the other. Therefore, it remains stationary in the center. Aegidius refutes this view by showing that it is impossible for a vacuum to exert this kind of attraction. There are two senses in which one could talk about the attraction of the vacuum. On the one hand, if we take the vacuum to be a positive nature, we must imagine the attraction it exerts to be fantastic indeed. In fact, it would be an attraction that causes no motion whatsoever. An example of this would be the earth staying at rest while attracted in this strange way by the vacuum. But there is a right way to understand the attraction of the vacuum: namely as an attraction for the void *not* to occur. This attraction can be observed in the experiment of the cupping glass. When the glass is placed against the flesh, the hot air suddenly cools and contracts. When this happens, the flesh is drawn in to fill the place formerly occupied by the air, so that a vacuum does not occur. Aegidius adds that, if you put a warm cloth on the cupping glass, the flesh would be attracted not only to avoid a vacuum, but also by the heat.

As the effect, i.e., the attraction itself, is positive, so must be its cause. When looking for what the positive and primary cause of the attraction might be, Aegidius first, if not very convincingly, rules out two possible causes to finally accept a third. The cause cannot be a mixed body (i.e., a compound of several elements), since the attraction can arise in pure elements as well, where there is no mixed body. Nor can it be postulated that the pure elements produce it themselves, because the motion of attraction can rise from anywhere and have any direction. But the elements themselves only move in one direction: towards their natural place, when they are separated from it. Therefore, Aegidius concludes, the attraction is exerted by a celestial power, "so that we must imagine that the whole sphere of active and passive beings is connected in virtue of a celestial power." This power, whose link attracts all beings, ensures that there is no gap or void between the bodies. To show how powerful this celestial attraction is, the author appeals to the magnetic force (*virtus*), a paradigm often considered when it comes to specifying the nature of an attraction between bodies. From this perspective, the attraction produced by the celestial power to connect celestial bodies is similar to the attraction the magnet exerts on the iron:[33]

> Whatever the place where it is located, iron is attracted by the magnet. In the same way, heaven wants to unite the individual parts of the universe. Whatever

[33] John Dumbleton draws a similar comparison in the same context. Cf. Duhem, *Système du Monde*, vol. VIII, p. 162.

> the place where a division and void might arise, the attraction of the celestial virtue acts to prevent this from happening in it.[34]

Albertus de Saxonia (ca. 1316-1390), member of the school of Paris and pupil of Buridan, aligns himself with authors that defend a "specific" (particular) and a "common" (universal) nature of motions. In his commentary on *De Caelo*, when it comes to specifying the type of motion that corresponds to heaven as a simple body, Albert concludes that "it is impossible for the same simple body to move naturally with specifically different simple motions in succession."[35] According to this thesis, a simple body (the four elements and the ether) has one and only one corresponding simple motion (rectilinear ascent, rectilinear descent or rotation) according to the inclination prescribed to it by its form. In this respect, Albertus de Saxonia subscribes to the medieval tradition following Aristotle. For Aristotle, water and air have relative and not absolute weight, unlike fire (absolute lightness) and earth (absolute heaviness). Therefore, water and air will move up or down, depending on the region they find themselves in when not in their natural place. For example, water moves downwards when in the region of air, but upwards when in the region of earth. Whereas earth always moves downwards and fire always moves upwards.[36]

However, Albertus de Saxonia acknowledges a possible objection to this thesis. For example, in a siphon from which air has been violently expelled, water rises to follow the extracted air. As a simple element in the region of air, water has a simple motion—that of descent—yet in this case it moves upwards. Faced with this possible objection, Albertus de Saxonia replies that it is possible to refute it through the following explanation:

> To this we reply that the fact that a simple body moves with specifically different simple motions is to be understood in two ways. On the one hand, as meaning that any of those motions properly belongs to it. On the other hand, as meaning that one of those motions properly belongs to it, while the other does not, but is common both to it and to any other body. Then we say that, in the first sense, it is impossible for a body to have different natural motions *simpliciter*. But, in the second sense, it has them. Hence the way water rises naturally, in order to avoid a vacuum when air is violently sucked upwards, is not specific to water, but to any body that finds itself in this situation and that

[34] *Aegidii Romani in libros de Physico auditu Aristotelis commentaria,* Venetiis: Heredis Octaviani Scoti, 1502, liber IV, lect. XII, dubitatio 5ta., fol. 79 c. Cf. Duhem, *Système du Monde*, vol. VIII, p. 153-155.

[35] Albertus de Saxonia, *Quaestiones subtilissimae in libros de caelo et mundo,* Venetiis: Octaviani Scoti, 1/8492, lib. 1, quaestio 1, fol. A3, col c.

[36] *Ibid*., fol. A2, col. b. Cf. Aristotle, *De Caelo*, IV,1,307b 30-35; IV, 4 -5, 311b15-313a13. On the Aristotelian tradition concerning weight, see Denis O'Brien, *Theories of Weight in the Ancient World*, 2 vols., Paris–Leiden: Les Belles Lettres–Brill, 1981-1984, vol. 1, pp. 6-40.

> is similarly positioned respecting the violently moved air. Some state this solution in different words, saying that a simple body only has one natural motion according to the species attached to its specific nature. Nonetheless, there is nothing preventing a simple body to have several specifically different motions according to its species. Of these, one would be natural to it according to its own nature and another, natural to it according to the nature or inclination it shares with other bodies.[37]

This explanation posits that the motions of a simple body stay in the realm of the natural and do not become violent, even when they do not correspond with what a body should normally do in that region: in the siphon experiment, water "naturally" moves upwards because this suits the whole universe. The tension between the specific and common inclinations is resolved according to the purpose of preserving continuity.

Already by the end of the Middle Ages and on the verge of the Renaissance, Paulus Venetus's (1369/72-1429) interpretation of the clepsydra experiment shows the influence of his Oxford masters. In analyzing the phenomenon of the clepsydra, Paulus Venetus makes use of the vocabulary of "appetites," which will be very frequently employed by later authors. He explains that, when no air enters a clepsydra whose upper opening is sealed,

> water is not prohibited from descending by something extrinsic but by something intrinsic to it. For it wants to descend according to the appetite of its species and it wants to unite with the body according to the appetite of its genus. And because genus is prior to species, the water first wants to join the body, and then to descend. But if water descended, a void would occur between it and the container. Therefore, so as not to produce a vacuum, the appetite of the genus prevents the descending.[38]

Paulus Venetus believes that the cause of the motions aimed at preventing a vacuum must be intrinsic. The attraction that keeps the bodies from going to their natural places is clearly negative, because its purpose is to prevent a vacuum. This attraction can come from the species—as in the case of the magnet attracting iron; from heat—as in the case of the sun attracting vapors from above; from vacuum alone—as in the case of water moving upwards along with the air extracted from a siphon; or from vacuum together with heat—as in the case of the cupping glasses attracting flesh. Paulus Venetus' conclusion concerning all of these cases is that the attraction exerted to prevent the vacuum is intrinsically caused by the natural motion of each body.

[37] Albertus de Saxonia, *Quaestiones subtilissimae*, lib. 1, quaestio 1, fol. A3, col c. Cf. Duhem, *Système du Monde*, vol. VIII, pp. 158-160.

[38] Paulus Venetus, *Expositio Pauli Veneti super octo libros physicorum Aristotelis necnon super comento* (sic) *Averois* (sic) *cum dubiis eiusdem,* Venetiis: Gregorium de Gregoriis, 1499, lib. IV, Xii, col. d.

This argument raises the same question Albertus de Saxonia's argument prompted: How is this conclusion to be reconciled with the Aristotelian theory the author subscribes to, whereby the simple bodies only have one simple motion?[39] Paul's solution is similar to Albert's and uses the same terms as those employed in his explanation of the clepsydra phenomenon. When Aristotle says that simple bodies have just one simple motion, he is referring to the motion that is primary to the body and that belongs to it by virtue of its species. But, apart from this motion, simple bodies can have any other motions as well, not as primary motions, but as motions conferred to them by their genus. Therefore, "if we consider simple bodies as elements of a given species, they have only one motion; if, apart from this, they are also considered as natural, they have all the motions equally [*indifferenter*], naturally, by an intrinsic [principle] to suppress the vacuum."[40]

It should come as no surprise then, that Paulus Venetus criticizes Aegidius' theory of a celestial power of attraction aimed at preventing a vacuum. He understands that Aegidius, in resorting to the celestial power of attraction, postulates an extrinsic cause. What Paulus Venetus does not accept is essentially the consequence of postulating an extrinsic cause for avoiding a vacuum: that of transforming the motion that seeks to avoid the void into a violent motion. In fact, many medieval authors explained the distinction drawn by Aristotle between natural and violent motions[41] through the contrast between an intrinsic and extrinsic principle of motion. From this perspective, natural motion is considered the effect of an intrinsic principle of the mobile, while violent motion is considered the effect of an extrinsic principle.[42]

To the authors already presented, we must add other medieval authors that used different versions of the theory of the two natures to ground their rejection of the vacuum starting from various experiments. Among them we can mention Walter Burley (c.1275-1345), Jean de Jandun (d. 1328), Pseudo-Aegidius Romanus, etc.[43] In short, at the end of the Middle Ages, the arguments on void that employed the teleological principle of subordination were firmly established, to the point of becoming a sort of commonplace of natural philosophy.

[39] Cf. Aristotle, *De Caelo*, I, 2, 268b-269a.

[40] Paulus Venetus, *Expositio Pauli Veneti super octo libros physicorum*, lib. IV, Xvi.

[41] Aristotle, *Physica*, IV, 8, 215a 1-5; V, 6, 230a 18-230b 20. This distinction raised various problems of interpretation for the commentators. See Denis Des Chene, *Physiologia. Natural Philosophy in Late Aristotelian and Cartesian Thought*, Ithaca and London: Cornell University Press, 1996, pp. 222-223.

[42] For example, Thomas Aquinas, *In octo libros physicorum Aristotelis expositio*, cura et studio M. Maggiòlo, Torino: Marietti , 1954, liber 8, lectio 7, n. 4: "*Manifestum est enim quod ea quae per violentiam moventur, ab alio moventur, ex ipsa violenti definitione. Est enim violentum, ut dicitur in III Ethicorum, cuius principium est extra, nil conferente vim passo*."

[43] Cf. Duhem, *Système du Monde*, vol. VIII, pp. 134-68; Grant, "Medieval Explanations," pp. 329-331 and *passim*.

3. The Reception of the Principle in the Sixteenth and Seventeenth Centuries

During the sixteenth and seventeenth centuries, we find the principle of subordination as postulated in arguments on the separate void enjoying a remarkable reception with authors from the most varied circles. Let us first turn to some of the Aristotelian textbooks most widely disseminated in the Protestant universities. The textbook by Johannes Magirus (d. 1526) holds a conception of the ends of nature similar to those we have been discussing. It asserts the primacy of the universal end, emphasizing its theological implications. The ultimate end, according to Magirus, is the exaltation and glory of the Creator.[44] Meanwhile, Bartholomäus Keckermann (1571-1609) in his *Systema Physicum*, applies this concept specifically to the problem of the vacuum. He argues that nature would rather break its own laws than permit the existence of a void. It would not come as a surprise then that Keckermann thinks this violation of the laws of nature can be effected through a violent motion, like the motion produced by cupping glasses.[45]

Other noteworthy cases are found among the Catholic Aristotelian textbooks. The Spanish Jesuit Francisco Toledo (1532-1596), a professor at the *Collegium Romanum* whose commentaries on the *Physics* were widely disseminated, holds an anti-vacuist position. Toledo acknowledges that a void between bodies could occur, if the divine omnipotence intervened to this end. In the regular course of nature, a vacuum is impossible because it goes against the contiguity between bodies, which is the most important principle of the order of nature:

> The contiguity of all bodies to each other is the greatest disposition of nature, so, just like a continuous part attracts another continuous part to itself by its motion, that which is contiguous attracts another contiguous to itself, when no other body can follow it. And this contiguity of bodies is in agreement with the nature of the universe and depends on the power of the universal causes which was redirected into these inferior bodies. But for their power to be controlled through these means, they must come in contact with the power of the higher causes through intermediate bodies. But if an intermediary void existed, that power of the virtual contact with the higher causes would be interrupted by it.[46]

In Toledo, the discussion of the duality between the particular and the universal natures, between the part and the whole, arrives at a synthesis that combines the different vocabularies we have found at the origins of this distinction, in

[44] Johannes Magirus, *Physiologiae Peripateticae libri sex cum commentariis. Accessit Caspari Bartholini Malmogii Dani, Enchiridion Metaphysicum*, Francofurti: Johannes Berneri, 1619 (first ed. 1597), lib. 1, cap. 3, theor. 17-20; lib. 1, cap. 3, comment. F, p. 63.

[45] De Waard, *L'expérience barométrique*, pp. 19-20.

[46] Francisco Toledo (Toletus), *Commentaria una cum questionibus in octo libros de Physica auscultatione*, Venetiis: Apud Iuntas, 1573, lib 4, c. 9, quaestio 10, fol. 131 r.

the works of R. Bacon and Thomas Aquinas. In fact, in explaining why the motions that avoid a vacuum should be regarded as natural and not violent, Toledo tells us that "although they appear not to agree with the particular appetite of the things themselves, they do agree with the order of the orb of the universe, and that which occurs on account of the whole is more natural than that which occurs on account of the part."[47] The vocabulary of the universal and the particular (R. Bacon) is grafted onto the vocabulary of the whole and the part (Aquinas).

The Jesuit Coimbra Commentaries emphasize both the omnipresence of the tendency towards good and the importance of the appetite for self-preservation. This appetite is presented within the framework of the ascendancy of the common good over the individual one. While the maxim of ascendancy is laid down in the context of natural philosophy, with reference to the discussion about the existence of a vacuum, it is made clear that this appetite affects not just inanimate bodies, but all beings in their different roles: "there is in everything a congenital appetite to protect and preserve itself. For example, the desire to seek healthy and useful things, and shun the harmful."[48] This appetite manifests itself in the tendency of the elemental bodies to produce bodies like themselves, in the animals' concern to educate their offspring, in the work of men of letters that write books, and in the fact that politicians and military men seek public recognition and admiration.

The Coimbrans refer to Aquinas when they declare that, although the private and common good can have different ends, the common interest prevails over the private one.[49] Looking for congruities with the Aristotelian doctrine, they add that, when Aristotle states in the *Nicomachean Ethics* that the private good is preferable to any other good, we have to take this claim not as opposing the private good to the public one, but as contrasting it with other private goods.[50] The superiority of the common good also asserts itself whenever there is a conflict between the preservation of the individual and that of the whole: "every natural being strenuously attempts to preserve two things: the common good of the whole nature and its own particular good. [...] The common good is the more excellent and divine [...] as with most earnest desire one aspires to it."[51] This is why nature abhors a vacuum:

> Because the void dissolves the preservative power of things and prevents the union, so that the sublunary world does not receive the force that spreads

[47] *Ibid*.

[48] Conimbricenses, *Commentariorum Collegii Conimbricensis Societatis Jesu, in octo Libros Physicorum Aristotelis Stagiritae*, Coloniae: Zetznerus, 1616 (first ed. 1592), lib. IV, cap. IX, qu. I, art. III, col. 79.

[49] Conimbricenses, *in Phys*, lib. IV, cap. IX, qu. I, art. V, col. 84. Cf. Des Chene, *Physiologia*, pp. 171-177.

[50] Aristotle, *Ethica Nic.,* VIII, 2, 1155b 21-27.

[51] Conimbricenses, *in Phys,* lib. IV, cap. IX, qu. I, art. III, col. 80.

> from heaven, since it cannot happen that this force travel through the interstitial vacuum. On which topic one may note that each natural thing dutifully strives to preserve two things: the common whole of nature and its own particular good. [52]

Another Jesuit, Francisco Suárez (1548-1617), also employs the traditional argument, briefly alluding to the universal nature, which he identifies with God himself or the divine providence.[53] In *Disputationes Metaphysicae*, a work widely distributed in Catholic and Protestant countries alike, Suárez examines this question in *Disputatio XVIII,* when he discusses the transmission of powers at a distance. He denies the possibility of action at a distance occurring in a vacuum. Suárez admits that his thesis cannot be proved by a positive experiment, since no one has ever created a vacuum. However, he believes it could be proved by "a negative experiment (so to speak) and by the providence of the universal nature or rather of its author, who created things in such a way and infused them with such a propensity or motion so as to absolutely avoid a vacuum, even if they were to leave their natural places for it."[54] This is a true and absolute necessity in nature, and Suárez justifies it by the same argument that had been advanced by the Coimbrans and by Toledo. Appealing to the authority of Aristotle,[55] he says that the contiguity of bodies is necessary so that the influence of heaven can be transmitted to the lower bodies: "It seems that this primarily serves the purpose that some might exert their actions through others and that distant bodies can participate, through intermediaries, in the influence of these others, and especially in that of the heavenly bodies."[56]

Suárez believes that the particular natures or causes are helped and supported by the celestial natures, when the former are not enough to ensure the order of the universe.[57] This is the sense in which one has to understand the essential subordination of the individual natures to the celestial ones. The teleology of this proposal is perhaps clearer than ever in Suárez' words:

> There are many motions or actions in these natural things that cannot be sufficiently accounted for by referring to the particular properties or inclinations of each thing; like when water rises to fill the void, a fact that cannot be

[52] Conimbricenses, *in Phys*., lib. IV, cap. IX, qu. I, art. III, col. 80.

[53] The same identification of God with the universal agent that guarantees the connection between bodies is present in Pseudo-Aegidius Romanus. Cf. Grant, "Medieval Explanations," p. 334 n13.

[54] Francisco Suárez, *Disputaciones Metafísicas*, traducción de Sergio Rábade Romeo, Salvador Caballero Sánchez and Antonio Puigcerver Zanón, Madrid: Gredos, 1961, Disp. XVIII, sect. VIII, 14, pp. 230-31.

[55] Aristotle, *Meteorologica,* liber 1, cap. 2.

[56] Suárez, *Disputaciones Metafísicas,* Disp. XVIII, sect. VIII, 14, pp. 230-231.

[57] *Ibid*., Disp. XXII, sect. V, pp. 682-694.

> accounted for by the peculiar nature of water and its own impetus, but only through the end which rests in the perfection of the whole universe, which is clearly intended by a superior agent.[58]

The principle of subordination was adopted by several Renaissance authors with different philosophical approaches. We find the anti-vacuist argument coming from the pen of Giovanni Battista della Porta (1535-1615), who reiterates the theory of the two natures.[59] On the other hand, in his anti-vacuist argument, Girolamo Cardano (1501-1576) appeals to the material continuity required by the universal consensus. In his most widely circulated work, *De subtilitate*, he distinguishes three main classes of natural motions. The first of these is introduced as *motus fuga vacui* or *motus a forma elementi*. It occurs when matter does not allow for greater rarity and its parts do not allow to be separated. The example advanced for this motion is that of the bellows, one of the favorite examples in the expositions on the vacuum. Experiment informs us that hermetically sealed bellows cannot be opened, unless air enters through some tiny opening or they are violently broken.[60] In explaining the phenomenon, Cardano says that it was not caused by a vacuum, alluding to the classic argument according to which a vacuum cannot—since there is no such thing—be the cause of anything. The cause of the bellows' motion is the "form" of air itself, which is "not capable to tear itself apart or separate itself." This is a motion that, although natural, is not particular. In Cardano, the relation between universal and particular natures is expressed in terms of "particular motion" and "universal consensus." Thus, bodies give up their own motions (their particular natures) to obey the universal consensus (the universal nature).[61]

Although in other respects Julius Caesar Scaliger (1484-1558) opposes much of what Cardano argued for in *De subtilitate*, his position regarding the vacuum coincides in some points with the one advanced in that work. Scaliger agrees with those who maintain that the vacuum is shunned in the pursuit of preservation. The appetite of preservation does not seek to preserve the place, as that is not an essential attribute of bodies. Nor does it seek the connection with other bodies, as the mathematicians have shown that connection and contact are possible without any need for a place.[62] Moreover, Scaliger adopts the theory we have just outlined, of the relation between the part and the whole, differentiating the tendency to preserve the whole of the universe from

[58] *Ibid.*, Disp. XXIII, sect. X, 10, p. 803.

[59] Cf. De Waard, *L'expérience barométrique*, pp. 61-62.

[60] For the experiments with the bellows, see De Waard, *L'expérience barométrique*, p. 17; Schmitt, "Experimental Evidence," pp. 355-357; and Grant, *Much Ado about Nothing*, pp. 82-83.

[61] Hieronymus Cardanus, *De subtilitate Libri XXI, nunc demum ab ipso autore recognovit atque perfeti,* Basileae: per Ludovicum Lucium, 1554, p. 8.

[62] Iulius Caesar Scaliger, *Exotericarum exercitationum liber XV de subtilitate, ad Hieronymum Cardanum*, Francofurti: Apud A. Wechelum, 1582, Exc. V, pp. 12-13.

the tendency to preserve the particular body as part of the universe. Finally, there is another point where he is an agreement with Cardano: what bodies seek to preserve is their form.[63]

The Averroist Alessandro Achillini (1463-1512) describes very clearly the aspiration to divinity which determines the appetite of things to preserve themselves and last forever: "What all things want the most is to be assimilated to the divine perfection. [...] All entities want to last forever and resemble God."[64] It is in light of this that he agrees with other authors who argue that corruption is not the product of the natural beings' appetite, but an accidental effect. Everything pursues the good and the good is the preservation of one's form: "natural agents do not tend to corruption themselves, as much as they become corrupt only by accident, but they themselves tend to generation, for the natural agent aspires to the good. And the good is the form. Privation is the evil."[65]

In the same vein, Jacopo Zabarella (1533-1589) supports the principle of subordination, from a predominantly Aristotelian perspective. Although he does not apply the distinction to the question of the vacuum, he does apply it in biology, in the same way Albertus Magnus had done centuries before him. In a passage from his work *De rebus naturalibus*, Zabarella states that all those actions of animals that do not attend to their own being or self-preservation seek the preservation of the species. Generation obeys the universal nature, on the one hand, in that it mainly seeks the preservation of the species. On the other hand, it also obeys the particular nature, which seeks first and foremost the preservation of the individual and only secondarily that of the species. Thus, the function of the universal nature is "to establish the ultimate goal to which things tend." By contrast, the objective of the particular nature is, first, for the animal to exist and, second, for it to survive to an age suitable for generation, so as to permit the preservation of the species.[66]

In another passage, this time concerning the nature of mixed bodies, Zabarella provides us with a precise definition of "universal nature" as "the order of all things and of all causes arranged in a certain order as they depend on a first principle, which imposes certain specific laws to individuals, which cannot be set aside." Although things do not want to perish, the universal nature decrees that they are subject to corruption, in such a way that their corruption has a

[63] This view concerning the conservation of the form, seen as a whole in which the parts find their purpose, is apparently a Renaissance development of the teleological foundations of Aristotle's biology. Cf. Allan Gotthelf and James Lennox, *Philosophical Issues in Aristotle's Biology*, Cambridge: Cambridge University Press, 1987, p. 200.

[64] Alexandrus Achillinus, *Opera omnia in unum collecta*, Venetiis, Hieronymus Scotus, 1545, lib. 1, 86v.

[65] ib. lib. 1, p. 87v.

[66] Jacopo Zabarella, *De naturalis scientiae constitut. liber*, 98 D-F, in *De rebus naturalibus, libri XXX,* 4th ed., Coloniae: Lazarus Zetznerus, 1602.

natural (final) cause and is produced by a natural agent.[67] . Thus, generation and corruption can be described as "fatal" since fate (*fatum*) is a "law laid down by the universal nature for every thing to be generated and corrupted." The particular nature is therefore subject to the law of the universal nature.[68]

Alongside the anti-vacuist positions we have reviewed, the sixteenth century also saw the rise of several voices defending vacuism, some of them by refuting arguments that appealed to the universal nature. These voices were defending the existence of the separate vacuum, not just of the extra-cosmic vacuum that a lot of medieval authors had come to accept as a hypothesis. Bernardino Telesio (1509-1588) was one of the first authors to argue against anti-vacuism. The same experiments the medieval and Renaissance authors cited to deny the existence of a vacuum, Telesio interprets in the opposite direction. Thus, he refers to the examples of the clepsydra, the bellows, and frozen water to show that a vacuum can exist in nature. In defense of this position, he criticizes the appeal to universal nature the "Peripatetics" make in order to account for the alleged absence of a vacuum. Telesio bases his rejection of the theory of universal nature, first, on the fact that one cannot see how it "comes to do what it is supposed to do in order for a vacuum not to occur." This is not to deny matter's tendency to preservation, as Telesio has no doubt that "entities enjoy mutual contact and do not bear to be separated and disunited." However, the preservation of mutual contact can be obtained only under certain circumstances, when the forces of matter are sufficient both for its weight and for its mass. A vacuum is produced when the material forces are not enough to prevent it. Telesio illustrates his position by using the example of the clepsydra. If the bottom holes of the clepsydra are very small, it is certain that water cannot descend, according to the appetite of contact between bodies. But, if the bottom holes were of a larger diameter, Telesio does not doubt that the water would flow out, even if that meant that a vacuum was produced in the container.[69]

Although Francis Bacon (1561-1626) pronounced Telesio "the first of the moderns," he was also very critical of various aspects of the latter's philosophy, including his defense of the existence of a void.[70] F. Bacon himself did not always hold the same opinion with respect to the vacuum. In his early philosophical works, he accepted the existence of some types of vacuum, whereas in

[67] Jacopo Zabarella, *De misti generatione et interitu*, lib. II, cap. IV, 618 C-E, in *De Rebus naturalibus, libri XXX.*

[68] *Ibid.*, 619 E-F.

[69] Bernardino Telesio (Telesius), *De rerum natura iuxta propria principia libri IX*, Neapolis: Apud Horatium Salvianum, 1586, lib. 1, cap. xxv, pp. 36-37. Cf. Schmitt, "Experimental Evidence," pp. 560-561.

[70] I discuss this theme in detail in Silvia Manzo, "The Argumentation on Void in the Seventeenth Century: The Case of Francis Bacon," *The British Journal for the History of Science* 36 (2003), pp. 26-43.

his last works, he staunchly denied the possibility of any kind of vacuum. For our present topic, it is interesting to note how, in justifying his anti-vacuism, he resorted, in his own way, to the theme of the distinction between natures.

In his classification of motions, F. Bacon allots a class for a motion he usually refers to as the "motion of connection" (*motus nexus*, also called *ne detur vacuum*). Bacon holds that, in the case of containers similar to the clepsydra, there is a conflict between two appetites, both of which tend to certain motions, one to the "motion of gravity" and the other to the "motion of connection." The conflict is decided according to a rule of dominance that Bacon establishes for motions at all levels of nature: "the motion of connection, serving the union of the universe, is more powerful than the motion of gravity, which serves the union of dense bodies."[71] Like in the case of the Coimbrans, for Bacon the primacy of the common good over the private one is a principle that applies throughout the universe. This principle is expressed in the most general axioms of physics, politics and theology, collected by the first philosophy:

> 'Whatever is preservative of a greater Form is more powerful in action,' is a rule in physics; for that the connexion of things should not be severed, nor a vacuum (as they call it) admitted, tends to preserve the fabric of the universe; whereas the collection of heavy bodies towards the mass of the earth tends to preserve only the region of dense bodies; and therefore the first motion overcomes the last. The same holds in Politics; for whatsoever contributes to preserve the whole state in its own nature, has greater power than that which only benefits the particular members of that state. It holds likewise in Theology, for, of the theological virtues, charity, which is the virtue most communicative of good, excels all the rest.[72]

The idea that the preservation of the whole is the highest good is best reflected in the way the principles that govern nature and those that govern politics converge, according to Bacon:

> But they express and expound into themselves the fundamental law of nature, whereby all things subsist and are preserved; which is that every thing in nature, although it has its private and particular affection and appetite, and does follow and pursue the same in small moments, when it is free and delivered from more general and common respects, yet, nevertheless, when there is question or case for sustaining of the more general, they forsake their own particularities and proprieties and attend and conspire to uphold the public.[73]

[71] Francis Bacon, *Novum organum*, in *The Works of Francis Bacon*, ed. by James Spedding, Robert Leslie Ellis and Douglas Denon Heath, 7 vols., London: Longman and Co, 1859-1864; repr. Stuttgart/Bad Cannsttat: Friedrich Frommann Verlag-Günther Holzboog, 1989, vol. I, p. 349. See the same example in *De augmentis scientiarum*, in *Works* I, p. 717.

[72] F. Bacon, *De augmentis scientiarum*, in *Works* I, pp. 541-542; IV, p. 338.

[73] F. Bacon, *A Brief Discourse Touching the Happy Union of the Kingdoms of Scotland and England*, in *The Letters and Life of Francis Bacon*, ed. by James Spedding, 7 vols., London:

This rule of the common good's dominance determines the minor appetites, because it seeks the preservation of a form that affects a greater portion of the universe (*forma amplioris*; *forma magis communis*). The example F. Bacon gives for the co-presence of the common and the private goods is reminiscent of Aegidius Romanus. It is in the magnetic attraction that one can see the degree to which the inanimate nature is structured the same way as the animate one: "Therefore we see the iron in particular sympathy moveth to the loadstone; but yet if it exceed a certain quantity, it forsaketh the affection to the loadstone, and like a good patriot moveth to the earth, which is the region and country of massy bodies."[74]

The metaphor of the good citizen and the principle of subordination reappear in similar terms, only to be refuted, shortly afterwards, in the writings of Robert Boyle (1627-1691). Beyond his committed promotion of the Baconian experimental program, Boyle disagrees with F. Bacon in his interpretation of the phenomenon of the vacuum. His research on the properties of air and his experiments with the vacuum pump only served to validate his total rejection of the ancient *horror vacui* idea. He considered this idea untenable, not least because it was based on meaningless assumptions, like that "a brute and inanimate creature" such as water not only had the power to move up, but also knew that it had this power and was so generous as to ascend, thus acting against "its particular inclination for the general good of the universe, like a noble patriot, that sacrifices his private interests to the publick ones of his country."[75]

4. Conclusion

This survey of the period from the thirteenth to the seventeenth centuries shows that the principle of subordination persisted for at least five centuries in a significant number of authors. While the vacuum question was at the center of important debates and subject to completely opposite approaches, the principle of subordination itself was never called into question. Thus, for example, when Telesio or Boyle reject the anti-vacuist argument based on the principle of subordination, they do not call into question the principle itself, only its application to the problem of the vacuum. Beyond all the changes that took place from the thirteenth century onwards in society and culture in general, and in natural philosophy in particular, it is remarkable that authors with different interests and different backgrounds, writing in various styles and starting from various questions, appealed to the same teleological principle,

Longman and Co., 1861-1874, vol. III, p. 90.

[74] F. Bacon, *The Advancement of Learning*, in *Works* III, p. 420; *De augmentis scientiarum*, in *Works* I, p. 717.

[75] Robert Boyle, *The Works of the Honourable Robert Boyle*, ed. by Thomas Birch, 6 vols., London: Rivington, 1772, vol. 2, p. 38. Cf. vol. 1, p. 75.

according to which nature is understood as a whole whose parts invariably defer to it in order to ensure its preservation.

This persistence we have described does not imply that the principle always appeared in the same way and without any modifications. The context in which the principle was embedded contributes the element of diversity which modifies the core element of continuity running through the studied cases. Certainly, there are those like Albertus de Saxonia, Paulus Venetus and Bartholomäus Keckermann, whose reflections on the vacuum were firmly anchored in the opposition, typical of Aristotelianism, between natural and violent motions. Therefore, their appeal to the teleological principle of the two natures was tied to an explanation in terms of the type of motions these natures implied. Other authors, such as F. Bacon and the Coimbrans, started from a view in which the principle of subordination applies to all aspects of reality. Thus the examples involving the vacuum and those involving projectiles (Pseudo-Grosseteste), originally from physics, have parallels not only in biology (R. Bacon, Zabarella or Albertus Magnus), but also in politics, ethics and theology (Aquinas, the Coimbrans and F. Bacon). In the field of physics itself, the idea that form is what must be preserved (Cardano, Scaliger, Achillini) is common currency in the sixteenth and seventeenth centuries. Meanwhile, the connection or identification of the universal nature with a superior celestial agent (Pseudo-Grosseteste, Albertus Magnus) or with God himself (Suárez) seem to be attempts to cast this teleology as a direct product of an agent that transcends either this world in full, or at least the sublunary realm.

The role of the universal nature and of equivalent concepts was, at times, to permit continuity between bodies so as to ensure the order of nature. Those who held that, in order to run properly, the sublunary world must be governed by the supralunary world (Pseudo-Grosseteste, Albertus Magnus, Aegidius Romanus, Toledo, Suárez, the Coimbrans) saw the continuity between bodies as a prerequisite. To this, one must add the theories in which the universal nature was considered responsible for the order of the world in aspects specifically pertaining to animate beings. Thus, in the field of biology (R. Bacon, Zabarella, Albertus Magnus, Achillini), the universal nature is seen as the guarantor of the continuity of each species' life, because it regulates the vital cycles. On the other hand, when the principle of subordination is presented as the ascendancy of the common good, the universal nature acts as a regulating principle not only in physics, but also in politics, ethics and theology (Aquinas, F. Bacon, the Coimbrans).

In F. Bacon's anti-Aristotelianism, which rejects the sharp distinction between the supra- and the sublunary worlds, the appeal to a higher transcendent agent is absent. What regulates the actions of animate and inanimate beings is the principle of the dominance of the common good, which is *in* nature and governs it. As a preliminary guess, one might say that it is precisely this emphasis on the principle's immanent character that represents a

significant change from Bacon's predecessors and from his contemporaries that were closer to traditional philosophy. F. Bacon's natural philosophy establishes horizontality among the various components of nature, which rules out a relation of subordination between the celestial and the terrestrial beings, but does not preclude the principle of action of the parts (terrestrial or otherwise) from deferring to the whole whose order must be preserved.

Finally, this study may help us reflect on the nature of the changes that took place in the history of philosophy and science in the transition from the Middle Ages to the Renaissance and early modernity. Duhem, the great pioneer of the history of medieval science, was convinced not only that the fourteenth century was the scene of important scientific developments, but also that medieval science was instrumental in shaping the scientific revolution. Decades later, the works of Alexandre Koyré upheld the opposite view, maintaining that it was not possible to establish any continuity between medieval natural philosophy and modern natural philosophy. Edward Grant, who, in his early writings published in the 1970s, adhered to Koyré's position and deemed the medieval contribution to modern science not very significant, had a change of heart with the passage of time. His latest works accept that the scientific revolution would not have been possible without certain conditions and intellectual changes that took place in the Middle Ages. However, Grant does not believe that specific medieval theories about nature influenced the emergence of modern science.[76]

In line with the historiographical approach of Peter Barker and Roger Ariew,[77] I believe that the matter of continuity or discontinuity in the historical development of science and philosophy should not be presupposed in advance by historians, but should be arrived at as a result of concrete historical research. On the other hand, it would be best not to assume that one must encounter one of these two alternatives, understood as incompatible and as absolute polar opposites. This article, focused on the discussions about the existence of the vacuum in nature, shows that there is recognizable continuity between the great periods covered, which indicates that, contrary to what a certain part of the traditional historiography has argued, the transformation

[76] Edward Grant, *The Foundations of Modern Science in the Middle Ages, their Religious, Institutional, and Intellectual Contexts*, Cambridge: Cambridge University Press, 1998, chap. 8. These are just some of the most representative proponents of each view. For a more panoramic view of the debate around the continuity vs. discontinuity between medieval and modern science, see for instance David Lindberg, "Conceptions of the Scientific Revolution from Bacon to Butterfield," in David Lindberg and Robert Westman (eds.), *Reappraisals of the Scientific Revolution*, Cambridge: Cambridge University Press, 1990, pp. 1-26; Bruce Eastwood, "On the Continuity of Western Science from the Middle Ages: A.C. Crombie's *Augustine to Galileo*," *Isis* 83 (1984), pp. 84-99.

[77] Cf. Peter Barker and Roger Ariew (eds.), *Revolution and Continuity. Essays in the History and Philosophy of Early Modern Science*, Washington: The Catholic University of America Press, 1991, Introduction, pp. 1-19, n. 1, p. 19.

of the image of the world engendered at the beginning of modernity did not necessarily involve abandoning the teleological reading of natural processes.[78] However, I do not assume a naïve view of historical continuity. I do not claim that the continuity I have pointed to is a simple, exact repetition, without any modifications, of the principle of subordination. The nuances that differentiate the theories we have examined do not allow us to ignore the diversity of the general framework from which they emerged. Thus, the principle of subordination is recurrent and can be identified along a historical continuum, but is not always presented in the same manner or with the same purpose. Where there is "continuity," it is also possible to find innovation and variety as to what changes. Where there is a gap, it is not always necessary that all traces of the past are completely gone.

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